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UNDERGROUND WATER

IN

SANPETE AND CENTRAL SEVIER VALLEYS, UTAH

BY

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UNDERGROUND WATER IN SANPETE AND CENTRAL SEVIER VALLEYS, UTAH.

By G. B. Richardson.

INTRODUCTION.

Sanpete and central Sevier valleys are situated at the border of the Basin Range and Plateau provinces in south-central Utah. They are bounded on the east by the Wasatch and Sevier plateaus and on the west by the Gunnison Plateau and the Valley and Pavant ranges, and are drained by Sevier River, which empties into Sevier Lake in the Great Basin. (See fig. 1, p. 6.)

These valleys rank with the richest parts of the State. They were occupied a few years after the Mormon pioneers founded Salt Lake City, in 1847, when settlements, which soon became thriving farming communities, were established where water for irrigation was most available. A variety of crops, especially wheat, are successfully grown, and the valleys are popularly known as the "granary of Utah." Sheep raising is also an important industry, the adjacent highlands being used for summer pastures. The climate is arid, and there is a striking contrast between those areas which in their natural state are covered with sagebrush and grease wood and the fruitful cultivated tracts. (See Pl. I, *A* and *B*.) Trees are normally absent in the valleys, but they flourish to a limited extent on the adjacent highlands, where there are thin growths of quaking aspen, scrub oak, and stunted conifers. Irrigation is necessary for the production of crops.[a] Canal systems are maintained by San Pitch Creek and Sevier River, and the mountain streams are tapped by ditches near the mouths of the canyons, but this supply is insufficient and attention is being turned to the subterranean store.

This report is a preliminary statement of the general conditions of occurrence of underground water in Sanpete and central Sevier valleys. The field work was carried on in cooperation with Sanpete and Sevier counties through the State engineer, Mr. Caleb Tanner, who detailed Mr. C. S. Jarvis to collect the data embodied in the list of springs and wells on pages 51–60.

[a] Dry farming has not yet been extensively practiced here.

TOPOGRAPHY.

Sanpete and central Sevier valleys are structural troughs filled with "wash" derived from the adjacent highlands. They trend northeast - southwest, and are occupied by relatively small streams, Sevier River draining the southern, and its tributary, San Pitch

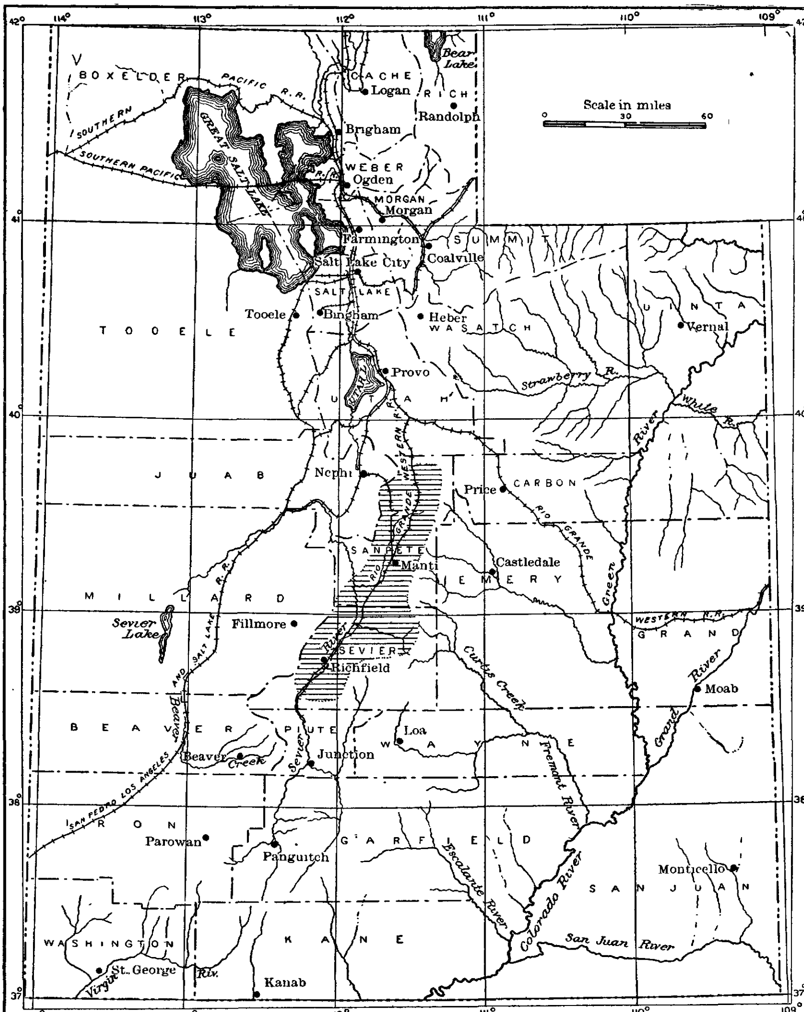


FIG. 1.—Map of Utah, showing position of Sanpete and central Sevier valleys.

Creek, the northern valley. Each valley is about 45 miles in length and averages 6 miles in width.

The main central streams have a number of tributaries, the more important of which flow from the eastern plateaus, where the precipitation is greater than on the relatively low and narrow western highlands. The streams flow perennially within the mountains, where they occupy steep, narrow valleys, but at the mouths of the canyons the discharge is largely diverted by irrigation canals, and the lower courses in the broad lowlands are generally dry, except during floods. The chief tributaries of San Pitch Creek are Cottonwood, Pleasant, Cedar, Oak, Canal, Ephraim, Willow, Manti, Sixmile, and Twelvemile creeks, all of which have small drainage areas on the Wasatch Plateau. Salina Creek, draining 255 square miles, is by far the largest tributary stream. It flows in the depression between the Wasatch and Sevier plateaus and joins Sevier River 13 miles above Gunnison. The other important tributaries of the Sevier in its central valley are Lost and Monroe creeks, which rise in the Sevier Plateau.

The elevation of Sanpete and central Sevier valleys ranges from 5,000 feet above sea level in their lower parts to about 6,000 feet at the upper border of the lowlands, above which the mountains rise from 2,000 to 5,000 feet higher.

Gunnison Plateau, bordering Sanpete Valley on the west and separating it from Juab Valley, is 35 miles long and varies from 2 to 8 miles in width. The plateau is considerably dissected, and only remnants of its former surface are preserved by horizontal beds of limestone. At its northern end the plateau has an elevation of almost 10,000 feet, but it slopes southward and merges into Sevier Valley at Gunnison. A sparse growth of vegetation is supported on the Gunnison Plateau, from which only a few feeble streams are tributary to Sanpete Valley.

The Wasatch Plateau borders Sanpete Valley on the east and extends as far south as the valley of Salina Creek. The crest of the plateau is underlain by Cretaceous and Tertiary sediments, which, on the east, form a wall of erosion, beyond which the surface slopes to Castle Valley, a lowland underlain by shale, which separates the plateau from the San Rafael swell. On the west the Wasatch Plateau slopes toward Sanpete Valley, conforming with a great monoclinal flexure. The Wasatch Plateau is comparatively well timbered and is the source of a number of perennial streams.

Sevier Plateau forms the greater part of the eastern boundary of Sevier Valley, above which it rises abruptly, and extends from the valley of Lost Creek far to the south of the area under consideration. Its culminating point is Monroe Peak, whose elevation is 11,240 feet. The plateau is underlain by a series of igneous rocks, chiefly Tertiary tuffs and lavas. The East Fork of Sevier River receives a considerable part of the drainage of Sevier Plateau, but Monroe Creek is the only important stream that drains directly from it into the area here considered.

Central Sevier Valley is bounded on the west by the Pavant and Valley mountains, which are the easternmost parts of the Basin

Ranges in this latitude. The Pavant Mountains are about 35 miles long and from 4 to 12 miles wide and are much dissected, their crest forming a narrow ridge about 10,000 feet in elevation. The range is but fairly well timbered and only a few small creeks flow from it to the valley. The eastern slopes are underlain by east-dipping strata, which unconformably overlie Paleozoic limestone. The Valley Mountains lie between the Gunnison Plateau and the Pavant Mountains, of which they are a faulted offset. They are 25 miles long, average 5 miles in width, and are about 7,000 feet high. They are practically bare of vegetation and give rise to no important streams.

GEOLOGY.

Sanpete and Sevier valleys are represented on the map of the Wheeler Survey[a] and are described in Dutton's report on the geology of the High Plateaus of Utah,[b] but no detailed geologic work has yet been done in this region. The character and structure of the rocks are fairly well known, however, and the following brief summary, together with the maps and sections (Pls. II, III, V, and VI), indicates the general geologic conditions of occurrence of underground water.

The rocks of these valleys can conveniently be classified as consolidated "bed rocks," which outcrop chiefly on the highlands, and unconsolidated deposits, which occur in the broad central valleys. Strata of Mesozoic and Tertiary age occupy the greater part of the highlands, and igneous rocks are found in their extreme southern portion. The valleys, on the other hand, are underlain to considerable depths by débris derived from the disintegration of the adjacent highlands. The underground water occurs chiefly in the unconsolidated deposits, but water contained in the bed rocks is locally important.

BED ROCKS.

JURASSIC SYSTEM.

So far as known, the oldest rocks of Sanpete and Sevier valleys are of Jurassic age. They consist of a considerable but undetermined thickness of fissile clay shales, generally drab in color, but locally red, with some intercalated layers of drab sandstone ranging in thickness from a few inches to a few feet. Lenses of gypsum and rock salt are irregularly interbedded throughout the formation. These rocks outcrop in a range of low hills, about 30 miles long and 2 miles wide, that extend along the eastern margin of Sevier Valley from Glenwood to the vicinity of Mayfield. A less extensive outcrop

[a] U. S. Geog. Surv. W. 100th Mer., Atlas.
[b] Dutton, C. E., Geology of the High Plateaus of Utah: U. S. Geog. and Geol. Surv. Rocky Mt. Region, 1880.

occurs in the center of the valley, mostly west of Sevier River, between Redmond and Gunnison. On the east a fault causes these Jurassic strata to abut against Tertiary beds, as mentioned later, but relations are generally concealed by Quaternary deposits. The hills are practically bare of vegetation, and the soft beds have been eroded into badland topography. These rocks are of no value in the recovery of underground water. They exert, however, an important deleterious influence upon the character of streams with which they come in contact because of the ready solubility of their interbedded salt and gypsum.

CRETACEOUS SYSTEM.

The Cretaceous system is represented by two divisions, the Colorado and the Laramie. A small outcrop of rocks of Colorado age occurs in the valley of Salina Creek just above the mouth of the canyon, about 3 miles from Salina. These are a thin-bedded buff sandstone, with subordinate drab shale carrying *Inoceramus labiatus*.[a] At the western limit of their outcrop the Colorado strata stand almost vertical and are directly overlain by horizontal Eocene beds. Because of their limited exposure these rocks also are unimportant in the recovery of underground water.

Sandstones and shales provisionally referred to the Laramie division of the Cretaceous occupy a much greater area. The coal-bearing Laramie beds of Carbon County, which outcrop along the eastern scarp of the Wasatch Plateau, are conformably overlain by massive, loose-textured, buff sandstone, with subordinate interbedded buff shale. The thickness of these rocks has not been determined, but it amounts to several hundred feet.[b] They locally cap the plateau and outcrop along its middle western flanks east of Sanpete Valley as far as Spring Creek, and are exposed farther south in the valleys of several creeks that have cut deeply into the Wasatch monocline.

The only fossils that have been found in this formation on the Wasatch Plateau are a few obscure fragments of leaves, but in what is probably the same formation, in a fault block south of Manti, in which the Sterling coal [c] occurs, a number of plant remains have been found. Among them F. H. Knowlton recognizes *Sabal?* cf. *Sabalites Grayanus*, *Asimina eocenica?* Lesq., and *Salix* sp.? From these he concludes that the formation is probably of Laramie age.

At many localities on the Wasatch Plateau these rocks are overlain, apparently conformably, by Eocene strata. Different sections at the base of the known Tertiary, however, show deposits so diverse and

[a] Determined by T. W. Stanton.

[b] Taff, J. A., Book Cliffs coal field, Utah: Bull. U. S. Geol. Survey No. 285, p. 292.

[c] Richardson, G. B., Coal in Sanpete County, Utah: Bull. U. S. Geol. Survey No. 285, p. 280.

thicknesses so different that there is no conformity in the sense of a succession of widespread, uniform, uninterrupted deposits. In the vicinity of Sterling a distinct local unconformity is marked by flat Tertiary beds resting on highly inclined Laramie(?) sandstone.

The sandstone on the flanks of the Wasatch Plateau is a probable source of artesian water. (See p. 22.)

UNDETERMINED AGE.

A considerable thickness of red and buff conglomerate and sandstone, amounting to at least 2,000 feet, is exposed on the eastern flanks of the Pavant Mountains and Gunnison Plateau. The conglomerate is composed of rounded pebbles of quartzite and subordinate limestone of variable size, up to 1 foot in diameter, embedded in a sandy matrix. The main mass of conglomerate is overlain by fine-textured sandstone, but intercalated with the sandstone there are also beds of conglomerate. Drab shale of minor importance is locally interbedded with the sandstone. In the valley of upper Corn Creek, about 8 miles northwest of Elsinore, the basal conglomerate rests upon the eroded surface of steeply tilted Paleozoic sediments, and a similar conglomerate overlies upturned Carboniferous strata at the eastern base of Mount Nebo, about 15 miles northwest of Fountain Green. These conglomerates and sandstones, both on the Gunnison Plateau and on the Pavant Mountains, are overlain in apparent conformity by strata of Eocene age, but no fossils have been found in either the conglomerate or the sandstone, and the age of the rocks is as yet undetermined. The disconnected areas that have the same color on the map are grouped together only provisionally.

The conglomerate sandstone formation on the eastern flank of the Pavant Mountains is likely to prove a source of artesian water. (See p. 23.)

TERTIARY SYSTEM.

Strata of Eocene age outcrop on the summit and western flanks of the Wasatch Plateau, on the summit and eastern part of the Gunnison Plateau, and on the eastern slope of the valley and Pavant Mountains, and also form low ridges in Sevier and Sanpete valleys. These Tertiary sediments consist of at least 2,000 feet of drab, green, and red shales, buff and reddish sandstones, and whitish, fresh-water limestones. The stratigraphy is varied, and even adjacent sections are rarely alike. Numerous fresh-water fossils, including *Sphærium*, *Planorbis*, *Physa*, *Goniobasis*, and *Vivipara*,[a] occur in these rocks, which are referred to the Wasatch stage of the Eocene. The following section was measured west of Wales.

[a] Identified by W. H. Dall.

Generalized section of Eocene rocks on Gunnison Plateau west of Wales.

	Feet.
Fine-textured white limestone	100+
Interval of talus	100
Gray limestone	10
Brown sandstone	10
Interval of talus	150
Brown sandstone	5
Drab limestone	15
Brown sandstone	10
Drab limestone	5
Interval of talus	100
White limestone	10
Drab shale	50
Buff limestone	15
Drab shale	50
Interval of talus	150
Drab limestone	10
Drab shale with streaks of purple shale	150
Brown sandstone	20
Drab shale with few thin beds of limestone	250
Brown sandstone	5
Drab shale	25
Brown sandstone	10
Buff shale	100
Gray limestone	25
Black limestone	5
Coal and bone	7
Black limestone	10
Dark shale	15
Brown sandstone	10
Drab shale	10
Gray limestone	5
Buff shale	40
Sandstone	10

The coal noted above is locally important,[a] but is not of widespread occurrence.

Younger Eocene strata outcrop in low ridges in Sanpete Valley, extending northward from Manti. They dip westward at low angles and their outcrops are surrounded by Quaternary deposits which conceal relations with the underlying rocks exposed on the flanks of the adjacent plateau. These younger rocks consist of light-colored sandstone, shale, and limestone, including a bed of oölitic limestone, and contain well-preserved specimens of fishes, turtles, etc. Cope [b] named them the Manti beds and regarded them as middle Eocene, corresponding to the Wind River stage. Because of insufficient knowledge concerning the base of the formation it is not differentiated here,

[a] Richardson, G. B., Coal in Sanpete County, Utah: Bull. U. S. Geol. Survey No. 285, p. 292.

[b] Cope, E. D., The Manti beds: Am. Naturalist, vol. 14, 1880, p. 303.

but is mapped as Eocene, together with the strata referred to the Wasatch stage.

The varying stratigraphy of Eocene strata, the prevalence of shale and limestone, and the minor occurrence of more pervious strata render the rocks of little importance as water reservoirs. Yet these relatively impervious beds serve to confine water in the underlying sandstones and conglomerates, and are thus important factors in the occurrence of artesian water.

IGNEOUS ROCKS.

Igneous rocks are unimportant as water reservoirs in Sanpete and Sevier valleys, for they occupy small areas and are massive, fine textured, and of low porosity. Their occurrence is chiefly restricted to the upper part of central Sevier Valley, to the Sevier Plateau south and east of Richfield, and to the base of the Pavant Range, west of Elsinore. They constitute the northern end of a mass which is well developed farther south. These rocks are for the most part a complex series of lavas that were poured out upon eroded surfaces of the underlying strata at different intervals in Neocene time.[a]

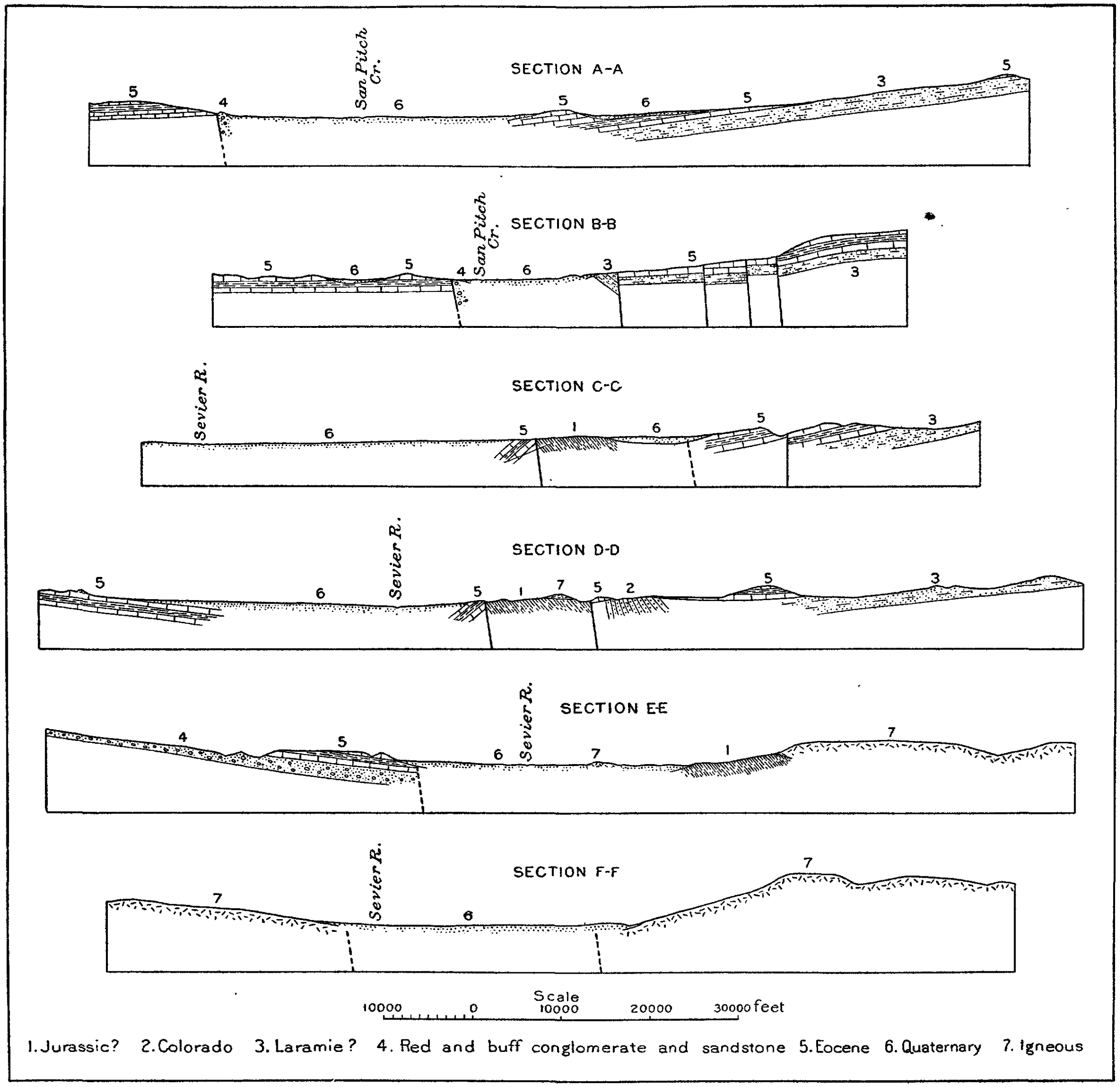
VALLEY DEPOSITS.

QUATERNARY SYSTEM.

The broad central floor of Sanpete and Sevier valleys is composed of fine-textured soils, chiefly sand and clay loam, but toward the highlands the material becomes coarser and the mountains are flanked by alluvial fans and slopes consisting of sand and gravel, with subordinate clay, the coarser material preponderating near the mountains. These deposits are derived from the disintegration of the adjacent highlands and transported to the valley by streams. In their mountain courses the volume and velocity of the creeks are considerable, especially during floods, and their carrying power is proportionally large, but upon entering the valley both volume and velocity decrease, the result being that the coarser materials carried by the streams are dropped near the base of the highlands while the finer débris is borne farther into the lowlands. Alluvial fans, consisting of heterogeneous masses of coarse sand and gravel, are thus formed about the mouths of the canyons (Pl. I, *A*), and alluvial slopes accumulate along the base of the mountains between the creeks, chiefly as the result of torrential storms.

The deposits beneath the surface of the broad valleys consist of gravel, sand, and clay, the thickness of which is considerable, but

[a] Dutton, C. E., Geology of the High Plateaus of Utah: U. S. Geog. and Geol. Surv. Rocky Mt. Region, 1880.



STRUCTURAL SECTIONS ACROSS SANPETE AND CENTRAL SEVIER VALLEYS.

unknown; minimum depths in the main part of the valleys are 530 feet in Sevier and 650 feet in Sanpete Valley, as shown by two wells,[a] in neither of which was consolidated rock found. Alternating beds of gravel, sand, and clay, from a few inches to many feet in thickness, are encountered in driving wells. Few records have been kept, however, and the detailed underground distribution of the valley deposits remains to be determined. In general, coarse material preponderates near the highlands and finer textured débris is more abundant in the lowlands, the inclination of the deposits being toward the valleys, in the attitude of deposition. Sections, even of neighboring wells, can rarely be correlated, which implies that the deposits, instead of having wide lateral distribution, as homogeneous beds, consist of series of lenses, with imperfect connection, as illustrated in the section forming fig. 2. These deposits are in large part loose, porous, and saturated with water, and constitute the most important underground reservoirs of the region.

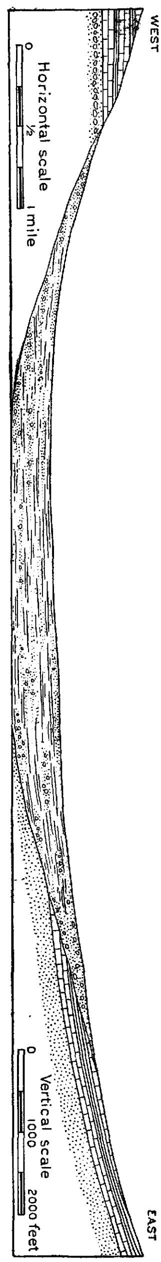


FIG. 2.—Hypothetical section across Sanpete Valley.

STRUCTURE.

The strata that cap the highlands lie practically flat, but have been tilted and faulted along the margins of the lowlands, and the central valleys are structural depressions. The rocks are not folded in the strict sense of the term, but incident to the uplift of the plateaus monoclinal flexures and normal faults have been developed. (See Pl. III.)

A conspicuous structural feature of the region is the monocline that marks the western border of the Wasatch Plateau. Near the rim of the plateau the strata dip westward, and along the flanks a dip slope of large proportions is developed. (See Pl. IV, *B*.) On this the strata that outcrop on the summit descend between 4,000 and 5,000 feet in about 5 miles and pass beneath the valley floor. Other large monoclines appear on the flanks of the Pavant and Valley ranges, where strata that dip eastward at a low angle descend toward Sevier Valley. The Jurassic shales that outcrop in a narrow belt between Glenwood and Mayfield constitute

[a] Nos. 101*a* and 186, pp. 53 and 55.

another conspicuous zone of tilted strata. Throughout their extent they dip eastward at an average angle of 45°.

One of the prominent faults in the area under consideration intersects the eastward-dipping strata of the Pavant Mountains at the base of the range. This fault extends along the border of the valley to a point about 8 miles north of Richfield, where it turns northwestward and causes the Eocene shales and limestones to abut against the underlying upthrown red conglomerates.

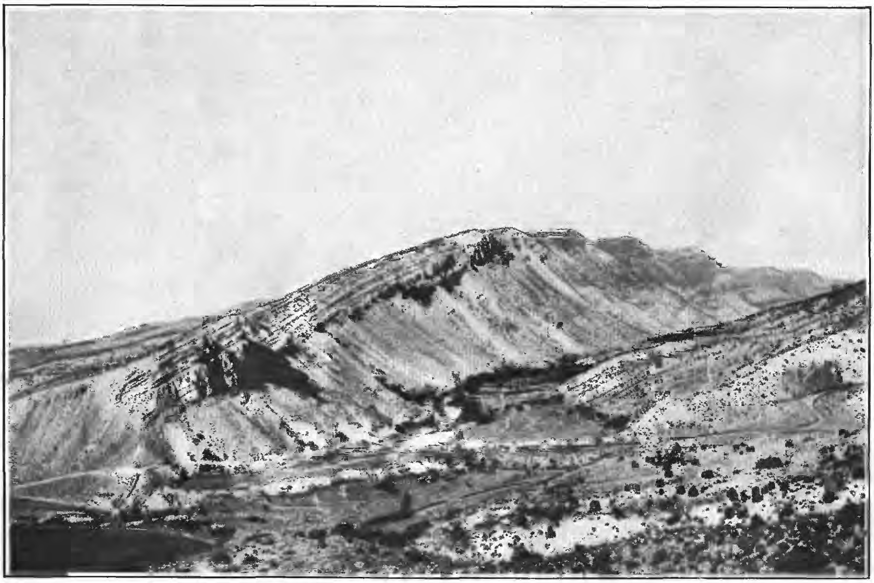
The abrupt rise of Sevier Plateau several thousand feet above the valley and the presence of springs along its base indicate a fault, and a number of displacements that can be traced east of the valley and parallel to it lie between Glenwood and Manti. The eastward-dipping shales there form an upthrust block bounded on the east and west by north-south trending faults, by which the Jurassic beds are brought into contact with Eocene strata. The northern end of this block adjoins a much-disturbed zone between Mayfield and Manti, where the area between the Gunnison and Wasatch plateaus has been broken by several approximately parallel faults, as shown by the map and sections. The southwestern flank of the Wasatch Plateau is traversed by a number of minor parallel displacements, which fade away to the north and have not been traced beyond Manti Creek. Along the eastern base of the Gunnison Plateau a fault brings the red conglomerate with a high eastward dip against practically horizontal Eocene limestones and shales. The throw of some of the faults is considerable, but data are lacking for close measurement.

These structural features have an important bearing on the occurrence of underground water, as described on pages 25–27. A number of strong springs are associated with the faults, and the monoclinal flexures control the occurrence of water under pressure.

SOURCE OF UNDERGROUND WATER.

The underground water supply of Sanpete and Sevier valleys is derived from the rain and snow that fall on their drainage areas. Of the total precipitation, part evaporates, part flows off in streams, and part sinks into the ground. The relative amounts that are thus disposed of vary greatly under different conditions, and a complex series of changes ensues between precipitation and the final disappearance of the water from the drainage basin. Evaporation occurs either directly—from snow, from a free surface of water, and from water contained in soils—or indirectly, by transpiration through the growth of plants. Of the portion of the precipitation that joins the run-off, part leaves the basin in surface streams and part is absorbed by the soils and rocks over which the streams flow. The underground supply is further augmented by direct absorption from the surface on

A. FAULT SPRING WEST OF FOUNTAIN GREEN.



B. THE WASATCH MONOCLINE AND MANTI CREEK.

which the rainfall occurs. Part of the subterranean waters find their way back to the surface in springs, another part is consumed by the growth of organisms and by mineralogical changes, and a third part joins the more permanent supply of underground water.

PRECIPITATION.

Precipitation on the highlands, especially snow, which falls early and lingers late, is the chief source of supply of the streams which, as will presently be shown, are the most important contributors to the store of underground water in the valleys. There are no records of precipitation on the highlands, but the marked difference in vegetation between the forested mountains and the naturally desert valleys implies a considerably greater amount on the former. In the valleys, on the other hand, rainfall data have been kept for a number of years, although this precipitation contributes relatively little to the supply of underground water.

The mean annual amount for the past seven years ranges from 6.73 inches at Richfield to 11.37 at Mount Pleasant, and of this about 40 per cent falls during January, February, and March, when the frozen condition of the ground is unfavorable for absorption. Besides the direct run-off, much of the precipitation in the valley joins the streams as seepage run-off, and, in addition to the water that is lost through plant growth, large amounts are evaporated from the ground, the supply being maintained by capillary action. A considerable part of the rainfall on the valley is therefore lost by run-off and evaporation. The remainder replenishes the more permanent supply of underground water, relatively large quantities being absorbed by areas that are underlain by porous sand and gravel.

The following tables of precipitation at Richfield, Manti, and Mount Pleasant, compiled from records of the United States Weather Bureau, show the amount and distribution of the valley rainfall for the past seven years:

Monthly and annual precipitation at Richfield from 1899 to 1905.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1899	0.30	0.55	4.65	0.70	T.	0.14	0.16	0.12	0.07	0.38	0.20	1.05	8.32
1900	.45	.20	0	......	0.08	T.	0	.07	.07	.05	.30	0	....
1901	.60	......	1.07	.23	.10	.07	.14	.03	0	......	......	.74	....
1902	.35	.65	1.35	.17	.32	.24	.18	.22	.64	.26	1.77	.47	6.62
1903	.60	......	.57	.....	1.39	T.	.31	.30	1.00	.83	......	.04	....
1904	.55	.20	.16	.07	1.03	.80	.27	.37	.05	.95	0	.80	5.25
1905	.90	1.66	......	......	......	......	......	......	......	......	......	.28	....
Mean	.54	.65	1.56	.29	.58	.31	.21	.19	.37	.49	.76	.56	6.73

Monthly and annual precipitation at Manti from 1899 to 1905.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1899	1.90	2.00	......	......	......	......	1.02	1.13	T.	2.38	0.31	1.30	....
1900	.61	.25	0.10	......	......	0	0	......	......	.60	.80	0	....
1901	.02	2.50	1.00	0.80	1.00	0.15	.22	1.23	0.08	1.05	.50	.55	9.10
1902	.52	.90	1.50	1.08	.49	.04	.26	T.	.83	.40	1.38	.86	8.26
1903	.73	1.18	1.16	1.22	2.20	.28	.53	.11	.98	1.21	.20	.40	10.26
1904	1.10	1.13	1.71	.93	2.03	.40	.61	.37	.48	.94	0	1.50	11.20
1905	.85	3.42	1.90	1.54	2.25	.05	T.	.20	3.09	.54	2.99	1.10	17.93
Mean	.82	1.63	1.23	1.11	1.59	.18	.53	.61	1.09	1.02	1.03	.95	11.35

Monthly and annual precipitation at Mount Pleasant from 1899 to 1905.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1899	1.40	3.60	2.29	0.57	1.02	0.99	0.76	1.24	0	1.80	0.88	2.10	16.65
1900	.36	.60	.10	2.56	.32	0	T.	.16	1.78	.59	1.56	T.	8.03
1901	.56	2.16	2.37	.13	.58	.29	.19	1.64	.16	1.32	.67	1.14	11.21
1902	.52	.90	1.50	1.08	.49	.04	.26	T.	.83	.40	1.38	.86	8.26
1903	1.24	1.10	1.40	1.41	1.49	.59	.56	T.	1.57	.58	.20	.20	10.34
1904	1.10	1.71	2.20	1.12	2.11	.76	1.12	.44	.36	.88	0	1.90	13.70
1905	.80	1.93	1.76	1.47	1.25	0	.17	......	......	0	1.15	1.10	....
Mean	.85	1.71	1.66	1.19	1.03	.53	.51	.87	.94	.93	.97	1.22	11.37

FLOW OF STREAMS.

The streams of Sanpete and Sevier valleys are of three distinct types—the relatively long master streams, the shorter transverse tributaries, and the canals. The master streams, as already stated, meander in a gentle grade in broad waste-filled valleys of structural origin. San Pitch Creek, which is confined to the northern valley, is fed by the direct but varying flow of its tributary streams and by more constant seepage. Sevier River, on the other hand, while having similar sources of supply within the portion of its valley under consideration, is fed chiefly from sources in the high plateaus in the southern part of the State.

The tributary streams are very different. In their mountain courses they occupy narrow, steep-graded, eroded valleys, and at the base of the highlands they emerge from their canyon-like courses and enter the broad débris-filled lowland, across which they flow at a lessened grade until they join the master stream. These tributary streams are fed almost entirely by the precipitation on their mountain watersheds through direct and seepage run-off, and as the main precipitation on the mountains occurs as snow, the discharge is heaviest in late spring and early summer. Figures are not available to show the run-off of the streams in the area under discussion, but the streams in Jordan Valley under similar conditions discharge during April, May, and June about 60 per cent of the annual run-off. Besides the annual floods, occasional violent summer storms temporarily increase the discharge of the streams. Conditions are different in each watershed, the discharge varying with the precipitation, topography, vegetation, and soils, and with the care that is taken to prevent fires, excessive grazing, and the destruction of timber. Seepage run-off is greater in valleys of relatively low relief that are abundantly clothed with vegetation, for under these conditions the products of rock disintegration are not readily washed into the valleys, and débris accumulates to absorb a large quantity of the precipitation, which thus escapes flood discharge and seeps slowly into the streams, maintaining their perennial flow. Below the mouths of their canyons the tributary streams, in the upper parts of their way across the broad valley, receive no augmentation to their flow, but, on the contrary, lose much by evaporation and absorption, which will presently be referred to, while in their lower courses, before they enter the main streams, their flow is generally increased by seepage. During the irrigation season the tributaries make small contribution directly to the master streams, for their water at the mouths of the canyons is diverted by canals and distributed over the valley.

Irrigation canals tap both master streams and tributaries, the tributaries at or near the mouths of the canyons, and San Pitch Creek and Sevier River at intervals throughout their courses, as shown on the map. Water is thus distributed over the valley where normally it would not flow.

The amount of water contributed by streams to Sanpete and Sevier valleys has not been measured. An indication, however, of the discharge of the most important ones is afforded by the following measurements, made with a current meter by C. S. Jarvis during the summer of 1905, but it must be borne in mind that at the time when most of the data were collected the streams were at a low stage.

Discharge measurements of streams in Sevier and Sanpete valleys in 1905.

Stream, with place of measurement.[a]	Date.	Discharge.
		Sec.-ft.
Sevier River above Clear Creek	June 17	310.4
Sevier River near Gunnison[b]	...do...	51.0
Sevier River above Clear Creek	June 29	269.4
Sevier River near Gunnison[b]	...do...	17.0
Clear Creek at mouth	June 17	119.2
Do	June 29	48.2
Monroe Creek	July 11	9.3
Lost Creek	Aug. 4	6.3
Salina Creek	Aug. 3	18.0
Willow Creek	Aug. 10	1.1
Twelvemile Creek	...do...	30.7
Sixmile Creek	Aug. 17	16.5
Manti Creek	Aug. 19	13.6
Ephraim Creek	Aug. 30	8.3
Canal Creek	Sept. 16	3.5
Oak Creek	Sept. 18	4.8
Cedar Creek	Sept. 19	1.5
Twin Creek	...do...	8.1
Pleasant Creek	...do...	8.3
North Creek	...do...	1.6
Cottonwood Creek at Fairview	Sept. 22	4.1

[a] If locality is not stated, the stream was measured at or near the mouth of its canyon.
[b] Estimated from gage reading.

Although the quantity of water tributary to Sanpete and Sevier valleys is not known, the amount that leaves them by San Pitch Creek and Sevier River near Gunnison has been measured for the last five years and is shown by the following tables, compiled from records of the United States Geological Survey:

Estimated discharge of San Pitch Creek near Gunnison.

Date.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
1905.				
January	15	11	13.3	818
February	24	9	14.1	783
March	15	8	12.1	744
April	94	13	24.2	1,440
May	338	82	136.0	8,362
June	304	90	179.0	10,650
July	166	110	143.0	8,793
August	720	64	126.0	7,747
September	82	30	40.5	2,410
October	46	26	32.0	1,968
November	35	22	28.1	1,672
December	30	20	23.9	1,470
Total	338	8	64.3	46,860
1904	264	6	43.7	31,920
1903	158	3	37.3	27,184
1902	155	7	27.0	19,855
1901	125	9	30.0	21,803

Estimated discharge of Sevier River near Gunnison.

Date.	Discharge in second-feet.			Total in acre-feet.
	Maximum.	Minimum.	Mean.	
1905.				
January 18–31	319	254	303.0	8,414
February	573	254	318.0	17,660
March	367	87	199.0	12,240
April	92	41	67.0	3,987
May	651	41	222.0	13,650
June	525	17	164.0	9,759
July	26	17	18.4	1,131
August	69	24	32.3	1,986
September	62	41	46.2	2,749
October	101	58	89.3	5,491
November	95	87	91.4	5,439
December 1–15	116	93	98.3	2,925
Total	651	17	....	95,009
1904	355	10	81.1	58,490
1903	366	8	....	73,000
1902	194	5	54.0	38,677
1901 [a]	239	5	56.0	40,481

[a] Five days missing in this year.

If the figures for 1905 represent normal conditions, the flood discharge of San Pitch Creek occurs in May and June, the maximum occurring in June, after which the flow gradually decreases to the period of low water in January, February, and March, the minimum occurring in March. By comparing the total discharge of San Pitch Creek for the last five years it appears that the flow is irregular, the discharge in 1905 being more than double that in 1902. The flow of

Sevier River, which drains a much larger area, is even more irregular. In 1905 the maximum occurred in February, and the discharge in May was large, while the minimum occurred in July and August. The annual discharge varies considerably and in the dry year of 1902 was less than half that in 1905. The flow of Sevier River is much affected by irrigation, return seepage, and absorption, as is shown by the fact that on June 17, 1905, the discharge of the river below Clear Creek, at the head of central Sevier Valley, was 429.6 second-feet, while 45 miles below, at Gunnison, the discharge amounted to only 51 second-feet. Similar results were obtained on June 29.

Although figures are lacking for estimating the quantity of water available for replenishing the underground store from the flow of streams, the data given below indicate that the amount is considerable. Absorption from stream beds is, in fact, the chief source of underground water in Sanpete and Sevier valleys.

A few measurements to illustrate the amount of water absorbed from individual streams in parts of their courses were made by C. S. Jarvis in the summer of 1905, as follows:

Ephraim Creek on August 30, flowing 8.2 second-feet near the mouth of its canyon, in a course of 0.6 mile over a gravelly bed lost 0.8 second-foot, amounting to 16 per cent a mile.

Oak Creek on September 18, flowing 4.88 second-feet at a point 3 miles southeast of Spring City, in a course of 2.5 miles lost 0.46 second-foot, amounting to 3.7 per cent a mile.

Twin Creek on September 19, flowing 8.1 second-feet at a point 3.5 miles southeast of Mount Pleasant, in a course of about 2.75 miles lost 3.1 second-feet, amounting to 13.8 per cent a mile.

Moroni upper canal on September 12, flowing 6.38 second-feet, in a course of 7 miles lost 1.76 second-feet, amounting to 3.8 per cent a mile.

These figures clearly indicate the manner in which the underground supply is maintained by streams.

An instructive example of the rôle played by seepage is afforded by the flow of Sevier River between the mouth of Clear Creek and Gunnison, a distance of 45 miles. At three places between these points dams have been constructed across the river, and at each place canals divert practically all of the flow of the stream, yet below each dam the seepage into the river is sufficient to supply the next succeeding canals. This fact is illustrated by the following measurements made by Caleb Tanner in 1902, which show that between Clear Creek and Rocky Ford the flow of the river was augmented through seepage by 26.06 second-feet, between Rocky Ford and Redmond Ford by 18.2 second-feet, and between Redmond Ford and West View Bridge by 22 second-feet.

Seepage in Sevier Valley between Clear Creek and Gunnison.[a]

[Measurements made by Caleb Tanner, August 13–16, 1902.]

BETWEEN CLEAR CREEK AND ROCKY FORD.

	Sec. ft.	
Surface water entering Sevier Valley:		
Sevier River above Clear Creek	47.5	
Clear Creek	7.3	
Monroe Creek	3.9	
Thompsons Creek	.2	
Redbutte and Cottonwood creeks	.3	
Water Canyon Creek	.3	
Spring Creek	5.3	
Cove Creek	9.5	
Cedar Ridge Creek	.5	
		74.8
Surface water diverted from Sevier Valley:		
Clear Creek canal	1.38	
Joseph canal	3.85	
Wells canal	2.38	
Isaacson canal	3.03	
Monroe canal	7.25	
Elsinore canal	2.75	
Brooklyn canal	5.50	
Richfield canal	17.50	
Annabelle canal	11.18	
Candor canal	.50	
Vermilion canal	9.04	
Surface water leaving valley:		
Sevier River	36.5	
Total diverted and remaining in stream		100.86
Seepage		26.06

BETWEEN ROCKY FORD AND REDMOND FORD.

Surface water entering Sevier Valley:		
Sevier River at Rocky Ford	36.5	
Lost Creek	.7	
Salina Creek	7.8	
		45.0
Surface water diverted from Sevier Valley:		
Rock Ford canal	35.0	
Other canals	8.5	
Surface water leaving valley:		
Sevier River	19.7	
Total diverted and remaining in stream		63.2
Seepage		18.2

[a] Water Sup. and Irr. Paper No. 85, U. S. Geol. Survey, 1903, pp. 91–94.

BETWEEN REDMOND FORD AND WEST VIEW RIDGE.

	Sec. ft.	
Surface water entering Sevier Valley:		
Sevier River at Redmond Ford	19.7	
Willow Creek	.5	
San Pitch Creek	15.2	
		35.4
Surface water diverted from Sevier Valley:		
Robbins canal	8.14	
Westview canal	4.20	
Other canals	15.70	
Surface water leaving Sevier Valley:		
Sevier River	18.7	
Dover canal	10.7	
Total		57.44
Seepage		22.04

OTHER SOURCES.

The undergrown water supply of Sanpete and Sevier valleys is augmented not only by rainfall that is directly absorbed by the surface on which it falls and by absorption from creek beds, but also by the flow of springs from bed rock, by the return waters of irrigation, and by the underflow from the creeks at the mouths of their canyons.

The occurrence of springs is described on pages 25–26, but it should be noted here that, in addition to many seeps, a number of springs that issue along fault lines convey water to the valley from a distant source in bed rock. The total discharge of these fault springs amounts to a constant flow of about 95 second-feet, and absorption of a part of the flow adds an appreciable amount to the underground waters.

In the practice of irrigation part of the water applied to the fields is absorbed by the soil and, percolating below the reach of roots and beyond the sphere of capillary action, joins the underground supply. The amount thus absorbed varies considerably from place to place, depending on the porosity of the soil and the quantity of water applied to the fields in excess of the need.

The underflow of the creeks at the mouths of their canyons also contributes an important quota to the underground supply of the valleys. No data are available to show this amount, but it can be determined by measuring the cross-section of the valley filling, its porosity, and the velocity of the underflow.

DISTRIBUTION OF UNDERGROUND WATER.

Underground water, derived from the sources that have been stated, is contained in both the unconsolidated deposits and the bed rocks of Sanpete and Sevier valleys. The former are the more valuable reservoirs, but some of the consolidated deposits also are important. All rocks, even the most dense, are to a certain extent porous, and the great mass of underground water is contained in rock pores and interstices. Fine-textured, compact deposits are relatively of little importance as water carriers, the chief reservoirs being the loose-textured, more permeable rocks.

WATER IN BED ROCKS.

As has been indicated in the preceding description of the rocks of this region, the general character of several of the formations renders them of little value as underground reservoirs. The massive, fine-textured igneous rocks, except locally, where they are cracked, are practically worthless in this connection; so, too, are the Jurassic shales. The strata of known Eocene age, which occupy a large area, composed as they are of close-grained shale and limestone and thin lenses of sandstone, have also little value for absorbing and transmitting water. On the other hand, the sandstone of probable Laramie age that outcrops on the Wasatch Plateau and the conglomerate and sandstone of undetermined age on the Pavant Mountains are probably important water-bearing beds, although they have not been developed. These porous strata are of considerable thickness and outcrop on large areas in the mountains where the opportunities for absorption are good. They are overlain by relatively impervious beds and dip toward the valley. The conditions for obtaining artesian water in the valleys are therefore favorable, except where there are disturbing factors, presently to be stated.

The geologic map and sections (Pls. II and III) show that the Laramie sandstone occupies many square miles on the summit and western flanks of the Wasatch Plateau east of Sanpete Valley, extending as far south as Salina Creek, and that toward the base of the plateau the sandstone is capped by shales and limestones of Eocene age. The dip is westward—toward the valley—at angles ranging from 5° to 20°. At the base of the highlands, however, the rocks are concealed by unconsolidated deposits, and little information is available concerning the position of bed rock beneath the valley filling. At the southern end of the Wasatch Plateau the western flank is broken by several north-south trending faults, which fade away northward, and none are known to extend beyond Manti Creek. No evidence of faulting at the base of the plateau has been obtained in the northern and central parts of Sanpete Valley, where the rocks that are exposed along the flanks of the plateau probably continue unbroken beneath the valley nearly to its western limit. The western dip, if continued beneath the valley at the same angle, would carry the water-bearing beds beyond the reach of profitable drilling, but the rocks in the ridge between Fountain Green and Mount Pleasant lie almost flat, and this fact suggests that the dips flatten out and cause the sandstone to occur possibly within profitable reach of the drill. Its position, however, can be determined only by prospecting.

The map (Pl. II) also shows that a large area on the crest and eastern flanks of the Pavant Mountains is occupied by a great thickness of coarse conglomerate and sandstone, which are advantageously located to absorb water directly from precipitation and from the flow of streams. These coarse-textured rocks are overlain by relatively impervious strata and dip gently toward the valley. They are, however, cut by the fault which extends along the eastern base of the mountains, and which, by intersecting water-bearing beds, is an important factor in connection with the water supply, as noted on page 14. The character and position of bed rock beneath Sevier Valley are unknown, and the presence of this fault makes the chance of obtaining artesian water from this source less favorable in Sevier than in Sanpete Valley.

WATER IN THE VALLEY DEPOSITS.

Water absorbed at the surface percolates downward for a greater or less distance through the unconsolidated valley deposits until it reaches the zone of saturation. The upper surface of this zone is known as the water table, beneath which the deposits are saturated, the water occupying the spaces between the solid particles of gravel, sand, and clay. In Sanpete and Sevier valleys the position of the water table conforms in a general way with the contour of the valley floor. Beneath the broad lowlands the water table slopes at a low angle upstream, away from the central valley axis, but near the highlands the slope of the surface of saturation is less than the inclination of the ground. As a result, the ground water in the lowlands lies close to the surface, and near the base of the mountains it lies at considerable depths. In the town of Mount Pleasant, for instance, the slope of the ground is about 170 feet to the mile, while the inclination of the water table is about 95 feet to the mile.

In the absence of adequate topographic maps on which the position of the water table could be shown by contours, the approximate depth to ground water is shown on Pls. V and VI by lines representing areas in which ground water lies, respectively, at depths between 0 and 10, 10 and 50, and over 50 feet beneath the surface. This information was compiled from the well data given on pages 51–57, which, with the location of the wells shown on the map, serve as an index to the available knowledge. Under much of the area in which the depth to ground water is shown as over 50 feet water can not be obtained within 100 feet or more, but it is impracticable to indicate on the map more than is shown.

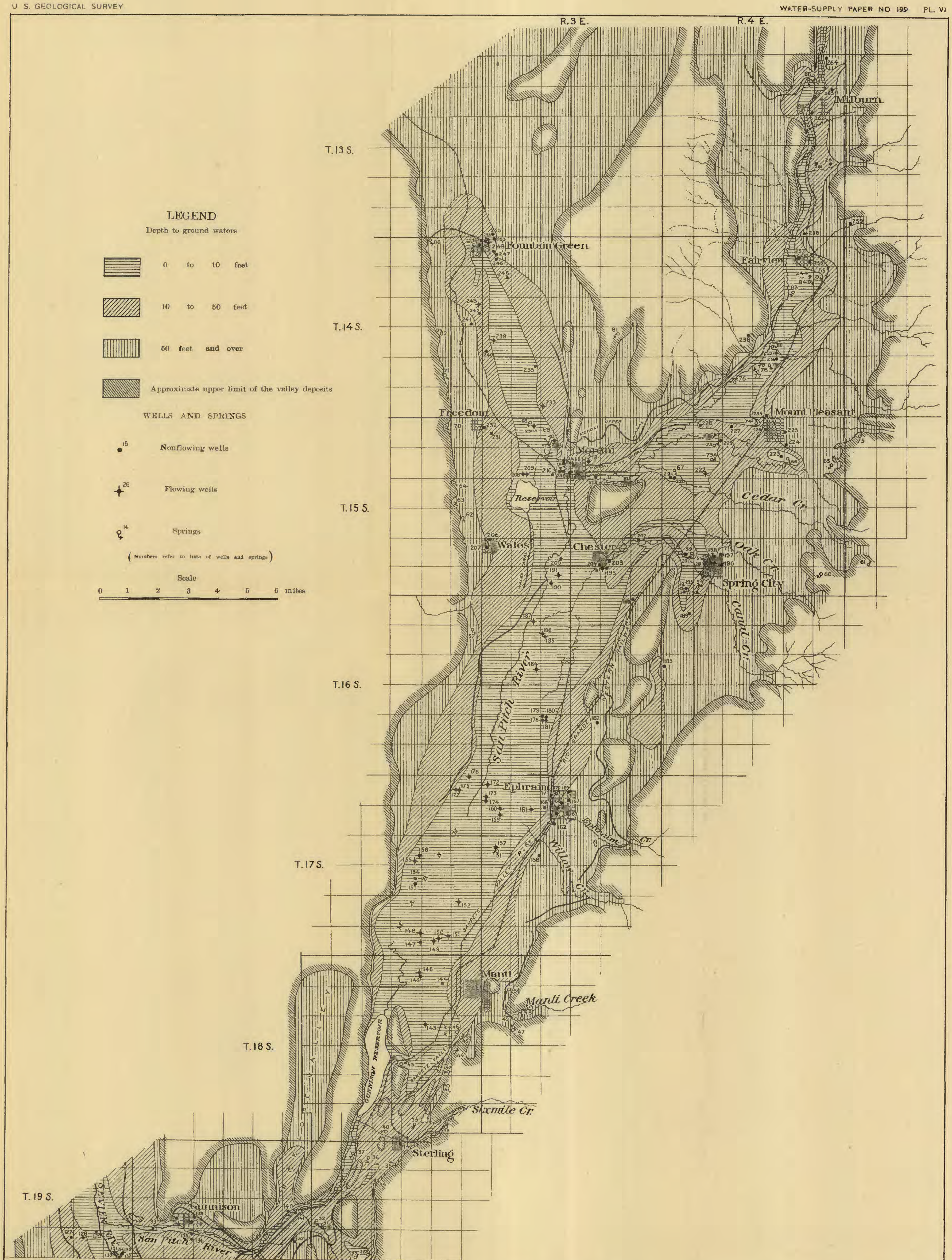
The position of the water table fluctuates measurably. It is highest in summer, after the period of heavy stream discharge and during the irrigation season, and lowest in winter, when there is comparatively little addition to the underground supply. A fluctuation of 20 feet has been observed in some wells, and variations between 2 and 10 feet are common between the summer maximum and the winter minimum. The use of ground water tends to lower the water table, but in the area under consideration persistent decrease has not yet been marked, though in places, as in the fields below Manti, a loss of head has followed the sinking of many shallow wells. Locally in the lowlands there has been a permanent rise in the level of ground water, due to the return waters of irrigation, whereby former fertile tracts have been converted into meadow and swamp lands.

The saturated beds contain varying amounts of water, their content depending on the character, thickness, and extent of the deposits. Coarse-textured gravel and sand, by reason of their greater porosity, hold and transmit relatively more water than fine-textured clay, and the coarser deposits therefore constitute the chief underground reservoirs. The wells that have been sunk in this region encounter beds of sand and gravel that range in thickness from a few inches to many feet and are separated by beds of clay of varying thickness. Locally these water-bearing beds have considerable horizontal extent, and, although the details of their distribution are not known, experience in sinking wells has shown that beds of sand and gravel are of widespread occurrence, both horizontally and vertically.

Underground water is seldom stationary, but moves very slowly from a higher to a lower level. The velocity varies with the head and with the number and size of the interstitial spaces, for the movement is not in open channels, but through the minute pores between the solid particles of the deposits. The rate of movement is only a few feet a day. The highest velocity of ground water that has been recorded is about 100 feet in twenty-four hours, and generally it is much less, the ordinary rates in sand being between 2 and 50 feet a day.

RECOVERY OF UNDERGROUND WATER.

The total amount of underground water in Sanpete and Sevier valleys, if it could be computed, would be expressed in cubic miles, but, by reason either of its depth or through its inclusion in fine-textured deposits, which do not readily yield their content, a large part of the subterranean store is not available. An estimate of the available amount is also impracticable because of the unknown extent



MAP SHOWING APPROXIMATE DEPTH TO GROUND WATERS AND LOCATION OF WELLS AND SPRINGS IN SANPETE VALLEY, UTAH of the irregular lenses of sand and gravel which constitute the important reservoirs. But, although figures can not be given, it is evident that a considerable supply of underground water awaits development in this area.

RECOVERY OF WATER FROM BED ROCKS.

Bed rocks are an important, but little developed, source of water in this area. A number of large springs originate in these consolidated deposits, and conditions for obtaining artesian wells are locally favorable.

RECOVERY OF WATER FROM BED ROCK BY SPRINGS.

Springs are a source of much water in Sanpete and Sevier valleys, 88 being recorded on pages 58–60. These can be classed either as fault springs or seep springs, the water from the first class issuing along a fault plane, that from the second class seeping out, generally in low areas, where the surface intersects the ground-water table. Of the 88 that are listed 30 are fault springs, yielding an aggregate discharge of 95 second-feet. Fault springs have their sources in bed rocks and commonly are located at the base of the mountains, along the principal planes of dislocation, prominent groups being on the eastern margin of Sevier Valley and on the western margin of Sanpete Valley, although isolated springs occur at a number of other places, as shown on the map. The discharge of fault springs varies little, if any, throughout the year; each spring commonly yields as much as 1 second-foot, the mean of all being over 3 second-feet, and one west of Fountain Green flows 12.4 second-feet. (Pl. IV, *A*.)

The temperatures of these springs differ greatly. That of many is only a few degrees above the mean annual temperature of the valleys, about 48°, but some are distinctly hot, Joseph Hot Springs (No. 3 in list on p. 58 and on Pl. V) ranging from 135° to 156° F. and Monroe Hot Springs (No. 5) ranging from 144° to 156° F. The temperature of some of the hot springs is probably due to the proximity of heated igneous rocks. That of others, as Richfield Spring (No. 71), which is 74° F., appears to be due to the internal heat of the earth, although the possible influence of igneous rocks must not be ignored. If the temperature of the Richfield Spring be due entirely to the normal heat of the earth, an index is thus afforded of the depth of the water before it rises. If an increment of 1° F. for each 50 feet be assumed without allowance for cooling, a depth of 1,300 feet is indicated.

The general occurrence of fault springs, although each one differs from others in details, may be illustrated by the Richfield Spring. (See fig. 3.) Here the porous conglomerates and sandstones that outcrop on the Pavant Mountains dip toward the valley and are overlain by the relatively impervious Wasatch bends. The mountains have been uplifted along the fault at their base, and the water-bearing beds—the conglomerate and sandstone—have been cut by the dis-

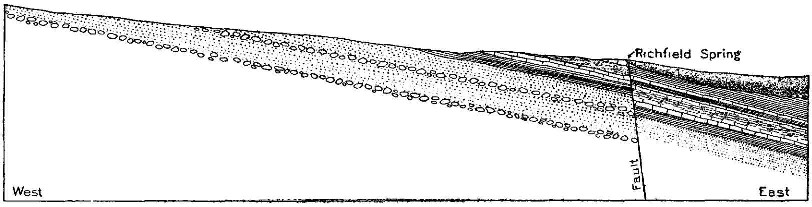


FIG. 3.—Diagrammatic section at Richfield Spring.

placement as if by a well. In consequence the water, which is under pressure, rises along the fault-plane, the place of actual issue being determined by a series of favorable conditions by which free passage is maintained.

RECOVERY OF WATER FROM BED ROCK BY TUNNELS.

The practicability of tunneling into fault planes to obtain water is suggested by the occurrence of springs along lines of displacement, and a notable successful tunnel is that of the Morrison coal mine east of Sterling. This tunnel was begun on a dry hillside and driven eastward toward the fault, which has not yet been reached. Water was encountered which in August, 1905, was found to discharge 5.6 second-feet. The probable conditions here are shown by fig. 4. The source appears to be in the westward-dipping sandstone that outcrops on the Wasatch Plateau. The water being under hydrostatic pres-

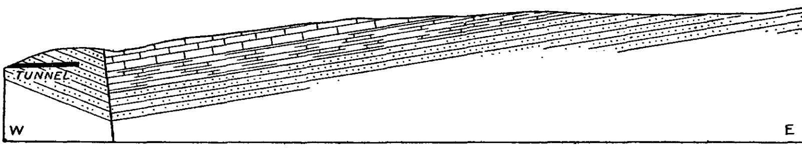


FIG. 4.—Diagrammatic section at Morrison Tunnel Spring.

sure, rises when it reaches the fault plane. Notwithstanding the success of this tunnel, similar results can not be generally predicted, because of the ever-present possibility of unfortunate conditions, such as cementation along fault planes and easier escape of the water in other directions. Yet tunneling into fault planes along which strong springs occur presents possibilities that would seem to justify prospecting.

Tunnels may be advantageously driven not only into fault planes, but possibly elsewhere, for it may be profitable to explore locally the base of the mountains where water-bearing beds dip valleyward, as in the Pavant Range and on the Wasatch Plateau, with the idea of penetrating saturated strata by tunnels instead of wells.

RECOVERY OF WATER FROM BED ROCK BY WELLS.

With the exception of well No. 237 (see list on p. 56, and map forming Pl. VI), between Mount Pleasant and Fairview, no wells, as far as the writer is informed, have been sunk to bed rock in Sanpete and Sevier valleys. Nevertheless flowing wells may possibly be obtained from consolidated rocks in certain areas as already suggested, the most promising sources being the eastward-dipping conglomerates and sandstones on the Pavant Mountains and the westward-dipping sandstone on the Wasatch Plateau.

Steep dips and faults are locally disturbing factors, but the conditions warrant sinking test wells.

In the center of Sevier Valley, on account of the faulting, it is possible that the water-bearing beds lie at depths too great for profitable wells, since the temperature of the Richfield Spring indicates a depth of 1,300 feet to the water beds at the border of the valley. Preliminary tests might be made west of the fault in valleys where streams have cut deep into the rocks.

Conditions for flowing wells are more favorable in Sanpete Valley, especially between Fairview and Spring City. The absence of faulting has not been proved here, but the westward-dipping rocks of the Wasatch Plateau may extend unbroken beneath the valley, where the dips probably flatten out. If these conditions actually prevail it is likely that profitable flowing wells can be obtained from the Laramie sandstone. Because of the uncertainty of the dip and the variable thickness and unknown erosion of the Eocene strata depths can not be predicted, but before a test well is abandoned it should be sunk until the Laramie sandstone is reached.

RECOVERY OF WATER FROM VALLEY DEPOSITS.

The source of most abundant underground water in Sanpete and Sevier valleys is the unconsolidated material by which they are underlain and from which water is recovered by springs, tunnels, and both flowing and nonflowing wells.

RECOVERY OF WATER FROM VALLEY DEPOSITS BY SPRINGS.

Although most of the fault springs issue through unconsolidated deposits, their origin is obvious and they should not be confounded with seep springs. As already stated, springs of the first class occur along faults. Those of the second are independent of structure and commonly occur in lowlands where the surface of the ground intersects the water table. The discharge of seep springs is generally unlike that of fault springs, since it often fluctuates with the season instead of flowing almost constantly. The temperature of fault springs is also more constant, and is commonly higher than that of seep springs, a fact that is especially apparent during the winter.

Seep springs are numerous in Sanpete and Sevier valleys, especially in their lower stretches, and the important part played by seepage in maintaining the flow of the streams has been already noted. Seepage is so widespread and in any one spot is usually so slight that over large areas it is impracticable to map places of exit of seepage water, but points where the flow appears in springs and is concentrated into considerable streams are shown on Pls. V and VI and are listed on pages 58 to 60. The flow of many seep springs can be increased by development, but some of them are at elevations so low that their waters are unavailable for use in the immediate vicinity except by pumping.

RECOVERY OF WATER FROM VALLEY DEPOSITS BY TUNNELS.

Tunnels driven into the unconsolidated deposits have procured large amounts of water. Especially favorable sites for tunnels are places where the low lands begin to raise at an increased angle toward the base of the mountains. At such places the ground water tapped

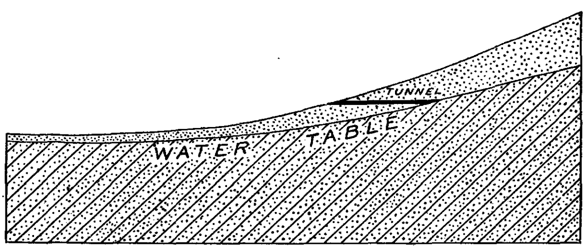


FIG. 5.—Section illustrating a tunnel in the valley deposits.

will drain by gravity into tunnels, as illustrated in fig. 5. A tunnel of this class is that of Madsen and Seely, west of Mount Pleasant. (See p. 49.)

RECOVERY OF WATER FROM VALLEY DEPOSITS BY NONFLOWING WELLS.

Nonflowing wells, the general features of which are indicated in the list, pages 51–57, are the most common means of recovering underground water in Sanpete and Sevier valleys. The maps show that ground water lies within 10 feet of the surface under a large part of the valleys, this area of course being in the lowlands, and that toward the highlands the depth increases. The nonflowing wells are commonly dug beneath the ground-water level to a porous bed of sand or gravel, from which water percolates into the opening. Most of the wells are sunk several feet below the summer stage of the water table in order to provide for the seasonal fluctuation. There are also a number of nonflowing bored wells, which have been put down with the hope of obtaining a flow at the surface.

Water is drawn from most of these wells by buckets or hand pumps. A few windmills are in operation, but the wind velocity is apparently not great or steady enough to give them general favor. There are few, if any, power pumps in the valley, which affords a promising field for their introduction and their use in irrigation. Water contained in coarse beds, which insure an abundant yield, lies within easy reach of the surface beneath large areas, and electric power can be cheaply developed from the near-by mountain streams.

RECOVERY OF WATER FROM VALLEY DEPOSITS BY FLOWING WELLS.

The irregular sheets of gravel, sand, and clay that slope valleyward from the base of the mountains afford conditions favorable for pressure in their contained water. Accordingly, where beds of sand and gravel that lie below a confining stratum of relatively impervious material are encountered by wells which enter the zone of saturation, the water tends to rise in the wells, and in the lowlands sufficient head is developed to cause flows at the surface. Above the lowlands on each side of the valley the water in deep wells rises a greater or less distance, the height it reaches depending upon the elevation of the ground.

It is estimated that there are more than 100 flowing wells in the two valleys, yielding an aggregate flow of about 5 second-feet. Most of the wells are 1½ or 2 inches in diameter, but a few of the larger ones are 3 or 4 inches. Flows are obtained at different depths between 20 and 344 feet, under pressures at the surface varying from 0 to 6 pounds per square inch. The average yield of the wells is possibly about 20 gallons a minute, but the range is wide, several discharging less than 1 gallon a minute. The greatest flow measured was 160 gallons a minute, from a 3-inch pipe. Beneath the first flow other flows are commonly obtained from each bed of sand and gravel encountered in boring the well.

The flowing wells are located in the fields below the towns, which generally are built at elevations so high that the water of the wells is little used for domestic purposes, for which, by its purity, it is eminently adapted. It is used to some extent for watering stock, but chiefly for irrigation.

The use of artesian water from the valley deposits has only begun, and the possibilities apparently are not realized. There is need for a number of test wells to exploit conditions in the lower deposits, and where good flows are obtained more wells of larger bore may profitably be sunk.

RECOVERY OF WATER FROM VALLEY DEPOSITS BY SUBSURFACE DAMS, ETC.

Under exceptional conditions ground water may be recovered by means of subsurface dams or similar contrivances which impound the underflow in unconsolidated materials. These conditions are practically impervious bottom within easy reach of the surface, to prevent excessive lowering of the ground-water level, and competent side walls, not too far apart, to intercept lateral escape. The presence of these conditions can be determined only by prospecting, and the economic desirability of building such structures at particular places is an independent question, but because of the high value of water in this area their feasibility at each possible site should be investigated. Possible locations of subsurface dams are suggested by rock walls at the mouths of the narrow canyons, where borings in search of suitable bottom should be made. Tests of the amount and porosity of the valley filling at and above the mouths of the canyons, together with measurements of the velocity of the underflow, would indicate the quantity of ground water available. At some places below the mouths of the canyons in the several creek valleys conditions favorable to the construction of infiltration galleries may also be discovered.

QUALITY OF WATER.

Few analyses have been made of the waters of Sanpete and Sevier valleys, although their general character is indicated by a number of field tests. During the summer of 1900 the Bureau of Soils[a] examined the waters of Sevier Valley, and in the fall of 1905 the writer made the following field assays, using the methods suggested by Mr. M. O. Leighton.[b] The figures given represent only approximate composition; yet, as all the tests were made under similar conditions, they afford rough comparative data:

Field assays of water from Sanpete and Sevier valleys, Utah.

[Parts per millon.]

Name and locality.	Calcium (Ca).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chlorine (Cl).
STREAMS.				
Pleasant Creek[c]	238	234	−35	6
Manti Creek[c]	238	204	157	Trace.
San Pitch Creek, west of Mount Pleasant	890	408	237	45
San Pitch Creek, east of Gunnison	550	408	492	519
Sevier River, west of Gunnison	1,150	377	+626	1,015
Sevier River, west of Joseph	261	....	80	29
Sixmile Creek[c]	360	245	65	19
Twelvemile Creek[c]	505	....	76	19
Upper Salina Creek, 7 miles above mouth of canyon.	410	245	113	9

[a] Soil survey in Sevier Valley, Utah, Rept. field operations Division of Soils, U. S. Dept. of Agriculture, 1900.
[b] Leighton, M. O., Field assay of water: Water-Sup. and Irr. Paper U. S. Geol. Survey No. 151, 1905.
[c] Samples obtained at mouths of canyons.

Field assays of water from Sanpete and Sevier valleys, Utah—Continued.

Name and locality.	Calcium (Ca).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4)	Chlorine (Cl).
STREAMS—continued.				
Lower Salina Creek [a]	151	265	127	119
Monroe Creek [a]	96	102	– 35	9
Dry Creek [a]	248	....	53	9
SPRINGS.				
Fountain Green (No. 86) [b]	(c)	265	0	19
Morrison tunnel (No. 38)	410	326	164	29
Ninemile (No. 34)	435	367	459	308
Glenwood (No. 12)	96	122	0	24
Richfield (No. 16)	228	265	Trace.	29
FLOWING WELLS.				
Allred	380	408	492	297
Seeley	274	204	– 35	258
West of Manti	274	367	135	14
Between Fairview and Mount Pleasant	274	286	– 35	19
Bolitho	340	326	74	59
Brooklyn Irrigation Co	595	326	530	498
DUG WELLS.				
Fairview (Bohney House)	715	367	– 35	19
Salina (White House)	595	510	135	218
South of Salina (Colby)	320	204	108	109
Ephraim (S. Sorensen)	1,150	551	+626	148
Moroni (Moroni House)	650	367	300	258
Ephraim (Ephraim House)	274	449	62	59
Gunnison (Gunnison House)	248	571	572	636

[a] Samples obtained at mouths of canyons.
[b] Numbers are those given on Pls. V and VI.
[c] Calcium content very large.

The general composition of the waters of the area under consideration can be inferred from the outline of the geology of the watershed, for the mineral content of surface and ground waters is determined by the chemical character of the rocks and soils with which they come in contact. (See pp. 8–14.) The prevalence of limestone causes an abundance of carbonates; the waters which come under the influence of the Jurassic salt and gypsum bearing rocks are rich in chlorides and sulphates; while streams like Monroe Creek, which traverse igneous rocks, carry relatively little mineral matter in solution. Water from wells of moderate or considerable depth is usually similar to that of the mountain streams in the same locality, but that from shallow wells in the lowlands, especially in irrigated tracts, contains abundant dissolved salts. This mineral content is largely derived from the return waters of irrigation, which leach the soils, for in the lowlands where ground water is within reach of capillary action the dissolved salts are deposited by evaporation and the soil is impregnated with an accumulation of "alkali." The combined deleterious effects of the soluble Jurassic rocks and of the alkali in the lowlands is shown in the table by the two tests of the water of Sevier River. The sample collected west of Joseph, in the upper part of the valley, contained only 261 parts per million of calcium, 80 sulphates, and 29 parts of chlorines, while the sample from the same river west of Gunnison contained 377 parts of bicarbonates, 1,150 parts of calcium, over 626 parts of sulphates, and 1,015 parts of chlorine.

The natural conditions are generally favorable for obtaining good water for domestic purposes, but the communities give little heed to the sanitary character of the water, and as a result epidemics of typhoid fever of greater or less violence are not uncommon. As ordinary hygienic precaution will prevent most of such epidemics the negligence in providing pure water supplies can not be too strongly condemned. Ill-kept privies and cesspools are nuisances that should not be tolerated in settled communities. Privies should be replaced by "dry-earth closets," provided with a supply of dry clay loam, and the fecal matter should be removed at short intervals. Where there are public water supplies it is desirable that sewers should also be installed and the sewage might, if desired, be used in irrigation on "sewer farms." The local custom of using old wells as cesspools pollutes the water of neighboring wells that are still used as sources of drinking water, and should be prohibited. Another prevalent unsanitary custom is the use, for drinking and cooking, of water running through the towns in open ditches, into which pollution is free to drain.

All the towns in the area except one or two can procure water supplies either from springs or from mountain streams, which with care can be protected from contamination, and outlying houses can be supplied with water from deep wells. But although pure water can easily be obtained, only four towns in Sanpete and Sevier valleys—Freedom, Mount Pleasant, Manti, and Richfield—have public waterworks.

SUGGESTIONS.

In view of the present undeveloped state of the ground waters of Sanpete and Sevier valleys and the need of more water, a few suggestions as to a more efficient use of the available resources may be pertinent.

As the only source of water is the precipitation on the drainage area tributary to the valleys, it is clear that attention should be given to conserving this supply by preventing waste whenever possible. The chief problem is to save the storm waters, and to this end large storage reservoirs have been built or planned, but it does not appear to be generally realized that the storm run-off can be saved also by other means. The underground supply can be considerably augmented by distributing the flood discharge over the uplands below the mouths of the canyons of the creeks that emerge from the mountains. The control of floods is difficult, but by placing obstructions in the ordinary channels flood waters can be spread over a wide area, so as to increase greatly the amount of water that is absorbed in the porous alluvial deposits. Small reservoirs can also be constructed at many places within the mountain watershed, whereby the storm run-off can be checked and the seepage run-off in the dry season increased. The advantage of preserving timber on the mountains should also be clearly understood. A drainage area well covered with vegetation is one of the most effectual checks to storm run-off. A heavy growth of underbrush and trees tends to prevent storms from washing away the products of rock decay and to accumulate a thick cover of soil and humus, which absorbs large quantities of water from storms and from melting snow, whereas if the covering of vegetation is scant, storms tend to keep the mountain sides relatively bare of soil by washing the débris into the creeks, so that the precipitation runs off rapidly and comparatively little is absorbed to seep slowly into the creeks to maintain their summer flow. The timber should therefore be protected from fire and from reckless cutting, excessive grazing should not be permitted, and trees might be planted to advantage in many areas.

Not only should the supply be conserved as far as possible, but more efficient use of the available water should be practiced. Much is lost by crude methods of irrigation. More water is often applied to the fields than is needed, and a large part is lost by seepage from faultily constructed ditches. The use of pipes whenever practicable and the construction of less permeable canals would prevent much waste. Much water is also lost by allowing artesian wells to flow constantly. It should be thoroughly realized that the limited supply of ground water comes from a common source, that the wastefulness of one person counteracts the prudence of another, and that the interest of all demands that the supply be rigorously conserved. Flowing wells should be capped, or the flow should at least be partly checked when water is not used, or the water should be collected in reservoirs for future use. A further incentive to economy in the use of water is the fact that by its conservation the evil of alkali accumulation and the raising of the water table too near the surface in the lowlands is retarded.

The distribution of underground water suggests that the most efficient use of the total supply in the valley would be to develop the fertile uplands toward the base of the mountains, as far as may be, from high-line canals, supplied by the mountain streams; and to use underground water, which in general is inaccessible on the uplands, in developing the lowlands, where the subterranean supply is plentiful. Owing to the present complicated ownership of water rights, it may be difficult to act upon this suggestion, but there can be no doubt that its adoption would materially add to the amount of land under cultivation. Flowing wells can be obtained in large areas in the lowlands, and at several localities where coarse water-bearing sand and gravel occur near the surface there is a possibility of establishing pumping plants, for which electric power developed from the adjacent mountain streams is generally available. It should be remembered, however, that although the underground supply is considerable, it must not be recklessly used. Observations on the fluctuation of the water table should serve as a guide to development.

Since the underground water supply in Sanpete and Sevier valleys is but little developed and local conditions are promising, further testing of the resources is very desirable. Deep wells should be sunk in both valleys to ascertain the conditions in the unconsolidated deposits, and to determine whether flowing wells can be obtained from bed rock. Where good supplies are found pipes of larger bore than those now used might well be employed. Also the flow of some of the springs can be materially increased by development, and possibly new ones found by prospecting.

DETAILED DESCRIPTIONS.

The descriptive details that follow are supplementary to the information contained in the maps forming Pls. VI and VII and the list of wells and springs on pages 51–60. The descriptions begin at the south and proceed northward, the areas described being grouped about the principal towns.

JOSEPH AND VICINITY.

About 6 miles south of Joseph the Sevier River emerges from a canyon and flows northeastward between the lava-capped foothills of the Pavant Mountains and a low ridge of igneous rocks. The town of Joseph is situated near the base of the long alluvial slope west of the river. Water for irrigation is furnished by the Sevier Valley canal, below which most of the land is under cultivation, and drinking water of poor quality is obtained from shallow dug wells. Most of the area lying below the canal is underlain by gravel and by subordinate streaks of sand and clay; ground water lies within 50 feet of the surface, and the wells are between 30 and 60 feet in depth. The annual fluctuation of the water surface amounts to about 10 feet, the water being highest in midsummer and lowest in late winter, when some of the wells go dry. A better supply for drinking purposes probably can be obtained from bored wells near the river, 100 feet or more in depth. These would avoid contamination and at least some seepage from the canals. There is little likelihood of profitably obtaining underground water for irrigating the arid slope west of Joseph, although it is possible that deep wells, after penetrating a considerable but unknown thickness of lava and the underlying Eocene strata, would strike artesian water in the underlying sandstones and conglomerates.

The Joseph Hot Springs issue from calcareous tufa, deposited by the springs, at the base of the low volcanic ridge about a mile southeast of the town. The temperature of the water ranges from 135° to 146° F., and the yield of all is estimated to be only about 30 gallons a minute.

ELSINORE AND VICINITY.

Sevier Valley broadens out a few miles above Elsinore, which is located in the midst of a prosperous agricultural district. Contiguous to the river, particularly south of it, a number of shallow wells have been dug, from which an abundant supply of water in coarse gravel is obtained at depths ranging from 20 to 35 feet. Two wells have been bored in this area, one, 178 feet deep, in the SE. ¼ sec. 32, T. 24 S., R. 3 W., the other, 171 feet deep, in the SW. ¼ sec. 34, in the same range and township. In sinking these wells the surface was found to be underlain chiefly by sand and gravel to a depth of 150 feet, where stiff yellow clay was encountered, through which the inadequate apparatus failed to penetrate. This immediate area is favorable for testing underground conditions, and it is desirable that a deep well be sunk here to determine the possibility of obtaining flowing wells in the valley deposits. The discharge of Monroe Creek, on the southeast, and the seepage from Sevier River in its sandy course below the mouth of its canyon are sources of an underground supply which may be under pressure in possible coarse deposits beneath the clay above mentioned. If flowing wells should not be obtained, pumping from the shallow gravels is an attractive possibility.

Midway between Joseph and Elsinore, near the river, in SE. ¼ sec. 6, T. 25 S., R. 3 W., there is a group of about 25 wells, in which the water rises within 2 or 3 feet of the surface. These are 1½ inches in diameter and less than 50 feet deep and the yield of all amounts to about 1 second-foot. Trenches have been dug, in which the flow is conducted to the Brooklyn canal. Clay was encountered in these wells down to 12 feet, below which water-bearing sand and gravel occur.

The town of Elsinore is built on an alluvial slope at the base of lava-capped foothills. Water for irrigation is obtained from several canals that are fed by Sevier River, and these also furnish an unsatisfactory domestic supply, which is supplemented by a few poor wells between 60 and 115 feet in depth. The chief desideratum is a good supply for domestic purposes. Possible sources are a number of feeble seep springs in the hills a few miles to the northwest, springs on the east side of the valley adjacent to Thompsons Creek, Monroe Creek, and wells. Although capable of development, the yield of the springs first mentioned appears to be insufficient; on the other hand, surface water of good quality and abundant quantity is available on the eastern side of the valley, but its use necessitates a pipe line extending several miles. The project of sinking wells, however, offers attractive possibilities. These are of two distinct classes, deep wells in the valley deposits and wells sunk to bed rock. The desirability of sinking a test well in the valley south of Elsinore has just been mentioned. It can hardly be expected, even if a flow should result, that the pressure would be sufficient to carry the water to Elsinore, yet it is probable that water of good quality can be thus obtained. Another possibility is to tap the sandstones and conglomerates that cap the Pavant Mountains and dip southeastward. The fault along the base of the mountains complicates the situation and makes it desirable that the first experimental well be drilled west of it. Another disturbing factor in the vicinity of Elsinore is the cap of hard lava. This, however, can be avoided by sinking a well in the valley about 2 miles north of the town. The surface strata will probably yield water of poor quality, but this could be cased off, for good water under pressure is to be expected from the underlying beds. The depth at which water will be found can not be predicted, but the beds that overlie the water-bearing strata are probably several hundred feet thick, and if exploration is undertaken at all preparations should be made to sink a well at least 1,000 feet deep.

MONROE AND VICINITY.

Monroe is prettily situated on an alluvial slope on the east side of the valley, at the base of the Sevier Plateau. Monroe Creek, the principal source of water supply, flows throughout its course over cystalline rocks, and its water therefore contains relatively little dissolved matter. In this respect it is the purest large stream in the entire area here considered. A number of canals, fed from Sevier River and Monroe Creek, furnish water for irrigation, and these canals are also largely resorted to for domestic supply. In view of the fact that excellent water is available in Monroe Canyon, it is surprising that the community is willing to continue using for household purposes the present relatively unsanitary supply. The depth to ground water is over 50 feet, and there are but few wells in Monroe.

The hot springs near Monroe are a valuable asset, but as yet they are little used. There are several groups of springs a half mile east of the town along a probable fault line at the base of the mountains, which are composed of igneous rocks. The salts held in solution by the water are deposited as tufa, from which springs now issue at a number of places. The total yield is about 100 gallons a minute, and the temperature of the water when it reaches the surface ranges from 144° to 156° F. The proximity of the springs to the town suggests the desirability of attempting to increase their flow with the idea of utilizing the heat.

The following analysis of the water of Cooper Hot Springs was obtained from the owner:

Analysis of water from Cooper Hot Springs, east of Monroe (No. 5).

[Analyst, P. A. Yoder.]

	Parts per million.
Ca	267.7
Mg	35.1
Na	591.4
K	37.5
Li	.6
Fe, Al	0.0
SiO_2	23.5
SO_4	167.6
CO_3	36.0
Cl	634.6
Total solids	1,794.0

The few wells that have been sunk in the valley southwest of Monroe show that the depth to ground water is over 70 feet. The most practicable way, therefore, of developing the area is from high-line canals supplied by Sevier River and Monroe Creek.

The presence of several springs between 1 and 3 miles south of the mouth of Monroe Canyon, along a probable fault, suggests that more water may be obtained by tunneling.

RICHFIELD AND VICINITY.

The portion of Sevier Valley between Monroe and Richfield that lies below the canals is in large part under cultivation, but the portion above them consists of desert alluvial slopes that extend up to the bases of the mountains. In the highlands bowlders and coarse-textured débris abound, while the lowlands are floored with sand and clay loam. The map forming Pl. VI shows that ground water lies within 10 feet of the surface under a considerable part of the lowlands, and that in this vicinity there are about 100 artesian wells, concerning which representative data are given in the list on pages 51–57. They are shallow, ranging from 50 to 95 feet in depth, and yield from 3 to 142 gallons a minute under a pressure at the surface of slightly over 2 pounds. In drilling, clay is usually encountered for 40 to 60 feet, below which lies said and gravel, whence the flows are obtained. The gravel appears to be widely distributed and constitutes a valuable reservoir. By a single well, No. 59, in list on page 52 and map (Pl. V), which is 4 inches in diameter, 62 feet deep, and yields 132 gallons a minute, a large tract of alkali land has been converted into an excellent meadow.

The deepest well in this vicinity was sunk in 1900 in NE. ¼ sec. 7, T. 24, S., R., 2 W., to a depth of 324 feet. The log of this well, as reported by the owner, is given below:

Log of well in sec. 7, T. 24 S., R. 2 W., in feet.

	Thickness.	Depth.
Clay	62	62
Sand and gravel	88	150
Clay	15	165
Sand and gravel	135	300
Clay	20	320
Sand and gravel	24	324

From the upper beds of sand and gravel in this well water rose within a few inches of the surface and a flow was obtained from the bottom, but the pipe broke and the well was discontinued. So far as known, this is the deepest hole in Sevier Valley proper, and the results serve to emphasize the desirability of a deep test well. The probabilities are that such a well will penetrate one or more beds of sand and gravel, bearing water under pressure great enough to cause flows at the surface, even if the well should be sunk at some distance from the river.

Not only the valley deposits, but the bed rock is an available source of underground water, especially along the base of the mountains, near Richfield. The considerable outcrop of sandstone and conglomerate on the crest and eastern flanks of the Pavant Range, as already stated (p. 23), presents a large area for the absorption of precipitation and run-off, and the eastward dip and cap of Eocene strata cause the contained water to be under pressure. Although deep valleys drain a large portion of the porous rocks, it is nevertheless likely that a well sunk through the capping of limestones and shales will strike artesian water in the underlying sandstone and conglomerate. The fault along the base of the mountains is a disturbing factor, yet apparently it is the cause of the spring west of Richfield, and thus serves to emphasize the possibility of obtaining water under pressure. The depth at which water may be expected can not be closely predicated. If a test well is attempted provision should be made for driving 1,000 feet or more, the depth depending on the location of the well; the farther away from the mountains it may be dug the deeper it will need to be sunk to reach the water-bearing beds. A rough approximation of the depth to the Richfield spring water may be afforded by its temperature, 74° F., which is 26° above the mean annual temperature. If the temperature be due to the internal heat of the earth, which, it is assumed, increases about

1 degree in every 50 feet, the water is derived from a depth of about 1,300 feet. It is possible, however, that the water owes its temperature in part to the proximity of heated igneous rocks.

Inverury and Annabelle, small towns situated on opposite sides of the Sevier, 4 miles south of Richfield, are supported by irrigation from canals fed by the river. Inverury is supplied with poor drinking water from shallow wells, although water of better quality can be obtained by driving deeper and casing off the upper flow. Annabelle, on the other hand, derives a good supply for domestic use from reservoirs in the mountains south of the town.

Richfield, the commercial center of Sevier Valley, has a population of about 2,000. The town is situated at the foot slope of the Pavant Range, and derives its water supply from the Sevier Valley and other canals and from the spring referred to on page 25. This spring, discharging 3.2 second-feet, besides furnishing water for local irrigation, supplies the city waterworks—the best system in the entire area considered in this report. The spring is inclosed in a brick structure, whence the water is piped to a concrete reservoir and distributed through an 8-inch main. Before the waterworks were installed the town depended largely upon wells that range in depth from 15 to 20 feet. Some of these are still used; others have been abandoned and are used as cesspools, thus introducing a source of contamination which should not be tolerated.

Glenwood is prettily located in a cove, at the base of Sevier Plateau, that is separated on the west from the main valley by a low lava-capped ridge. The town and its vicinity are supplied with water for irrigation and domestic use by springs. East and west of the lava-capped ridge there are springs whose discharge aggregates about 20 second-feet. Those on the west side of the ridge are reported to have broken out since 1880, and their flow is so copious that a considerable area has been converted into marsh land. The conditions here can be improved by drainage and by conveying the surplus water where it is more needed. The springs on the east side of the ridge discharge 9 second-feet and are the source of Cove Creek. At an elevation of 250 feet above the town Glenwood Springs issue from débris at the base of igneous hills and form the main local supply for all purposes, the discharge being 7 second-feet. Although the supply is plentiful, a needed improvement is the installation of a waterworks system that would do away with the present insanitary practice of obtaining domestic water directly from open ditches in the streets. The springs also afford an excellent source of power, which is as yet undeveloped. North of Glenwood, along the base of the mountains, there are other springs, notably Herrins Hole Springs and Black Knoll Springs, which yield respectively 1 and 12 second-feet. All of these springs probably rise along faults.

SALINA AND VICINITY.

Between Richfield and Salina the character of the country changes. On the east of the valley the Sevier Plateau, an area of igneous rocks, slopes rapidly northward to the interval separating it from the Wasatch Plateau, which is underlain by sedimentary rocks. A narrow belt of gypsiferous drab and red shales, capped here and there with lava, lies between the base of the plateaus and Sevier River. On the west side of the valley the eastward-dipping Eocene beds of the Valley Mountains are separated by a fault from the red conglomerates and sandstones of the Pavant Range. The appearance of the valley also changes. West of the river the canals water a relatively narrow strip, beyond which there is a long desert slope up to the base of the mountains, while on the east still less land is irrigated from small ditches fed by creeks.

Here, as throughout the valley, the lowlands are superficially underlain by fine-textured soils, while the foot slopes of the mountains are littered with coarse débris. Ground water lies between 10 and 50 feet from the surface in a belt contiguous to the river, where most of the wells have been sunk. They are chiefly driven wells, 2 or 3 inches in diameter and from 100 to a little over 200 feet in depth. This depth, unusual in Sevier Valley, is necessitated by the strongly saline character of the water nearer the surface, due to the proximity of the salt and gypsum-bearing shales. The wells first penetrate about 60 feet of clay, below which lie alternating layers of gravel and clay. Each gravel bed yields water under pressure that causes it to rise within a few feet of the surface. Along the entire length of Sevier Valley, between Venice and Gunnison, the character of the ground water is impaired by salts leached from the adjacent Jurassic beds. These salts, however, apparently do not permeate the valley deposits throughout their entire thickness, but seem to be confined largely to the upper layers by beds of clay, so that water of better quality is obtained by deep wells.

The character and structure of the bed rocks in the highlands immediately adjacent to the valley between Richfield and Salina are not in general favorable for storing or yielding much water, but water under pressure probably can be obtained in the red sandstone and conglomerate north of Richfield (p. 10). Artesian water may probably also be obtained in the valley of Salina Creek, several miles above Salina, a probability which, in view of the needs of the town, becomes important. As has been stated in the outline of the geology of the region (p. 9), thick sandstones that dip westward at a low angle and are overlain by Eocene beds outcrop in the upper valley of Salina Creek. Here the opportunities for absorption are good, and it is likely that wells that penetrate to saturated horizons of the sandstone will strike artesian water. If a test well be sunk it should be located at least 5 miles up the creek from Salina, for a fault probably lies between the small outcrop of Colorado age and the water-bearing beds.

Salina is situated at the base of the salt and gypsum bearing shales, near the mouth of Salina Creek. The town obtains its supply of water for domestic uses from ditches fed by the creek, and from dug wells, but the water from both sources is of poor quality. An effort was made in 1905 to obtain good water by sinking a 4-inch well to a depth of 163 feet, where water was encountered which rose within 42 feet of the surface. The site was not particularly good and the depth not great, so the test proved unsuccessful.

Log of Salina town well, in feet.

	Thickness.	Depth.
Clay and sandy soil	35	35
Sand and gravel	91	126
Hard white layer	24	150
Sand and gravel	13	163

A sample of water from the lower sand and gravel in this well was analyzed by H. Harms, of Salt Lake City, and found to contain 1,708 parts per million of dissolved solids, 728 of which are chlorine. This large content of salts renders the water undesirable for drinking purposes. A number of families have their drinking water hauled from Colby's well (No. 85 on map), about 4 miles southwest of Salina, which is reported to contain only 576 parts per million of dissolved salts, but this practice is only a makeshift. Further tests should be made with deep wells in the valley, away from the immediate influence of Salina Creek, and deep enough to escape seepage of water containing salts derived from the adjacent hills. It is desirable also that a test be made for artesian water up the valley of Salina Creek. The nearest good surface water is derived from feeble streams in the Pavant Mountains and from Salina Creek above the belt of saline rocks.

The small town of Aurora, 5 miles southwest of Salina, is supplied mainly by canals. A few wells, over 100 feet in depth, here obtain a fairly good supply beneath the saline surface water. The water rises in these wells within 20 or 40 feet of the surface. It is desirable that a deep test well be sunk in this part of the valley to determine whether water of good quality can be obtained under pressure sufficient to flow at the surface. It is possible that the spring 2 miles west of town can be developed so as to yield enough water for domestic uses.

Redmond is plentifully supplied with water, its chief asset being the springs that feed Redmond Lake. These issue from the bottom and edges of the lake and discharge about 13.5 second-feet. The temperature of one small spring of the group in August, 1905, was 70° F., which, together with the large amount of water the springs yield, suggests that they occur along a fault, which, however, has not been traced on the surface. Ditch water is generally used for domestic use, and little attention is given to its sanitary character. By fencing the lake and piping the supply used for drinking, water of excellent quality can be cheaply obtained. Ground water occurs within 10 feet of the surface in the lower part of the town, although there are but few wells. One well (No. 106 on the map), about a mile northeast of Redmond, was sunk to a depth of 180 feet passing through the following material:

Log of well No. 106, in feet.

	Thickness.	Depth.
Clay	20	20
Sand and clay	83	103
Clay	17	120
Gravel	22	142
Clay	38	180

Water in the lower gravel rises within 3.5 feet of the surface.

GUNNISON AND VICINITY.

A few miles north of Redmond, west of the river, there is a narrow belt of low hills, below which the valley broadens, reaching a width of 9 miles at Gunnison. The lowlands are underlain by clay, while the slopes on both sides of the valley are composed of coarser textured deposits that extend to the base of the mountains. Canals, fed either from Sevier River or San Pitch Creek, supply the lower part of the valley, which locally is so wet as to need drainage; but above the ditches desert conditions prevail.

Ground water lies within 50 feet of the surface in a considerable area in this part of the valley, and a number of wells have been sunk here. West of Gunnison, near the river, there are many flowing wells that average only 30 feet in depth. The water occurs in gravel beneath about 25 feet of clay, and the wells, which are 2 inches in diameter, flow about 50 gallons a minute under a pressure at the surface of about 1 pound.

Farther up the valley, in the vicinity of Axtel, about 1 mile east of the river, there is a group of dug wells that average 60 feet in depth. The deepest bore hole in this part of the valley is 1½ inches in diameter and 200 feet deep (No. 109 on the map). In this well alkaline water is found in sand at a depth of 45 feet, below which between

160 and 200 feet of alternating beds of sand and gravel, separated by clay, were encountered, which yielded a better quality of water that rose within 26 feet of the surface. Although the strata of the valley range dip toward the river, the catchment area is small, the rocks are chiefly fine-textured shales and limestones, and the opportunities for absorption and transmission are poor. On the east side of the valley the conditions are worse, for the little water that is contained in the gypsiferous shales is strongly impregnated with dissolved salts.

The town of Gunnison is situated at the southern end of the Gunnison Plateau, near the mouth of San Pitch Creek. A fair amount of water is furnished by canals, but there is urgent need for a supply of pure drinking water. There are a few shallow wells which derive their supply largely from the seepage of the canals. The water level in these wells fluctuates about 10 feet a year, being highest in the midst of the irrigation season. South of Gunnison a number of wells, less than 50 feet deep, have been sunk into the valley deposits, in which water is found in gravel beneath the surface cover of clay. The supply is derived largely from the seepage from the canals, and the quality of the water is only fair. No deep wells have been sunk in this part of the valley, and although the elevation is so high that flowing wells can hardly be expected, it is likely that a better quality can be obtained beneath the upper waters, and a test should be made. Probably the most satisfactory domestic supply for Gunnison is obtainable from springs at the base of the Wasatch Plateau north of Mayfield, presently to be described.

MAYFIELD AND VICINITY.

Mayfield is situated on Twelvemile Creek where it emerges from its canyon in the Wasatch Plateau, in a narrow lowland known as Arapien Valley, that trends north-south along a fault. On the west is a range of hills composed of eastward-dipping gypsiferous shales, and on the east is the dip slope of the Wasatch monocline. Mayfield and Arapien Valley are watered by ditches that tap Twelvemile Creek at the mouth of its canyon. A spring near the bed of the creek about 1 mile above town may be utilized as a source of domestic supply.

A number of wells, ranging in from 45 to 60 feet, have been sunk in the town, but many of them go dry, or almost dry, in the late winter, although during the irrigation season they contain between 15 and 20 feet of water. The westward-dipping sandstones that outcrop in the upper valley of Twelvemile Creek may contain water under pressure. The conditions here are complicated by minor step faulting along the flanks of the monocline, but it is likely that wells sunk near the mouth of the canyon deep enough to penetrate the overlying Wasatch beds will strike artesian water in the sandstone.

In the hilly faulted zone between Mayfield and Manti the main supply of underground water is derived from springs, including both fault and seep springs, 14 of which yield more than 16 second-feet. These comprise both seep and fault springs. The most remarkable spring in this area is that in the Morrison coal mine (No. 28 on map), east of Sterling. Before the mine was opened the hillside at the entrance to the mine was dry, but in driving the tunnel through the eastward-dipping sandstone water was encountered, the amount increasing with the length of the workings, until a stream was developed which in August, 1905, discharged 5.6 second-feet. It is likely that the water is brought up through the fault east of the mine from the westward-dipping sandstone that outcrops on the Wasatch Plateau. The water being under hydrostatic pressure, rises when it reaches the fault plane, as illustrated in fig. 4, p. 26. This spring suggests the desirability of prospecting for similar occurrences.

The small town of Sterling is watered by Sixmile Creek, which furnishes a good supply for irrigation, but the insanitary custom prevails of using for domestic purposes the ditch water that flows through the streets. The conditions can also be improved by developing springs or by piping from the creek above the town.

MANTI AND EPHRAIM.

Above the narrows of San Pitch Creek the valley broadens to a width of 5 miles at Manti and becomes 8 miles wide at Ephraim. On the west Gunnison Plateau, which is underlain for the most part by Eocene strata that dip west at a low angle, rises abruptly above the valley along a fault. On the east low, detached hills, composed of westward-dipping Manti beds, lie at the base of the Wasatch monocline. Where the creeks have cut deep, small outcrops of Laramie (?) sandstone are exposed below the Eocene strata, which underlie the surface of the greater part of the monocline in this area. Water for irrigation is supplied by San Pitch, Ephraim, Willow, and Manti creeks, which are supplemented in the lowlands to a small extent by flowing wells. The central part of the valley between Manti and Ephraim is occupied by a marsh. The conditions here, however, are reported to have been improved since the early days of settlement by the diversion of the waters of San Pitch Creek for use in irrigation, and considerable areas have been reclaimed.

Ground water lies within 10 feet of the surface in a large area in the central part of the valley, where many wells have been driven, but toward the mountains water lies deeper and there are only a few dug wells. Most of the wells in the lowlands are 1½ or 2 inches in diameter and between 125 and 300 feet in depth. Judging by the imperfect records, there is little uniformity in the distribution of the deposits, which appear to be lenticular masses of gravel, sand, and clay. A typical section is afforded by the following log:

Log of R. Taylor well, in SW. ¼ sec. 33, T. 15 S., R. 3 E. (No. 190 on p. 55.)

	Thickness.	Depth.
Clay with streaks of gravel	25	25
Clay	115	140
Sand and gravel	6	146
Clay and sand	145	291
Gravel	3	294

In this well the first flow was obtained at 140 feet, and a stronger flow, amounting to 28 gallons a minute under a pressure of 5 pounds at the surface, was encountered in the lowest gravel. Most of the wells in this area do not go beyond the first flow, which is commonly reached at a depth of about 125 feet, but in some wells as many as six flows are encountered between 125 and 300 feet. The flow of all the wells in this vicinity varies more or less with the season, and the yield of the shallower ones particularly is greater in summer than in winter. It is also found that the sinking of a new well in an area where wells are close together frequently interferes with the flow of the old ones. On the eastern side of the valley, whence the main supply is derived, the wells are better and more gravel is reported. It is desirable in this region to drive a deep well to test conditions and to sink more wells of larger bore to the lower horizons to obtain increased flows. In order to ascertain conditions concerning the available supply for pumping, experimental wells should also be put down outside of the area where flows are obtained. It is probable also that deep wells sunk near the base of the mountains on the east side of the valley will strike water under pressure in the Laramie sandstone, but the absorption area here is not so large as that farther north.

Manti is built on the alluvial fan of Manti Creek, which is the chief source of water supply. The town is underlain by coarse gravel in which are few wells, the deepest having been sunk about 100 feet, and very little water is reported to have been found. Manti is one of the few towns in this area that are provided with waterworks. Seep springs in the mountains on the south side of the creek have been developed, whence the water is piped to the city, and furnish a good supply.

Ephraim, situated on the alluvial slope about 2 miles below the mouth of the canyon of Ephraim Creek, is supplied with water for domestic purposes by a number of wells, the depth of which increases with the surface elevation. The wells in the lower part of town are only 30 feet deep, but those farther east are 90 feet. In the upper outskirts there are no wells, and the people depend on the ditches for water. A few years ago a well 2 inches in diameter and 440 feet deep was sunk near the town hall in search of flowing water. At 160 feet water was found which rose to 17 feet below the surface, and at 340 feet water stood in the pipe 60 feet below the ground. It is reported that the lower 100 feet of the drilling was through bed rock. A considerable part of the town appears to be underlain to a depth of from 10 to 20 feet by clay, which overlies water-bearing sand and gravel. The water is therefore protected to a certain extent from contamination, but a better supply is available in springs a few miles up Ephraim Canyon.

MORONI AND VICINITY.

Between Ephraim and Moroni the conditions are similar to those farther south. A number of flowing wells have been obtained in the lowlands, while the uplands remain to a large extent undeveloped. Some of the best wells in the area under consideration are located here. Most of them are 2 inches in diameter and about 130 feet deep, and discharge from 10 to 30 gallons a minute; but a well in NW. $\frac{1}{4}$ sec. 9, T. 16 S., R. 3 E., belonging to Joseph Seely, is exceptional in character. This well is 4 inches in diameter and 344 feet deep and yields 160 gallons a minute under a pressure of 6 pounds at the surface. An approximate record of this well is as follows:

Approximate record of well No. 205, in feet.

	Depth.	Thickness.
Clay	15	15
Sand with streaks of clay	80	65
Clay	130	50
Sand	150	20
Alternating layers of gravel, sand, and clay	344	194

Several flows were obtained between 130 and 344 feet, but the best one occurred at the latter depth, in a bed of gravel 10 feet thick. In one well the drill was sunk 300 feet deeper, through clay all the way. These results will probably encourage the sinking of other wells in this vicinity. The extent of the area in which these conditions prevail can be determined only by testing, but it may be conjectured that they persist at least over several square miles.

The town of Moroni is situated at the southern end of the highland between the two forks of Sanpete Valley. Canals fed by San Pitch Creek form its chief source of water supply, but the town is poorly provided with water for domestic purposes. There are a number of dug wells, ranging in depth from 10 to 60 feet. The quality of the water, however, is impaired by seepage from the upper canal. Probably the springs on the west side of the valley (p. 103) are the most desirable source of water for the domestic supply of Moroni.

FOUNTAIN GREEN AND WALES.

The broad western fork of Sanpete Valley is bordered on the east by a low, barren ridge, underlain by Eocene shales and limestones and capped by lava flows, and is limited on the west by the high and narrow Gunnison Plateau. The northern end of the plateau is underlain by beds of sandstone and conglomerate, which lie almost flat or dip westward at a low angle, while farther south these beds are capped by shales and limestones, and along the eastern border steep-lying, eastward-dipping beds of sandstone and conglomerate mark the presence of a fault. Toward the northwest the valley narrows, and about 4 miles above Fountain Green terminates at the débris-covered divide between Sanpete and Salt Creek valleys. No perennial streams are fed by the run-off in this area, but a remarkable series of springs issue along the base of Gunnison Plateau.

Between Moroni and Fountain Green, ground water lies within 10 feet of the surface in a narrow belt, above which it lies at greater depths, as shown on the map (Pl. VI). In this region there are a few flowing wells and a number of pumping ones, but the main water supply is derived from springs.

Within a distance of 10 miles between Wales and Fountain Green, associated with the fault at the base of Gunnison Plateau, there are seven springs, the aggregate yield of which amounts to 15.9 second-feet. These springs have many features in common. Their temperature is about the same, approximating the mean annual temperature of the region; the water of all contains abundant calcium carbonate, which is deposited as tufa; and the flow, except that of one spring, is reported not to vary. The discharge of these springs is not affected by heavy showers, and in view of the small tributary drainage area and the scarcity of limestone, a distant though unknown source is indicated. Possibly the water is derived from the westward-dipping sandstone that outcrops on the Wasatch Plateau and probably underlies the valley. This chance suggests the desirability of sinking a deep well in the valley in search of artesian water from bed rock (pp. 22–23). The dip of the sandstone may flatten out, for the low temperature of the springs does not imply a deep-seated source, but the depth to the water-bearing beds can not be predicted.

It is reported that the flow of one of these springs (No. 70 on map) was increased fivefold by driving a tunnel through débris to bed rock. This, together with the general facts of occurrence, suggest that prospecting might profitably be undertaken along the fault line with the idea of increasing present supplies and of developing new ones.

Another point should be mentioned. The springs are separated from the settlements by a mile or more of sand and gravel, in which loss occurs by absorption, although aeration of the water causes the precipitation of calcium carbonate, which tends to seal the channels, especially in their upper part. Much of this loss could be prevented by using pipes instead of ditches.

Wales is situated on the alluvial slope near the base of the plateau and is supplied with water principally from Wales Creek and from springs northwest of the town. There are a few wells in Wales, ranging from 30 to 90 feet in depth, and the fields below the town are irrigated from a reservoir below Moroni. The quality of the domestic supply can be much improved by using pipes instead of open ditches to convey water from the springs.

The small town of Freedom is noteworthy as being one of the few settlements in the area under consideration that have public water systems. The flow of Current Spring, amounting to about 1 second-foot, is distributed through pipes and furnishes a very satisfactory supply.

Fountain Green is suppled almost entirely by the large spring at the base of the plateau about a mile and a half west of the town. (Pl. IV, *A*.) The yield of this spring, as measured by C. S. Jarvis in September, 1905, amounted to 12.4 second-feet. It is reported that the winter discharge falls off perceptibly, but figures to verify this report are not available. The domestic supply would be bettered in quality if the water were distributed in pipes instead of open ditches.

There are a number of dug wells in and about Fountain Green, ranging from 10 to 50 feet in depth; and about 1896 the town sank a 2-inch well to a depth of 285 feet, the log of which is given below:

Log of well at Fountain Green, No. 218.

	Thickness.	Depth.
Gravel	15	15
Alternate beds of clay, sand, and gravel	98	113
Clay	87	200
Sand	60	260
Clay	25	285

MOUNT PLEASANT AND VICINITY.

The eastern fork of Sanpete Valley is occupied by the headwaters of San Pitch Creek. On the west the low hills that separate the two forks are underlain by Eocene shales and limestones that dip westward at a low angle and are locally capped by lava, and on the east the Wasatch Plateau towers above the valley. In this part of the plateau the summits and most of the western flank are formed of Laramie (?) sandstone, and Eocene strata outcrop on the lower slopes. Here, as farther south, the monocline is well developed, and the rocks that cap the plateau dip beneath the valley filling. Spring City, Mount Pleasant, Fairview, and Milburn are situated on the east side of the valley, and their water supply is derived from the main creek and its branches, supplemented by a number of wells and springs.

The central part of the valley is occupied by a narrow belt in which ground water lies within 10 feet of the surface. Above the lowlands the surface rises to the base of the mountains at a rate of slightly over 100 feet a mile. The upper portion of this slope, above the canals, is a sagebrush-covered desert, beneath which ground water lies at a considerable but unknown depth.

The wells in the lowland are chiefly shallow dug ones, possessing no unusual features, and the main supply of underground water is derived from springs. These are situated in low meadows adjacent to creeks and are all seep springs, of which there are several groups in this portion of the valley. An important group includes those belonging to the sugar company, located about 3 miles east of Moroni, adjacent to Cedar Creek, which in all discharge 3.8 second-feet. Another group, about 2 miles northeast of these, flows 2½ second-feet. Above Mount Pleasant, adjacent to San Pitch Creek, there are numerous seeps, and in the vicinity of Fairview the total discharge of springs, determined by gaging the creek above and below the town in September, 1905, amounted to 12 second-feet.

The Madsen and Seely tunnel, about half a mile west of the railroad station at Mount Pleasant, affords an instructive example of the successful development of a spring. There the flow of a small seep has been increased several fold by tunneling, and the experiment might be repeated elesewhere to advantage. (See p. 28.)

The extensive outcrop of sandstone on the crest and flanks of the Wasatch Plateau east of upper Sanpete Valley affords an excellent opportunity for absorption, and the westward dip and capping of Wasatch beds at the base of the plateau are favorable for obtaining water under pressure in wells sunk into the sandstone. These conditions are well developed between Spring City and Milburn. If results are favorable, it is likely that flows can be obtained well up on the barren slopes toward the base of the mountains.

Spring City is situated near the base of a long alluvial slope in an embayment that is partly separated from the main valley by a low ridge of westward-dipping Manti beds. The main water supply is obtained from ditches fed by Canal and Oak creeks, supplemented by springs and wells. Ground water lies within 10 feet of the surface in a narrow stip adjoining the lower part of the town, but in the upper part the depth to water increases to 50 feet or more. There are a few flowing wells in the valley deposits southwest of Spring City. Wells Nos. 194 and 195 are 2 inches in diameter, 200 feet deep, and yield an average flow of 20 gallons a minute under a pressure of 3½ pounds at the surface. A feeble first flow was obtained at 150 feet and the main flow at 200 feet. Similar results can doubtless be obtained in other wells. There are a number of seep springs in and near the town, the discharge of which ranges between 4 and 44 gallons a minute. It is likely that the yield can be increased and other springs developed by tunneling.

Mount Pleasant, located on the alluvial slope about midway between San Pitch and the base of the mountains, has lately installed public waterworks. Water is diverted from Pleasant Creek near the mouth of its canyon and flumed to a reservoir, whence it is distributed throughout the town. The success of this project shows what can be accomplished at small cost by most of the settlements in Sanpete and Sevier valleys. The depth to ground water ranges from 10 feet in the lower part to more than 100 feet in the upper part of the town. Approximate measurements show that the slope of the ground-water surface is less than that of the ground, the figures being respectively 95 and 170 feet in a mile. The annual fluctuation of the ground-water surface between summer maximum and winter minimum is reported to average about 10 feet.

Fairview and Milburn are situated near San Pitch Creek, at the base of the alluvial slope. In the lower part of the towns ground water lies near the surface, and swampy places exist, while on the upper slopes depth to water is considerably over 50 feet. Springs can be developed in this vicinity, and it is desirable that a deep test well should be sunk in the lower part of the valley.

WELL AND SPRING DATA.

Data concerning wells in Sanpete and Sevier valleys, Utah.

No.	Name.	Year sunk.	Location.			Diameter.[a]	Depth.	Height of water.[b]	Depth to main water bed.	Nature of main water bed.	Use.[c]	Yield.
			Township.	Range.	Section.							
						Inches.	*Feet.*	*Feet.*	*Feet.*			
1	J. H. Levi	1905	25 S.	4 W.	NE. ¼, 32		40	−32	38	Clay and gravel	D. S.	*d* 150
2	W. F. Bridges	1905	25 S.	4 W.	SW. ¼, 28		47	−37	42	Sand	D.	*d* 100
4	A. Sorenson	1890	25 S.	3 W.	NW. ¼, 21		112	−90	96	Gravel	D. S.	*e* 8
5	F. M. Ross	1902	25 S.	4 W.	NE. ¼, 22		72	−63	70	do	D.	*d* 50
6	A. McMeekin	1900	25 S.	3 W.	NW. ¼, 15		98	−86	94	do	D.	
7	E. S. Skinner	1897	25 S.	4 W.	SE. ¼, 15		54.5	−43	52	do	D. S.	*d* 200
8	O. Bowen	1900	25 S.	4 W.	SW. ¼, 14		35	−25	33	do	D.	*d* 75
9	A. Gay	1890	25 S.	4 W.	NE. ¼, 14		27	−16	25	do	D.	*d* 100
10	J. A. Ross	1892	25 S.	4 W.	NE. ¼, 15		56	−44	54	do	D. S.	*d* 200
11	G. L. Ross	1895	25 S.	4 W.	NW. ¼, 14		47	−36	46	do	D. S.	*d* 400
12	G. W. Ross	1894	25 S.	4 W.	NW. ¼, 14		45	−35	42	do	D.	*d* 200
13	H. Tuft	1899	25 S.	3 W.	SW. ¼, 10		90	−65	77	do	D. S.	*d* 300
14	A. Anderson	1896	25 S.	3 W.	SW. ¼, 10		64	−56	73	do	D. S.	*d* 300
15	D. M. Crawford	1897	25 S.	3 W.	SE. ¼, 8		81	−71	70	do	D. S. I.	*e* 10
16	A. N. Warenshi	1881	25 S.	4 W.	SW. ¼, 11		18	−7		do	D.	*d* 50
17	J. Ross	1898	25 S.	4 W.	SW. ¼, 11		47	−38	44	do	D.	*d* 75
18	U. Graham	1895	25 S.	4 W.	NW. ¼, 11		46	−38	44	do	D. S.	*d* 200
19	C. Winget	1895	25 S.	3 W.	NW. ¼, 3		23±	−13±	14	Gravel and sand	D.	*d* 100
20	J. Bland	1900	25 S.	3 W.	SE. ¼, 5		52	−43	50	Gravel	D. S.	*d* 300
21	D. Barney	1898	25 S.	3 W.	SE. ¼, 5		50	−43	45	do	D. S.	*d* 400
22	L. Lisenbee	1903	25 S.	3 W.	NE. ¼, 5		46	−35±	43	do	D. S.	*e* 5
23	Brooklyn Co	1903	25 S.	3 W.	SW. ¼, 6	1½	53	−3	21, 30, 53	Sand and gravel	I.	*e* 8
24	do	1905	25 S.	3 W.	SW. ¼, 6	1½	23	−1.8	23	do	I.	*e* 31
25	do	1905	25 S.	3 W.	SW. ¼, 6	1½	21	−.75	21	do	I.	*e* 29
26	N. M. Higgins	1901	25 S.	3 W.	NW. ¼, 6		102	−90±	98	Quicksand	D. S. I.	*e* 5
27	M. W. Prisbrey	1895	25 S.	4 W.	SW. ¼, 1		33	−28	31	Gravel		
28	T. Roberts	1893	25 S.	4 W.	SE. ¼, 2		41	−35	39±	do	D.	*d* 50
29	J. Willes	1900	25 S.	4 W.	SW. ¼, 2		46	−40	44	do	D. S.	*d* 200
30	P. P. Washburn	1889	24 S.	3 W.	NW. ¼, 35		31	−27	26	do	D. S.	*d* 125
31	L. Anderson	1885	24 S.	3 W.	NW. ¼, 35		39	−29	32	do	D. S.	*d* 200
32	G. Hicks	1893	24 S.	3 W.	SW. ¼, 34		19	−11	13	do	D. S.	*d* 300
33	N. Foreman	1887	24 S.	3 W.	NW. ¼, 34		20	−15	20	do	D. S.	*d* 200
34	J. H. Lowe	1889	24 S.	3 W.	NE. ¼, 33		25	−16	23	do	D. S.	*e* 8
35	O. P. Lee	1896	24 S.	3 W.	NW. ¼, 33		37	−20	29	do	D. S. I.	*e* 5

[a] If bored. Wells whose diameter is not given or queried (?) are dug.
[b] Height of water below surface indicated by minus mark (−); height to which water rises above surface indicated by plus mark (+).
[c] D.=Domestic; S.=Stock; I.=Irrigation.
[d] Gallons per day.
[e] Gallons per minute.

Data concerning wells in Sanpete and Sevier valleys, Utah—Continued.

No.	Name.	Year sunk.	Location.			Diameter.	Depth.	Height of water.	Depth to main water bed.	Nature of main water bed.	Use.	Yield.
			Township.	Range.	Section.							
						Inches.	*Feet.*	*Feet.*	*Feet.*			
36	J. A. Moore	1897	24 S.	3 W.	NW. ¼, 33		35	− 24	33	Gravel	D. S.	a 200
37	L. W. Munson	1893	24 S.	3 W.	NE. ¼, 32		50	− 30	35	Sand	D. S.	b 6
38	C. L. Hutchings	1887	24 S.	3 W.	E. ½, 32		40	− 30	26	Gravel	D. S.	a 400
39	J. F. Shaw	1892	44 S.	3 W.	NE. ¼, 32		40	− 31	38	do	D. S.	b 5
40	C. O. Keeler	1898	24 S.	3 W.	SW. ¼, 32		48±	− 35±	36	do	D. S.	b 5
41	J. W. Nunley	1904	24 S.	3 W.	NE. ¼, 32		35	− 24	33	do	D. S.	b 5
42	S. C. Petersen	1892	24 S.	3 W.	SE. ¼, 29		50±	− 36	45	do	D. S.	b 8
43	J. P. Hansen	1902	24 S.	3 W.	SE. ¼, 29		55	− 53	53	do	D.	b 6
44	S. Sorenson	1890	24 S.	3 W.	SE. ¼, 29		60	− 53	56	do	D.	b 5
45	J. B. Sylvester	1903	24 S.	3 W.	NE. ¼, 29		60	− 59	62		D.	b 4
46	R. M. Nieken	1903	24 S.	3 W.	NE. ¼, 29		115	−110±	109	Sand	D.	b 4
47	H. Christophersen	1903	24 S.	3 W.	NE. ¼, 29		98	− 56	93	Gravel and sand	D.	b 4
48	W. F. Porter	1898	24 S.	3 W.	SE. ¼, 23	1½	40	− 18±	18	Clay and gravel	D. S.	a 500
49	E. B. Stewart	1896	24 S.	3 W.	NW. ¼, 23		27	− 21	24±	do	D. S.	a 300
50	J. Nordfors	1903	24 S.	2 W.	SW. ¼, 18		60	− 58	58	Gravel	D. S.	a 200
51	G. W. Williams	1897	24 S.	2 W.	SE. ¼, 18		62	− 59	59	do	D. S. I.	b 6
52	E. B. Keyes	1899	24 S.	2 W.	SW. ¼, 18		33	− 30	30	do	D.	a 100
53	F. L. Hansen	1902	24 S.	3 W.	NE. ¼, 12	1¼	49	+ 3.7	49±	do	S. I.	b 15½
54	W. F. Wright	1900	24 S.	2 W.	NE. ¼, 7	2	63	+ 0.5	60	Sand and gravel	D. S. I.	b 15±
55	J. M. Petersen	1895	24 S.	2 W.	NW. ¼, 6	1½	60±	+ 3.7	50±	Gravel	I.	b 18
56	do	1900	24 S.	2 W.	NW. ¼, 6	3	57		50±	do	I.	b 95
57	do	1900	24 S.	2 W.	NW. ¼, 6	6	63±	+ 2.9	50±	do	I.	b 142
58	G. Petersen	1900	23 S.	3 W.	NW. ¼, 36		13	− 4	7	Clay	D.	a 75
59	J. Wilkinson	1902	23 S.	2 W.	NE. ¼, 31	4	62	+ 3.6	40, 60	Gravel	S. I.	b 132
60	J. Borgquist	1901	23 S.	2 W.	NE. ¼, 31	4	70	+ 2.5	50	Sand and gravel	I.	b 110±
61	do	1890	23 S.	2 W.	SE. ¼, 31	¾	70	+ 2.4	50	do	I.	b 3½
62	do	1901	23 S.	2 W.	NE. ¼, 31	4	70	+ 2.5	50	do	I.	b 110±
63	W. H. Seegmiller	1901	23 S.	2 W.	NE. ¼, 32	3	72	+ 2.9	71	Gravel	I.	b 42
64	do	1901	23 S.	2 W.	NE. ¼, 32	3	69	+ 2.9	68	do	I.	b 62
65	J. Sorenson	1890	23 S.	2 W.	SE. ¼, 26		13	− 11	12.5	Sand	D. S.	a 100
66	P. Johnson	1890	23 S.	2 W.	SE. ¼, 26		20.5	− 18	18	do	D. S.	a 350
67	J. M. Bolitho	1901	23 S.	2 W.	SW. ¼, 29	2	82.5	+ 3.1	56+	Sand and gravel	S. I.	b 27
68	do	1901	23 S.	2 W.	SW. ¼, 29	3	95	+ 3	56+	do	S. I.	b 62
69	do	1901	23 S.	2 W.	NW. ¼, 29	4	88	+ 2.2		do	D. S. I.	b 125
70	H. P. Petersen	1887	23 S.	3 W.	SE. ¼, 25		17	− 10	14	Gravel	D. S.	a 50
71	H. Neilsen	1898	23 S.	3 W.	NE. ¼, 26		80	− 76	77	do	D.	a 50
72	P. Jensen	1903	23 S.	3 W.	NE. ¼, 26	4	208	−110±	{ 110 200 }			
73	J. M. Lauritzen	1905	23 S.	3 W.	SE. ¼, 23		51	− 50	50			
74	J. M. Kirkman	1902	23 S.	2 W.	SE. ¼, 15	2	75	+ 2.3	75	Gravel	D. S. I.	b 25
75	J. C. Cowley	1900	23 S.	2 W.	SE. ¼, 15	2	80	+ 1.1	{ 66 70 }	Sand and gravel	D. S. I.	b 10±

76	E. Wall	1901	23 S.	2 W.	SE. ¼, 15	2	73	+ 2.7	64	do	I.	b 34
77	G. Pectol	1898	23 S.	2 W.	NE. ¼, 1	2	38	− 11±	36±	Gravel and sand	D. S.	a 100
78	O. Dastrup	1896	23 S.	2 W.	NE. ¼, 1	1½	62	− 11	40 60	Sand	D.	a 100
79	C. Myers	1899	22 S.	2 W.	SE. ¼, 36	2	102	− 16	18+		D. S.	a 300
80	O. Dastrup	1901	22 S.	2 W.	SE. ¼, 36	1½	51	+ 3.75	50±	Gravel and sand	D. S.	b 8±
81	F. Glenhill	1902	22 S.	2 W.	NE. ¼, 25	2	109	− 29	30 105	Sand and gravel	D. S. I.	a 350
82	J. Tholman	1898	22 S.	2 W.	NE. ¼, 25		41	− 40	40	Gravel	D. S.	a 150
83	A. Shaw	1903	22 S.	1 W.	NW. ¼, 19		57	− 54.5	54±	do	S.	a 100
84	M. Kane	1905	22 S.	1 W.	NE. ¼, 19	2	73	− 30±	25 50 70	Sand	D. S.	a 100
85	J. Colby	1901	22 S.	1 W.	SE. ¼, 4	2	120	− 15	15 110	Sand and gravel	D. S.	a 600
86	D. E. Stevens	1898	22 S.	1 W.	SW. ¼, 4	2	100	− 7	100	do	D. S.	a 300
87	J. H. Kennedy	1902	22 S.	1 W.	NE. ¼, 4	2	95	− 3	90	Gravel and sand	D. S.	a 350
88	G. Holdaway	1900	22 S.	1 W.	NW. ¼, 4	2	212	− 6	212	Gravel	D. S.	a 750
89	E. Sorenson	1905	22 S.	1 W.	SE. ¼, 5	3	215	− 32	20	do	D. S.	a 225
90	J. Curtis	1905	22 S.	1 W.	SW. ¼, 5	2	176	− 47	60+	do	D. S.	a 200
91	S. Harding	1898	21 S.	1 W.	SE. ¼, 34	2	125	− 8±	125		D. S.	a 200
92	J. Neilson	1900	21 S.	1 W.	NE. ¼, 26		17	− 13	15	Gravel	D. S.	a 200
93	H. C. Neilson	1893	21 S.	1 W.	NE. ¼, 26		27	− 23	25±	do	D. S.	a 200
94	J. W. Phillips	1888	21 S.	1 W.	NW. ¼, 25		35	− 30	35	do	D. S.	a 250
95	Townwell Salina	1905	21 S.	1 W.	NW. ¼, 25	4	163	− 42	37 150	do		b 30
96	J. S. Jensen	1889	21 S.	1 W.	NW. ¼, 25		43	− 35	43	do	D. S. I.	a 2,500
97	White House well	1899	21 S.	1 W.	NE. ¼, 25		46	− 40	43	do	D. S.	a 200
98	E. W. Crane	1889	21 S.	1 W.	NE. ¼, 25		52	− 41	42	do	D. S.	a 300
99	G. S. Williams	1901	21 S.	1 W.	NE. ¼, 25		65	− 61	65	do		
100	J. Anderson	1892	21 S.	1 W.	NE. ¼, 24		23	− 17	23	do	D. S.	a 200
101	H. C. Neilson	1888	21 S.	1 W.	NW. ¼, 22		46	− 40	44	Clay	D. S.	a 300
101a	A. J. Scott	1905	21 S.	1 W.	NE. ¼, 19	2	530	− 8	69	Gravel		
102	D. Allred	1890	21 S.	1 W.	SE. ¼, 13		10.5	− 9.5	9.5±	do	D. S.	a 100
103	W. B. Humphrey	1901	21 S.	1 W.	SW. ¼, 15		60	− 55	60	Clay	D. S.	a 300
104	L. M. Breinholt	1890	21 S.	1 W.	NE. ¼, 11		19.5	− 16	18±	Gravel	D. S.	a 450
105	P. A. Petersen	1902	21 S.	1 W.	SW. ¼, 1	2	39	− 4	39	do	D. S.	a 150
106	F. A. Peterson	1903	21 S.	1 W.	NE. ¼, 1	2	180	− 3.5	142	do	D. S.	a 200
107	J. C. Hansen	1898	20 S.	1 E.	NW. ¼, 29		64	− 63	63	Sand	D.	a 75
108	J. Jensen	1894	20 S.	1 E.	SW. ¼, 20		56	− 53	54	Gravel	D. S.	a 200
109	S. Anderson	1889	20 S.	1 E.	SE. ¼, 19	1½	200	− 26	200	Sand and gravel	D.	a 140
110	J. Peterson	1880	20 S.	1 E.	SE. ¼, 19		54	− 46	50	Sand	D. S.	b 11
111	F. T. Tilton	1898	20 S.	1 E.	SW. ¼, 16		70	− 40	64	Gravel	S.	a 200
112	S. Caldwell	1895	20 S.	1 E.	NW. ¼, 9		55	− 53	55	do	S.	a 200
113	A. J. Robbins		20 S.	1 W.	C. ¼, 12	(?)	100		60			
114	O. B. Burgland	1895	20 S.	1 E.	SE. ¼, 5		42	− 31	31+	Gravel	D. S.	a 450
115	N. Larsen	1884	19 S.	1 E.	NE. ¼, 32		46	− 25	20	do	D. S. I.	a 500
116	S. Whiting	1885	19 S.	1 E.	NW. ¼, 33		54	− 33	52	do	D. S.	a 100
117	F. K. Christianson	1891	19 S.	2 E.	SE. ¼, 32		58	− 36	36	do	D. S.	a 200
118	P. Christianson	1900	19 S.	2 E.	NE. ¼, 32		60	− 35	35	do	D. S.	a 250
119	C. C. Larsen	1899	19 S.	2 E.	NW. ¼, 32		51	− 35	35+	do	D. S.	a 350

a Gallons per day. b Gallons per minute.

Data concerning wells in Sanpete and Sevier valleys, Utah—Continued.

No.	Name.	Year sunk.	Location. Town-ship.	Range.	Section.	Diame-ter.	Depth.	Height of water.	Depth to main water bed.	Nature of main water bed.	Use.	Yield.
						Inches.	*Feet.*	*Feet.*	*Feet.*			
120	J. Olsen	1897	19 S.	2 E.	SE. ¼, 29		45	−34	34+	Gravel	D. S.	*a* 125
121	J. Neilson	1901	19 S.	1 E.	NE. ¼, 28		36	−21	20	do	D. S.	*a* 100
122	A. Jensen	1884	19 S.	1 E.	SW. ¼, 28		48	−25	25	do	D. S.	*a* 100
123	C. Sorenson	1890	19 S.	1 E.	SE. ¼, 29		40	−20	18	do	D. S.	*a* 75
124	D. W. Woolrey	1890	19 S.	1 E.	NW. ¼, 29		28	−14	14	do	D. S.	*a* 100
125	A. J. Robbins	1890	19 S.	1 E.	NW. ¼, 30	2	18	− 3	3	do	D.	*a* 75
126	do	1904	19 S.	1 E.	NW. ¼, 30	3	186	− 2	15	do		
127	A. H. Lund	1897	19 S.	1 W.	NE. ¼, 22		40	− 38	39	do	D. S.	*a* 100
128	F. L. Copering	1902	19 S.	1 W.	NW. ¼, 23	2	80	−12±	20±	do	D. S.	
129	L. H. Erickson	1895	19 S.	1 W.	NE. ¼, 23		13.5	−11	11±	Clay	D.	
130	do	{1902 1903 1904}	19 S.	1 W.	SW. ¼, 24	2	30	+ 2.9	23±	Gravel	D. S. I.	*b* 55
131	do	1904	19 S.	1 W.	SW. ¼, 24	2	30	+ 2.6	23±	do	D. S. I.	*b* 51
132	do	1904	19 S.	1 W.	SW. ¼, 24	2	20	+ 2.9	23±	do	D. S. I.	*b* 58
133	do	1904	19 S.	1 W.	SW. ¼, 24	2	30	+ 3.7	23±	do	D. S. I.	*b* 32
134	do	1904	19 S.	1 W.	SW. ¼, 24	2	30	+ 3.7	23±	do	D. S. I.	*b* 59
135	A. Kearns	1885	19 S.	1 E.	NE. ¼, 20		43	−18	20	do	D. S. I.	*a* 100
136	J. W. Edwards	1883	19 S.	1 E.	NE. ¼, 20		42	−19	19	do	D. S.	*a* 75
137	C. W. Perkins	1890	19 S.	1 E.	SW. ¼, 17		20	−12	12	do	D. S.	*a* 125
138	T. E. Christensen		19 S.	1 E.	SE. ¼, 17		20	−12	20	Sandstone	D. S.	*a* 200
139	H. M. Childs	1890	19 S.	1 E.	SW. ¼, 16		20	− 9	9	do	D.	*a* 75
140	T. E. Christensen	1880	19 S.	1 E.	NW. ¼, 13		22	−18	17	Gravel		
141	F. Swalberg	1885	19 S.	1 E.	NW. ¼, 13		23	−15	15	do	D.	*a* 75
142	R. Edwards	1889	19 S.	2 E.	NE. ¼, 4		40	−30	30	do	S.	*a* 75
143	H. A. Larsen	1890	18 S.	2 E.	NW. ¼, 14	1½	118±	+98	80	do	S. I.	*b* 3½
144	E. Fox	1899	18 S.	2 E.	SE. ¼, 2	(?)	209					
145	A. Barton	1889	18 S.	2 E.	SE. ¼, 3	2	180±	+ 8	170	Gravel	S. I.	*b* 39
146	do	1889	18 S.	2 E.	SE. ¼, 3	2	180±	+ 7	170	do	S. I.	*b* 15±
147	F. Tuttle	1883	17 S.	2 E.	SE. ¼, 34	1½	110±	+ 9	107±	do	S. I.	*b* 18
148	Robins & Erickson	1904	17 S.	2 E.	NE. ¼, 34	2	{110 210}	+22	{110 210}	Sand and gravel	I.	(*c*)
149	F. Tuttle	1890	17 S.	2 E.	C. ¼, 35	1½	135±	+ 5.6	133±	Gravel	S. I.	*b* 3
150	W. Tuttle	1890	17 S.	2 E.	NE. ¼, 35	1½	75	+ 5.8	70	do	S.	*b* 6±
151	G. B. Cox	1894	17 S.	2 E.	NE. ¼, 35	1½	60	+ 6.7	55±	do	S.	*b* 6
152	F. Keller	1894	±17 S.	2 E.	NW. ¼, 25	1½	80±	+ 6	77	Sand	S. I.	*b* 2
153	H. Maylett	1892	17 S.	2 E.	SE. ¼, 22	1½	130±	+11	130	Gravel	S.	*b* 1−
154	do	1892	17 S.	2 E.	NE. ¼, 22	1½	130±	+ 3.5		do	S.	*b* 3
155	E. S. Madsen	1897	17 S.	2 E.	SE. ¼, 15	1½		+ 4	125	do	I.	*b* 9±
156	do	1898	17 S.	2 E.	SE. ¼, 15	1½		+ 7	125	do	D. S. I.	*b* 6
157	P. Peterson	1900	17 S.	3 E.	NE. ¼, 18	1½	115	+ 3.2	115	do	D. I.	*b* 9
158	T. S. Lund	1888	17 S.	3 E.	SE. ¼, 17		101	−90±	83	do	D. S.	*a* 100

159	P. Greaves	1885	17 S.	3 E.	NE. ¼, 7	1½	125	+ 7	125	Gravel and sand	S. I	b 1⅓
160	....do	1890	17 S.	3 E.	NE. ¼, 7	1½	125±	+ 3.5	125	Gravel	S. I	b 11
161	....do	1895	17 S.	3 E.	NE. ¼, 8	1½	130±	+ 6.9	{ 80 / 130 }	....do	S. I	b 11
162	G. L. Neilsen	1892	17 S.	3 E.	SW. ¼, 9	....	66	−53	50	....do	D. S	a 175
163	H. J. Lindhardt	1895	17 S.	3 E.	NE. ¼, 9	....	80	−69	79.5	....do	D. S.	a 225
164	J. Stevenson	1899	17 S.	3 E.	NW. ¼, 9	....	42	−40	40	....do	D. S.	a 75
165	P. Graves	1860	17 S.	3 E.	NE. ¼, 9	....	64±	−40	38 to 50	....do	D.	a 100
166	H. G. Hansen	1898	17 S.	3 E.	NW. ¼, 9	....	23	−18	15	....do	D. S.	a 100
167	M. Dorins	1898	17 S.	3 E.	SE. ¼, 4	....	82	−76	70 to 82	Gravel and sand	D. S.	a 75
168	Ephraim town well	1901	17 S.	3 E.	SE. ¼, 4	2	340	−60	340	Gravel	D.	a 200
169	A. C. Olsen	1902	17 S.	3 E.	SE. ¼, 4	....	53	−47	45	....do	D.	a 75
170	O. Thursby	1880	17 S.	3 E.	SE. ¼, 4	....	33	−26	23	....do	D. S.	a 100
171	B. Carlson	1858	17 S.	3 E.	SW. ¼, 4	....	40	−34±	35±	....do	D.	a 75
172	C. Briggs	1895	17 S.	3 E.	NW. ¼, 6	1½	150	+ 6	3, 80, 150	Sand	S. I	17½
173	P. Jensen	1903	17 S.	3 E.	SW. ¼, 6	2	212	+24.5	212	Gravel	S. I	b 55
174	....do	1903	17 S.	3 E.	SW. ¼, 6	2	156	+ 5	85, 132	....do	S. I	b 19
175	J. Larsen	1903	17 S.	2 E.	NW. ¼, 1	2	294	+11.5	140	....do	S. I	b 28
176	C. Christensen	1900	17 S.	2 E.	NE. ¼, 1	1½	150	+ 4	147	....do	S. I	b 15
177	J. Larsen	1900	17 S.	2 E.	NW. ¼, 1	1½	152±	+ 2.5	140	....do	D. S.	a ½—
178	P. Kesko	1904	16 S.	3 E.	NW. ¼, 28	2	130	+ 2	130	....do	....	b 1¾
179	....do	1904	16 S.	3 E.	NW. ¼, 28	2	45	+ 8.6	45	....do	....	b 72
180	....do	1904	16 S.	3 E.	NW. ¼, 28	1½	135	+ 7	135	....do	....	b 11
181	....do	1904	16 S.	3 E.	NW. ¼, 28	2	130	+ 4	130	....do	S. I	b 30
182	P. C. Petersen	1905	16 S.	3 E.	NE. ¼, 27	(?)	79	−76	78±	....do	....	....
183	W. Larsen	1895	16 S.	4 E.	NW. ¼, 18	....	51	−49	50±	....do	D. S.	a 200
184	P. Kesko	1887	16 S.	3 E.	NE. ¼, 17	1½	170±	+ 4.3	1.70±	....do	D. S.	a 200
185	J. Seely	1901	16 S.	3 E.	NW. ¼, 9	4	344	+13.7	344	....do	D. S. I.	b 157
186	....do	1901	16 S.	3 E.	NW. ¼, 9	3	650	+12.5	344	....do	S. I	b 51
187	J. A. Nyberg	1902	16 S.	3 E.	SE. ¼, 5	2½	125	+ 7.5	125	....do	D. S. I.	b 36
188	H. C. Jensen	1898	16 S.	3 E.	NW. ¼, 1	....	27	−14	27	Sand	S	a 100
189	C. Crawford	1875	16 S.	4 E.	SE. ¼, 6	....	39	−35	37±	Gravel	D. S.	a 150
190	R. Taylor	1889	15 S.	3 E.	SW. ¼, 33	1½	125±	+ 2.75	125	....do	D. S.	b ¾
191	J. Beck	1890	15 S.	3 E.	NW. ¼, 33	1¼	128	+ 2.1	128	....do	S	b 1
192	C. R. Allred	1902	15 S.	3 E.	NW. ¼, 35	4	170	+ 4.5	170	....	S. I	b 16
193	P. D. Allred	1903	15 S.	3 E.	NW. ¼, 35	2	23±	−12	10	Gravel and sand	D. S. I.	b 15
194	S. T. Beck	1893	15 S.	4 E.	SE. ¼, 31	2	200±	+ 7	150	....	D. S. I.	b 16
195	....do	1893	15 S.	4 E.	SE. ¼, 31	2	200±	+ 9	150	Gravel and sand	D. S. I.	b 24
196	D. Jensen	1898	15 S.	4 E.	SE. ¼, 29	....	73	−68	72±	Gravel	D. S.	a 75
197	C. Christensen	1899	15 S.	4 E.	SE. ¼, 29	....	62	−57	60±	....	D. S.	a 150
198	D. H. Sorenson	1887	15 S.	4 E.	SE. ¼, 29	....	14	−11	12±	Gravel	D. S.	a 125
199	F. E. Allred	1865	15 S.	4 E.	SE. ¼, 29	....	17	−12	15±	....	....	....
200	D. Zabriskie	1902	15 S.	4 E.	SE. ¼, 29	....	28	−24	27±	Gravel	D	a 75
201	A. C. Strate	1900	15 S.	4 E.	SE. ¼, 30	....	31	−27	29	....do	D	a 75
202	M. L. Irving	1899	15 S.	3 E.	NW. ¼, 25	....	12	−11	11	Clay	D	a 75
203	Gunnison Bros.' well	1905	15 S.	3 E.	SW. ¼, 26	....	25	−12	12	Sand	I	....
204	Chester School	1894	15 S.	3 E.	SE. ¼, 27	2	40	−10±	40	Gravel and sand	D	....
205	B. Conrad	1887	15 S.	3 E.	SE. ¼, 2.8	1¼	70	− 3	45	Gravel	S	a 100
206	E. Christensen	1898	15 S.	3 E.	NW. ¼, 30	....	34	−31	32±	Clay	D. S.	....
207	A. R. Lamb	1895	15 S.	3 E.	NW. ¼, 30	....	66	−64.5	65	Gravel	D. S.	a 75
208	S. Anderson	1894	15 S.	3 E.	SW. ¼, 8	1½	75	+ 2.4	....	....	S. I	b 1

a Gallons per day. b Gallons per minute. c Plugged.

Data concerning wells in Sanpete and Sevier valleys, Utah—Continued.

No.	Name.	Year sunk.	Location.			Diameter.	Depth.	Height of water.	Depth to main water bed.	Nature of main water bed.	Use.	Yield.
			Township.	Range.	Section.							
						Inches.	*Feet.*	*Feet.*	*Feet.*			
209	S. Anderson	1894	15 S.	3 E.	SW. ¼, 8.	1¼	118	+ 2.7	118	Gravel	S. I.	
210	M. Sorenson	1890	15 S.	3 E.	SW. ¼, 9.	1½	18±	− 4.5	15	Sand	D. S.	*a* 200
211	M. Madsen	1879	15 S.	3 E.	SE. ¼, 9		11	− 6	5	Gravel	D. S.	*a* 75
212	S. Jensen	1901	15 S.	3 E.	SE. ¼, 9		15	−11	10	Sand	D. S.	*a* 100
213	E. Bertram	1895	15 S.	3 E.	SW. ¼, 10.		27	−25	26	Gravel	D. S.	*a* 350
214	B. Neilson	1890	15 S.	3 E.	NW. ¼, 10		35	−29	32	....do	S	*a* 50
215	M. Draper	1890	15 S.	3 E.	NE. ¼, 9.		65	−51	51	Sandstone	D. S.	*a* 150
216	J. Syme	1880	15 S.	3 E.	SE. ¼, 9		58	−53	57		D. S.	*a* 100
217	H. Christensen	1885	15 S.	3 E.	SE. ¼, 9		38	−33	38	Limestone	D. S.	*a* 150
218	S. R. Neilson	1895	15 S.	3 E.	NE. ¼, 10.		26	−21	21	Gravel	D. S.	*a* 100
219	P. P. Draper	1895	15 S.	3 E.	SE. ¼, 10		10	− 6	9	Gravel and sand	D. S.	*a* 300
220	A. Johannsen	1899	15 S.	4 E.	SW. ¼, 7.	1¼	100	− 6±	100	Gravel		
221	....do	1891	15 S.	4 E.	SW. ¼, 7.		13	− 8	11	....do		
222	C. F. Peel	1889	15 S.	4 E.	SW. ¼, 8.	1½	50	+ 3.2	45	....do	D. S. I.	*b* 9
223	J. Bigler	1885	15 S.	4 E.	NE. ¼, 10.		13	− 6	10	....do	D. S.	*a* 100
224	J. Burton	1896	15 S.	4 E.	SW. ¼, 2.		52	−49	52	....do	D. S.	*a* 100
225	A. Paulson	1899	15 S.	4 E.	NW. ¼, 2		84	−74	82	....do	D. S.	*a* 75
226	S. Jacobson	1875	15 S.	4 E	NW. ¼, 3.		39	−30	35	....do	D. S.	*a* 75
227	E. Davidson	1903	15 S.	4 E	NW. ¼, 4.		20	−16	17	....do	D. S.	*a* 250
228	N. P. Neilson	1895	15 S.	4 E	NW. ¼, 5.	2	133		130	Clay and rock	I.	*b* 1
229	Jos. Seely	1900	15 S.	4 E	SE. ¼, 5.		18.5	−17	17	Gravel	D. S.	*a* 350
230	L. Johnson	1899	15 S.	3 E	SW. ¼, 4	1½	55±	+ 3.5	52	....do	S	*b* 1½
231	W. Draper	1904	15 S.	3 E	SW. ¼, 6	1½	80	−10±	80	Sand and gravel	D. S.	*a* 150
232	J. C. Stark	1895	15 S.	3 E	NW. ¼, 6.		47	−46	46	Gravel	D. S.	*a* 60
233	A. Mirley	1900	14 S.	3 E	SW. ¼, 33	1½	56	+ .8	56	....do		*b* ½
234	D. C. Madson	1875	14 S.	4 E	SW. ¼, 31		45	−36	42	....do	D. S.	*a* 200
235	P. Jacobson	1904	14 S.	3 E	NE. ¼, 29		13	−10	10	Sand	D. S.	*a* 200
236	S. E. Jensen	1894	14 S.	4 F	NE. ¼, 27		11	−10	10	Sand and gravel	D. S.	*a* 50
237	....do	1896	14 S.	4 E	SE. ¼, 22.	2	132	+	132	Sandstone	D. S.	*b* 3
238	Zabriskie & Co.	1903	14 S.	4 E	NE. ¼, 21	(?)	(?)		160			
239	G. W. Ivory	1894	14 S.	3 E	NW. ¼, 19.	1¼	205	+ 3	60	Sand		
240	C. C. Livingston	1904	14 S.	3 E	SW. ¼, 19		30	−27	27	Gravel	D. S.	*a* 100
241	J. C. Livingston	1895	14 S.	2 E	SE. ¼, 14.		54	−53	53	....do		
242	J. Otteson	1895	14 S.	2 F	SE. ¼, 13.		17	−16	11	....do	S	*a* 150
243	H. C. Hansen	1893	14 S.	2 E	NE. ¼, 13	(?)	71	+ 4.2	60	Gravel and sand	S	*b* 1−
244	J. M. Allred	1905	14 S.	4 E	NE. ¼, 11		10	− 5	8	Clay	D	*a* 50
245	C. Otteson	1896	14 S.	3 E	NE. ¼, 7		27	−23	22	Gravel	D. I.	*a* 150
246	A. Anderson	1885	14 S.	3 E	SW. ¼, 6		42	−38	30	....do	D	*a* 75
247	O. C. Anderson	1903	14 S.	3 E	SW. ¼, 5		53	−46.5	53	....do	D. S.	*a* 150
248	L. Neilson	1873	14 S.	2 E	SW. ¼, 6.		15	−12	10	....do	D. S	*a* 125
249	H. C. Hansen	1890	14 S.	2 E	SE. ¼, 1		11	− 6	6	....do	D	*a* 75
250	A. Frandsen	1905	14 S.	3 E	NE. ¼, 1.		26	−24	25±	....do	D	*a* 75

251	E. Draper	1897	14 S	2 E	NE. $\frac{1}{4}$, 1	....	23	−12	20	....do	D. S	a 75
252	Fountain Green town well	1886	14 S	3 E	NW. $\frac{1}{4}$, 6	2	285	− 3	200	....do	....	....
253	J. H. Robertson	1896	14 S	3 E	NW. $\frac{1}{4}$, 6	....	31	−29	29±	....do	D	a 200
254	C. Bristol	1901	14 S	3 E	NW. $\frac{1}{4}$, 6	....	42	−40	40±	....do	D	a 75
255	C. Larsen	1900	13 S	3 E	SW. $\frac{1}{4}$, 31	....	39	−36	36±	....do	D	a 75
256	A. Christensen	1892	14 S	4 E	SE. $\frac{1}{4}$, 2	....	32	−22	28	....do	D. S	a 50
257	A. B. Cox	1875	14 S	4 E	SW $\frac{1}{4}$, 2	....	29	−20	27	....do	D	a 100
258	H. Jones	1897	13 S	4 E	SE. $\frac{1}{4}$, 35	....	72	−67	71	....do	D. S	a 150
259	O. Miner	1903	13 S	5 E	SE. $\frac{1}{4}$, 31	....	12	− 9	10	....	D	a 50
260	C. Hartley	1903	13 S	4 E	SE. $\frac{1}{4}$, 24	....	41	−36	40	Gravel	D	a 50
261	N. Hansen	1900	13 S	4 E	SW. $\frac{1}{4}$, 24	....	35	−30	33	....do	D. S	a 200
262	R. Graham	1889	13 S	4 E	SE. $\frac{1}{4}$, 11	....	36	−27	33	....do	D. S	a 350
263	O. J. Terry	1903	13 S	4 E	NE. $\frac{1}{4}$, 12	....	35	−33	33	Clay	D. S	a 75
264	W. E. Mowers	1898	13 S	4 E	NW. $\frac{1}{4}$, 1	....	59	−50	58	Gravel and clay	D. S	a 75

a Gallons per day.

b Gallons per minute.

Data concerning springs in Sanpete and Sevier valleys, Utah.

No.	Name.	Location.			Temperature.	Use.a	Yield.	Occurrence.
		T.	R.	Sec.				
					°F.			
1	Sevier	25 S.	4 W.	NE. ¼, 32	59	D. S.	b100±	In gravel near bed of creek.
2	N. Johnson	25 S.	3 W.	NE. ¼, 27	80	S. I.	b180	In igneous rock along fault.
2a		25 S.	3 W.	SW. ¼, 23	50	D. I.	b22 and 11	Near creek bed.
3	Joseph	25 S.	4 W.	NE. ¼, 23	135 to 146	I.	b30±	In calcareous tufa at base of igneous ridge.
4	T. J. Jukes	25 S.	3 W.	NE. ¼, 15		D. S. I.	b17	
5	T. Cooper	25 S.	3 W.	SE. ¼, 10	144 to 156	D. I.	b60±	4, 5, and 5a occur along fault at base of Sevier Plateau.
5a		25 S.	3 W.	NW. ¼, 11	154	I.		
6	Jericho	25 S.	3 W.	SW. ¼, 6	65	I.	b670	Marsh near river bed.
7	Collar and Neilson	24 S.	3 W.	NW. ¼, 25	58.5	D. S. I.	b25±	Igneous débris at base of foothills.
8	Red Butte	24 S.	2 W.	SW. ¼, 29	49	D. S. I.	b18±	In bed of canyon at base of mountains.
9	L. Thomson	24 S.	3 W.	SW. ¼, 24	56	D. S. I.	b35±	Igneous débris at base of foothills.
10		24 S.	4 W.	SW. ¼, 14	52	S	b6±	Several feeble seep springs.
10a	Rock	24 S.	4 W.	11		S		On lava and tuff-capped hills northwest of Elsinore.
11		23 S.	2 W.	NE. ¼, and SE. ¼, 33.	52 to 61	S. I.	b4,500±	Group of springs along west base of ridge of igneous rock.
11a		24 S.	2 W.	NW. ¼, and SW. ¼, 4.				
12	Glenwood	23 S.	2 W.	SW. ¼, 36	57	D. S. I.	b3,285	In débris at west base of lava-capped ridge.
13	Parcel Creek	23 S.	2 W.	SW. ¼, 25	60	D. S. I.	b60±	In igneous débris at base of ridge.
14	Indian	23 S.	2 W.	NW. ¼, 25	60	D. S. I.	b75±	Do.
15	Cove	23 S.	2 W.	SW. ¼, 27	60	S. I.	c9	Group of springs at northeast end of ridge of igneous rock.
16	Richfield	23 S.	3 W.	NE. ¼, 26	74	D. S. I.	b1,440	Joints in limestone along fault.
17	Herrins Hole	23 S.	2 W.	NW. ¼, 23	63	S. I.	b450±	In igneous débris at base of ridge.
18	Wall	23 S.	2 W.	SE. ¼, 15	52	D. S. I.	b40±	In clay in Cove Creek bottoms.
19	Black Knoll	23 S.	2 W.	NW. ¼, 12	55	D. S. I.	c12.5	In débris at base of igneous knoll.
20	Rocky Ford	22 S.	2 W.	SE. ¼, 36		I.	c35	Seep springs in bed of Sevier River.
21	Christianson	22 S.	2 W.	SW. ¼, 1	59	S	b15±	Débris on hillside.
22	Oak	22 S.	2 W.	NE. ¼, 1	61	S	b3±	Do.
22a	Mud	21 S.	1 W.	NW. ¼, 20	53	S	b12	
23	Salt	21 S.	1 E.	SW. ¼, 17	72		b1½±	In débris at base of Jurassin hills.
24	Redmond	21 S.	1 W.	NE. ¼ & SE. ¼, 11. NW. ¼ & SW. ¼, 12.	60; 70	D. S. I.	c13.5	Group of springs in Redmond Lake.
25		20 S.	2 E.	SE. ¼, 32	58	S. I.	b15±	Débris near creek.
26	Mayfield	19 S.	2 E.	SE. ¼, 33	50	I.	c.14±	In clay near creek bed.
27	Carlsons	19 S.	2 E.	SW. ¼, 20	52	S. I.	b90±	In meadow.
28	Spannard	19 S.	2 E.	SE. ¼, 20	51.5	D. S. I.	c1.75	Along fault (?) at base of monocline.
29	Robbins	19 S.	1 E.	NW. ¼, 23	57	I.	b60±	In meadow.
30		19 S.	2 E.	SW. ¼, 18	54	I.	c.15±	Near creek bed.
31		19 S.	2 E.	SW. ¼, 18	49 to 50	I.	c5	Do.
32	Tiltons	19 S.	2 E.	SW. ¼, 18	53 to 58	D. S. I.	b180±	Do.
33	Gunnison	19 S.	1 E.	SE. ¼, 18	61	S	b8±	Do.

34	Nine Mile Cold	19 S.	2 E.	NW. ¼, 9	53.5	S. I	c 2.2	Along fault (?) at base of monocline.
35	Nine Mile Warm	19 S.	2 E.	SE. ¼, 4	72	D. S. I	c 2	Along fault (?) at base of monocline.
36	Pettyville	19 S.	2 E.	SE. ¼, 5	57		c 0.25±	In meadow.
37	Olsen	19 S.	2 E.	NW. ¼, 5	56		c 0.2±	Near river bed.
38	Morrison Tunnel	18 S.	2 E.	SE. ¼, 35	61	I	c 5.64	In coal mine along fault (?) at base of monocline.
39	Barithwaite	18 S.	2 E.	SE. ¼, 34	55, 56		c 1.2	Along fault (?)
40	Funk's	18 S.	2 E.	SW. ¼, 33	50 to 53		c 1±	Near creek bed.
41	A. D. Squires	18 S.	2 E.	NE. ¼, 26	53	I	b 7	In sandstone along fault (?).
42	Do.	18 S.	2 E.	SE. ¼, 23	56, 59.5	I	b 20	Do.
43	Saleratus	18 S.	2 E.	SW. ¼, 22	54	I	c 1¼±	In débris along fault (?).
44	Lowry	18 S.	2 E.	NE. ¼, 23	62	I	b 20	Do.
45	Livingston Warm	18 S.	2 E.	SW. ¼, 13	73	D. S. I	c 0.61	Do.
46	Livingston Sulphur	18 S.	2 E.	SW. ¼, 13	57 to 62		b 10±	Do.
47	City	18 S.	3 E.	NW. ¼, 17	57	D	b 8	In débris at side of canyon.
48	Manti	18 S.	3 E.	NW. ¼, 17	59	D	b 20±	Do.
49	Manti Silver	18 S.	3 E.	NW. ¼, 17	65	D	b 12	Do.
50	Temple	18 S.	3 E.	NE. ¼, 7	57	D. I	b 60±	In débris at base of hill.
51	Shumway	17 S.	3 E.	NE. ¼, 18		S. I	b 65±	In meadow.
52		16 S.	2 E.	NE. ¼, 12	54	D. S. I	b 6	In débris at base of mountain along fault (?).
53	Beck	15 S.	4 E.	SE. ¼, 31	51.5	D. S. I	b 44	In meadow.
54	Larsen	15 S.	4 E.	SW. ¼, 32	51, 53	S. I	b 20±	Do.
55	Ellis	15 S.	4 E.	NW. ¼, 32	57	D. S. I	b 30	Near creek bed.
56	Harris	15 S.	4 E.	SW. ¼, 29	50	D. S. I	b 27	In soil in Spring City.
57		15 S.	4 E.	SW. ¼, 29	50	D. S. I	b 4±	In street in Spring City.
58	Ford	15 S.	4 E.	SW. ¼, 29	52	D. S. I	b 16	In soil in Spring City.
59	Separator	15 S.	4 E.	SE. ¼, 30	52	D	b 4±	In meadow.
60	Freeman	15 S.	4 E.	NW. ¼, 36	48.5	S. I	b 20	In foothills.
61	Jensen	15 S.	5 E.	SE. ¼, 30	43	D. S.	b ½	In débris at base of mountain.
62		15 S.	2 E.	N. ½, 24	57 to 60	D. S. I	c 0.35	In débris at base of mountain along fault.
63		15 S.	2 E.	SW. ¼, 13	58	D. S. I	c 0.08	In débris along fault.
64	Brewer's	15 S.	2 E.	NW. ¼, 13	62	D. S. I	c 0.45	In débris at base of mountain along fault.
65	Proctor	15 S.	4 E.	SE. ¼, 12	51	D. S	2.3	In débris at base of mountain.
66	A. Zabriskie	15 S.	4 E.	NW. ¼, 11	51	D. S. I	20±	In sand in valley.
67	Sugar Factory	15 S.	4 E.	SW. ¼, 7	50 to 52	D. S. I	c 3.8	In meadow.
68	Silver Creek	16 S.	3 E.	NE. ¼, 5	51	S. I	c 0.6	Along creek bed in meadow.
69	Duck	15 S.	3 E.	SW. ¼, 4	54.5	S. I	c 2.4	Group of small springs at base of hill.
70	Freedom	15 S.	2 E.	NE. ¼, 2	51.5	D. S. I	c 0.97	In débris at base of mountain along fault.
71	L. Christensen	14 S.	2 E.	SE. ¼, 26	51.5	D. S. I	c 0.15	Do.
72	Seely	15 S.	4 E.	SE. ¼, 5	48.5	S. I	b 20±	In meadow.
73	Erickson & Seely	15 S.	4 E.	SE. ¼, 5	56	S. I	b 270	Do.
73a	Snake	15 S.	4 E.	NE. ¼, 8	49 to 55	S. I	c 0.9	Do.
74	Seely and Madsen tunnel	15 S.	4 E.	NW. ¼, 3	51	D. S. I	c 0.21	Small seep, increased by tunneling.
75	Christian	15 S.	5 E.	SW. ¼, 6	45.5	D. S. I	b 40	In débris on mountain side.
76	McArthur	14 S.	4 E.	SW. ¼, 28	54	S. I	c 0.61	Seep near Sanpitch Creek.
77	Zabriskie South	14 S.	4 E.	NW. ¼, 27	51	D. S. I	c 0.27	In meadow.
78	Zabriskie Small	14 S.	4 E.	NW. ¼, 27	55	I	b 1.5	Do.
79	Crystal	14 S.	4 E.	NW. ¼, 27	49	D. S. I	c 0.2	Do.
80	Jensen	14 S.	4 E.	SE. ¼, 22	48.5	S. I	c 0.15±	Do.

a D.=Domestic; S.=Stock; I.=Irrigation. b Gallons per minute. c Second-feet.

Data concerning springs in Sanpete and Sevier valleys, Utah—Continued.

No.	Name.	Location.			Temperature.	Use.[a]	Yield.	Occurrence.
		T.	R.	Sec.				
					°*F.*			
81	Hardy	14 S.	3 E.	NE. ¼, 23	55.5	D. I.	[b] 12	
82	Birch Creek	14 S.	2 E.	NE. ¼, 23	51	D. S. I.	[c] 1.53	In débris at base of mountain, along fault.
83	Miner	14 S.	4 E.	SW. ¼, 11	48	S. I	[c] 0.25±	In meadow.
84	Alfred	13 S.	4 E.	NE. ¼, 11	50	S. I	[c] 12.1 (84 and 85)	Do.
85	Spring Creek	13 S.	4 E.	NW. ¼, 12	46	S. I		
86	Fountain Green	14 S.	2 E.	NW. ¼, 2	53	D. S. I.	[c] 12.37	In débris at base of mountain, along fault.
87		13 S.	4 E.	SE. ¼, 11	53	D. I.	[b] 20±	Near creek.
88	Spring Branch	13 S.	4 E.	SE. ¼, 2	47.5	D. S. I.	[c] 0.6	Do.

[a] D.=Domestic; S.=Stock; I.=Irrigation.
[b] Gallons per minute.
[c] Second-feet.

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