U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS.

MILTON WHITNEY, Chief.

SOIL SURVEY OF THE BOISE AREA, IDAHO.

BY

CHARLES A. JENSEN AND B. A. OLSHAUSEN.

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SOIL SURVEY OF THE BOISE AREA, IDAHO.

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LOCATION AND BOUNDARIES OF THE AREA.

Boise Valley is situated in the southwestern part of Idaho, near the western line of the State. It is bounded on the north by the Boise Mountains and on the south by Snake River, south of which are situated the Owyhee Mountains. The valley lies nearly east and west, with a maximum width of about 35 miles at the eastern end, and extends from Boise Canyon west to the junction of the Boise and Snake rivers, a distance of nearly 50 miles. Boise River, the only natural stream in the valley of any importance, flows through the valley longitudinally on the north side, near the Boise Mountains.

The area surveyed extends from Boise Canyon to the junction of Snake and Boise rivers, a distance of 48 miles, the width varying from a mile at the eastern end to a maximum width of 12 miles a short distance east of Caldwell. The extent of the area surveyed approximates 400 square miles. Practically all the work was confined to the south side of Boise River, the season being too short to take up the area on the north of that river. (See fig. 17, p. 421.)

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Up to the time of the building of the Oregon Short Line Railroad, which was completed in the early eighties, the development of the agricultural interests of Boise Valley was very slow. The development of the State when first settled was mainly along the lines of mining and stock raising, very little attention being paid to farming.

Boise City was located on July 7, 1863, and the first right to divert water from Boise River for irrigating purposes was granted in 1864. The water was used to irrigate the townsite of Boise and to supply Fort Boise, which was located about the same time as the town.

The valley did not become of any importance in agriculture or fruit raising until the early eighties. With the exception of the Boise and Nampa Canal, which was not used until 1878 and which was much smaller than at present, there were no canals of much consequence before 1882 or 1883. After 1880 or 1881 the valley grew steadily in population, and since 1885, owing to the impetus given by the building of canals and railroads, its growth has been quite rapid.

CLIMATE.

The climate of Boise Valley is arid. It is characterized by little precipitation, moderate temperature, somewhat low relative humidity, slow wind movement, and abundant sunshine.

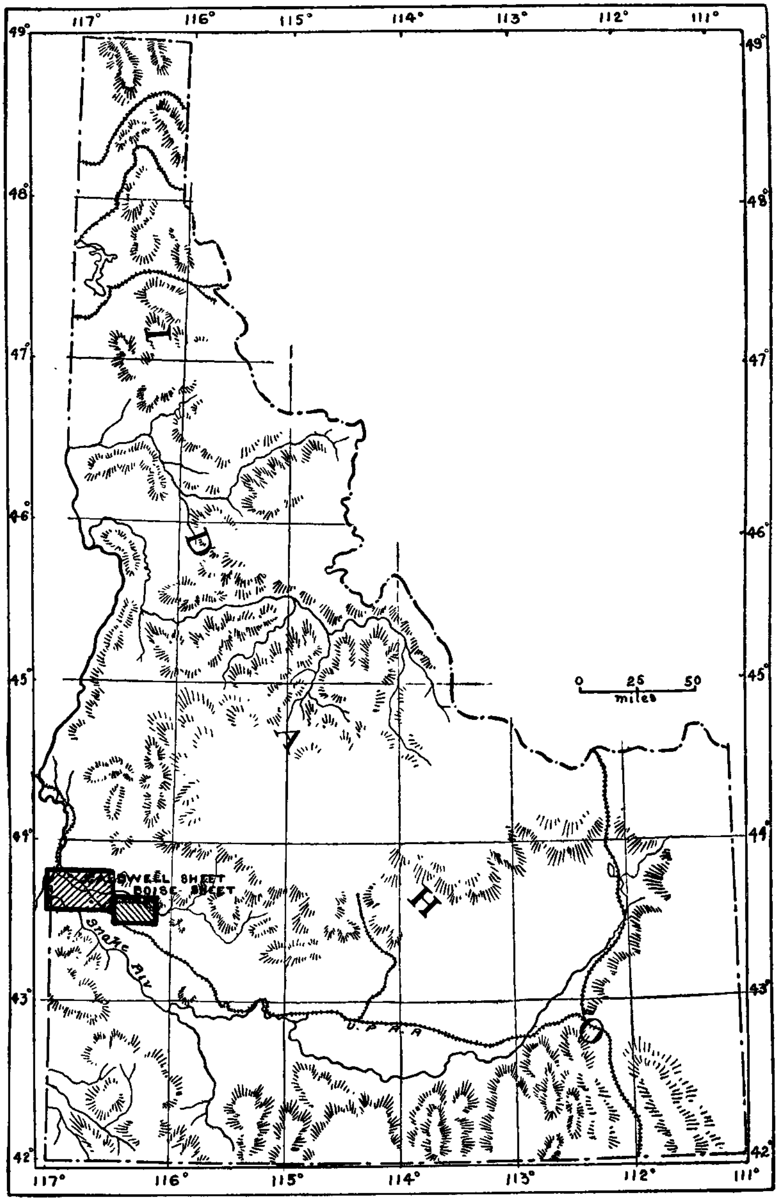


FIG. 17.—Sketch map showing areas surveyed in Idaho.

Data obtained from the Idaho section of the United States Weather Bureau at Boise show that most of the rain occurs in the spring and autumn, the months of June, July, August, and September receiving less than 1.50 inches, an amount too small to figure in the water supply. The temperature being highest and the relative humidity lowest during this time of the year, conditions are favorable for excessive evaporation, and consequently more water is needed for irrigation there than in some other irrigated areas.

The accompanying tables show the normal monthly and annual precipitation and temperature, the relative humidity, and the dates of first and last killing frosts in spring and autumn.

Normal monthly and annual precipitation, temperature, and relative humidity, Boise, Idaho.

Month.	Precipitation.	Temperature.	Relative humidity.	Month.	Precipitation.	Temperature.	Relative humidity.
	Inches.	°*F.*	*Per cent.*		*Inches.*	°*F.*	*Per cent.*
January	1.90	29.38	74	August	.11	71.22	47
February	1.51	32.54	71	September	.59	60.67	49
March	1.42	40.67	61	October	1.28	50.35	62
April	1.35	49.51	56	November	1.58	39.96	74
May	2.17	56.96	56	December	1.18	31.82	78
June	.60	64.44	38	Year	14.25	50.04	60
July	.13	72.48	36				

Dates of killing frosts.

Year.	Last in spring.	First in fall.
1899	May 1	Oct. 2
1900	Apr. 26	Oct. 23
1901	Apr. 16	Nov. 2

The annual precipitation in the mountains is much greater, and it is upon the snow falling there during the winter that the people are dependent for their summer supply of water for irrigation. Some seasons this is not as great as could be desired, as, for instance, in the years 1900 and 1901, when Boise River, which furnishes the only natural water supply, was quite low during the latter part of the season.

The normal annual temperature for Boise is 50.04° F. The maximum temperature for the last four years was 104°, on July 30, 1900, and the minimum for the same period was 9° below zero, on February 5, 1899.

The average wind movement for the year at Boise is less than 5 miles per hour. Occasionally the wind blows down the valley at a much higher rate, though the strongest winds move probably not more than 15 or 20 miles an hour, doing little, if any, damage.

The table showing the last killing frosts in spring and first in autumn applies to Boise. There was a freeze on June 5, 1901, farther down the valley, that killed most of the fruit. This freeze is the most destructive to occur at that time of the year in the history of the valley. Late frosts were quite general throughout the intermountain States in that year.

GEOLOGY.

Broadly considered, Boise Valley is really a portion of Snake River Valley, being a branch of the general depression that extends from the Teton Mountains, near the Wyoming State line, to Weiser, a distance of about 400 miles.

The geologic time of the formation of the general topography of the region is uncertain, but the uplifting of Boise Mountains and the subsidence of Snake River Valley are regarded with certainty as being at least Pre-Neocene. The drainage system of Boise Valley is thought to have similar age. Boise Canyon, also, was eroded to about its present level, though later it was filled up with basalt flows and lacustrine deposits.

During the earlier part of the Neocene period a large fresh-water lake occupied the present depression of Boise Valley, and extended north beyond the Payette River. Evidences of it are also found far east of Boise. It is supposed that this lake was practically contemporaneous with the John Day Lake in the Columbia Basin in Washington, though it was probably separated from it by a spur of the Blue Mountains. In Idaho this Neocene lake accumulated deposits to a depth of 1,000 to 1,200 feet, as evidenced by the beds exposed just east of Boise.

While this lake was being drained by Snake River large basaltic eruptions occurred to the east, the lava reaching down to a point west of Boise Canyon. This has disturbed somewhat the lacustrine deposits in that part of the valley. Immense basaltic eruptions during the latter part of the Neocene period filled Snake River Valley with basalt, from the Tetons to near the confluence of Snake and Boise rivers. While this lava flow covered considerable areas the basaltic beds are not of great thickness, the maximum being probably not more than 900 or 1,000 feet and the average much less.

Since this period, during Pleistocene time, Snake River has cut through 200 to 700 feet of basalt and lacustrine beds, and Boise Canyon, which was filled with gravels and basalt during the eruptive period tc a depth of at least 300 feet, has been worn down by the Boise River to the present level—practically its level before the advent of the lava flows. There were repeated eruptions near the close of the Neocene period and several lava flows interstratified with gravels and sands, mostly granitic, can be seen in Boise Canyon. This canyon shows well how laboriously the river has cut its way through these successive strata. The last basalt flow which occurred in this region was larger than the preceding ones and reached down to and across Ten Mile Creek. One small flow of basalt, through which Boise River has cut its way, extends west to and beyond Caldwell. This bed is about 20 feet thick and a quarter of a mile wide where cut by the river. Good contact metamorphism is shown at the under side of the basalt.

Boise River was thus continually being dammed at the mouth of Boise Canyon by the successive lava flows and forced to change its course.

The two principal mesas, or river terraces, to the south of the present course show the earlier courses of the river.

There was a period of comparative quiet during the latter part of the existence of the lake, as shown by the uniform deposit of clay and clay loam on the mesa plains. This deposit, however, may be due to a Pleistocene lake, as the present mesas were formed before this sediment was deposited.

PHYSIOGRAPHY.

The alluvial soils extend from Boise Canyon, 5 or 6 miles southeast of Boise, to the junction of the Boise and Snake rivers, a distance of about 50 miles. The area varies in width from 1 to 3 miles. It is level throughout its entire length and is somewhat low, though not generally subject to overflow. South of the river bottom is a series of benches from 1 to 5 miles wide; the bluff south of the river is from 20 to 75 feet above the river bed and the succeeding terraces south of it are at about the same elevation above each other. These terraces terminate in a ridge about 2 miles from Snake River and parallel to it. This ridge has an elevation of from 250 to 700 feet above the river. The bench lands between the terraces are nearly level, but with a gentle slope toward the Boise River. Just northeast of Snake River and parallel to it is a small valley known as Deer Flat, which varies in width from 1½ to 5 or 6 miles. This flat is inclosed by a line of ridges at its eastern end, varying in height from 50 to 200 feet above the valley floor, gradually becoming lower westward, and finally disappearing between range lines 4 and 5 west. From there west to Snake River the flat forms a level table-land with an elevation of about 200 feet above Boise River. This flat is level throughout, and with water would be choice land for agricultural uses.

SOILS.

Six types of soil were recognized in the area surveyed. Arranged in order of acreage these are:

Areas of different soils.

Soil.	Boise sheet.	Caldwell sheet.	Total.	
	Acres.	*Acres.*	*Acres.*	*Per cent.*
Boise sandy loam	39,800	56,050	95,850	37.6
Boise loam	47,560	14,400	61,960	24.3
Deer Flat sandy loam	....	45,380	45,380	17.7
Caldwell sandy loam	11,780	21,320	33,100	13.0
Snake River sand	....	17,430	17,430	6.8
Caldwell loam	....	1,500	1,500	.6
Total	99,140	156,080	255,220	....

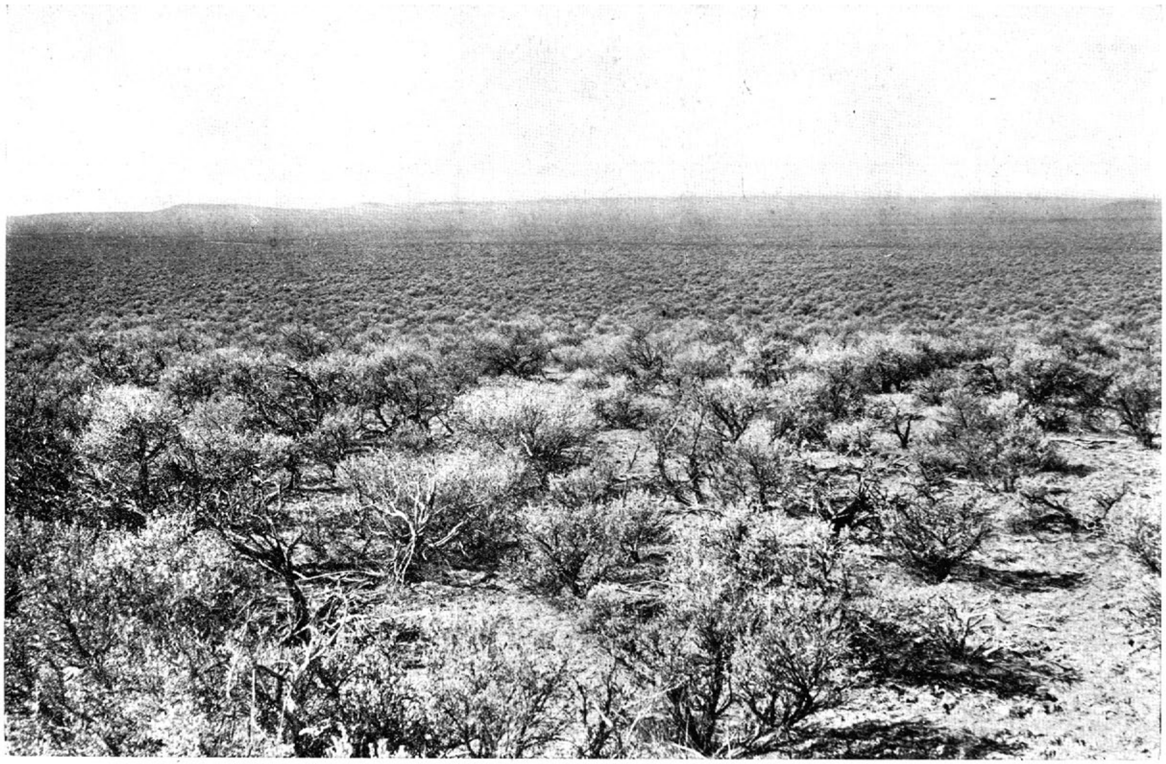
BOISE SANDY LOAM.

Boise sandy loam is a grayish-colored light sandy loam, with a soft, ashy feel, carrying a large amount of silt and having an average depth of about 2 feet. The subsoil of this type south of Boise River is loam or clay loam which has an average depth of about 18 to 24 inches. This in turn is underlain usually with sandy loam, but sometimes with sand, generally cemented together with calcium carbonate, forming a hardpan. In the southern portion of this type the subsoil is altogether sandy loam and there hardpan is found nearer the surface. Hardpan, which is a prominent feature in this soil, will be treated separately. In the creek depressions gravel underlies the soil at an average depth of about 2 or 3 feet.

Excepting the terraces forming the mesas south of Boise River and the range of low hills and ridges encircling Deer Flat, the area occupied by Boise sandy loam is level. The slopes of the terraces and hills vary from 2° or 3° to about 10°.

In origin the type is sedimentary, and probably the soil is decomposed basalt, though this is not yet definitely established.

The soil is well adapted to cereals, truck, and clover, and, when the hardpan is not too thick, to alfalfa and fruit.



NATIVE VEGETATION OF SAGEBRUSH. SOIL FREE FROM ALKALI.

This character of vegetation is usually associated with alkali soils, but it seems to be no safe indication of such conditions in the Boise

Following is a table of mechanical analyses of this type:

Mechanical analyses of Boise sandy loam.

No.	Locality.	Description.	Soluble salts, as determined in mechanical analysis.	Organic matter and combined water.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
5836	W. cen. sec. 20, T. 4 N., R. 1 W.	Surface soil, 0 to 12 inches.	0.02	3.50	0.40	0.80	0.86	4.32	11.98	68.76	8.48
5829	NE. cor. sec. 35, T. 4 N., R. 1 E.	0 to 15 inches.....	.02	3.86	.22	.42	.48	2.20	19.40	64.42	8.10
5830	Subsoil of 5829....	15 to 30 inches....	.03	3.48	.32	.72	.52	2.12	22.32	59.92	10.23
5831	Subsoil of 5830....	Hardpan, 36 to 50 inches,	.04	5.22	14.60	13.72	5.44	9.98	9.30	34.28	7.74
5832	Subsoil of 5831....	Hardpan, 72 to 92 inches.	.04	3.38	11.38	12.78	8.44	18.30	18.62	22.10	5.24
5834	W. cen. sec. 8, T. 3 N., R. 2 E.	24 to 36 inches....	.05	5.74	2.20	4.58	2.20	4.26	8.26	59.04	14.11
5835	Subsoil of 5834....	Disintegrated hardpan, 48 to 51 inches.	.05	5.02	6.34	11.74	6.28	9.72	9.82	39.68	11.29
5846	¼ N. of SE. cor. sec. 20, T. 4 N., R. 1 E.	5th foot, hardpan.	.04	2.26	18.20	18.60	11.20	20.60	5.00	20.74	3.20

BOISE LOAM.

Boise loam occurs on the mesas and the slopes of the terraces and hills south of Boise River. The surface soil is sandy loam to an average depth of about 6 inches, underlain by loam, which sometimes shades into clay loam, and is underlain at about 2 feet with sandy loam or fine sand, which often forms a hardpan.

The upper stratum of the loam in the uncultivated areas usually consists of concretions varying from small grains to the size of a pea. These concretions are made up of particles of loam or clay loam cemented together with calcium carbonate. Owing to the fissile character of this material it never forms a solid mass of hardpan such as is found in the sandy loam. The upper stratum of the loam is red in color, but the lower is reddish-yellow or yellow. The yellow loam does not contain the concretions found in the red.

This type of soil, owing to its peculiar physical properties, requires special cultivation for the best results. This question is considered in the chapter on cultivation.

Clover and cereals do fairly well on this type. Cereals do better after the soil has been seeded to clover and timothy or alfalfa for several years, the mechanical conditions of the soil being much improved by the growth of these crops.

The following table shows the mechanical analyses of the type:

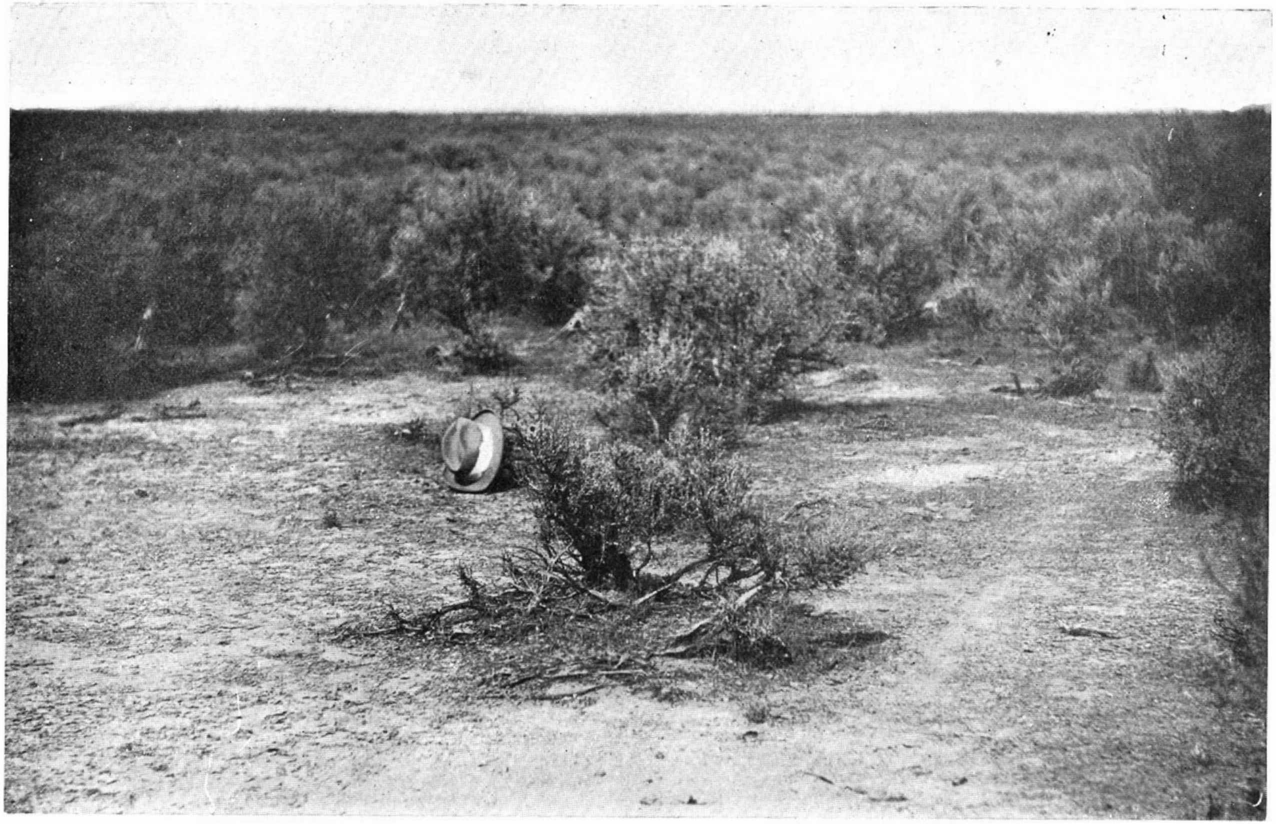
Mechanical analyses of Boise loam.

No.	Locality.	Description.	Soluble salts, as determined in mechanical analysis.	Organic matter and combined water.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
5825	E. cen. sec. 20, T. 3 N., R. 1 E.	Loam, 0 to 12 inches.	0.03	3.74	1.52	1.98	1.10	4.52	26.06	43.50	17.43
5826	Subsoil of 5825....	Loam, 12 to 24 inches.	.06	5.74	3.70	5.78	3.12	10.42	24.94	33.24	12.64
5828	Subsoil of 5827....	Loam, 36 to 48 inches.	.07	5.50	4.98	6.46	2.78	8.62	20.64	32.02	18.71
5827	S. cen. sec. 16, T. 3 N., R. 2 E.	Loam, 24 to 36 inches.	.07	4.92	1.66	2.78	1.34	5.36	23.50	36.88	23.89

DEER FLAT SANDY LOAM.

This type occupies the greater part of Deer Flat from its eastern end nearly to Snake River. The soil averages about 2 feet in depth and is underlain with a finer sandy loam or sand. The soil is red, somewhat micaceous, and contains more coarse sand and less silt than the Boise sandy loam. The subsoil is not as fertile as the soil itself, but owing to its light texture, the ease with which crop roots penetrate it, and its ready permeability to water, crops do very well on it.

Hardpan is generally absent in this type. Very little of the area in Deer Flat is cultivated, owing to scarcity of water, but this soil on the bench land at Roswell is nearly all under cultivation and forms one of the best cultivated districts in the area. The soil is well adapted to fruit, clover, alfalfa, and truck. The area occupied by this type is practically level.



SMALL ALKALI SPOT SUCH AS IS FREQUENTLY FOUND ON THE DESERT.

These spots are always underlain with a heavy subsoil.

SMALL ALKALI SPOT IN ALFALFA FIELD.

These spots are local, do not spread, and are always underlain with heavy soil.

The following table gives the mechanical analyses of this soil type:

Mechanical analyses of Deer Flat sandy loam.

No.	Locality.	Description.	Soluble salts, as determined in mechanical analysis.	Organic matter and combined water.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
5818	SE. cor. sec. 1, T. 2 N., R. 3 W.	Sandy loam, 0 to 12 inches.	0.07	3.22	2.10	6.22	3.10	9.36	42.36	23.34	10.37
5823	W. cen. sec. 20, T. 5 N., R. 5 W.	Sandy loam, 0 to 18 inches.	.10	3.04	.04	.46	.50	4.46	55.26	29.26	6.30
5819	Subsoil of 5818....	Sandy loam, 24 to 36 inches.	.07	4.54	2.24	5.76	4.00	18.78	27.50	24.08	12.79
5824	Subsoil of 5823....	Sandy loam, 24 to 60 inches.	.90	4.08	.04	.32	.76	3.58	48.18	36.20	6.08
5822	Subsoil of 5819....	Very fine sand, 96 to 108 inches.	.15	2.98	2.06	2.64	1.84	13.70	62.10	9.74	4.67

CALDWELL SANDY LOAM.

This is an alluvial soil, of quite recent formation, owing its origin to Boise River, along which it extends from Boise Canyon west to the Snake River. It is all level and much of it comparatively low, water being found at the time the survey was made at about 7 feet from the surface, excepting in a few small slightly higher areas. It is, however, seldom subject to overflow, except near the river, and then only in seasons of high water, when some damage is caused. The river bank is nowhere high, the river bed being only 3 to 7 feet below the surface of the surrounding area. The soil averages about 4 or 5 feet in depth and is underlain with rounded gravel and cobbles similar to those that form the present river bed. Its texture is sometimes quite sandy, and sometimes gravelly, where the substratum reaches the surface.

As mentioned under the heading "Alkali in soils," considerable alkaline carbonate occurs in this soil in and around Caldwell and west to the limit of the map. For this reason that part of the area is not extensively cultivated, but is left to salt-grass and greasewood pasturage.

The soil generally is well adapted to truck farming; oats do well on it, and on the higher areas alfalfa and fruit flourish. Most of the areas, however, are preeminently adapted to hay and pasturage and are largely used in that way. The large brushy areas next to the river are particularly adapted to grazing.

The following tables show the mechanical analyses of Caldwell sandy loam:

Mechanical analyses of Caldwell sandy loam.

[Fine earth.]

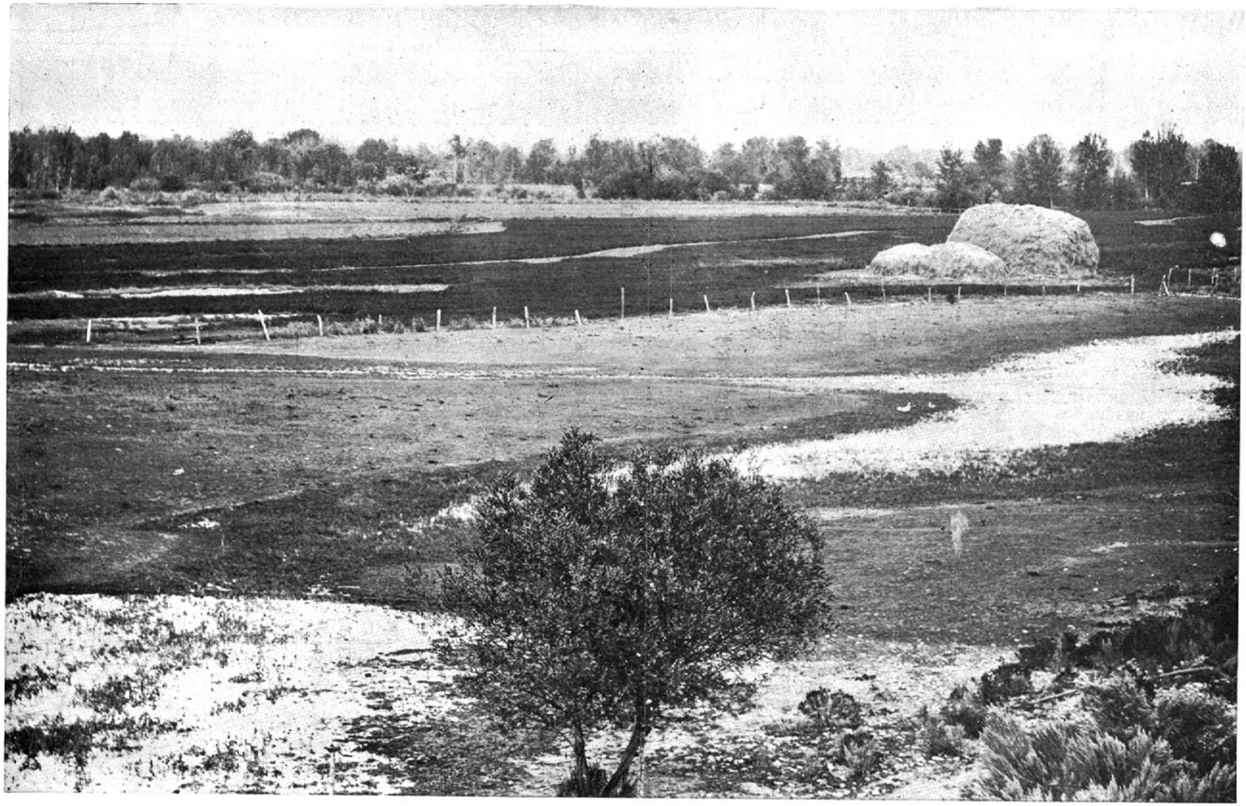
No.	Locality.	Description.	Soluble salts, as determined in mechanical analysis.	Organic matter and combined water.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
5843	Cen. N. ½ sec. 4, T. 3 N., R. 2 E.	Sandy loam, 0 to 12 inches.	0.07	3.84	18.16	11.46	5.54	11.56	2.92	35.08	10.97
5838	Cen. sec. 15, T. 4 N., R. 4. W.	Sandy loam, 0 to 12 inches.	1.40	2.08	Tr.	2.04	3.24	26.36	16.26	40.88	6.66
5844	Subsoil of 5843....	Sandy loam, 12 to 24 inches.	.05	2.90	27.46	9.36	5.12	11.08	2.88	28.52	11.33
5839	Subsoil of 5838....	Sandy loam, 24 to 36 inches.	.02	2.82	.12	.56	1.02	22.98	16.42	44.88	10.62

SNAKE RIVER SAND.

This soil occurs in the southwestern portion of the area surveyed and follows the line of ridges and hills forming the north boundary of the Snake River channel and south boundary of Deer Flat. This soil is quite light and loose and as far as determined varies in depth from a few inches to several feet. The areas are generally level, but with the exception of the area west of Deer Flat, which is irrigated by the Riverside Canal, they lie above any present water supply. The area under cultivation contains considerable gravel, which is not the case in those situated in the Deer Flat plateau. The type is practically untried, but was being settled quite rapidly at the time the survey was made. This soil is well adapted to fruit, truck, and alfalfa.

Mechanical analysis of Snake River sand.

No.	Locality.	Description.	Soluble salts, as determined in mechanical analysis.	Organic matter and combined water.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
5845	Deer Flat.........	Sand, 0 to 15 inches.	0.01	1.64	0.54	3.30	6.16	54.00	11.66	16.42	6.05



TYPICAL FARM SCENE ON CALDWELL SANDY LOAM. FREE FROM ALKALI BUT HAS SOME SEEPAGE WATER.

This seepage water comes from a nearby canal and illustrates the necessity either of protecting the sides and bottom of the canal or providing drainage to keep down the water table in adjoining fields.

CALDWELL LOAM.

This soil occurs southwest of Caldwell, and is also alluvial. It is very level, and in some places alkaline. Its characteristics are practically those of the Caldwell sandy loam, except that it is a much heavier soil and carries much more organic matter. A little hay and alfalfa are produced on this soil, but it is not generally cultivated, being used mainly for pastures.

Mechanical analyses of Caldwell loam.

No.	Locality.	Description.	Soluble salts, as determined in mechanical analysis.	Organic matter and combined water.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
5840	SW. cor. Sec. 20, T. 4 N., R. 3 W	Loam, 0 to 12 inches.	0.12	11.62	Tr.	0.52	0.84	3.80	2.00	64.62	15.76
5842	Subsoil of 5840....	Loam, 48 to 60 inches.	.06	2.62	Tr.	.08	.12	7.30	11.40	61.12	15.90

HARDPAN.

As shown by the accompanying sketch map (fig. 18, p. 432), hardpan is quite general in the eastern and central parts of the area surveyed. It is sometimes found as an outcrop on the slopes of the terraces and draws, but elsewhere, of course, does not occur on the surface. There are usually several strata of it, the depth to the first varying from a few inches to about 5 feet.

Hardpan is found throughout practically the entire loam area, though the loam itself does not form a solid mass of hardpan. The individual soil particles are, however, cemented together in such a way that the loam when first cultivated is composed of small granules and concretions of small size which are angular in shape, owing to natural cracking. This peculiarity of the soil is treated more fully in the chapter on "cultivation."

Under the loam at various depths, though usually from 1 to 4 feet from the surface, a solid stratum of hardpan is found. It is usually formed of the underlying sandy loam or sand and varies in thickness from one-half inch to 2 feet or more. Below this hardpan is found sandy loam and, under that, sand or light sandy loam, which is also often cemented into a hardpan.

In the areas where the loam does not occur, hardpan is found at from 15 to 24 inches below the surface, and there is often, perhaps always, alternate strata of sandy loam and hardpan to some depth. In one place this formation was found to extend to a depth of 9 feet below the surface and in another to 25 feet.

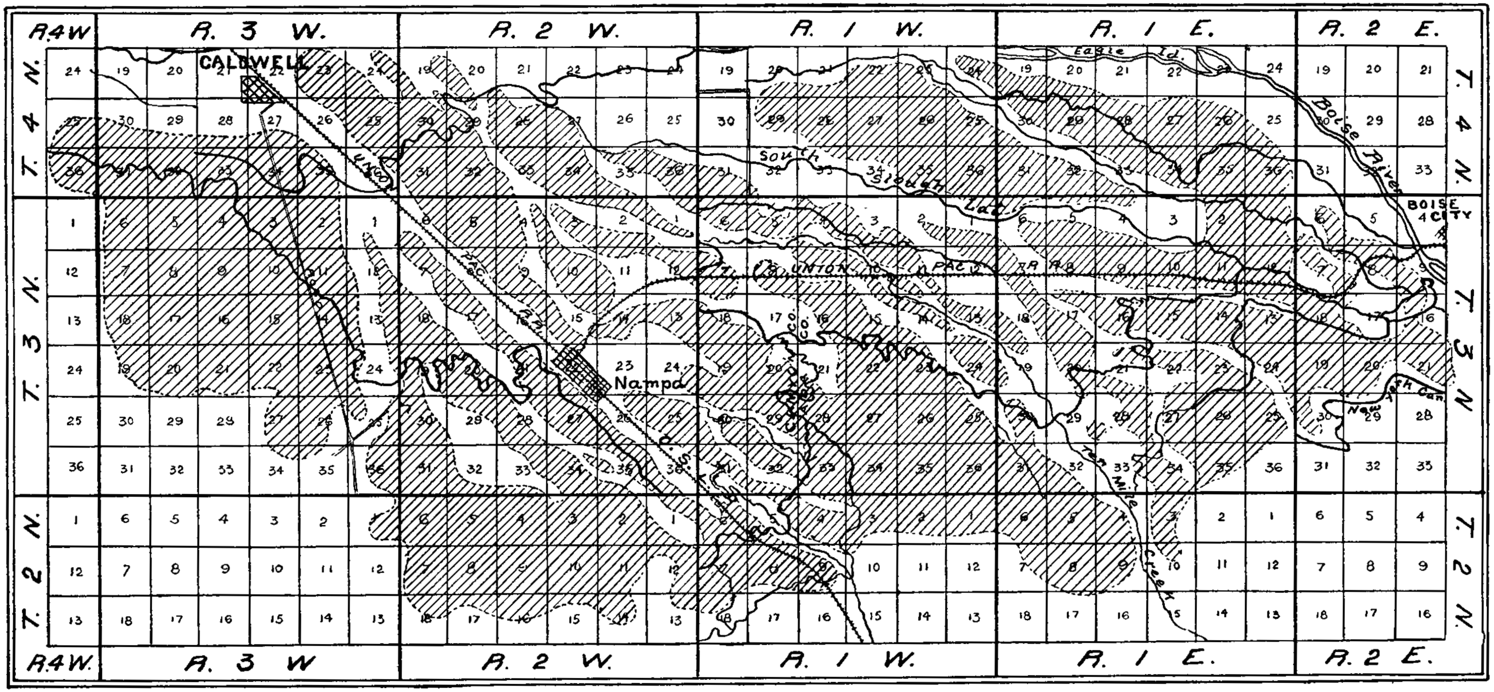


FIG. 18.—Map of hardpan areas, Boise and Caldwell sheets, Idaho.

As the subsoil water is usually comparatively far below the surface—15 to 100 feet—it can not be a contributing factor in the formation of the hardpan, nor could this formation be traced to irrigation, as the hardpan was distributed independently of the soils as virgin or cultivated. As far as could be determined by borings the moisture content was the same below and above the hardpan. The soluble salt content at water saturation did not seem to hold any definite relation to the occurrence of hardpan, though the hardpan itself very often showed more soluble matter than the soil either above or below it. This, though, was not the general rule, as the cementing material is mostly calcium carbonate, which would not dissolve in large quantity with the amount of water used and in the time allowed for solution. By continual irrigation the upper layers of hardpan become pretty well dissolved. However, as most of the lime remains in the soil the hardpan is apt to form again when the soil becomes thoroughly dried. Borings were made in fields that had been irrigated and cultivated for six or seven years, and though the upper part of the hardpan had been disintegrated, forming a rather coarse, sandy soil, the hardpan at a depth of from 5 to 7 feet was found to be perfectly hard.

The hardpan on the bench lands also occurs independently of the position of the subsoil water, which is found at a depth ranging from 15 to 100 feet or more below the surface; nor does it appear to depend upon the presence in the soil of excessive amounts of the more soluble salts, the cementing material being calcium and magnesium carbonates. As in the loam areas, the soil moisture also appears to be about the same in amount below and above the hardpan.

On the other hand, the formation in this area invariably occurs at the change from a heavier to a lighter soil downward, and it is reasonably fair to assume that an important factor in its origin is the mechanical characteristics of the soil itself. The moisture in descending through the soil dissolves part of the more soluble salts, and a part of the carbon dioxide gas, more plentiful in the soil than in the atmosphere. This forms a solution which is capable of dissolving a much larger amount of calcium and magnesium carbonates than carbon dioxide free water can dissolve. Now when this solution descends through the heavier, or finer grained soil, the soil spaces being small will be practically filled and a chemical action will take place by which the calcium and magnesium carbonates in the soil will be dissolved, forming the hydrogen carbonates of these bases, but in the lighter soil the air spaces and the surface of the individual soil grains are larger, and as the solution passes into it the moisture will not be sufficient to fill all the air spaces. There will then result a lowering of the partial pressure of the carbon dioxide and a partial liberation of this constituent of the solution, with the result that part of the calcium and magnesium hydrogen carbonates in solution will be changed to the more insoluble normal carbonates of these bases and will form as a precipitate around the soil grains. The accompanying sketch (fig. 19) represents the conditions under which this will occur.

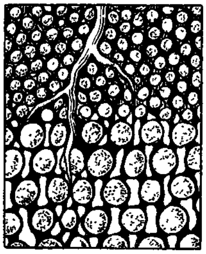


FIG. 19.—Section through soil to illustrate formation of lime carbonate hardpan.

This occurring at the change from a heavier to lighter soil texture, will give rise to the formation of the hardpan in the lighter, rather than in the heavier soil, as is actually the case in the area surveyed. This same explanation would hold if the subsoil water were near enough the surface to reach it by capillarity, bringing up with it the dissolved carbon dioxide and soluble salts from below, and there is no doubt that the process is actually reversed after heavy rains or excessive irrigation.

The writer is indebted to Dr. Cameron, of this Bureau, for assistance in formulating the above probable explanation of the occurrence of the extensive hardpan areas found in Boise Valley.

CULTIVATION, IRRIGATION, AND WATER SUPPLY.

Practically all crops are seeded in the spring. The soil when first brought under cultivation should be treated according to its nature. Mere plowing, seeding, and harrowing will not give uniformly good results, owing to the peculiar nature of some of the soils. When both soil and subsoil are sandy loam, and hardpan does not occur near the surface, the customary practices will do very well, but when the soil is heavy, or the light soil has a loam or clay loam within 8 or 12 inches of the surface, the cultivation must be more thorough, in order to get the heavy soil intermixed with the light. This is necessary, owing to the peculiar character of the loam, the individual particles of which are usually cemented together into small, hard lumps. Upon exposure these lumps, or granules, are separated by innumerable small cracks and fissures, so that when plowed the soil, instead of being turned over in a solid furrow, breaks into pieces which roll down the furrow like marbles. If the surface sandy loam only is plowed, leaving this heavy subsoil untouched, the first application of irrigating water goes through the surface sandy loam and down the fissures in the loam, the whole apparently taking the water very well. The water that reaches the subsoil, however, merely serves to partially dissolve the cementing material of the loam, with the result that the fissures become closed and a heavy mass of clay, practically impervious to water and impenetrable to plant roots, results. It was often found that immediately after an irrigation only the surface foot of sandy loam and about 1 or 2 inches of the loam subsoil had been benefited by the application of water. This unfavorable condition could be largely, if not wholly, overcome by deep plowing or subsoiling.

In some parts of the area one sees patches, usually but a few feet in extent, on which no vegetation grows—not even greasewood or sage brush. In such places the first 2 feet or so consist of loam or clay loam, which appears on the surface in small blocks or granules like the loam previously mentioned. The soil usually carries quite a large percentage of alkali, and when irrigated it bakes like the loam subsoil, which condition, together with the alkali and the absence of a surface covering of sandy loam, prevents quite completely the introduction of crops by the usual method of cultivation. The only way to obtain immediate results from these places would be to subsoil them, bringing up sandy loam, where it is sufficiently near the surface, and intermixing it with the loam. In this condition the spots will take water much better, the alkali can be washed out quite easily, and the crop roots will penetrate the soil without difficulty.

Another difficulty which the farmer has to overcome in this area is the hardpan. In many places, but more especially on the slopes of draws, this material occurs near, i. e., within a foot or so of the surface, and until it has been plowed up the soil is practically useless. Underneath the hardpan a light soil is always to be found, which plant roots can easily penetrate. Attempts to grow crops without first breaking up the hardpan are commonly unsuccessful. Plants may show quite a vigorous growth at first, but they fail rapidly when their roots encounter the hardpan.

It is especially important to break the hardpan in the places where fruit trees are to be set, as they need a large root area if they are to continue yielding good results after the first two or three years' fruiting. It has been shown[a] that the root of a peach tree will penetrate the soil to a depth of 25 feet, the particular tree reported having gone successively through loam, gravel, and clay, and as the peach is comparatively short-lived it is probable that apple trees will penetrate to even greater depths if there are no obstacles in the way.

Of course the first hardpan, which occurs usually at a depth of 12 to 30 inches, is always broken through, but there is quite a general stratum of hardpan at a depth of 5 to 7 feet which is much thicker than the first one and usually harder; it was sometimes found to be 3 feet thick, though this is more than the average thickness. This is the important obstacle to be removed, and it can best be gotten rid of by blasting. The process of dissolving out this hardpan by irrigation is too slow for the purpose, more especially where the superimposed soil is a loam.

The necessity of rotation of crops in the areas of shallow sandy loam with a heavy subsoil can not be too much emphasized. The surface sandy loam, excepting that in the creek bottoms, is not nearly as fertile

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[a] Bul. No. 37, Arizona Exp. Sta.

nor as recuperative as the heavier soil, and, without a proper selection of crops and good cultivation, declines in fertility more or less rapidly. Clover is an excellent introductory crop for the new land with the heavy subsoil. Peas of various kinds will serve the purpose of adding nitrogen to the soil, but they will not effect the improvement of the mechanical condition of the heavy soils as well as clover. More attention should be paid to this matter, as the unfavorable mechanical condition of the bench soils rather than a deficiency of natural fertility is the real cause of most of the trouble with this land.

Irrigation is absolutely necessary to the agriculture of the area. Without it it would be useless to try to make farming a success. In only the lowest places, where the subsoil water is sufficiently near the surface, can crops be grown successfully without artificial watering, and even there the surface foot or so is apt to become too dry. Both the flooding and furrow methods are used, but over most of the area surveyed flooding would be the better method if enough water could be had, as at the best it is very difficult to get the water into the heavy subsoil. Without accomplishing this there is no reserve moisture to be drawn upon, for the sandy loam on the surface quickly loses its moisture by capillary action and the soil is left in as dry a condition as before irrigation. More than the usual amount of water is necessary in the area where this soil type occurs, as the land must be irrigated often to keep it in condition for plant growth. Subsoiling improves the soil as regards retention of moisture. Where the soil type consists entirely of sandy loam, especially the Deer Flat sandy loam, the usual amount of water answers very well.

The area has a good canal system, theoretically, as practically all the land is under some canal or other; but, notwithstanding this, there is not nearly enough water to bring all the land under cultivation. From Boise to Meridian and a little beyond probably a little more than half of the area is cultivated, but from there to Caldwell and beyond a very much smaller proportion of the higher lands is under cultivation, owing to the fact that not enough water can be delivered to the farmers. Most of the canals carry their full capacity during the early part of the season, but as Boise River decreases in volume the supply falls short. The shortage usually begins during the middle or latter part of August and lasts into October.

The following statements relative to the canals on the south side of Boise River were obtained partly from the Report of the State Engineer for 1899–1900 and partly from canal officials.

One of the first canals constructed in the area was the Ridenbaugh, now known as the Boise and Nampa Canal. It was first used in 1878, and is to-day one of the largest and longest canals in the valley. The main canal is about 52 miles long, and the length of its larger branches amounts to 110 miles. It was built as far as T. 3 N., R. 1 W. during the first construction, and in 1880–81 was extended to practically its present length. The construction of several storage reservoirs situated along the line of the upper branches of the canal is contemplated. It is the intention to use these to store the surplus water until August. These storage basins will have a combined capacity of 26,000 acre-feet. At present the average flow of water in the upper section of this canal is about 400 second-feet. Water in this canal is charged for at the rate of $1.50 per miner's inch, 1 inch being supposed to irrigate 1 acre in twenty-four hours. About 19,000 acres were under cultivation in 1900, while the canal is designed to irrigate about 80,000 acres.

The construction of the New York Canal was begun in 1890 and finished in 1901, which was its first season. Its capacity is about 200 second-feet, and its length at present about 14 miles. A proposed extension will increase it to about 30 miles. The area covered by the present system is 20,000 acres. With the proposed construction this will be increased to 50,000 acres. The canal is controlled by a stock company, and each share of stock sold to the farmer entitles him to four-fifths of a miner's inch of water, continuous flow, under a pressure of 4 inches. In 1901 the stock sold for $15 per share.

The Lemp Ditch, first used in 1892 and built by the settlers, but now owned by a company, has a total length of 7 miles, a capacity of about 100 second-feet, and irrigated in 1900 about 5,400 acres. It is to be enlarged soon, when it will irrigate about 20,000 acres.

The Phyllis Canal was finished in 1890. It was built by a company, but has since been acquired by an individual. Its capacity is 125 second-feet, and its length about 65 miles. Only about 35 miles was in use in 1901, covering an area of about 30,000 acres, with about 3,200 acres actually irrigated. The canal extends west across Deer Flat to within 2 miles of the State line. Water costs $1.50 per acre for the season, the maximum amount allowed being 1 second-foot, which will irrigate from 60 to 70 acres.

The Caldwell Ditch, owned by an individual, irrigates the lower bench lands north of Caldwell. Its capacity is about 75 second-feet, and its length 14 miles. It covers about 12,000 acres, of which but 2,000 acres are irrigated.

The Riverside Canal irrigates the river-bottom lands northwest of Caldwell. Its capacity is 200 second-feet in the upper section. It is 23 miles long, and covers about 12,000 acres, of which 3,000 acres are irrigated. The canal is owned by the Riverside Irrigation Company, of Roswell. The ownership is divided up into shares, each share costing $10, carrying with it a water right for 1 acre, and entitling the holder to at least 2½ acre-feet of water during the irrigating season. The cost of maintenance is at present about 75 cents per acre.

The above-described canals include all on the south side of Boise River. There are several on the north side, but as that area was not surveyed a description of them is omitted.

Owing to a light snowfall in the mountains, the supply of irrigation water was less, and lasted a shorter time, in the years 1900 and 1901 than during any previous year in the history of the valley. The valley itself received little snow during those years, and what it did receive rapidly disappeared. There was, however, more water in the river during the earlier part of the season than the present canal systems could use, which shows that an enlargement of the canals would improve conditions materially.

The advantage that would result if some means were provided for storing the surplus water of the winter and spring for use later in the season, when the natural supply falls short, would be invaluable. There are, however, no large and really good natural reservoir sites in the area surveyed, though sites for reservoirs of smaller capacity exist. Lake Nampa and Lake Paradox—really not lakes at present, but dry basins—furnish good small sites, and the Boise and Nampa Canal Company contemplates utilizing these in the near future, as they are situated along the main lines of their canal system. This would greatly increase the efficiency of their present system and bring more of the Deer Flat country under irrigation. Something of this kind will have to be done before much more of the area can be cultivated.

Table showing the mean monthly discharge of Boise River, at Boise Canyon, for the months of April, May, June, July, August, and September of the years 1895-1901; also mean acre-feet of water for same period. (Drainage, 2,450 square miles.)

[Compiled from data obtained from United States Geological Survey, Division of Hydrography.]

Month.	Mean second-feet.	Acre-feet.
April	5,507	325,164
May	[a] 7,951	[a] 488,888
June	8,103	484,458
July	3,040	186,921
August	1,034	63,578
September	867	51,589
Season	2,417	266,766

[a] Year 1897 not reported.

The mininum mean flow from 1895 to 1900 was 648 cubic feet per second, in September, 1900. In 1901 the flow was somewhat less.

The irrigation water found in the canals in the eastern part of the valley is of good quality, the total amount of salt being from 11 to 13 parts per 100,000 parts of water. Of this total salt content 8 to 10 parts is bicarbonate, the rest being mostly chlorides, sulphates, and carbonates, with some silica. An analysis of the Riverside Canal water

Report of Bureau of Soils, U. S. Dept. Agr., 1901.

CALDWELL CANAL IN GRAVELLY RIVER BLUFF, SHOWING SEEPAGE.

The loss of water through seepage from canals is the cause of the rise of underground water in most of the irrigated districts and of the rise of alkali in many areas. It would in all cases be cheaper to prevent this seepage than to underdrain the lands or to abandon once valuable farms.

showed 17.5 parts total solids per 100,000 parts of water. The water in this canal being partly seepage water one would expect it to have a higher salt content than the upper canals. This, however, is a good water, and notwithstanding the fact that it runs through several miles of black alkali area in the river-bottom lands, no alkaline carbonate was present, that salt having been converted into the bicarbonate, as the high percentage of the latter would indicate. The water can be used on the alkaline lands under it for their reclamation, as well as in the irrigation of the better lands, without danger of injury.

UNDERGROUND AND SEEPAGE WATERS.

A large number of samples of well water were examined in the field, and a good general idea of the condition of the underground water was obtained. Well waters are to a large extent indicators of the alkali condition of the subsoil. It is to be remembered, however, that the soil may not contain injurious amounts of salt and yet the subsoil water may be highly impregnated. This is especially true in a deep, porous soil, where there is a slow but continual movement of water which leaches out the salt and continually becomes more and more concentrated. The process is of course much hastened through irrigation, especially if the soil is sufficiently porous to readily permit the percolation of water. It is a common case to find well water at quite a depth—30 to 50 feet—so heavily charged with alkali as to render it wholly unfit for use. There are cases in which water artificially applied has leached out the salt, the subsoil water at the same time accumulating and rising. In such cases when the water rises to within capillary distance of the surface the soil sooner or later becomes contaminated with alkali. The existence of the salt in the alluvial soils along the Boise River is due to this cause, the seepage waters from the bench lands rising in the river bottom. As the water here is near the surface—from 3 to 6 feet—the salt is nearly all in the first foot of soil—a surface accumulation being quite general.

Generally speaking, and except that the content of hydrogen carbonate is usually greater, the well waters in the alluvial soils are of better quality than those on the bench lands. This would be expected, as the river soils are generally not very deep. Moreover, they are underlain with a stratum of coarse gravel and cobbles, which furnishes good natural drainage, and the salt is thus carried away by the water. The existence of considerable quantities of alkaline carbonate in this soil accounts for the larger amounts of hydrogen carbonates in the water.

Much of the subsoil water in the river-bottom lands between Boise and Caldwell is due to seepage from the canals that follow the gravelly bluff forming the south boundary of the river soils. The seepage in some places here is considerable, being not only damaging to the soils below, but also causing considerable loss in the waste of water from the canals. However, except in the draws there is no immediate likelihood of the subsoil water reaching dangerously near the surface in the bench lands, as these lands have a moderately high elevation. In addition to elevation the soils on the benches do not become thoroughly saturated by the water applied in irrigation, for reasons mentioned in the chapter on cultivation, and but a small part of this land is at present under cultivation, both which facts will retard the accumulation of subsoil waters there.

The accompanying tables, compiled from field determinations and laboratory analyses, show the condition of some typical well waters. By referring to the soil map for the locations it will be noticed that the wells situated some distance from the draws and sloughs or other natural drainage channels are generally in worse condition than those in the draws, the reason being that in the former cases the subsoil water has very little movement. The various salt constituents correspond to those found in the soil, excepting the alkaline carbonates, these being readily converted into hydrogen carbonates by the action of the carbon dioxide in the soil, or by the replacement of the sodium by one or more of the bases combined with sulphions.

Samples 99 and 100 are interesting as showing the difference of salt content in the first and second veins of water. The two wells are within a few rods of each other, but in sample 100 the well was terminated when water was first encountered, while in sample 99 the well was carried down to the second vein of water, the first supply being shut out by pipes. It will be noticed that sample 100 carries nearly seven times as much salt as sample 99. Other interesting cases are samples 123 and 124. The former had been dug about four years, and the latter about nine months, before the tests were made. They are but a few rods apart and within 2 feet of the same depth. Notwithstanding the difference in age, the salt content, which is low, is identical in these wells. The only irrigated land above them, however, is the farm on which they are located, and even there irrigation has been quite light.

Boise Valley well and irrigation waters (laboratory analyses).

Constituent.	29. Well 50 feet deep, cen. of SW. 40, sec. 7, T. 3 N., R. 1 E.	55. Well 40 feet deep, ¼ E. of SW. cor. sec. 2, T. 3 N., R. 1 W.	141. Well 30 feet deep, SE. cor. sec. 30, T. 4 N., R. 2 W	186. Well 34 feet deep, W. cen. sec. 27, T. 5 N., R. 5 W.	Riverside Canal, cen. sec. 15, T. 4 N., R. 4 W.
	Parts per 100,000	*Parts per 100,000*	*Parts per 100,000.*	*Parts per 100,000*	*Parts per 100,000.*
Ions:					
Calcium (Ca)	15.49	24.41	1.30	5.89	1.90
Magnesium (Mg)	4.49	8.18	.70	4.00	.40
Sodium (Na)	5.70	63.51	9.30	51.60	2.30
Potassium (K)	2.80	6.98	Tr	1.78	.30
Sulphuric acid (SO_4)	24.50	133.32	6.90	66.82	1.20
Chlorine (Cl)	15.80	39.73	....	9.78	.60
Bicarbonic acid (HCO_3)	30.90	57.77	23.30	75.12	10.80
Conventional combinations:					
Calcium sulphate ($CaSO_4$)	34.71	17.60	4.58	20.00	1.70
Calcium bicarb. ($Ca(HCO_3)_2$)	21.39	77.90	....	....	5.60
Magnesium bicarb. ($Mg(HCO_3)_2$)	17.69	....	....	....	2.40
Magnesium chloride ($MgCl_2$)	6.19	....	....	....	....
Potassium chloride (KCl)	5.30	13.32	Tr.	3.40	.50
Sodium chloride (NaCl)	14.40	15.99	....	13.48	.70
Magnesium sulphate ($MgSO_4$)	....	40.60	3.38	19.80	....
Sodium sulphate (Na_2SO_4)	....	131.09	1.60	54.79	....
Sodium bicarb. ($NaHCO_3$)	....	....	31.95	103.52	6.60
Total salt content	99.7	333.9	41.5	215.0	17.5

Boise Valley well waters (field determinations).

Salt.	47. Well 30 feet deep, SE. cor. sec. 34, T. 4 N., R. 1 W.	67. Well 15 feet deep, ¼ S of cen. sec. 26, T. 4 N., R. 2 W.	99. Well 40 feet deep, N. cen. sec. 12, T. 3 N., R. 3 W.	100. Well 17 feet deep, N. cen. sec. 12, T. 3 N., R. 3 W.	123. Well 38 feet deep, ¼ S. of cen. sec. 3, T. 3 N., R. 3 W.	124. Well 36 feet deep, ¼ S. of cen. sec. 3, T. 3 N., R. 3 W.
	Parts per 100,000.	*Parts per 100,000.*	*Parts per 100,000.*	*Parts per 100,000.*	*Parts per 100,000.*	*Parts per 100,000.*
Bicarbonates	52	66	20	60	26.7	26.7
Chlorides	16	28	21	156	4.1	4.6
Sulphates	Slight.[a]	Much.[a]	6	90	None.	None.
Total salt content	98	107	48	323	33	33.0

[a] Not determined quantitatively.

ALKALI IN THE SOILS.

The alkali maps show the salt content of the soils at the time the survey was made. The figures represent the mathematical mean percentage of soluble salts in the first 6 feet of soil at water saturation, the amount of salt in each foot section being determined by means of the electrolytic bridge. The black-alkali map shows the percentage of alkaline carbonates in the surface foot, the amount being determined volumetrically on a portion of the sample used for the total salt determination. The chlorides and bicarbonates were also determined volumetrically on the portion used for the alkaline carbonate determination. The sulphates were determined qualitatively. The ratio of soil to water used in these determinations was 11.80 cc. of saturated soil to 250 cc. water. The solution was cleared of all material not in solution by means of a Pasteur filter pump.

While the greater portion of the area is mapped as having less than an average of 0.20 per cent of salt in the first 6 feet, this is not without some minor exceptions. Throughout much of the area from Meridian to Caldwell a number of small bare spots occur in the sagebrush land. The soil in these patches usually consists of loam or clay loam from 1 to 3 feet deep. Little or no vegetation grows on these spots, both because of the high salt content and because of the physical condition of the soil. A number of determinations made in these places showed that the mean percentage of salt was usually from 0.40 to 0.60 per cent in the first 6 feet, but tests were made in other spots carrying from 0.20 to 0.40 per cent and from 0.60 to 1 per cent. The maximum was usually in the first or second foot, the salt content then decreasing downward, with only a small amount in the fifth or sixth foot. As these spots were usually only a few feet in dimensions and very irregular in occurrence, it was found impracticable to map them on the scale used. These places are considered further in the chapter on cultivation. The distribution of the salt in the soil depends upon the influence of the subsoil water and surface irrigation. On the uncultivated uplands the maximum was found either in the fourth or fifth foot, while in the lower areas, in the alluvial soils, the maximum was found in the surface foot, with generally but a small percentage farther down. The relation of the various components of the salt to one another also varies with the condition of the subsoil water.

As the alkali map shows, the highest percentages of salt found in the bench soils, except in surface accumulations, are found on or near the slopes of drains and bluffs, this being where the soil moisture first approaches the surface, carrying with it the salt in solution. It may seem inconsistent that these places should carry more salt than the draws, where heavy accumulations of salt occur, but a consideration of the origin of the salt in these latter places shows the probable reason for this. In the bench lands the soil moisture and subsoil water carrying the salt in solution naturally gravitate toward the lower creek and river bottoms. This process going on continually raises the water table in these lower lands. As the soil in these places is generally light and underlain with coarse sand and gravel, the water moves away quite readily. This movement of the subsoil water in the low lands constantly carries the salt away, leaving only as much salt in the soil as the water itself is capable of giving to it, which depends upon the concentration of the subsoil water. In the bottoms the subsoil water is near the surface, being found at a depth of from 3 to 7 feet at the time the survey was made. This is near enough to favor capillary movement of the water toward the surface, and accounts for the surface deposits found there, as well as for the fact that the maximum salt content is in the surface foot. There is little salt below this depth.

On the virgin soils of the bench lands the moisture does not reach the surface, and consequently the salt does not, the maximum being found either at the lower limit of the downward movement of the surface moisture or near the upper limit of the capillary movement of the subsoil water.

In but few places on the bottom lands does the total salt content in the first 6 feet exceed 0.40 per cent, most of which is in the surface foot, with from one-fourth to five-eighths of it alkaline carbonates. As a general rule chlorides and sulphates are not present in large quantities in the alluvial soils, the salt consisting principally of carbonates and hydrogen carbonates. On the bench lands the sulphates and chlorides are more abundant, forming a large proportion of the total salt content. The reason for a smaller percentage of sulphates and chlorides in the river soils than in the bench lands, the same concentration considered, is undoubtedly due to the fact that these constituents have either been carried away in the process of formation of the river soil or, if they have ever been present in larger quantities, have been dissolved out and carried away by irrigation water or subsoil water, or both. The alkaline carbonates are present in much larger quantities in the surface foot in the river-bottom soils than in the bench soils. While the sulphates and chlorides are washed out of the river soils by the movement of the subsoil water, and are not being replaced as rapidly with the same salts from the subsoil or from the waste water from the bench lands, the alkaline carbonates are continually increasing in amount in the river soils. Doubtless the source of these salts is principally the seepage water from the bench lands, which contains a little alkaline carbonate and much hydrogen carbonate. The latter reaches the surface by capillarity, there to lose some of its carbon dioxide and form alkaline carbonates.

No natural accumulations of alkali were found in the bench lands, but there is more or less alkali uniformly distributed throughout the soil, and this of course shows itself along the draws and in the lower places wherever irrigation has been carried on long enough. The alkali in the western end of the area is mostly alkaline carbonate, this also being due to the rise in subsoil water containing much hydrogen carbonate. This semicircular area is an earlier channel of Snake River and the soil is alluvial.

Table illustrating the difference in character and amount of salts in soils influenced by subsoil water and in soils not influenced by subsoil water (field determinations).

RIVER-BOTTOM SOILS, INFLUENCED BY SUBSOIL WATER.

Field boring number.	Location.	Number of foot section.	Depth to standing water.	Total salt.	Alkaline carbonates.	Hydrogen carbonates.	Chlorides.	Sulphate precipitate.[a]
			Feet.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
113	Cen. of NE. 40, sec. 35, T. 4 N., R 3 W.	1	2½	0.69	0.397	0.194	0.084	None.
118	NW. cor. sec. 27, T. 4 N., R. 3 W ...	1	3½	.34	.145	.121	.059	None.
127	W. cen. sec. 21, T. 4 N., R. 3 W.....	1	2½	.70	.206	.248	.235	Light.
153	Cen. NW. ¼ sec. 20, T. 4 N., R. 3 W .	1	4½	.95	.260	.061	.135	Heavy.
156	¼ N. of cen. sec. 13, T. 4 N., R. 4 W .	1	5	1.65	.825	.629	.051	None.
161	W. cen. NE. ¼ sec. 23, T. 4 N., R. 4 W.	1	3	.16	.109	.047	Tr.	None.

BENCH SOILS NOT INFLUENCED BY SUBSOIL WATER.

Field boring number.	Location.	Number of foot section.	Depth to standing water.	Total salt.	Alkaline carbonates.	Hydrogen carbonates.	Chlorides.	Sulphate precipitate.[a]
80b	Near cen. sec. 19, T. 3. N., R. 2 W..	7	....	.50	Tr.	.067	.236	Medium.
81	.....do..............................	2	....	1.05	Tr.	.054	.503	Heavy.
98	SW. cor. sec. 8, T. 3 N., R. 2 W.....	1	....	.86	Tr.	.040	.298	Heavy.
106	NE. cor. sec. 8, T. 3 N., R. 2 W......	2	....	.40	.061	.085	.084	Medium.
108	NW. cor. sec. 6, T. 3 N., R. 2 W....	1	....	2.30	.538	.375	.404	Heavy.

[a] No satisfactory volumetric method for field determination of sulphates having been devised, this salt was determined qualitatively only.

Chemical analyses of soluble salts in alkali soils.

Constituent.	5824. W. cen. sec. 20, T. 5 N., R. 5 W. Subsoil of Deer Flat sandy loam, 24 to 60 inches.	5838. Cen. sec. 15, T. 4 N., R. 4 W. Soil of Caldwell sandy loam, 0 to 12 inches.	Standardization solution of Boise Valley.	X. Alkali, surface deposit.	5852. Alkali, surface deposit.	5851. Alkali, surface deposit.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Ions:						
Calcium (Ca)	2.05	0.18	Tr.	0.37	1.75	0.17
Magnesium (Mg)	2.05	.18	0.31	.47	1.24	.09
Sodium (Na)	15.22	31.25	34.46	30.58	29.02	34.70
Potassium (K)	20.51	5.23	1.05	2.28	.97	.92
Sulphuric acid (SO_4)	8.88	12.31	31.71	48.74	54.91	10.04
Chlorine (Cl)	40.87	3.85	6.29	6.63	11.53	3.38
Bicarbonates (HCO_3)	10.42	23.35	9.58	6.93	.53	26.88
Carbonic acid (CO_3)	....	33.65	16.29	4.00	.05	23.69
Phosphoric acid (PO_4)	....	....	.31	Tr.	....	.13
Nitric acid (NO_3)	....	....	....	....	....	Tr.
Conventional combinations:						
Calcium sulphate ($CaSO_4$)	6.83	.64	Tr.	1.28	5.93	.57
Magnesium sulphate ($MgSO_4$)	5.10	.82	1.53	2.20	6.15	.41
Magnesium chloride ($MgCl_2$)	3.93	....	....	....	....	....
Potassium chloride (KCl)	38.98	8.08	1.98	4.34	1.84	1.75
Sodium chloride (NaCl)	30.79	....	8.84	7.54	17.56	4.19
Sodium bicarbonate ($NaHCO_3$)	14.37	31.27	13.20	9.55	.72	36.97
Sodium sulphate (Na_2SO_4)	....	16.54	45.13	8.01	67.70	14.12
Sodium carbonate (Na_2CO_3)	....	41.55	28.78	7.08	.10	41.75
Potassium bicarbonate ($KHCO_3$)	....	1.10	....	....	....	.24
Sodium phosphate (Na_3PO_4)	....	....	.54	....	....	....
Total salt content	1.17	2.17	[a]3.529	14.83	20.25	43.22

[a] Grams per 100 cubic centimeters.

Chemical analyses of soluble salts in alkali soils.

Constituent.	5850. Alkali surface deposit.	5858. Alkali surface deposit.
Ions.	*Per cent.*	*Per cent.*
Calcium (Ca)	3.48	0.27
Magnesium (Mg)	.53	.27
Sodium (Na)	27.24	13.36
Potassium (K)	2.19	2.76
Sulphuric acid (SO_4)	55.54	53.02
Chlorine (Cl)	10.17	3.48
Bicarbonates (HCO_3)	.85	3.34
Carbonic acid (CO_3)	....	5.50
Conventional combinations.		
Calcium sulphate ($CaSO_4$)	11.84	.82
Magnesium sulphate ($MgSO_4$)	2.66	1.38
Sodium sulphate (Na_2SO_4)	66.66	78.59
Potassium chloride (KCl)	4.18	5.26
Sodium chloride (NaCl)	13.50	1.63
Sodium bicarbonate ($NaHCO_3$)	1.16	4.59
Sodium carbonate (Na_2CO_3)	....	7.73
Total salt content	14.10	7.23

RECLAMATION OF ALKALI LANDS.

The difficulty with alkali soils on the bench lands is confined chiefly to the "spots" which are discussed in the chapter on "Cultivation." There is some black alkali in these spots, but it is not present in sufficiently large quantities to make it worth the expense of adding gypsum. These spots owe their condition largely to their peculiar physical properties, and they should be subsoiled and well irrigated. The reclamation of the alluvial soils will depend upon the removal of the underground water, this being the principal cause of the black alkali in these areas. The addition of gypsum would be beneficial, but amelioration by this method would be but temporary, as the cause of the formation of the alkali would still exist and the accumulations continue. To get rid of the effect remove the cause, which is the underground water carrying abnormal amounts of hydrogen carbonates in solution. This can be done only by underdrainage, but there are many natural sloughs leading to the river that could be used as natural drains, and the reclamation of the affected lands in this area would not be difficult. Most of the soil is good and well worth reclaiming.

AGRICULTURAL CONDITIONS.

The principal crops grown in the area surveyed are alfalfa, clover, wheat, oats, and fruit, the fruit consisting principally of apples, pears, peaches, and prunes. On the light alluvial soils truck farming is carried on to some extent.

Alfalfa does well on the lighter soils or on the heavier soils with a light subsoil. Two good crops are grown, and if sufficient water can be obtained a third crop can be secured. Three successful crops will yield from 5 to 7 tons of hay per acre, though the average for the area is perhaps not more than 5 tons. The price obtained for alfalfa varies with the severity of the winter, but the usual price is from $3 to $4.50 per ton in the stack.

Clover is sometimes grown alone, but is usually mixed with timothy. Together they will yield two good crops if well cared for, timothy predominating in the first crop and clover in the second, after which, if irrigated, the field will furnish good pasturage. A very common yield is 3 tons per acre for two crops. Clover alone brings only about 50 cents more per ton than alfalfa, and clover and timothy mixed about $1 more per ton.

The yield of wheat and oats under favorable conditions is about 35 bushels and 55 bushels, respectively, though the average for the district is somewhat less.

In favorable seasons, as regards frost, apples and prunes do well. In 1900 apples sold for from 65 to 90 cents per box. Prunes are a somewhat more profitable crop than apples, but they are more easily damaged by frost. In 1901 the frost destroyed the prune as well as the peach and other earlier fruit crops, but in that year frost was exceptionally severe. Apples survived to some extent, but the harvest was small. The year 1901 was a poor one for fruit throughout the intermountain States, late spring frosts being quite general.

Greater development and larger population would speedily follow the successful storage of water for irrigating purposes. The supplementing of the present water supply must be acccomplished in some way before the valley can be completely developed. Only about 20 per cent of the land now under the canals and susceptible of immediate irrigation can be actually irrigated. This does not, however, represent the limit of the amount of land that might be irrigated by the present water supply if it were economically used and greater efforts were made to conserve the moisture in the soil through thorough cultivation, as is done in some irrigation districts in California having an insufficient supply of water.

The State engineer is making strong efforts to have the State legislature enact laws that will effect an equitable distribution of irrigating water. He has also shown quite conclusively in his report of 1899–1900 that the present duty of water in Boise Valley can be much increased by a proper method of handling the water supply. Indeed, it appears that in many cases the present duty of water could be doubled.

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