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GROUND WATER IN PAVANT VALLEY
Millard County, Utah

By P. E. DENNIS, G. B. MAXEY, and H. E. THOMAS

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GROUND WATER IN PAVANT VALLEY
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ABSTRACT

Pavant Valley lies in the eastern part of Millard County in central Utah, about 150 miles south of Salt Lake City. It is an arm of the Sevier Desert Basin, separated from the main basin by a series of low volcanic hills. It comprises about 300 square miles of flat bottomlands and alluvial slopes which rise gradually eastward to the base of the Pavant Range.

The population of the valley is less than 4,000, of which nearly one-half live in Fillmore, and the rest in the towns of Holden, Meadow and Kanosh and on farms throughout the valley. The climate is arid to semi-arid, and practically all the flow of the streams which rise in the mountain area is used for irrigation. In the lower western part of the valley, particularly in the small agricultural district of Flowell, large flowing wells provide water for irrigation.

Ground water occurs principally in the unconsolidated sediments of the valley fill, dominantly gravel, sand, silt and clay of Recent and Pleistocene age. It occupies the interstices between the individual grains of these sediments which are essentially a ground-water reservoir bounded by the consolidated rocks that form the Pavant and Canyon Ranges and underlie the valley fill at depths of a few feet to 500 feet or more. The reservoir may leak considerably along its western margin which is formed of basalt cones and lava fields. The valley fill consists of relatively long, thin and narrow lenses of poorly-assorted alluvial fan gravel, sand, silt and clay, interbedded with the more widespread and continuous deposits of well-assorted lacustrine clay,

marl, silt and near-shore sand and gravel. The sand and gravel beds of this fill constitute the ground-water aquifers. They are the conduits through which the water is transmitted underground from intake areas along the upper parts of the alluvial slopes to wells and points of natural discharge westward and northwestward. These beds of coarser materials are also the chief reservoirs in which the water is stored until discharged. They are more extensive and are composed of coarser, more permeable material near the mountain front; they become progressively less permeable westward. Lacustrine clay beds form the chief confining beds. Thus the valley fill contains a number of interconnected aquifers extending westward in finger-like projections from their more thoroughly interconnected portions which outcrop at the surface near the mountain front.

As water moves westward in the aquifers beneath the clay beds, it is confined by them, giving rise to the artesian conditions which produce flowing wells at the lowest elevations in the valley. The principal artesian aquifers are penetrated at depths of 200 to 400 feet in most wells. Ordinarily, at least three or four and sometimes six or more water-bearing beds are encountered. On the other hand, the water in aquifers on the higher parts of the alluvial slopes and in the shallowest aquifer over much of the lower valley is essentially unconfined and its upper surface constitutes a water table.

The area underlain by the ground-water reservoir in Pavant Valley has been divided into six districts based upon differences of geologic and hydrologic conditions and economic development. They have been designated the Fillmore, Flowell, Meadow, Hatton, Kanosh and Pavant districts. Of these the Flowell district is by far the most important economically. Of a total of about 17,000 acre-feet yielded annually by wells in Pavant Valley, more than 75% is discharged by the 100-odd artesian irrigation wells of the Flowell district.

The total discharge from the Pavant Valley ground-water reservoir amounts to more than 40,000 acre-feet in a normal year, of which less than half is discharged from wells, and only about a third is put to economic use. About 5,000 acre-feet a year may be wasted from uncontrolled or leaking wells, and about 25,000 acre-feet annually is lost by spring discharge, evapo-transpiration, and underground movement toward the Sevier desert.

Fuller utilization of the water resources of the valley may be achieved by artificial recharge to increase the inflow to the ground-water reservoir, making more water available to wells; by eliminating waste from existing wells, repairing those that leak around the casing; and by drilling wells to pump water from shallow zones above the artesian aquifers and thus reducing the natural discharge from the valley. Increasing the number of artesian wells in developed areas, or pumping existing wells, also would doubtless result in some increase in the total water put to economic use, but would necessarily reduce the quantity which is obtained by artesian flow from existing wells.

INTRODUCTION

GEOGRAPHY

Pavant Valley lies in the eastern part of Millard County in central Utah, about 150 miles south of Salt Lake City. (Fig. 1). Bordered on the east and south by the Pavant Range, and on the north by the Canyon Range, it is actually an arm of the Sevier Desert Basin, but is separated from the main basin by a series of low volcanic hills, north of which the valley plain is continuous with the broad plain of the Sevier Desert to the west. Pavant Valley comprises flat bottomlands and an alluvial slope which rises gradually to the base of the Pavant Range; it is about 30 miles long in a north-south direction, and 8 to 12 miles wide. In the north central part of the valley several hills project above the level of the valley plain.

The population of Pavant Valley is less than 4000, of which 1785 (1940 census) live in Fillmore, the largest town and county seat. U. S. Highway No. 91, connecting Salt Lake and southern California, traverses the eastern part of the valley and passes through Fillmore and the smaller farming settlements of Holden, Meadow, and Kanosh, each of which is located upon the alluvial fan of one of the small streams that drain the west slope of the Pavant Range. Water from these streams is utilized for irrigation in the vicinities of each of the settlements. In the lower western part of the valley, particularly in the small agricultural district of Flowell, large flowing wells provide water for irrigation.

PURPOSE AND SCOPE OF INVESTIGATION

The users of wells for irrigation in Pavant Valley, particularly in the Flowell district, have long been cognizant of their utter dependency upon ground water for livelihood, and were among the first in the State to make an organized effort to conserve supplies by prevention of waste. Since passage of the State ground-water law in 1935, the State Engineer has not approved applications for new wells in the

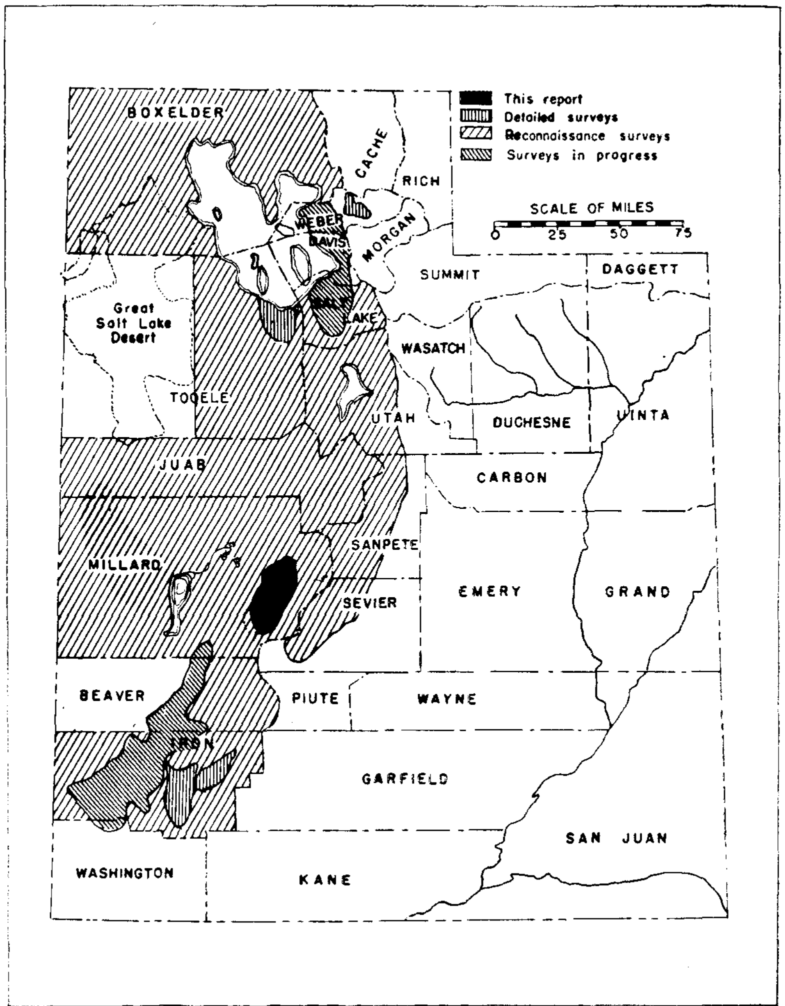

Figure 1.—Index map showing location of Pavant Valley and other areas covered by ground-water investigations.

areas of most concentrated development, and has deferred adjudication of existing water rights until adequate data concerning the ground-water resources become available. The investigation of ground-water resources in Pavant Valley was suggested by the State Engineer and constitutes one of a series that are being made in the important ground-water basins of Utah by the Federal Geological Survey in cooperation with the State Engineer. The investigation was under the general supervision of Oscar E. Meinzer, geologist in charge of the ground-water division of the Federal Geological Survey. H. E. Thomas, in charge of ground-water investigations in Utah, returned from military service overseas in time to assist in the completion of the manuscript, and edited the report.

Records of water levels and artesian pressures in Pavant Valley have been obtained since 1935 as part of a State-wide program, and have been published annually in Water-Supply Papers of the Geological Survey.[1] Intensive field work was begun in November 1942 and continued until October 1945. This field work included a study of the geology in relation to the occurrence of ground water, involving reconnaissance mapping of the adjacent mountains and detailed mapping of the unconsolidated deposits of the valley; periodic measurements of water level and flows of practically all wells in the valley, and maintenance of six water-level and pressure recorders; measurement of leakage from wells; location of wells, springs, marshes, and other features of importance to hydrologic study; establishment, under the direction of M. T. Wilson, District Engineer at Salt Lake City, of a gaging station on Chalk Creek, and periodic measurements of flow of other streams in the area.

The Pavant ground-water district has not been studied in the same detail as the remainder of the valley. Geologic study did not encompass the Canyon Range and the northern limits of the Valley, and only a limited amount of hydrologic data has been obtained there. War activities prevented a more comprehensive examination of that area, which is of minor importance compared to the southern part of the valley. The present report therefore offers only tentative conclusions concerning the ground water in the area north of Fillmore and Flowell.

Two reports have been published covering special phases of the ground-water investigation of Pavant Valley.

[1] Meinzer, O. E., Wenzel, L. K., and others, Water levels and artesian pressures in observation wells in the United States; U. S. Geol. Survey Water Supply Papers as follows: 777, pp. 241-242; 817, pp. 409-413; 840, pp. 551-555; 845, pp. 622-625; 886, pp. 845-848; 910, pp. 112-115; 940, pp. 74-75; 948, pp. 79-82, 990, pp. 80-94; 1020, in press.

Underground leakage from artesian wells in the Flowell area is described in detail in a paper by Livingston and Maxey,[2] and suggestions were made for the repair of leaking wells. The geology of most of Pavant Valley is discussed in a paper by Maxey.[3] Detailed data included in these publications are not repeated in the present report.

Published and unpublished data from several previous investigations have been studied by the writers, and have permitted a more comprehensive analysis than would otherwise have been possible. Pavant Valley was included in a study of the ground water in Juab, Millard and Iron Counties, by O. E. Meinzer in 1908,[4] prior to the drilling of the first flowing well in the Valley. Water levels in selected wells were measured by the Utah State Agricultural College during the years 1923 to 1935. Since 1935 the State Engineer has obtained a large amount of data concerning wells in the area, including locations and elevations of bench marks established at the wells, descriptive data provided by well owners on underground water claims, and numerous measurements of artesian pressures and flows during the years 1937 to 1941.

ACKNOWLEDGMENTS

The writers appreciate the cooperation of the residents of the area, particularly the owners of flowing wells who supplied valuable information and permitted closing or regulation of their wells during special tests. Messrs. H. H. Hatton and O. E. Brower, both residents of Flowell, assisted materially by making periodic measurements of water levels in selected wells. Messrs. Frank Paxton, Ras Rasmussen, Leo Stott and Frank Sweeting permitted installation of recording gages upon their wells, and sacrificed the use of those wells while the gages were in operation. Appreciation is also expressed to the personnel of the Soil Conservation Service and the Forest Service in the area who supplied pertinent information and other assistance during the investigation.

PRECIPITATION

The monthly and annual precipitation at Fillmore is tabulated below and shown in figure 2. According to this

[2] Livingston, Penn, and Maxey, G. B. Underground leakage from artesian wells in the Flowell area near Fillmore, Ntah: Utah State Engr. Technical Publication No. 1, 37 pp., 1944.

[3] Maxey, G. B., Geology of part of the Pavant Range, Utah: Am. Jour. Sci. vol. 224, pp. 324-356, 1946.

[4] Meinzer, O. E., Ground water in Juab, Millard, and Iron Counties, Utah: U. S. Geol. Survey Water Supply Papar 277, pp. 86-94, 1911.

record the annual precipitation during 54 years of record has averaged 14.29 inches, and has ranged from 21.28 inches in 1906 to 6.72 inches in 1934. The spring months are normally wettest, and nearly half the annual precipitation commonly occurs during the four months from February to May. The following four months, from June to September, ordinarily receive less than one-quarter of the annual rainfall.

The curve showing cumulative departure from normal precipitation at Fillmore, also in figure 2, indicates periods of greater than normal rainfall by a rising trend, and periods of deficient rainfall by a downward trend. Thus there is a pronounced downward trend during the years 1900 to 1904 and again from 1926 to 1935, reflecting the two most pronounced drought periods in the half century of record. Pronounced upward trends result from the heavy precipitation in 1905 to 1909 and in 1920 to 1924, inclusive. In other years the precipitation has been more nearly normal, and the general trend of the graph is approximately horizontal. The cumulative departure from normal precipitation is of significance to studies of ground water, because the rising trends indicate natural conditions favorable for increased recharge and the declining trends represent periods when low recharge and hence decreased storage may be expected, if natural conditions are the controlling factor.

The weather station at Fillmore is the only one in Pavant Valley, and no record has ever been made of the precipitation in the adjacent mountains. According to residents of the area, the western part of Pavant Valley is more arid than the eastern slopes that border the Pavant Range, and it may be inferred from observations in adjacent regions that in the mountains to the east there is a progressive increase in precipitation with increasing altitude. Records of the Great Basin Experiment Station at stations east of Sanpete Valley (about 50 miles northeast of Pavant Valley) show that in three years the precipitation at 7400 feet altitude was 166%, at 8700 feet altitude 208%, and at 9850 feet altitude 232% of the amount falling at Manti, which is located at the edge of Sanpete Valley at 5575 feet altitude. By analogy, some areas of the Pavant Range may receive two to three times the precipitation recorded at Fillmore.

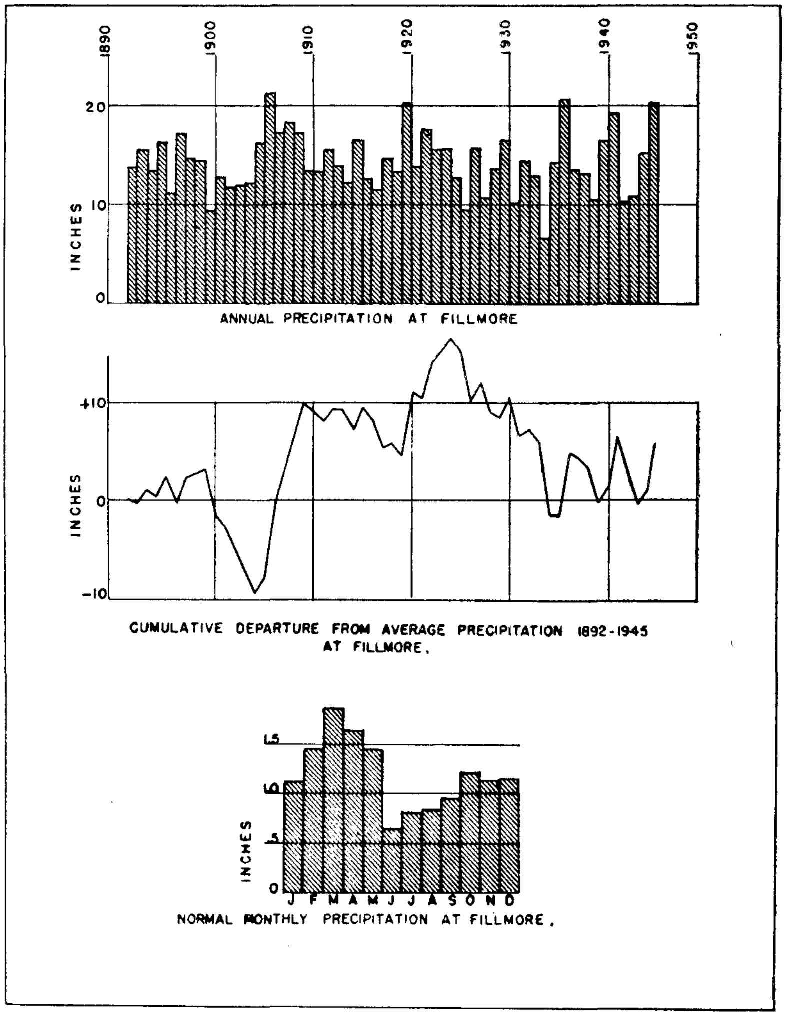

Fig.2- Graphs showing precipitation at Fillmore, Utah.

PRECIPITATION AT FILLMORE, UTAH
(by U. S. Weather Bureau)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1892	.85	2.10	2.25	2.11	2.03	.82	.29	.47	.06	1.07	.53	1.20	13.78
1893	.81	1.51	2.89	2.09	1.53	.00	.48	1.71	1.21	.46	1.11	1.79	15.59
1894	.70	.56	1.04	2.43	.64	2.04	.34	1.19	1.94	.41	.31	1.77	13.37
1895	1.93	2.15	2.06	1.23	1.51	.80	.56	.97	1.66	.93	1.46	1.10	16.36
1896	.75	.16	.94	1.47	1.06	.01	2.36	1.69	.85	.37	1.17	.33	11.16
1897	2.15	2.17	2.89	1.26	.03	.26	.19	.31	1.50	3.58	1.15	1.55	17.04
1898	.15	1.20	3.07	.59	4.44	.92	.99	.60	T	.60	1.27	.76	14.59
1899	.50	1.40	5.00	1.45	.85	.96	.01	.28	.00	1.94	1.06	1.03	14.48
1900	1.25	.45	.15	3.18	.35	.60	T	.14	1.58	.93	.66	.03	9.32
1901	.35	2.00	1.54	2.35	1.92	.57	.41	.90	.00	.72	.15	1.97	12.88
1902	1.03	1.03	2.59	.36	.90	.09	.49	.16	1.51	.58	2.70	.46	11.90
1903	1.44	1.26	1.19	2.66	2.27	.04	.27	.38	1.00	1.06	.00	.40	11.97
1904	1.89	1.90	2.16	.26	2.81	.25	.07	1.13	.10	.62	.00	.95	12.14
1905	.90	2.48	2.66	1.53	2.45	T	.53	.62	2.81	.51	1.13	.54	16.16
1906	.72	1.16	3.88	4.38	2.18	.40	1.27	1.20	2.38	.15	2.93	.63	21.28
1907	1.67	1.96	1.34	.55	3.20	.88	.97	1.23	1.24	1.99	.25	1.86	17.14
1908	1.01	.87	.36	.50	4.15	1.13	1.46	1.38	2.02	3.31	.69	1.55	18.43
1909	1.12	2.66	1.23	2.91	.35	.02	.79	3.02	1.81	.51	1.61	1.22	17.25
1910	1.02	.92	.88	.38	.58	.10	1.84	.68	2.46	1.84	.87	1.70	13.27
1911	1.77	1.14	1.11	.32	.88	1.15	1.76	.11	1.63	1.39	.90	.98	13.14
1912	.15	1.47	3.08	1.71	1.32	.20	.70	.27	1.47	3.54	1.40	.38	15.69
1913	.35	1.48	1.11	.83	.49	.75	1.04	1.50	1.14	1.62	1.67	1.99	13.97
1914	1.87	.92	.36	3.54	.25	1.29	1.24	.16	.42	1.43	.46	.09	12.03
1915	1.43	2.70	1.06	2.09	1.73	.84	1.09	.11	1.54	.35	2.06	1.53	16.53
1916	2.33	1.12	2.31	.25	.77	T	1.80	.19	.01	2.09	.32	1.29	12.48

PRECIPITATION AT FILLMORE, UTAH
(by U. S. Weather Bureau)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1917	1.14	.82	1.20	2.40	2.40	.05	.58	1.11	.32	.00	1.21	.29	11.52
1918	1.97	1.64	1.76	1.32	.85	.34	1.06	.09	1.83	.98	1.68	1.10	14.62
1919	T	2.09	1.53	.67	.45	.00	.11	1.17	1.88	.85	3.30	1.05	13.10
1920	1.21	.92	2.89	4.03	2.14	.28	.28	.26	.32	3.94	.63	3.27	20.17
1921	1.31	.99	1.15	3.61	1.62	.07	1.26	.93	.27	1.27	.44	1.02	13.94
1922	1.69	2.34	.85	3.74	1.59	.03	.43	.77	.06	1.93	1.36	2.86	17.65
1923	.86	1.12	2.01	2.50	1.47	.12	2.28	.34	.62	2.09	.25	1.78	15.44
1924	1.57	.58	3.43	1.62	1.44	.00	.17	.20	.79	1.44	1.30	3.05	15.59
1925	.68	1.11	1.17	.86	.29	2.41	.75	.77	.49	1.65	1.43	.49	12.70
1926	.82	1.50	.68	.86	1.41	.03	.68	.73	.44	.14	.61	1.60	9.50
1927	1.55	1.41	3.29	1.54	1.03	.76	.97	.64	.56	2.10	1.09	.95	15.89
1928	.51	1.88	1.85	.71	.70	.62	.43	.32	.21	.99	2.14	.50	10.86
1929	.77	2.15	2.63	2.16	.29	.63	1.40	.70	1.55	.96	.22	.29	13.75
1930	2.12	1.37	1.23	.18	2.74	.42	1.73	3.21	1.16	.75	1.39	.19	16.49
1931	.10	1.77	1.48	1.09	.54	.77	.05	.17	.30	.30	2.24	1.21	10.02
1932	2.36	1.23	2.11	1.36	.34	.88	1.54	1.70	.02	.97	.31	1.59	14.41
1933	1.34	.83	1.61	1.87	4.04	.11	.57	.80	.02	.40	.16	1.18	12.93
1934	1.00	1.46	.32	.86	T	.17	.23	.11	.05	.24	1.58	.70	6.72
1935	.49	2.45	2.27	2.06	3.74	T	.55	.68	.33	.10	.32	1.25	14.24
1936	1.01	2.07	1.95	.67	.29	4.48	4.14	.96	.03	1.73	.86	2.53	20.72
1937	3.11	.90	1.76	.33	1.45	.21	.78	.20	1.72	.62	.26	2.09	13.43
1938	.59	1.32	2.33	1.28	2.47	.31	.37	.83	.18	.79	1.71	.90	13.08
1939	1.02	1.38	.85	.46	1.48	.89	.10	.44	2.32	1.24	.10	.31	10.59
1940	2.52	2.51	3.48	1.33	T	.46	.21	.02	1.84	.73	1.86	1.48	16.44
1941	1.48	1.03	2.13	2.10	1.87	.75	.28	.77	1.15	4.34	1.30	2.06	19.26

PRECIPITATION AT FILLMORE, UTAH
(by U. S. Weather Bureau)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1942	.28	.79	1.26	1.79	.80	.08	.42	1.08	.20	.28	2.65	.67	10.30
1943	.52	1.05	1.10	.19	.81	1.87	.86	1.30	.31	1.58	.63	.72	10.94
1944	2.75	1.62	2.23	3.46	.81	1.33	.04	.15	.10	.59	1.83	.37	15.28
1945	.74	1.60	3.89	2.12	1.50	2.51	.14	3.62	1.22	.49	1.28	1.12	20.23
54-year Average	1.18	1.46	1.86	1.62	1.43	.64	.80	.82	.94	1.21	1.11	1.18	14.29

PHYSIOGRAPHY

TOPOGRAPHY

Pavant Valley lies along the eastern edge of the Great Basin section of the Basin and Range physiographic province, and the Pavant Range is included in the Utah High Plateaus of the Colorado Plateau province.[5] Pavant Valley forms the extreme southeast part of the broad basin known as the Sevier Desert, which is divided at its southern end into two lobes by the Beaver or Cricket Mountains, the western lobe being occupied by Sevier Lake. The eastern lobe is approximately 30 miles wide, and slopes gently northward from low volcanic hills which form its southern boundary. This lobe is divided into two broad valleys by basalt flows which form a broad, low ridge extending from Kanosh Butte to Pavant Butte, about 25 miles north. The eastern of these two valleys is known as Pavant Valley (Fig. 3).

Pavant Valley is bounded on the east and south by the rugged Pavant Range, which has a north-south trend in its northern part, and veers southwestward below the latitude of Fillmore. The irregular crest of this range is commonly above 9,000 feet elevation, and several peaks east of Meadow and Fillmore are more than 10,000 feet above sea level, or 4,500 feet above the bajada at the west base of the range. The north boundary of the Valley is formed by the Canyon Range, which is separated from the north tip of the Pavant Range by the low pass traversed by U. S. Highway No. 91. The Canyon Range extends northward for about 30 miles to form part of the east border of the Sevier Desert. West of this range Pavant Valley merges into the Sevier Desert plain, and the boundary between the two is set arbitrarily along the westward-sloping bajada that flanks the south portion of the Canyon Range. The basalt flows and cinder cones which form the west margin of Pavant Valley rise generally 50 to 400 feet above the valley plain; the most conspicuous feature, Pavant Butte, is 800 feet high, and on the other hand, many flows barely protrude above the general plain.

Pavant Valley includes many striking features which have resulted from the incursion of the ancient Lake Bonneville. Beaches, bars, and spits are common in all parts of the valley which lie below the highest shoreline of this lake

[5] Fenneman, N. M., Physiography of the United States: McGraw-Hill Book Co., New York, pp. 294-299, 348-367, Plate I, 1931.

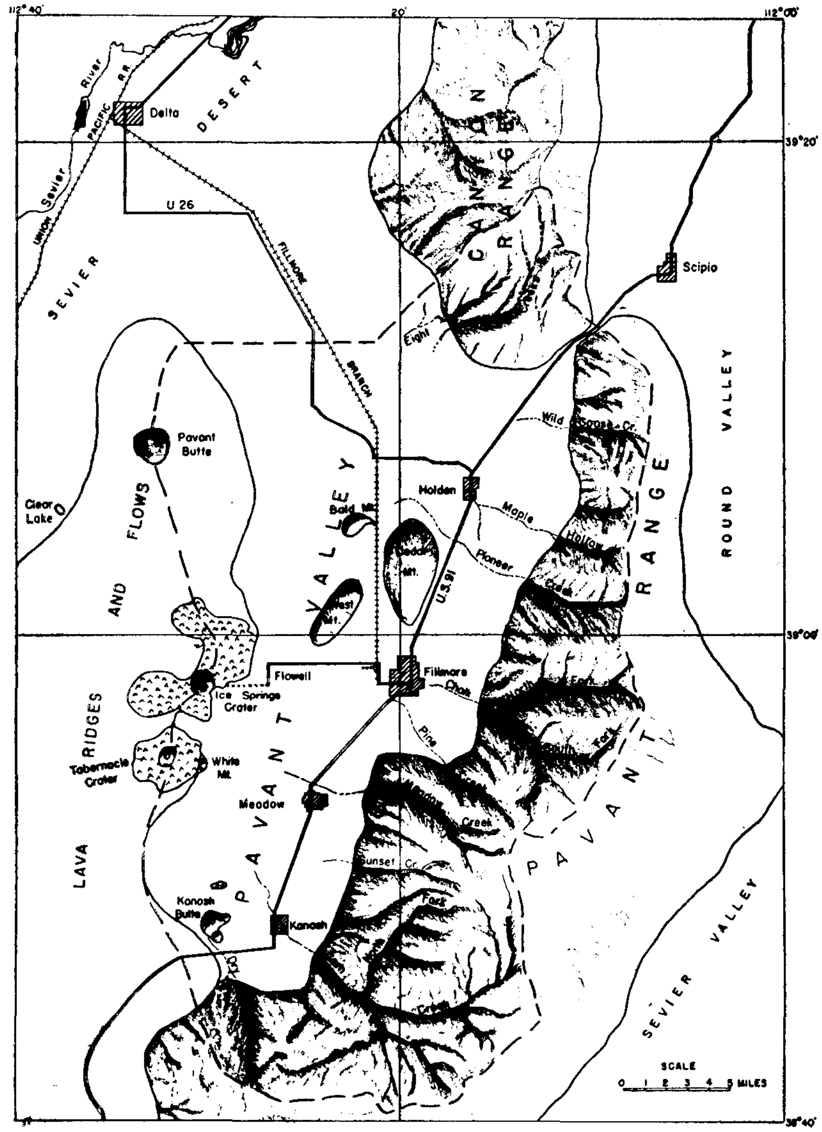

Fig. 3- Sketch map of Pavant Valley and vicinity.

at 5130 feet elevation. This highest shoreline is particularly well marked throughout most of the valley, and forms the dividing line between the gently-sloping lake plain below, and the alluvial apron or bajada above. The slope of this bajada, averaging about 12° near the base of the Pavant Range, decreases rapidly westward until the bajada merges with the lake plain. Low hills known as Cedar Mountain, West Mountain, and Bald Mountain project above the Pavant Valley plain north and northwest of Fillmore.

DRAINAGE

Pavant Valley lies in the Southwestern Bolson groundwater province[6] which in Utah is coextensive with the Basin and Range physiographic province. Like the majority of the intermontane valleys in that province, Pavant Valley is a closed basin, or bolson, with no surface drainage outlet; but it is exceptional in that the lava fields forming its western border are so recent, so porous, and in so arid a region that practically no drainage pattern has yet been developed. No topographic maps are available to certify the closure at the north end of the basin, but the great bajadas extending westward from the Canyon Range, and the large sand dunes which have accumulated on them athwart the north end of the Pavant Valley would seem to preclude any surface drainage into the Sevier Desert.

Pavant Valley and its tributary drainage area comprise approximately 750 square miles, of which 375 square miles is occupied by the valley itself. Of the remaining mountainous and hilly area, the portion of the Pavant Range which is drained by streams tributary to Pavant Valley totals 270 square miles. These streams of the Pavant Range are the only source of water used for irrigation on the upper parts of the alluvial slopes, in the vicinity of the principal settlements of the valley, and they also furnish supplemental water for irrigation farther west. These streams are also of paramount importance to the groundwater reservoir, as they are the principal source of water for recharge of the artesian aquifers (p. 52). The most important streams entering the valley from the Pavant Range are listed below, in order from north to south. Their

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[6] Meinzer, O. E., Occurrence of ground water in the United States: U. S. Geol. Survey Water Supply Paper 489, p. 314, plate XXXI, 1923.

aggregate drainage area is about 70% of the Pavant Mountain area which is tributary to Pavant Valley.

Stream	Drainage basin (sq. mi.)	Stream	Drainage basin (sq. mi.)
Wild Goose Creek	7	Meadow Creek	10
Maple Hallow	6	Walker Creek	4
Pioneer Creek	15	Sunset Creek	6
Chalk Creek	48	Cottonwood Creek	4
Pine Creek	6	Corn Creek	83

All the water of these streams is diverted and used for irrigation throughout the growing season, except possibly during periods of peak flow of the spring freshet, when the natural channels carry the excess. Much of the winter discharge likewise goes down the natural channels, and disappears by seepage within a few miles of the mouths of the canyons. Peak discharges may fill the channels of Chalk Creek and Corn Creek as far as the "sinks" in the western part of the valley, where the water is distributed over considerable areas, and disappears rapidly by seepage into porous strata rather than by evaporation.

A very small amount of surface water enters Pavant Valley from sources other than the Pavant Range. East and West Eightmile Creeks which drain the south end of the Canyon Range, have a combined basin of more than 30 square miles, and are used for irrigation of lands near Holden and at Greenwood farther west.

The Central Utah Irrigation Canal, distributing water from the Sevier Bridge Reservoir, is the chief source of irrigation water in the McCornick area of North Pavant Valley. It also brings some supplemental water into the northwest corner of the Flowell area. Because water from this canal is spread only on the lowland areas, it plays no part in recharge of the artesian reservoir although some of it may add to the shallow, unconfined water in those areas.

Records of Stream Discharge

Prior to 1944 the records of discharge of streams in Pavant Valley are limited to a few miscellaneous current-meter measurements of the larger streams, chiefly in the years 1938 to 1943. Since March 1944 a gaging station has been operated on Chalk Creek by the Geological Survey,[7]

[7] Surface water supply of the United States, 1944, Part 10, Great Basin: U. S. Geol. Survey Water Supply Paper 1010, p. 135, 1945.

and periodic measurements have been made of the discharge of Corn and Meadow Creeks. Hydrographs for these streams are presented in figure 4. The available data on these streams and minor streams entering Pavant Valley are summarized in the following paragraphs:

Chalk Creek. The annual runoff in two years when precipitation at Fillmore was 25% above normal has averaged 35,700 acre-feet, of which about 75% occurred during the annual freshet in April, May, and June. The highest recorded discharge was 429 second-feet on May 15, 1944, and the base flow during the months from September to February inclusive ordinarily ranges between 10 and 15 second-feet. Chalk Creek is by far the largest stream entering Pavant Valley, probably because its drainage basin of 48 square miles includes many of the highest peaks of the Pavant Range. It is used for irrigation of about 5,000 acres in normal years, which may be increased to 6,000 acres in years of maximum runoff. Discharge measurements prior to 1944 are tabulated below.

Discharge of Chalk Creek, in second-feet
(Measurements by Geological Survey except as indicated)

†Apr. 21, 1938	103	Feb. 18 1939	5.6	†April 4, 1940	56.6
†May 6	72.2	†Mar. 13	36.1	†Apr. 29	143
†May 27	175	†May 9	75.1	†May 18 (est.)	220
†June 10	49.8	May 10	82.0	†Feb. 5, 1941	8.0
Sept. 3	13.4	†June 2	34.0	†Mar. 11	8.8
†Sept. 13	7.9	†Nov. 16	7.6	†May 1	76.0
Dec. 10	9.1	†Mar. 5 1940	21.6	†May 21	128

† Measured by State Engineer

Corn Creek. Corn Creek is an appreciably smaller stream than Chalk Creek, although its drainage basin (83 square miles) is about 75% greater. Much of this drainage basin is at comparatively low altitude. On 29 days when both streams have been measured, the discharge of Corn Creek has ranged from 23% to 91% of that of Chalk Creek, and has averaged about 60% of the flow of the larger stream. The flow of the stream is diverted

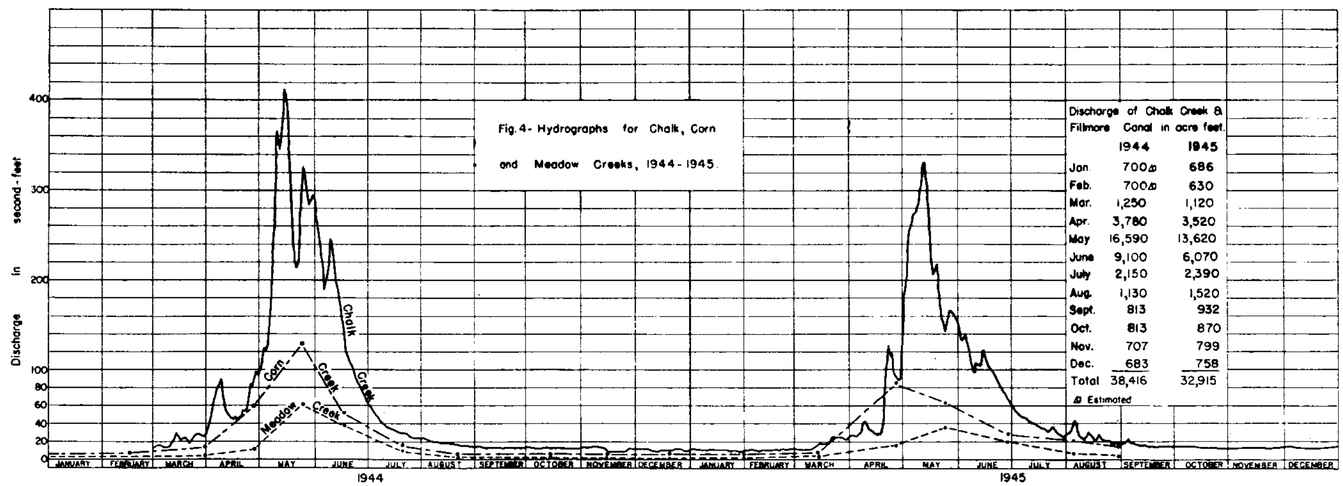


Fig. 4- Hydrographs for Chalk, Corn and Meadow Creeks, 1944-1945.

Discharge of Chalk Creek & Fillmore Canal in acre feet.

	1944	1945
Jan.	700⊿	686
Feb.	700⊿	630
Mar.	1,250	1,120
Apr.	3,780	3,520
May	16,590	13,620
June	9,100	6,070
July	2,150	2,390
Aug.	1,130	1,520
Sept.	813	932
Oct.	813	870
Nov.	707	799
Dec.	683	758
Total	38,416	32,915

⊿ Estimated

for irrigation of 4,000 to 4,500 acres in most years. Discharge measurements of Corn Creek are tabulated below.

Discharge of Corn Creek, in second-feet

(Measured by Utah State Engineer prior to October 1943; since that date by Geological Survey)

Jan. 13, 1938	7.1	Mar. 5 1940	4.9	June 16, 1944	51.1
Mar. 10	6.9	Apr. 4	30.5	July 20	15.6
Apr. 21	91.3	Apr. 29	85.2	Aug. 22	7.1
May 6	46.4	May 18	41.0	Oct. 14	7.9
May 26	63.2	Feb. 5, 1941	7.2	Nov. 14	6.4
June 9	32.1	Mar. 10	7.8	Dec. 19	7.6
Sept. 15	7.2	May 6	51.7	Jan. 31, 1945	7.3
Nev. 10	4.6	May 22	92.1	Mar. 14	8.2
Mar. 30, 1939	25.1	Oct. 31, 1943	6.4	Apr. 26	85.7
May 9	21.6	Dec. 9	6.7	May 24	65.0
June 2	11.8	Feb. 16, 1944	8.2	June 28	28.7
Aug. 14	5.1	Mar. 30	14.2	Aug. 4	21.7
Nov. 16	6.2	Apr. 27	58.9	Aug. 29	14.5
		May 24	129	Oct. 15	13.1

Meadow Creek. The drainage basin of Meadow Creek covers only 10 square miles, but includes several high peaks. Measurements during 1944 and 1945 have shown the discharge to be about 20% to 25% of that of Chalk Creek. The flow, together with that of Walker Creek, irrigates about 1,800 acres in normal years.

Discharge of Meadow Creek, in second-feet

(Measurements by Geological Survey except as indicated)

†Apr. 21, 1938	40	‡May 18, 1940	27.2	Oct. 14, 1944	2.6
†May 6	18	‡May 22	45.2	Nov. 14	2.6
†May 26	75	Oct. 31, 1943	1.5	Dec. 10	2.0
†June 9	20	Dec. 9	1.2	Jan. 31, 1945	1.8
†Sept. 15	.5	Mar. 30, 1944	4.6	Mar. 14	5.0
†Nov. 10	.7	Apr. 27	11.3	Apr. 26	17.6
‡May 9, 1939	14.4	May 24	61.0	May 24	35.8
‡June 2	6.6	June 16	38.5	June 28	20.2
‡Mar. 5, 1940	3.6	July 20	9.9	Aug. 4	7.4
‡Apr. 29	25.3	Aug. 22	3.9	Aug. 29	4.9
				Oct. 15	2.9

† Estimated by State Engineer

‡ Measured by State Engineer

Minor Streams. The smaller streams entering Pavant Valley are intermittent, that is, they are dry at the mouths of their canyons during parts of most years, although there may be flow in portions of their canyons in the mountains. Measurements of Sunset Creek on June 16, 1944, show the rate of seepage as these streams cross the upper portion of their alluvial fans: the flow at the mouth of Sunset Canyon was 11.1 second feet, and 1½ miles farther west, it was 8.9 second-feet, indicating a loss of more than 10% in a flow distance of less than 1¾ miles.

Available data on minor streams are summarized below, based chiefly on information supplied by Mr. George Whornham, the Millard County Agricultural Agent.

Data on Minor Streams in Pavant Valley

Stream	Drainage Basin (sq. mi.)	Estimated Flow (second-feet)		Use	
		Base	Flood Maximum	Irrigated Area (acres)	Location
West Eightmile Creek	12	0	15	200	Greenwood
East Eightmile Creek	16	0	25	300	North Holden
Wild Goose Creek	7	0	5 }		
Maple Hollow	6	0	2 }	650	Holden
Pioneer Creek	15	2	25 }		
Pine Creek	6	1	25	500	Fillmore
Walker Creek	4	0	5	*	
Sunset Creek	6	1	30	300	Hatton
Cottonwood Creek	4	0	5	100	Hatton
Dry Wash	7	0	15	100	West Kanosh

* Part of Meadow Creek system

GEOLOGIC RELATIONS

The geology of a large part of Pavant Valley and the Pavant Range to the east has been described in considerable detail by Maxey.[8]

The areal geology is shown on plate 1, and the stratigraphic and hydrologic characteristics of the geologic formations which crop out in the vicinity of Pavant Valley are summarized in the following tabulation (pp. 26-32.)

The unconsolidated sediments of Recent and Pleistocene age, dominantly gravel, sand, silt, and clay, constitute the valley fill and underlie the floor of Pavant Valley to depths of 500 feet or more. Ground water occupies the voids or interstices between the individual grains of these sediments, and the Pavant Valley ground-water reservoir is essentially

[8] Maxey, G. B., Geology of a part of the Pavant Range, Millard Co., Utah: Am. Jour. Sci., vol. 244, pp. 324-356, 1946.

limited to these unconsolidated sediments. The pre-Pleistocene formations are composed of consolidated rocks such as sandstone, limestone, shale, and quartzite. These rocks form the Pavant and Canyon Ranges, which constitute the east and north rims of the ground-water reservoir, and extend under the floor of Pavant Valley to form the lower limit of that reservoir.

The basalt cones and lava fields which form the west border of Pavant Valley do not form a ground-water barrier or retaining wall of the sort provided by the Pavant and Canyon Ranges along the other margins of the valley. These volcanic materials in part overlie the alluvial and lacustrine beds which are encountered in Pavant Valley, and may well permit loss of ground water from the valley by westward movement. Older lava flows and volcanic materials occur beneath the valley plain and are encountered in wells; these may be highly permeable and may likewise permit discharge of ground water from Pavant Valley. Thus the ground-water reservoir in this valley may well leak considerably along its western margin.

In their relationship to the occurrence of ground water, the geologic formations may be divided into the pre-Quaternary formations, which are generally consolidated and relatively impermeable, and the Quaternary formations, which include many highly permeable zones and constitute the principal source of ground water in Pavant Valley.

WATER IN THE PRE-QUATERNARY ROCKS

The pre-Quaternary formations which make up the Pavant Range yield through springs and seeps the bulk of the stream flow entering Pavant Valley, except when there is runoff from melting snow. In particular, springs rising in the Paleozoic limestones supply most of the base flow of the perennial streams. Some of the largest limestone springs are those which occur in Chalk Creek canyon between Threeforks and Chokecherry Creeks, and at Balsam Camp. There are also large springs in Meadow Creek canyon near the confluence of the two main branches, and in the East Fork of Corn Creek about two miles above its confluence with Second Creek. Springs localized by faults are rather common, but generally have small yields. Examples are the springs in North Canyon, near Black Cedar Hill, and along the thrust fault south of Kanosh.

In Pavant Valley, the pre-Quaternary rocks appear to be of no importance as sources of ground water. Outcrops

ROCKS EXPOSED IN THE VICINITY OF PAVANT VALLEY

(Formations separated by dashed lines are inferred to be contemporaneous in part)

Geologic age: System	Geologic age: Series	Formation and symbol on Plate 1	Thickness (feet)	General character	Principal area of outcrop	Water-bearing properties
Quaternary	Recent	Alluvium (Qal)	Max 25	River silt, sand, gravel, some large boulders, poorly to moderately well assorted	Beds of streams and gullies throughout area.	Sand and gravel highly permeable, finer materials less so.
		Sand dunes (Qd)	Max 50	Wind-blown sand, well assorted	Northwestern part of valley, extending from slopes of Pavant Butte.	Highly permeable.
		Gypsite (Qg)	Max 20	Greenish-gray gypsiferous clay, with beds of granular gypsum up to 7 feet thick in upper part	Spring and playa area south of White Mt.	Moderately permeable.
		Ice Springs craters flow (Qis)	Max 400	Basalt scoria, lapilli, and lava in flows having thickness of 30 feet or more	Ice Springs craters and lava field.	Highly permeable so that precipitation on outcrop is entirely absorbed without runoff.
		Calcareous tufa (Qc)	Max 30	Spring deposits of calcareous tufa	Spring and playa area south of White Mt.	Moderately permeable

ROCKS EXPOSED IN THE VICINITY OF PAVANT VALLEY—(Continued)

(Formations separated by dashed lines are inferred to be contemporaneous in part)

Geologic age		Formation and symbol on Plate 1	Thickness (feet)	General character	Principal area of outcrop	Water-bearing properties
System	Series					
Quaternary (Cont'd)	Pleistocene	Tabernacle flow (Qt)	Max 300	Basalt tuff, lapilli, scoria, and lava in flows having a thickness of 30 feet or more	Tabernacle crater and lava field.	Sufficiently permeable that there is very little runoff from precipitation on outcrops
		Lake Bonneville beds (Qb)	5-40	Clay and marl generally 10 to 15 feet thick over former lake bottom; sand and silt somewhat thicker near shore lines; and gravel and sand forming large embankments and bars along former shorelines.	Throughout Pavant Valley below elevation of 5130′.	Course materials of embankments highly permeable. Fine materials of lake bed slightly permeable.
		Alluvial fan deposits (Qaf)	200-500	Poorly rounded boulders, gravel, sand and silt, poorly assorted and generally unconsolidated in lenticular beds. Finer materials form a poor cementing medium, sometimes reinforced by caliche. Farther west, be- (Continued)	Bajadas 1 to 4 miles wide, bordering Pavant Range along east side of Pavant Valley, and Canyon Range at north end of valley.	Gravel and sand beds highly permeable and constitute the principal source of ground water in Pavant Valley. Silt and clay beds are imper- (Continued)

ROCKS EXPOSED IN THE VICINITY OF PAVANT VALLEY—(Continued)

(Formations separated by dashed lines are inferred to be contemporaneous in part)

Geologic age: System	Geologic age: Series	Formation and symbol on Plate 1	Thickness (feet)	General character	Principal area of outcrop	Water-bearing properties
Quaternary (Cont'd)	Pleistocene			neath Lake Bonneville beds, formation is prevailingly of finer material including much pre-Bonneville lacustrine and alluvial clay.		meable and act as confining layers to the artesian aquifers. These aquifers are commonly composed of gravel near base of mountains, sand farther west.
Tertiary or Quaternary	Pleistocene or Pliocene	Pavant flow (QTp)	1800+	Volcanic tuff and basalt lava in flows of varying thickness. Base not exposed.	Along west border of Pavant Valley from Pavant Butte south as far as Kanosh Butte.	Lavas appear to be porous and permeable, but tuffs may be fine-grained and relatively impermeable.
		Sevier River formation (QTsr)	800+	Fanglomerate composed of sub-angular cobbles, gravel, sand, silt, and clay with calcareous cement, pink to orange-red in color, and poorly assorted. Occasional beds of volcanic ash. Friable argillaceous sandstone. Base not exposed.	Eastern edge of Pavant Valley, in beds of main streams and in hills projecting above the bajada. Also, in Cedar Mt.; south end of Canyon Range.	Generally impermeable; this formation probably constitutes the floor as well as the east and north walls of the ground-water reservoir in Pavant Valley.

ROCKS EXPOSED IN THE VICINITY OF PAVANT VALLEY—(Continued)

(Formations separated by dashed lines are inferred to be contemporaneous in part)

Geologic age: System	Geologic age: Series	Formation and symbol on Plate 1	Thickness (feet)	General character	Principal area of outcrop	Water-bearing properties
Tertiary	Miocene (?)	Rhyolite (Tr)	50+	Light-gray vesicular rhyolite and black vesicular obsidian. Base not exposed.	Small knoll west of Kanosh, known as "White Mountain."	Relatively impermeable, compared to the basaltic volcanics described above.
	Eocene	Wasatch formation (Tw)	2000-4000	Lower part includes 300-foot basal conglomerate of quartzite pebbles with red sandy clay matrix, overlain by beds 5 to 400 feet thick of light sandstone, sandy and algal limestones, and more conglomerate in repeated sequence. Upper part, exposed only on east slope of range, is predominantly yellow, bright pink and red non-resistant shale with some limestone, sandstone, and conglomerate.	Crest and eastern slope of Pavant Range.	Formation includes some moderately permeable sandstone and conglomerate beds, and solution channels in limestone, which because of easterly dip carry water from higher parts of Pavant Range eastward into Sevier and Round Valleys. Produces some springs on Pavant Valley side.

ROCKS EXPOSED IN THE VICINITY OF PAVANT VALLEY—(Continued)

(Formations separated by dashed lines are inferred to be contemporaneous in part)

Geologic age: System	Geologic age: Series	Formation and symbol on Plate 1	Thickness (feet)	General character	Principal area of outcrop	Water-bearing properties
Jurassic and Triassic		Sandstone (Jr) (referable to Navajo sandstone and Chinle formation.)	2000+	Well assorted, light red, fine to medium sandstone, in cross-bedded, massive beds; some thin-bedded sandstone, and purplish red shaly sandstone.	Belt 1 to 5 miles wide along lower western slopes of Pavant Range south of Pioneer canyon.	Some beds are sufficiently porous or fractured to be moderately permeable and give rise to small springs in canyons crossing the outcrop. However, formation is too remote from the valley fill to affect supplies in ground - water reservoir.
Triassic		Shinarump conglomerate (Trs)	80	Light gray to tan medium sandstone with thin layers of pebble conglomerate, forming ridges of thin to massive beds.	Thin, discontinuous belt at base of Pavant Range.	Dense and relatively impervious

ROCKS EXPOSED IN THE VICINITY OF PAVANT VALLEY—(Continued)

(Formations separated by dashed lines are inferred to be contemporaneous in part)

Geologic age: System	Geologic age: Series	Formation and symbol on Plate 1	Thickness (feet)	General character	Principal area of outcrop	Water-bearing properties
Triassic		Moenkopi formation (Tr m)	470+	Light grey, finely crystalline, argillaceous limestone overlain by maroon, sandy, laminated, soft red shale and inter-bedded sandstone.	Discontinuous belt ½ mile wide in lower foothills of western slope Pavant Range.	Generally impermeable. The shales act as barriers to ground-water movement, and give rise to small springs in overlying limestone and sandstone beds.
Permian		Kaibab limestone (Pk)	300+	Grey, fine to medium, crystalline cherty limestone in medium to thin resistant beds. Base not exposed.	Low hills projecting above bajada along base of Pavant Range south of Meadow Creek.	Impermeable except along bedding planes and joints which have been widened by solution.

ROCKS EXPOSED IN THE VICINITY OF PAVANT VALLEY—(Continued)

(Formations separated by dashed lines are inferred to be contemporaneous in part)

Geologic age		Formation and symbol on Plate 1	Thickness (feet)	General character	Principal area of outcrop	Water-bearing properties
System	Series					
Cambrian		Undifferentiated limestone (Cl)	2500+	Grey, compact to crystalline limestone in thin to medium, sometimes massive, beds, with a few thin beds of tan to green shale in lower part.	Belt 0.1 mile to 1 mile wide along higher western slopes of Pavant Range.	Moderately permeable as a result of development of solution channels. Many of the largest springs in the Pavant Range issue from these rocks, and supply most of the base flow of the perennial streams
	Lower Cambrian	Tintic quartzite (Ct)	3000+	Pink to white, fine to coarse meta-quartzite in massive to medium beds, with many layers of pebble conglomerates and with micaceous shales in the upper part. Base not exposed.	Belt 1 to 3 miles wide along higher western slopes of Pavant Range.	Generally impermeable and acts as barrier to ground-water movement in overlying limestone, so that springs emerge near contact.

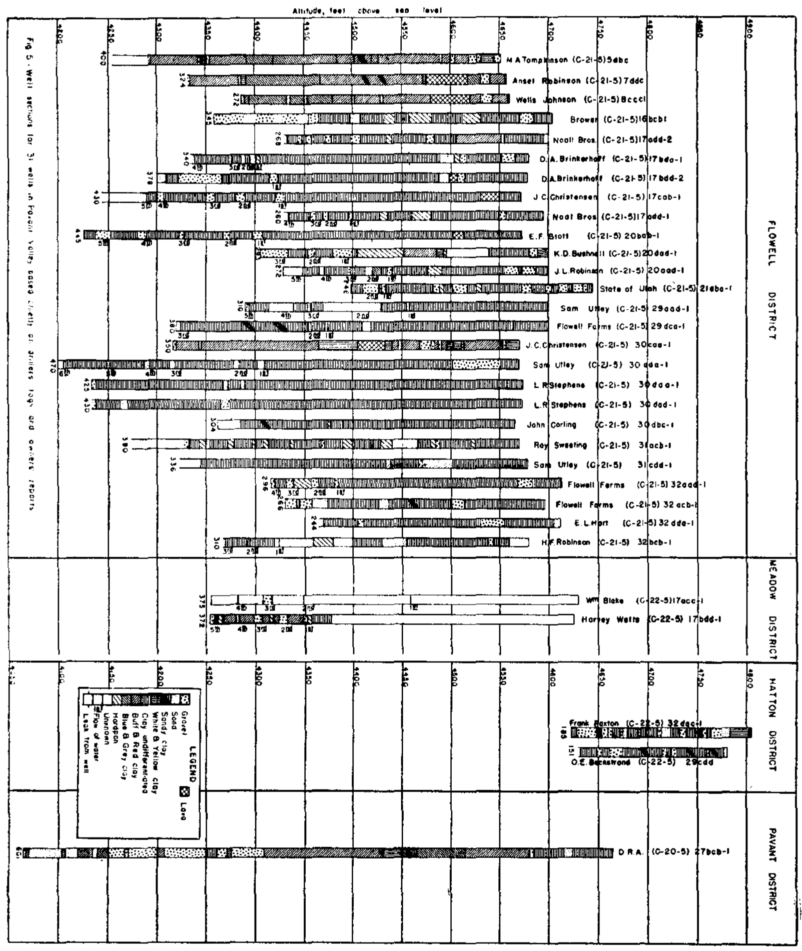
in the foothills and in the central part of the Valley are impervious materials which would yield little or no water. Beneath the floor of the valley, these formations have been encountered in several deep wells drilled in the north central part of the valley near West Mountain and Bald Mountain. The log of one of these wells is reproduced below.

Log of Westwood Oil Co. Well No. (C-20-5)36cbd1 Drilled in 1914

Material	Thickness	Depth
Pleistocene lacustrine and alluvial sediments:		
Unconsolidated material, water level 50 feet below land surface	64	64
Sevier River (?) formation:		
Shale, light brown	34	98
Shale, light gray, fossiliferous	30	128
Shale, blue, paraffin shavings in lower part	52	180
Shale, light blue, water bearing	145	325
Shale, light gray, petroliferous	135	460
Shale, gray, hard, some grit, with sulphur water	38	498
Sandstone, gray, oil-bearing	18	516
Shale, fossiliferous	14	530
Shale, light gray, with salt water	60	590
Shale, blue, with salt water	25	615
Shale, gray, fossiliferous, with salt water	59	672
Shale, gray, petroliferous	46	718
Shale, blue	22	740
Shale, gray	22	762
Shale, blue, probably fossiliferous	32	794
Shale, gray	36	830
Shale, blue, fossiliferous	36	865
Sandstone, dense	28	893
Unknown	37	930
Shale, blue	140	1,070
Shale, brown, gray and blue, petroliferous	130	1,200

Another well drilled unsuccessfully for oil in sec. 15, T. 20 S., R. 5 W., was 1800 feet deep, and is reported to have penetrated quartzite for much of this distance. The deepest well now extant in the Valley, No. (C-20-5)27bcb1,[9]

[9] The well number indicates the location of the well with reference to land subdivision, according to a system adopted by the State engineer and described in his Twentieth Biennial Report, page 87, 1936. Briefly, the State is divided into four quadrants by the Salt Lake base and meridian, and, according to the well-numbering system, these quadrants are designated by capital letters, thus: A for the northeast quadrant, representing townships north, ranges east; B for the northwest quadrant; C, southwest; and D, southeast. In the well number, the designation of the township is inclosed in parentheses, and includes one of these letters, a figure showing township, and a figure showing range. Thus, in the number of the well here cited, the portion within parentheses indicates that the well is in T.20S, R.5W. The number following the parenthesis designates the section, and the lower-case letters following the section number give the location of the well within the section, the first letter indicating the quarter section (the letters a, b, c, d, representing respectively the northeast, northwest, southwest, and southeast quarters, as before) and succeeding letters showing location within the quarter section down to a 10-acre tract. Thus, well (C-20-5)27bcb1 represents well 1 in the NW¼ SW¼ NW¼ sec. 27, T.20S., R.5W.



Altitude, feet above sea level
FLOWELL DISTRICT
MEADOW DISTRICT
HATTON DISTRICT
PAVANT DISTRICT
LEGEND

is reported by the driller to have penetrated shale, clay, and sandstone below 560 feet depth, which may be part of the Sevier River formation. The logs of this well and of others in Pavant Valley are shown graphically on figure 5.

WATER IN THE QUATERNARY ROCKS

The valley fill consists of relatively long, thin and narrow lenses of poorly-assorted alluvial fan gravel, sand, silt and clay, interbedded with the more widespread and continuous deposits of well-assorted lacustrine clay, marl, silt and near-shore sand and gravel. The sand and gravel beds of this fill constitute the ground-water aquifers. They are the conduits through which the water is transmitted underground from intake areas along the upper parts of the alluvial slopes to wells and points of natural discharge westward and northwestward. These beds of coarser materials are also the chief reservoirs in which the water is stored until discharged, although a small part of the water stored in the silts and clays may become available to the aquifers by slow percolation into them during periods of large discharge. The aquifers are more extensive and are composed of coarser, more permeable material near the mountain front; they become progressively less permeable westward. The lacustrine clay beds which form the chief confining beds vary in lateral extent, for they were deposited in periods of restricted or expanded lake areas, but none of them extends as far mountainward as the shoreline of the Bonneville stage of Lake Bonneville. Thus the valley fill contains a number of more or less interconnected aquifers extending westward in finger-like projections from their more thoroughly interconnected portions which crop out at the surface near the mountain front. Practically all of the water obtained from wells in Pavant Valley comes from these aquifers. This study is therefore concerned primarily with where and how much water gets into these aquifers, where and at what rate it moves through them, and where and in what quantities it is discharged from them.

The Quaternary volcanic rocks which border Pavant Valley on the west are highly permeable, and absorb readily most of the water that falls on them as precipitation. However, they do not contribute any appreciable ground-water supplies to Pavant Valley. Instead, the aquifers of the valley fill may discharge into porous volcanic materials where the two come in contact. Thus these lavas and associated rocks constitute one means by which ground water is discharged from the ground-water reservoir.

The character of the materials that form the ground-water reservoir is determined chiefly by examination of drillers' logs and other data obtained during construction of wells. Many of these records are inaccurate, because the wells were completed long before the logs were prepared. Efforts to correlate the water-bearing horizons encountered in adjacent wells were unsuccessful, partly because of errors in these records, and no doubt also because the gravel and sand of the aquifers were deposited in discontinuous, irregular, and lenticular beds, as is typical of alluvial deposition. However, several general conclusions may be drawn concerning the character of the valley fill, based on study of the logs shown graphically on figure 5, and of sediments encountered in shallow test holes.

The Lake Bonneville beds immediately beneath the surface at a large number of wells form a layer of white marl rather uniformly 9 to 17 feet thick, thinning rapidly east of the Provo shore line, (the shoreline formed at the Provo stage of Lake Bonneville). This marl includes a thin layer of basalt and lapilli which may correspond to the eruption of Tabernacle Crater, prior to the Provo stage. The marl is generally underlain by a bed of gravel and sand 1 to 15 feet thick. Ground water occurs in this gravel generally under water-table conditions. The shallow gravel, or in its absence, the white marl, rests upon red or yellow clay as much as 45 feet thick, which is probably a playa and flood plain deposit, at least around the outer margins of the valley, but which may represent the earlier deposits of Lake Bonneville ("yellow clay" of Gilbert) in the lowest part of the valley.

In some wells in the western part of the valley and within 2 miles of the Ice Springs Craters flow, lava is reported at depths of 40 to 80 feet. For many other wells in this same general area and farther east, "hardpan" or gravel was reported at this horizon, averaging about 60 feet beneath the surface. This coarser detritus may correlate with the lava reported in the westernmost wells. Shallow ground water occurs in this gravel horizon under sufficient pressure to rise approximately to the level of the water table in the gravel beneath the white marl.

The shallowest artesian aquifer occurs at a depth of about 140 feet in the easternmost wells, but apparently lenses out to westward, for it is not encountered in wells in the western part of the developed area.

The principal artesian aquifers are penetrated at depths of 200 to 400 feet in most wells. Ordinarily at least three or four and sometimes six or more water-bearing beds are encountered in this zone.

Most of these conditions are indicated in the profile of the central part of Pavant Valley presented as Figure 6. This section is based on the logs of the wells indicated, supplemented by interpretation of available geologic and hydrologic data for zones which have not been penetrated by wells. Thus the buried hill of Sevier River formation is postulated as an extension of the south end of West Mountain, and the discontinuity of beds in the eastern part of the section is based on the hydrologic characteristics of wells in that area.

The beds which constitute the aquifers have gentle westward and northwestward dips and the confining beds dip even more gently in the same direction. As water moves westward in the aquifers beneath the clay beds, it is confined by them giving rise to the artesian conditions which produce flowing wells at lower elevations in the valley. On the other hand the water in aquifers on the higher parts of the alluvial slopes and in the shallowest aquifer over much of the lower valley is essentially unconfined and its upper surface constitutes a water table.

GROUND-WATER DISTRICTS

Detailed study shows that the Pavant Valley ground-water reservoir is not a single homogeneous unit, but that it includes several subdivisions in which the hydrologic characteristics may vary considerably from those of adjacent subdivisions. These subdivisions or ground-water districts are delimited on the basis of geologic or hydrologic conditions in large part, although economic development may also be an important factor. For convenience in subsequent discussions these ground-water districts are defined in the following paragraphs, and their boundaries are shown on plate 1. The basis for subdivision will appear in the discussions of ground-water occurrence and movement which follow.

The Fillmore district includes the upper part of the Chalk Creek alluvial fan, plus the smaller North Canyon and Pine Creek fans which are adjacent to the north and south, and comprises essentially the recharge area for the Flowell ground-water district farther west. The Fillmore

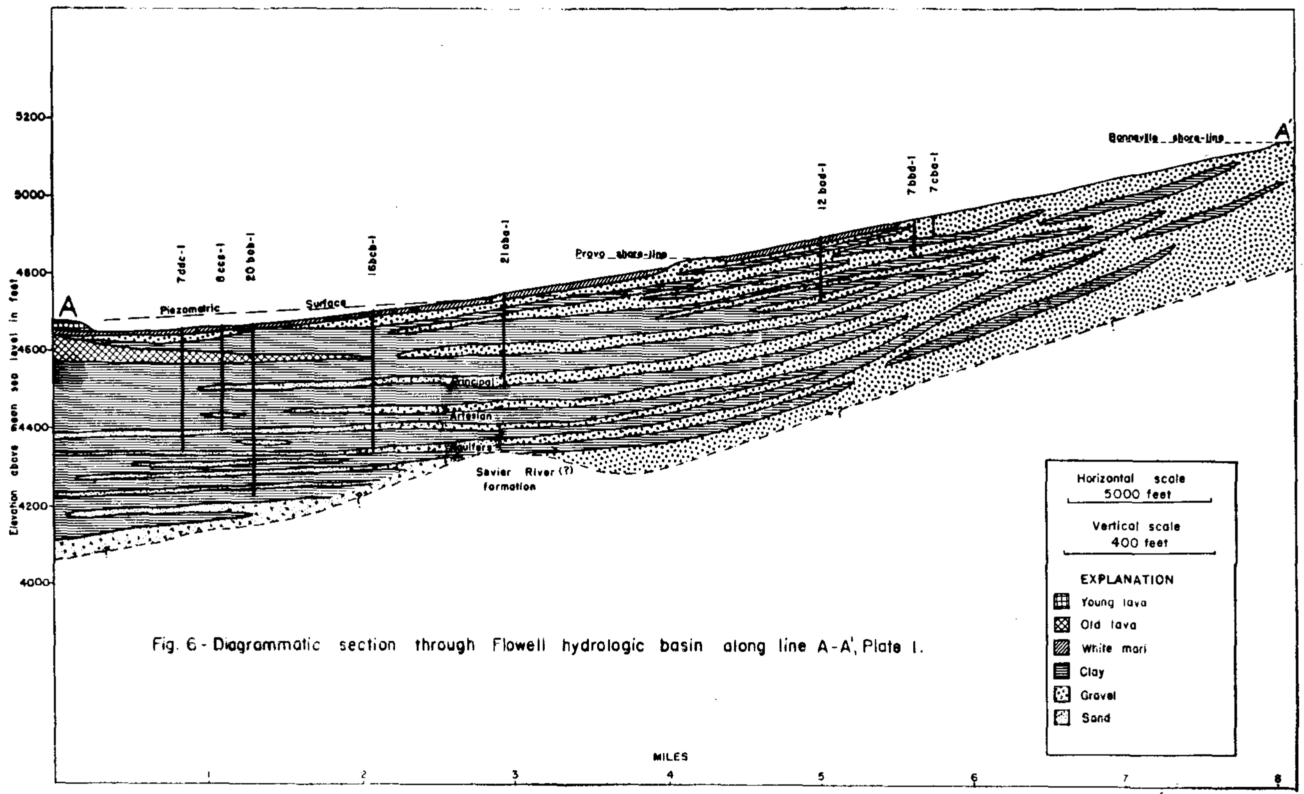


Fig. 6 - Diagrammatic section through Flowell hydrologic basin along line A-A', Plate I.

district is bordered on the east by the base of the Pavant Range; on the south by the divide between Pine and Meadow Creeks; on the west by the Provo shore line; and on the north by Cedar Mountain and West Mountain.

The Flowell district occupies the lake plain west of the Chalk Creek alluvial fan and includes the principal area of artesian well development in Pavant Valley. It is bordered on the east by the Fillmore district at the Provo shore line, which is considered to be the eastern limit of the lacustrine clays that confine the Flowell water under artesian pressure; on the south by the Meadow district; on the west by the Ice Springs lava field; and on the north by the Pavant District.

The Meadow district is situated on the Meadow Creek alluvial fan, and includes a small area on the lake plain where flowing wells have been obtained. It is bordered on the east by the base of the Pavant Range; on the south by the Hatton district; on the west by the Tabernacle lava field; and on the north by the Flowell district.

The Hatton district occupies the alluvial fan of Sunset Creek, the lower parts of the Corn Creek and Cottonwood Creek fans and the lake plain west of those fans. It includes a small area in the vicinity of Hatton village where unconfined water has been pumped for irrigation and other uses. No artesian wells have been obtained, but numerous springs rise in the western part of the district. The district is bordered on the east by the Pavant Range; on the south by the Kanosh district; on the west by lava fields; and on the north by the Meadow district.

The Kanosh district on the upper part of the Corn Creek alluvial fan has not been prospected for ground water, but is considered to be comparable in water resources to the Fillmore district on the Chalk Creek fan. It is bordered on the east and south by the base of the Pavant Range, on the west by the Kanosh Butte lava field; and on the north by the Hatton district.

The Pavant district embraces the alluvial fans of Pioneer Creek and smaller streams farther north, and the lake plain west of these fans where many small flowing wells have been obtained. It is bordered on the east by the Pavant Range, on the south by Cedar Mountain, West Mountain, and the Flowell district; on the west by the Pavant lava fields; and on the north by the Sevier desert and the Canyon Range.

OCCURRENCE OF GROUND WATER

UNCONFINED WATER

Several wells have been dug or drilled in Pavant Valley to comparatively shallow depths in permeable beds of gravel and sand, in which the water does not rise above the level at which it was first encountered. This water, not confined under pressure, lies in a saturated zone whose upper surface is defined as the water table. The number of wells yielding water from shallow zones is insufficient to define the water table throughout the valley. Indeed, there are only three small isolated areas where any wells are available for determination of the water-table conditions. The conditions in these areas are discussed briefly below.

Fillmore District

Several wells have been dug or drilled in the "Old Field" area about 2½ miles northwest of Fillmore, in which water was encountered 30 to 70 feet beneath the land surface. In three of these, periodic measurements of water level have been made since 1943 which show the conditions of occurrence of ground water in this portion of the Chalk Creek alluvial fan. The water level in the Brunson well, No. (C-21-4)7 bbd1, declined steadily from March 1943 to March 1944, and then rose more than 30 feet by June of that year. From then until March 1945 there was a decline of about 12 feet, and in the spring of 1945 the water level rose 15 feet, to a level 3 feet higher than had been recorded in the spring of 1944. In the Partridge well No. (C-21-4) 7cba1 (which is about 1600 feet south of the Brunson well), the fluctuations of water level are parallel to those in the Brunson well, but the elevation of water surface above sea level is ordinarily about 18 feet higher. In the Hatton well (C-21-4)12bad1, the water surface is ordinarily 50 feet lower in elevation than in the Brunson well which is ¾ mile to the east; seasonal fluctuations of water level are similar but of less amplitude, and the periods of rise and decline ordinarily occur one to two months later. Hydrographs for these wells are included on figure 7.

These records suggest that the aquifers supplying the three wells are imperfectly connected, each well probably being developed in a separate "finger" of the alluvial materials. The continued decline in water levels through the

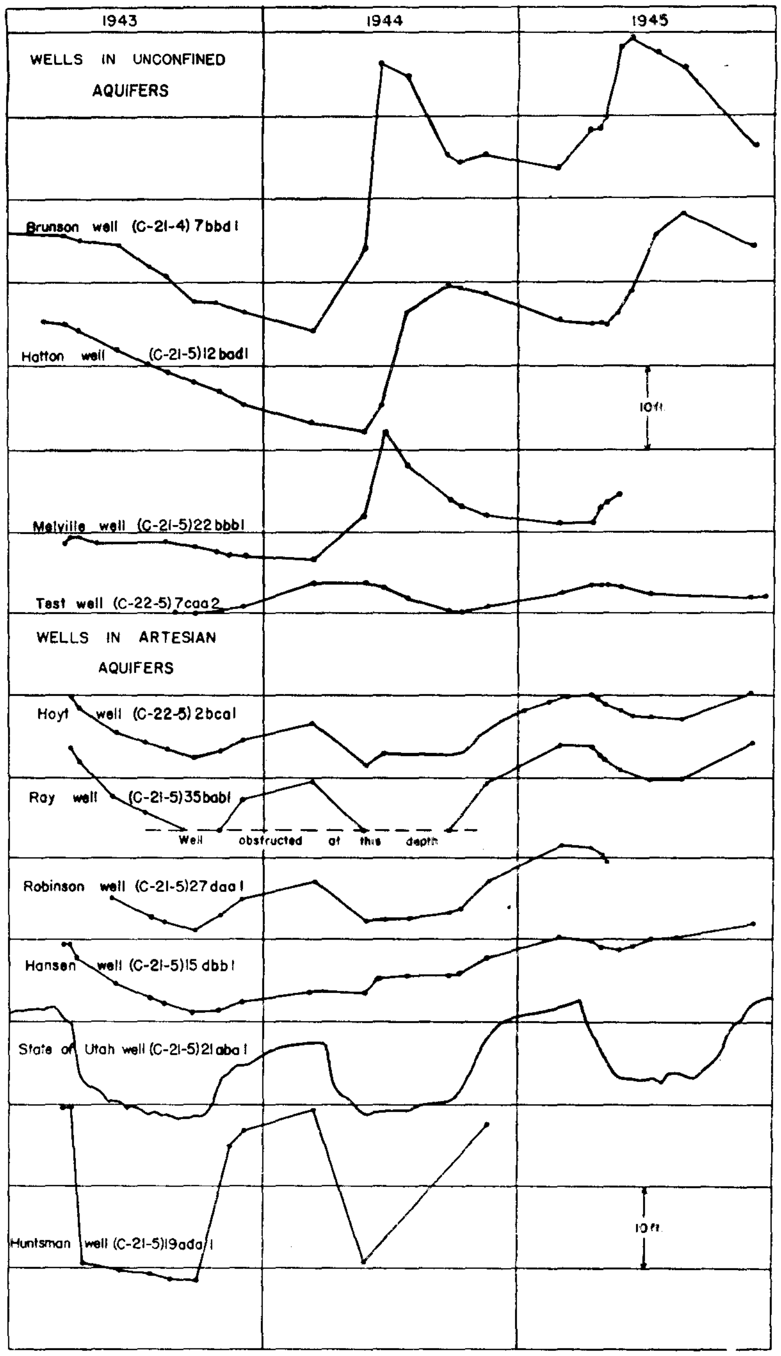


Fig. 7- Hydrographs for 10 wells in Pavant Valley, 1943-1945.

spring and summer of 1943 and the sustained high levels in the fall and winter of 1944-45 suggest that the shallow water in this area forms a series of perched water tables which rise as water enters through the more permeable channels during years and seasons of recharge. Gradually this water percolates into the lower gravels which are more directly connected with the artesian aquifers. The shallow waterbearing zones thus function as temporary storage reservoirs and extend the period of recharge to the main artesian reservoir.

Hatton District

In the area south of Meadow and west of highway U. S. 91 to and including the village of Hatton, about 20 wells have been dug or drilled to the water table, of which four have been pumped for irrigation. Depth to the water table ranges from about 60 feet in the easternmost and southernmost wells to about 8 feet in the wells at the northwest margin of the area.

The elevation of the water table varies considerably from well to well and there are too few wells to define the water table over the area. However, the available data suggest a northwestward slope of the water table similar to that of the piezometric surface of the artesian aquifers of the Meadow area. It appears that the water table in the Hatton area may be continuous with the piezometric surface of the artesian aquifers in the Meadow district.

Flowell and Meadow Districts

In an area which extends westward from Flowell, Meadow and Hatton to the lava fields, the water table is encountered at depths ranging from 1 to 15 feet below the land surface. The total area occupied by this shallow water comprises nearly 20 square miles. Springs occur in several parts of this area, notably along the Meadow Slough which runs northwesterly and northerly through the central part, and in the Warm Spring area farther west. Where the water table is less than 7 feet deep, the surface of the ground is damp throughout the year. Salt grass and other halophytes grow over much of this damp surface.

According to observations in two auger holes and one dug well in this shallow water area (see hydrograph for well (C-22-5)7caa1 on figure 7), water levels are lowest in

September and October, then rise until about the middle of April, when a decline begins which lasts until the following September or October. Water levels remained higher during the summer and fall of 1945, than in like periods of the two preceding years. It is significant that the rise in the water table in this area begins soon after the artesian wells are closed in the fall and continues until shortly after the wells are opened in the spring. Artesian pressures remained high during the summer and fall of 1945 as compared to the same period of the previous year and the water table likewise remained high. It seems probable therefore that a considerable and perhaps a major contribution to the water table in this area comes through the confining beds from the artesian aquifers. The water table may be lowered appreciably in some areas because of losses due to evaporation and transpiration during the summer.

That the water table in this area was formerly higher and that springs were more numerous and their flows larger is indicated by local reports and by comparison of present conditions with those reported by Meinzer in 1908.[10] The general consensus is that the springs west of Meadow began drying up about the time the majority of flowing wells were drilled in the Flowell area — chiefly from 1915 to 1930. During 1943 and 1945, when artesian pressures were higher than they had been since 1929, some of these old springs again flowed. It is reported that the water table in the Flowell area declined throughout the period of well construction, but its position has changed very little since 1930.

Pavant District

Very few of the existing wells in the Pavant district end in the shallow zone of unconfined water. However, in 1908, Meinzer found more than a dozen shallow wells in the town of Holden, which were sufficient to define the position and slope of the water table within the village.[11] He found that the water table was very near the surface at the eastern edge of town, and that it sloped westward at a rate of about 150 to 300 feet in a mile; the depth to water beneath the land surface increased rapidly westward until in the northwestern part of town it was approximately 100 feet.

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[10] Meinzer, O. E., Ground water in Juab, Millard, and Iron Counties, Utah: U. S. Geol. Survey Water Supply Paper 277, pp. 89-90, 1911.
[11] Ibid, pp. 91-92.

ARTESIAN WATER

The majority of wells in Pavant Valley, particularly in the Flowell and Meadow ground-water districts, penetrate strata which yield water under sufficient pressure to flow at the surface. This artesian pressure is created by the weight of water at higher levels in the areas farther east, and is maintained by relatively impermeable confining beds over the aquifers, which prevent or impede upward movement of the water. The data concerning these artesian aquifers were obtained chiefly from the Flowell district, where flowing wells are most numerous.

The uppermost stratum which bears confined water occurs at elevations about 4600 feet above sea level, or 60 to 120 feet below the land surface in the Flowell district. This aquifer was penetrated by most wells in the area, but none is bottomed in the stratum. In the northwestern part of the Flowell district, it consists of porous, water-bearing volcanic material, and farther east of "hardpan," sand, and gravel, which are separated from the overlying zone of unconfined water by clay 15 to 75 feet thick. No flows have been obtained from the aquifer, but reported water levels indicate that the water is under weak artesian pressure.

The highest artesian aquifer which produces a flow in the Flowell district is encountered at an elevation about 4540 feet above sea level and at a depth of 140 to 200 feet below the land surface. The aquifer was not encountered in some wells, particularly in the western part of the district, and in others the water was under insufficient pressure to cause it to flow at the surface. The materials of the aquifer vary from pea gravel in the eastern part of the Flowell district to medium sand in the western part of the area; in the J. C. Christensen well (C-21-5)30caal volcanic rocks were encountered at this horizon.

Sand and gravel beds separated by clay produce flows at various elevations below 4540 feet. In some wells as many as seven such flows have been reported. In the deepest well in the area a flow was encountered at a depth of 470 feet, at an elevation of 4200 feet above sea level. In general, water from the deeper aquifers is under higher pressure than that from shallow aquifers, but many of the wells have been perforated at several aquifers and the resulting flow from the high-pressure to low-pressure aquifers has greatly diminished the original difference in pressure head, especially in the area of greatest well density.

No wells have been drilled deep enough in the Flowell or Meadow districts to indicate the lower limit of the artesian reservoir. However, in the Pavant district, well (C-20-5)27bcbl was drilled to 601 feet, of which the lower 75 feet is believed to be in the Sevier River formation.

Seasonal Fluctuations of Water Levels

In Pavant Valley the major seasonal fluctuations of water levels and artesian pressures in wells are caused by opening and closing of artesian wells and by additions of water to the ground-water reservoir. Small daily fluctuations result from changes in barometric pressure, earth tides, etc. These daily fluctuations bear no relationship to the amount of storage in the aquifer and are not discussed in this report.

The greatest fluctuations of water level in artesian wells are caused by opening and closing of flowing wells. Prior to 1929 a Millard County ordinance required closing of flowing wells for six months of each year, and wells in the Flowell district were closed regularly from October 1 to April 1, while the Meadow district selected a season beginning and ending a month later. However, as pressures in the Flowell district declined in the early 1930's, some of the easternmost wells ceased to flow in the summer and permission was granted to owners to open those wells from March 1 to November 1. Beginning in 1938, State control and district agreements have resulted in some variation in date of well opening and closing, so that in 1938 and 1939 the majority of wells were opened in mid-March, and since 1940 most wells have been open from April 1 to mid-September. The effects of this regulation are clearly shown in the hydrograph for the State of Utah well (C-21-5)21abal (figure 7), located near the eastern margin of the area of artesian flow. Each year the water level has declined 6 feet or more in April, due to opening of flowing wells. The decline becomes progressively more gradual until the lowest level for the year is reached, sometimes in May or June, sometimes as late as September. Thereafter, there is a gradual rise until late September, then a sharp rise as the wells are closed, succeeded by a progressively more gradual rise until the end of February. Unless some edge wells are opened, this rise continues through March, when the water level commonly reaches the highest level for the year. These fluctuations are characteristic of all wells that penetrate the artesian aquifers. In the area of greatest well discharge, the range of fluctuation of water levels is considerably greater than in the State well, as shown in the hydrograph of the Huntsman well (C-21-5) 19adal.

The hydrographs of several artesian wells in the eastern part of the Flowell district exhibit in varying degrees the composite effects of well opening in the spring, recharge in the summer, and well closing in the fall. Thus in the Hoyt well (C-22-5)2bcal the effect of recharge is appreciable, causing a rise of water levels in May and June of 1943 and again in 1944, and slight rises in April and June of 1945, (the opening and closing of the artesian wells causes pronounced declines in the spring and rises in the fall). The Ray well (C-21-5)35babl shows a fluctuation of at least 7 feet resulting from the opening and closing of wells but there is a lag of nearly a month before these effects reach this well. The comparatively large amount of recharge during the summer of 1944 and 1945 partly offset the normal decline resulting from discharging wells, and the lowest water level in 1945 was as high as the highest water level in 1944 in that well.

In the Robinson well (C-21-5)27aaal, the dominant fluctuations are those caused by opening and closing of wells, but the effect of recharge is suggested by the gradual rise of water levels in the summer of 1944 from a low point in May. Finally, the Hansen well (C-21-5)15dbbl appears to be more influenced by recharge than by discharging wells, although it is closer than either the Hoyt, Ray, or Robinson wells to the area of greatest well discharge. Opening of wells causes a slight decline of water level in the spring, and closing results in a more pronounced rise in the fall of most years, but this well is less affected by artesian withdrawals than other wells more distant from the center of the district.

Long-term Fluctuations

Records of the water-level fluctuations in the State of Utah well (C-21-5)21abal have been obtained, with only two extended interruptions, since May 1929, and a recording gage has provided a continuous record of these fluctuations since September 1935. Hydrographs for this well and four other wells are presented in figure 8.

The State well is just east of the area of artesian flow as of 1945, (plate 1) but is close enough that the effects

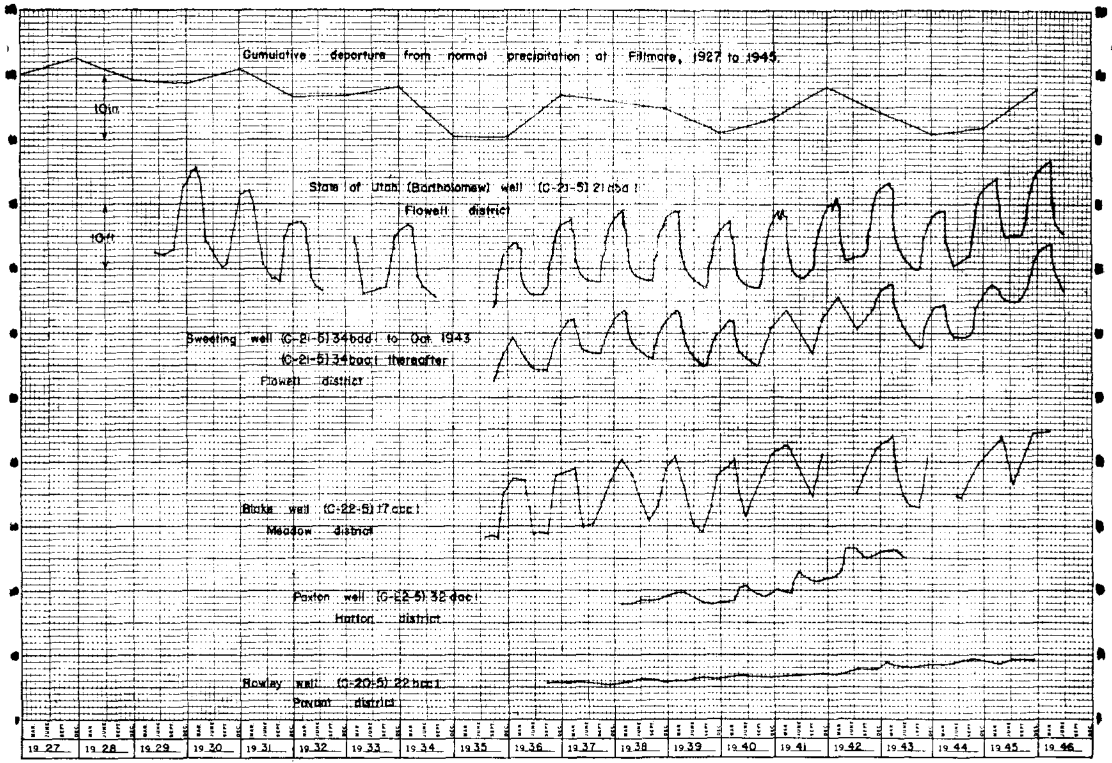

Fig. 8- Hydrographs for 5 wells in Pavant Valley, 1929 to 1945.

of opening or closing wells are clearly shown, whether the discharging well is withdrawing water chiefly from the aquifers tapped by the State well or from deeper aquifers (many of these deeper wells are perforated in the aquifers tapped by the State well). The State well is also close enough to the recharge area that annual influx of water to the basin can be identified, although this recharge effect is masked in large part by the greater fluctuations due to well discharge. Thus, in the summers of 1938, 1939, 1940, and 1943, following years of subnormal rainfall, the water level continued to decline until late summer, but in 1941, 1942, and 1945, following years of abundant rainfall, the water level rose slightly throughout July and August, suggesting that the recharge was sufficient to offset the discharge from wells.

The highest annual water levels in the State well show a general correlation with rainfall at Fillmore, except that there may be a lag of as much as a year before the effects of extraordinarily wet or dry years are apparent. It is to be noted that the effects of well discharge are so great that any appreciable increase in the number of wells left open during the winter will cause a corresponding decline of water levels in the State well, and conversely a decrease of winter discharge will cause a rise of water level in the observation well. The close correlation between water levels and rainfall (the ultimate source of water in the artesian reservoir) indicates that conditions in the area have been more or less constant from year to year: certain wells have been closed each year at approximately the same time, and others have remained open or leaking about the same amount year after year. The State well is thus considered to be an excellent well for indicating the relative amount of storage in the artesian reservoir, at least so far as the Flowell district is concerned, provided all well owners cooperate to minimize wastage during the non-irrigation season. This well will also record the effects of well discharge in violation of district regulations.

The State well is reported to have ceased flowing in 1927. In the spring of 1930 the high water level was 5 feet below the flow line at the top of casing. Thereafter the yearly high-water level declined until 1935 (following the severe drought of 1934) and in the spring of 1936 was 16 feet below the top of the casing. The record since 1936 shows a gradual rise, with setbacks in 1940 and 1944 following periods of deficient rainfall, until by the spring of 1946 the high point exceeded that recorded in 1930, the first year of record.

The Sweeting well (C-21-5)34bddl is located near the southeast margin of the Flowell area. The fluctuations of water level are similar to those in the State well but the magnitude of the seasonal fluctuation, produced largely by the discharge of the flowing wells, is somewhat less because the well is farther removed from the principal discharge area.

The Blake well (C-22-5)17accl is in the Meadow district. In minor details the graph for this well differs from those of the State and Sweeting wells. The water level is affected by discharge of wells in the Meadow district, where wells are used largely for stock watering, and the period of well discharge is more irregular and generally later in the year than in Flowell. There is a general correspondence between years of high and low-water levels in the two districts as indicated by the graphs.

The Rowley well (C-20-5)22bccl is located in the Pavant district. In contrast to wells in the Flowell and Meadow districts the seasonal fluctuations in this well amount to only a few tenths of a foot, and the highest levels ordinarily occur in mid-summer. There has been a general though slight rise in water level in this well from 1936 to 1945.

The Paxton well (C-22-5)32dacl, like most other wells in the Hatton district, appears to tap unconfined water. The water level in this well rises each spring or early summer, partly due to infiltration of irrigation water applied in the Hatton district and especially in the vicinity of the well, and no doubt also due to recharge of the alluvial fans from streams. The general rise of water level from 1938 to 1943 parallels that shown in wells in other districts.

The present limit of the area of artesian flow is shown on plate 1 together with the reported limit of flow during the period when the first flowing wells were drilled. The boundary of the area is shown to have shifted about one-fourth mile down slope to the west—the change in water level amounting to about 5 or 6 feet. The shift occurred chiefly during the period of well development, and practically no change has been noted in the position of the area of artesian flow since about 1931 when the area reached its present state of development.

Piezometric Surfaces

The piezometric or pressure-indicating surface of an aquifer—the surface to which water in that aquifer will rise under its full head—is defined by the static levels in the wells which tap only that aquifer. The position and form of a piezometric surface will change from day to day, from season to season, and from year to year, and those changes are recognized by the fluctuations of water level in the individual wells. Each aquifer has its own piezometric surface, and in the intermontane valleys of Utah the deeper aquifers commonly have higher piezometric surfaces than the shallow aquifers above them.

In Pavant Valley, conditions did not permit delineation of separate piezometric surfaces for each of the aquifers encountered in wells. Individual aquifers cannot be mapped with any degree of certainty, partly because of their discontinuity and irregularity, but largely because of the inadequacy and probable inaccuracy of data obtained during the drilling of the wells. Furthermore, many wells tap several of the principal aquifers, so that pressures tend to become equalized by movement of water in the well, and the measured shut-in pressure represents the composite effect of pressures in the aquifers.

Plate 1 shows isopiestic lines, or contours, on a composite piezometric surface for March 1941 when the water level in most wells was at approximately its highest position for the year. These contours connect all points where the piezometric surface is the same elevation above sea level. The direction of movement and of maximum hydraulic gradient is perpendicular to these contours. Outside the areas of artesian flow, there are insufficient wells to furnish the information necessary for the determination of the piezometric surface. Isopiestic lines are therefore drawn only for the Flowell district and adjacent parts of the Meadow and Pavant districts where wells are fairly numerous.

In the Flowell district the piezometric surface in March 1941 sloped westward with a hydraulic gradient ranging from 10 to 20 feet per mile in the central and western part of the district. Farther east the slope is more gradual, and in the eastern part of the district near the Provo shore line it is less than 3 feet per mile. Although no data are available for the Fillmore district, it is postulated that the piezometric surface merges with a water table in the upper portion of the Chalk Creek fan, where gravel and sand predominate and ground water is probably not confined under pressure. In materials so coarse, it may be assumed that the water table has a slope similar to that of the piezometric surface near the Provo shore line, and therefore that the water table is probably more than 400 feet below the land surface in Fillmore, and at an elevation less than 4800 feet above sea level.

In the Meadow district the piezometric surface slopes northward and northwestward with a gradient of about 5 feet to the mile in the higher part of the area of artesian flow, increasing to 15 feet per mile in the lower northern part of the district. Farther south, in the Hatton district, some wells appear to be deep enough to reach the artesian aquifers which yield water in the Meadow district. From the sketchy information provided by these wells, it appears that the piezometric surface south of Meadow may have a decreasing gradient analogous to that east of the Flowell district, and that it merges eastward and southward with a water table in the coarse sand and gravel of the upper parts of the alluvial fans of Sunset, Cottonwood, and Corn Creeks.

In the Pavant district—at least in the southern part where most of the wells are located—the piezometric surface has a westward slope comparable to that in the districts farther south. However, west of West Mountain in the area adjacent to the Flowell district, the slope of the piezometric surface is steeply northwestward. Tests described on page 60 indicate that the deep aquifers of the two areas are separated, possibly by a buried ridge of the Sevier River formation projecting westward from West Mountain.

MOVEMENT OF GROUND WATER

The movement of ground water in Pavant Valley follows more or less the drainage pattern shown by streams and is generally from the mouths of the canyons that drain the Pavant Range westward and northwestward toward the lowest parts of the Valley, where a large proportion is discharged by springs, evaporation, transpiration and wells, and the remainder continues westward and northwestward through the more permeable strata of the valley and the bordering lava fields toward the Sevier Desert. The ultimate source of practically all the ground water is rainfall upon the drainage basin tributary to Pavant Valley, but some of the highly mineralized water which rises in springs west of Meadow and Hatton may originate from magmatic sources.

In the following sections, the means by which water is added to the ground-water reservoir are discussed, followed by a detailed description of the movement and discharge of ground water in each district.

GROUND-WATER RECHARGE

Infiltration of water from streams constitutes a major source of ground water in Pavant Valley. On the upper parts of the alluvial fans, where the stream channels lie in permeable gravel and sand, seepage losses are known to be high and a large proportion of the flow disappears underground to enter the ground-water reservoir. In these areas water levels in wells reach their highest stage in late spring and early summer, shortly after the period of maximum stream discharge. Although the larger streams appear to be the major contributors, a considerable amount of ground water is probably derived also by seepage from intermittent streams during the spring freshet, and by underflow in the beds of small gulches and valleys which are dry most of the year. Direct penetration into permeable ground of rainfall during major storms may also contribute to ground water in the valley.

Recharge to the artesian reservoir may occur in most of the area above the Provo shore-line. Most of this water doubtless originates as drainage from the Pavant Range, both as flow in stream channels and underflow in the loose materials in the bottoms of the canyons. Water diverted from these streams and used for irrigation on the upper parts of the alluvial fans may contribute substantially to the artesian reservoir. Rainfall on these areas may also furnish some water to the artesian reservoir, especially during major storms.

Water entering the ground below the Provo shore-line, whether from stream channels, irrigation ditches, irrigated tracts, or rainfall, is not likely to enter the artesian reservoir because of the clay beds which occur above the artesian aquifers. The surface soils in this area are prevailingly fine-grained and not highly absorbent; the small quantities which do get underground join the unconfined water in strata overlying the clay beds.

GROUND-WATER MOVEMENT AND DISCHARGE

The direction of movement of water in the artesian aquifers is derived from the slope of the piezometric surface as indicated on plate 1, movement being in the direction of maximum gradient and at right angles to the isopiestic lines. The direction of movement of the shallow water above these aquifers must be inferred from the topography and from water levels in about a dozen test-holes drilled during the investigation.

Fillmore District

Movement of ground water in the Fillmore district is chiefly downward through the coarse alluvial materials to the zone of saturation and thence westerly to replenish the artesian reservoir. Movement is slow through the finer materials, and some water may not reach the artesian reservoir for many years after it enters the ground. In the western part of the district there is sufficient interbedded clay to create zones of perched water, but this water probably reaches the artesian reservoir eventually by slow downward percolation. Similar conditions presumably prevail in the upper parts of the other alluvial fans in Pavant Valley.

Flowell District

Water in the artesian aquifers of the Flowell district moves westward in the eastern part of the district. Farther west, and especially in the northwest corner of the district the direction of movement is northwesterly. A large part of this water is discharged by flowing wells within the district, but natural discharge still occurs through or over a restricted outlet into the Pavant district. Some natural discharge may also occur to the west through or beneath the lava. A third method of natural discharge is through the clay confining beds to the shallow zone of unconfined water. Before the flowing wells were drilled, discharge through the natural outlets was greater than it is now because of the high pressure built up in the artesian aquifers. Losses through natural discharge are greatest during the periods when artesian pressures are highest and least when the wells are open and artesian pressures are lowest.

Like the artesian water the shallow water seems to be moving westward and northwestward in the Flowell district. A considerable part is probably discharged by evaporation and transpiration in the lower western part of the area, but substantial quantities are also discharged westward and northwestward through the lava flows. Flood waters from Chalk Creek which flow northwestward as far as section 6, T. 21S., R. 5 W. (beyond the northwest corner of the Flowell district), disappear rapidly by seepage into a shallow depression known as "The Sink." The Sink is very near the east margin of the basalt of the Ice Springs Craters flow and it is likely that the water enters permeable volcanic materials in an area otherwise underlain by relatively impervious lake clays and marls. Much water has been reported by drillers in the volcanic rock and associated gravel encountered at depths of about 60 feet in the vicinity of the Sink. The water is under little if any artesian pressure, suggesting that although it is overlain by impermeable clays, it has a relatively open lateral outlet. Furthermore, the north end of the Flowell district, unlike the shallow-water area farther south, seems to have good subsurface drainage and the water table occurs at greater depths beneath the land surface. All of these facts indicate that the shallow water, from the north end of the Flowell district at least, finds its way westward and northwestward through or between the lava flows.

Pavant District

Movement of water in the south end of the Pavant district is northwesterly, but farther north it appears to be westerly. A large part of the district probably receives its water from the alluvial fans of Pioneer Creek, Wild Goose Creek, and Maple Hollow, but some water enters the south end of the district from the Flowell district. Some water is discharged from the artesian aquifers through wells within the district, and the rest of the water moves westward or northwestward toward the Sevier Desert. The small yield of the wells, and the fact that most of the aquifers are reported to be fine sand, indicates that the total amount of ground water passing through the district is not large.

Meadow District

The artesian water in the Meadow district moves generally northwestward but in the north part of the district the direction is northerly. Some artesian water doubtless moves from the Meadow district into the Flowell district, but the small yields of wells drilled in the inter-fan area between the two districts suggests that only small quantities of water are involved. Numerous springs rise west of the principal area of artesian flow, along the Meadow Slough in sections 8, 17 and 20, T. 22S., R. 5 W. Before the flowing wells were drilled these springs are reported to have been more numerous and to have discharged more water. In 1945, with artesian pressures near their maximum during the period of record, many of the old springs began to flow again. This relationship of spring flow to artesian pressures in the wells suggests that the spring discharge is either directly from the artesian aquifers by upward movement through the clay confining beds or from water in the shallow water zone which was rejected as recharge to the artesian aquifers because they were already filled. Water from these springs flows northward along the Meadow Slough, and is dissipated by evaporation and transpiration and possibly by seepage into the lavas near its north end. The flow of the Meadow Slough at the junction of the two main channels in section 1, T. 22 S., R. 6 W., was 4.6 second-feet on June 20, 1944, and 5.1 second-feet on April 12, 1945. The flow in this slough is reported to be greatest in early spring and least in midsummer.

Kanosh and Hatton Districts

The water in the developed portion of the Hatton district appears to be moving in a general northwesterly direction. No data are available concerning water levels or piezometric surfaces in the Kanosh district, on the upper part of the Corn Creek alluvial fan, but it is assumed that this district is analogous to the Fillmore district, and that the ground water therefore moves down the fan with gentle gradient toward the Hatton district which comprises the lower part of the alluvial fan. The ground water in the Hatton district is considered to be derived in part from Corn Creek, and partly from the smaller Cottonwood and Sunset Creeks. Some of this water may move beneath clay confining beds and enter the artesian aquifers of the Meadow district. The rest, remaining unconfined in shallow zones, may move northward toward the Meadow Slough or westward toward the Warm Springs area.

The Warm Springs area west of Hatton is a major area of natural discharge of ground water. In addition to the warm springs there are hundreds of cold water seeps and small springs in this area. A gypsum-floored playa west of the spring area and extending southwestward from White Mountain receives some of the discharge from these springs. This playa is sometimes referred to locally as a sink but whether the water sinks rapidly into the ground here as it does north of Flowell was not determined. Proximity to the volcanic ridge and the warm temperature of at least one of the springs may signify some small contribution to the ground water from volcanic sources. The ancient craters of extinct springs in this area give evidence of larger contributions from this source in the past. The springs and seeps are considered to be discharged chiefly from the shallow water body at the present time. Water levels in four auger holes show that the water table in this area has a gentle westward gradient.

Clear Lake About 10 miles northwest of Flowell, at the west margin of the volcanic ridge, several large springs discharge into a pond or lake area known as Clear Lake. On June 20, 1944, the discharge of these springs, measured at the pond outlet, was about 18 second-feet. The flow is reported to be fairly constant throughout the year. The elevation at Clear Lake as established by several measurements with an aneroid barometer is about 4600 feet. The elevation of the land surface in the sink area north of Flowell is about 4635 feet and the elevation of the piezometric surface near the northwest corner of the Flowell district is about 4690 feet. Thus, there is sufficient gradient for movement of both the shallow water and the artesian water from the Flowell area to Clear Lake. Water levels in wells at the Clear Lake railroad station and at other points in the desert west of the Clear Lake springs indicate that the piezometric surface slopes westward from the lake, and therefore that Clear Lake cannot be fed by ground water moving from the west. A part of the rain which falls upon the volcanic ridge may find its way to channels which supply the Clear Lake springs. The water in these springs is considered to flow chiefly from the artesian aquifers or shallow unconfined zones of the Pavant and/or Flowell districts.

CHEMICAL CONSTITUENTS OF THE GROUND WATER

Chemical analyses are presented in an accompanying table for the waters from 3 streams, 3 municipal supplies, 89 wells, and 7 springs in the Pavant Valley drainage basin. The major chemical constituents of some of these waters are shown graphically in figure 9.

According to these analyses, the principal streams entering Pavant Valley carry calcium and magnesium bicarbonate waters of low concentration, with 200 to 250

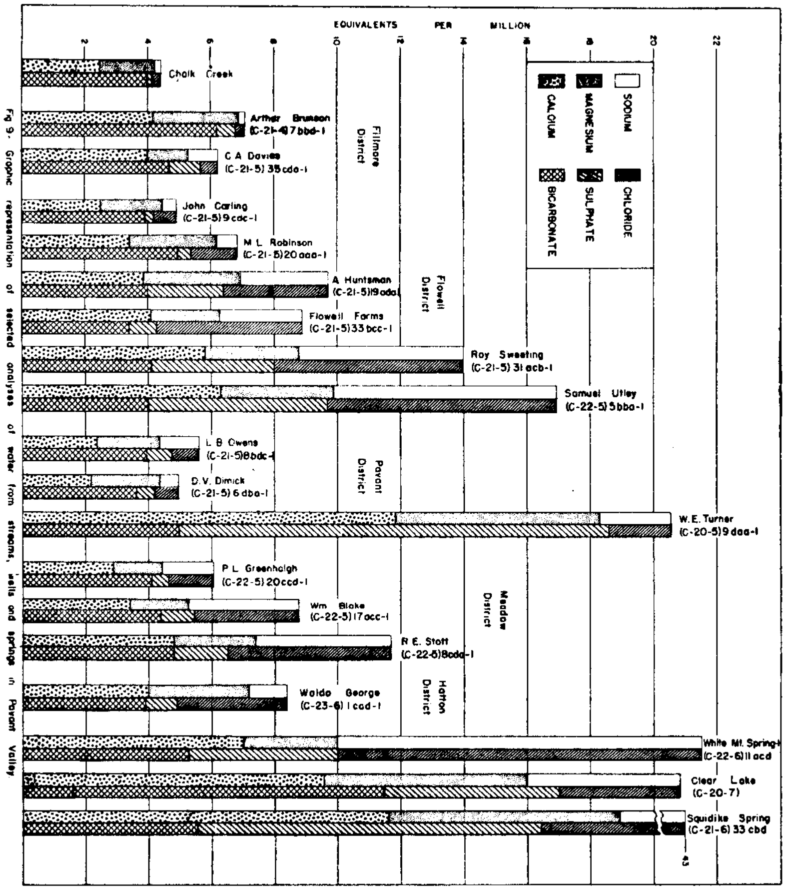

Fig 9- Graphic representation of selected analyses of water from streams, wells and springs in Pavant Valley

Analyses of Water from Streams, Wells, and Springs in Pavant Valley

[Parts per million. Well numbers correspond to numbers in table of records of wells]

Analyses by Geological Survey except as indicated

Well number	Depth (feet)	Temperature (°F.)	Date of collection	Dissolved solids	Calcium (Ca)	Magnesium (Mg)	Sodium & potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Borate (BO_3)	Total hardness as $CaCO_3$
			Streams and municipal supplies										
Chalk Creek			Nov. 22, 1944	213	50	22	2.8	243	9	9	.5		216
Meadow Creek			Nov. 22, 1944	205	52	15	7.1	220	14	8	.6		192
Corn Creek			Nov. 22, 1944	239	48	25	9.0	235	21	20	.2		223
Fillmore City			Feb. 8, 1941†	251	53	19	19	205	14	23	0		211
Meadow Town			June 12, 1941†	125	27	6	8	82	9	12	tr.		80
Kanosh Town			July 2, 1941†	276	59	18	21	220	10	28	0		222
			Wells in Fillmore district										
(C-21-4)7bbdl	73		Nov. 17, 1944	342	84	33	4.4	397	13	10	2.0		345
(C-21-5)12badl	120		Nov. 17, 1944	373	61	31	43	397	28	11	3.2		280
35cdal	120		Nov. 22, 1944	325	80	16	21	285	46	20	2.0		266
			Wells in Flowell district										
(C-21-5)8cccl	272		July 29, 1943	276	47	24	4.2	237	tr.	20			213
9cdcl	300	55	May 31, 1943	243	50	25	9.7	242	11	27	1.0	.1	228
15dbbl	400?		Nov. 18, 1944	359	74	30	25	353	13	41	1.7		308
16bcc2	254	56	Apr. 8, 1943	334	68	29	21	336	14	24	12	0	288
17adcl	236	56	May 31, 1943	330	42	29	47	260	13	69	2.0	.1	224
17bdd2	371	57	May 31, 1943	301	56	30	19	280	15	41	2.5	.1	264
17ccdl	347	57	Nov. 20, 1944†						44				
17cdal	420	58	May 31, 1943	298	59	29	16	276	17	38	3.5	.2	266
17cddl	315	57	May 31, 1943	296	55	29	19	276	17	37	2.5	.2	256
18adal	453	61	May 31, 1943	325	58	28	26	234	37	59	2.0	.2	260

Analyses of Water from Streams, Wells, and Springs in Pavant Valley—(Continued)

[Parts per million. Well numbers correspond to numbers in table of records of wells]

Analyses by Geological Survey except as indicated

Well number	Depth (feet)	Temperature (°F.)	Date of collection	Dissolved solids	Calcium (Ca)	Magnesium (Mg)	Sodium & potassium (Na+K)	Bicarbonate (HCO₃)	Sulfate (SO₄)	Chloride (Cl)	Nitrate (NO₃)	Borate (BO₃)	Total hardness as CaCO₃
			Wells in Flowell district (Continued)										
(C-21-5)18add1	508	62	Nov. 21, 1944	362	61	30	31	234	60	60	4.2		276
18dad2	400	60	Nov. 20, 1944†						61				
18dda1	448	62	Nov. 21, 1944†						147				
18ddd1	376	61	Nov. 22, 1944	530	74	34	69	252	146	80	3.1		324
19aad1	455	63	Nov. 21, 1944	309	50	24	32	236	47	32	7.8		224
19ada1	337	62	Nov. 21, 1944	534	76	38	64	242	120	112	4.8		346
19daa1	403	63	May 31, 1943	714	84	46	104	212	209	164	2.5	1.5	398
19daa2	232	61	May 31, 1943	680	90	45	90	256	182	145	1.5	1.0	410
19dcd1	330	61	May 31, 1943	605	76	40	88	286	149	110	1.5	1.5	354
20aaa1	334	55	May 31, 1943	343	70	34	15	308	19	52	1.0	.3	314
20bab1	445	60	Nov. 21, 1944	303	52	22	32	262	35	23	9.6		220
20bad1	395	59	Nov. 20, 1944†						47				
20cbd1	355	60	Nov. 20, 1944†						75				
20cca1	488	63	May 31, 1943	1,009	126	55	150	234	316	244	2.5	1.0	540
20dda1	323	58½	May 31, 1943	261	51	25	16	272	13	18	3.7	.2	230
20dda2	145	57	May 31, 1943	248	52	24	11	260	13	17	3.1	.2	228
21bba1	281	54	May 31, 1943	287	56	31	11	256	19	42	2.0	.2	268
21cba1	279	55	May 31, 1943	296	62	27	16	298	11	30	3.2	.2	266
29aac1	315	61	Nov. 20, 1944	297	54	24	24	226	44	36	3.9		234
29aad1	290	60½	Nov. 20, 1944	286	54	20	27	253	31	22	6.9		217
29aba1	330	59	Nov. 20, 1944†						61				
29baa1	224	61	Nov. 20, 1944†						128				
29bdd1	207	62	Nov. 18, 1944	345	63	23	36	265	48	44	.6		252
29cad1	440	63½	May 31, 1943	805	109	44	115	252	228	182	2.5	.8	453
29cdd1	368	62	May 31, 1943	867	126	42	124	280	235	200	2.0	.8	487

Analyses of Water from Streams, Wells, and Springs in Pavant Valley—(Continued)

[Parts per million. Well numbers correspond to numbers in table of records of wells]

Analyses by Geological Survey except as indicated

Well number	Depth (feet)	Temperature (°F.)	Date of collection	Dissolved solids	Calcium (Ca)	Magnesium (Mg)	Sodium & potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Borate (BO_3)	Total hardness as $CaCO_3$
			Wells in Flowell district (Continued)										
(C-21-5)29dca1	380	63	Apr. 8, 1943	1,204	181	51	171	302	362	287	3.0	2.5	661
29dcd1	266	60	Nov. 20, 1944†						112				
29ddd1	277	62	May 31, 1943	352	56	20	49	234	51	57	4.2	.8	222
30ada1	470	62	May 31, 1943	686	80	46	101	230	181	163	1.5	.8	388
30caa1	350	60	Nov. 21, 1944	801	105	45	118	274	221	175	1.9		447
30dad1	420	63	May 31, 1943	829	114	52	110	282	208	205	1.0	.8	498
30dbd1	350	61	Apr. 11, 1943	756	111	40	107	296	172	178	2.5	1.3	442
31acb1	390	60	Nov. 18, 1944	802	116	37	121	253	188	212	3.9		442
31cda1	330	60	Nov. 20, 1944†						496				
31cdd1	336	59	Apr. 11, 1943	1,173	176	47	175	318	323	293	1.5	1.2	632
32acb1	250	59½	May 31, 1943	599	108	35	63	212	78	208	2.5	.7	414
32bcb1	285	60	May 31, 1943	528	76	32	72	190	98	154	2.5	.6	321
32bcd1	254	60	Nov. 18, 1944	890	124	46	130	238	212	258	2.7		498
32ccd1	284	59	Nov. 20, 1944†						264				
33bcc1	245	59½	May 31, 1943	480	82	27	60	208	45	162	1.0	.7	316
33bcc2	318	61	May 31, 1943	493	78	23	70	226	107	102	1.5	.3	289
33dcc1	200	57	May 31, 1943	448	58	22	78	174	64	136	4.8	.3	235
34bbb1	200	55	May 31, 1943	229	34	22	23	159	13	58	.5	.4	176
(C-21-6)25dab1	20		Nov. 22, 1944	4,370	207	285	951	255	1,090	1,710	1.0		1,690
(C-22-5)4baa1	10		Nov. 17, 1944	464	77	22	67	233	46	130	7.0		282
4daa1	218		Nov. 18, 1944	692	96	30	117	281	138	172	1.0		363
5aca1	248	58	May 31, 1943	711	94	31	121	254	164	174	1.5	1.5	362
5bba1	280	59½	May 31, 1943	991	127	44	164	246	274	260	1.0	1.5	498
5bca1	288		Nov. 17, 1944†						1,201				
5bcd1	350	58	Nov. 17, 1944†						584				
6acd1	319	58	May 31, 1943	907	148	52	101	280	238	230	.5	.5	584

Analyses of Water from Streams, Wells, and Springs in Pavant Valley—(Continued)

[Parts per million. Well numbers correspond to numbers in table of records of wells]

Analyses by Geological Survey except as indicated

Well number	Depth (feet)	Temperature (°F.)	Date of collection	Dissolved solids	Calcium (Ca)	Magnesium (Mg)	Sodium & potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Borate (BO_3)	Total hardness as $CaCO_3$
			Wells in Pavant district										
(C-20-5)9daal	330	58	Apr. 11, 1943	1,238	236	78	53	300	656	67	.5	.4	910
22bccl	400	65	Nov. 17, 1944	960	115	84	85	244	543	102	1.2		632
27bcbl	601		Apr. 11, 1943	1,361	178	130	79	248	687	162	2.6	.5	978
27cbbl	286	63	Nov. 16, 1944	343	45	42	22	230	70	50	.4		285
28cddl	354	65	Nov. 16, 1944	396	52	46	26	247	107	43	.4		319
28daal	330	62	Nov. 16, 1944	355	54	44	14	244	70	52	.4		316
28dddl	309	62	Nov. 16, 1944	352	49	38	28	247	72	43	.8		278
31dcdl	508	64	Nov. 16, 1944	660	92	57	60	235	189	145	1.5		464
32aaal	490	65	Apr. 8, 1943	443	34	34	85	138	52	160	.2	.3	225
33bbal	325	66	Nov. 16, 1944	400	32	29	78	166	55	123	1.0		199
33bdal	360	68	Nov. 16, 1944	553	55	48	77	228	139	121	1.0		335
(C-21-5)6dbal	400	61	May 31, 1943	254	45	26	16	228	26	28	1.0	0	220
8babl	455	63	Nov. 22, 1944	384	61	28	43	260	74	49	.6		267
8bdcl	320	62	May 31, 1943	288	48	25	28	248	32	32	1.0	.3	223
			Wells in Meadow district										
(C-22-5)4ccdl	284	62	Nov. 17, 1944†						618				
7bddl	390		Nov. 20, 1944	414	56	20	75	268	49	81	.8		222
7cadl	176	55	Apr. 11, 1943	383	66	25	44	236	41	88	1.8	.2	268
8aadl	325	60	May 31, 1943	692	126	36	76	256	118	208	1.5	.3	462
8cdal	270	59	Apr. 11, 1943	635	96	32	99	304	74	182	1.2	1.4	371
8cddl	460	60	May 31, 1943	524	62	23	106	280	63	131	1.0	.4	249
9dbcl	196		Nov. 20, 1944	536	83	26	83	262	60	154	.5		314
17accl	375	58	Apr. 8, 1943	479	69	23	82	268	51	118	2.6	1.2	266
20ccdl	282	56	Apr. 11, 1943	324	58	19	40	252	28	48	6.8	.2	222

Analyses of Water from Streams, Wells, and Springs in Pavant Valley—(Continued)

[Parts per million. Well numbers correspond to numbers in table of records of wells]

Analyses by Geological Survey except as indicated

Well number	Depth (feet)	Temperature (°F.)	Date of collection	Dissolved solids	Calcium (Ca)	Magnesium (Mg)	Sodium & potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Borate (BO_3)	Total hardness as $CaCO_3$
Wells in Hatton district													
(C-23-6) 1cadl	146		Nov. 22, 1944	443	81	39	28	239	47	123	7.1		362
8bdbl	100		Nov. 22, 1944	4,430	354	287	761	317	1,610	1,260	6		2,060
Springs													
Ice Springs			Nov. 19, 1944	5,190	274	181	1,380	234	914	2,320	4		1,430
Squidike Springs		58	Nov. 22, 1944	2,550	231	93	564	340	526	962	3		909
White Mt. Springs		55	Apr. 8, 1943	1,198	145	46	227	308	255	370	2.6	3.0	551
White Mt. Springs		55	Apr. 8, 1943	1,233	129	44	263	318	237	400	2.6	3.0	503
Warm Spring		95	Apr. 8, 1943	4,810	464	95	1,152	392	1,045	1,830	2.0	15	1,548
Devil's Ridge Spring		56	Apr. 8, 1943	8,080	720	169	1,946	316	1,951	3,120	1.0	20	2,492
Clear Lake Spring			Apr. 11, 1943	1,189	98	78	221	214	267	400	7.5	.8	565

†Analysis by M. E. Christiansen, Utah State Chemist.

parts per million of dissolved solids, probably derived chiefly from the limestone and dolomite formations which comprise a considerable part of the Pavant Range. Wells on the upper parts of the alluvial fans yield water of similar composition, but the dissolved mineral matter is somewhat greater. For instance, analyses of waters in the Fillmore district show 325 to 375 parts per million of solids, chiefly calcium and magnesium bicarbonate. Waters obtained from wells lower on the fans generally carry more dissolved solids with increasing distance from the apex of the fan, indicating that additional mineral matter is dissolved as the waters pass through the materials of the various aquifers. The amount and character of the matter so dissolved varies considerably in different parts of the valley, and even in different aquifers in the same area. In general, however, the waters having high mineral content contain much larger proportions of sodium, chloride and sulphate than do the streams and wells in the eastern part of the valley. Wells and springs near the western margin of the valley yield sodium chloride and sulphate waters with dissolved solids ranging from 1000 to 8000 parts per million.

In the artesian aquifers of the Flowell district, the purest waters are obtained in the northern and eastern parts of the district, where many wells such as the Carling well (C-21-5)9cdc1 yield water with less than 300 parts per million of dissolved solids. In the western part of the district the dissolved mineral matter in wells is ordinarily greater than 500 parts, as in the Huntsman well (C-21-5) 5bbal. In the Pavant district just north of the Flowell district, wells yield water of low mineral content, as in the Dimick well (C-21-5)6dbdal, but farther north the waters are more mineralized, as typified by the Turner well (C-20-5)9daal.

Wells in the Meadow district yield water similar in character to that in the Flowell district. The dissolved mineral matter is less than in nearby wells in the south end of the Flowell district, but is similar to that of wells farther northeast. Here, as in the Flowell district, wells lower on the alluvial fan yield waters containing more mineral matter than those higher on the fan, as shown by comparison of the graphic analyses for wells (C-22-5)20ccdl and (C-22-5)8adal. In the Hatton district some wells, such as the George well (C-23-6)1cad1, yield waters of intermediate concentration similar to those in the Meadow district. Farther west, however, all wells and springs yield highly mineralized waters characterized by high content of

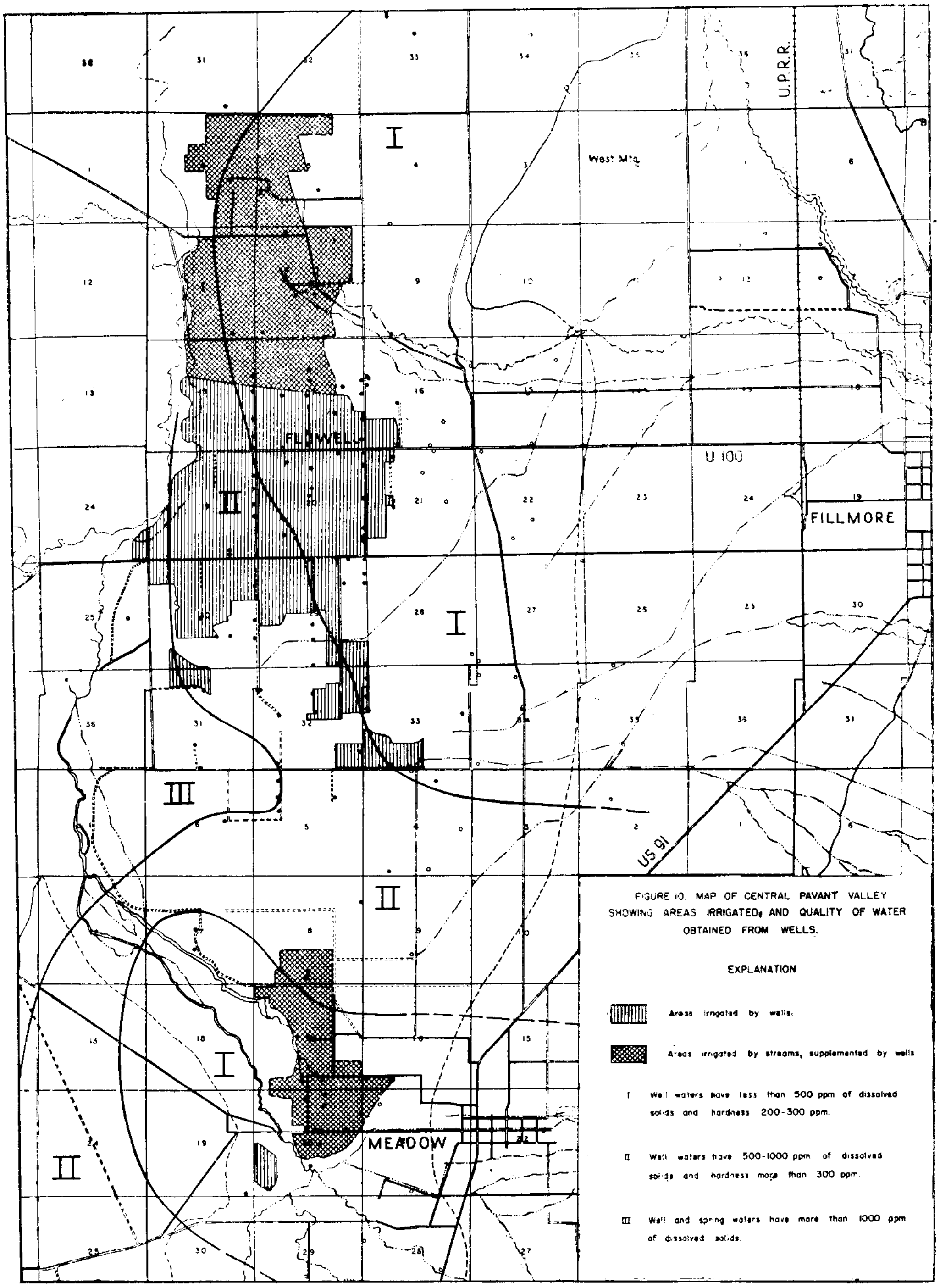

FIGURE 10. MAP OF CENTRAL PAVANT VALLEY SHOWING AREAS IRRIGATED, AND QUALITY OF WATER OBTAINED FROM WELLS.

sodium chloride and sulphate.

The accompanying map (figure 10) shows the areas in which, according to available analyses, waters of good, intermediate, and poor quality have been obtained from wells. It is noteworthy that the areas of occurrence of waters of low to moderate mineral concentration extend far to the west on the alluvial fans of Chalk and Meadow Creeks, where coarse permeable materials permit greater movement of ground water than is possible in the intervening areas.

TESTS OF INTERFERENCE AND PERMEABILITY IN THE FLOWELL DISTRICT

In November of 1943 and 1944, after the flowing wells had been closed, interference tests were made in various parts of the Flowell and Meadow districts using 5 different discharging wells. The well selected for discharge and all wells within the suspected radius of influence were first capped securely, and after they had remained this way for about 24 hours the pressure of each well was measured. The well selected for discharge was then opened for about 24 hours, and its flow and the pressure in the surrounding wells were measured at frequent intervals. The measurements of pressure were continued for at least 24 hours after the well was closed. The locations of the wells and the maximum interference caused in each by the discharging well are shown in figure 11.

In test No. 1, the Oren Allen well (C-21-5)20ddal, 323 feet deep, was opened at 1:30 p.m. on November 12, 1943, and closed at 1:20 p.m. on November 13. The average discharge during that period was about 540 gallons a minute and the drawdown of water level was 22.8 feet. The pressure in the nearest well (C-21-5)20dda2 was reduced 4.4 feet by the discharging well although it is only 145 feet deep. Thus a connection is indicated between the aquifers tapped by the two wells probably resulting from perforations or other leakage from the deeper well at the shallower horizon. Why the effect on the Samuel Utley well (C-21-5)29aaal, reported to be 269 feet deep, should have been greater than that upon the Millard County School District well (C-21-5)20dadl, reported to be 293 feet deep, is not known, although the discharging well may be perforated at the one horizon and not at the other. Because of these differences in depths of the wells and horizons at which they are perforated the magnitudes of the effects observed at the wells are not always proportional

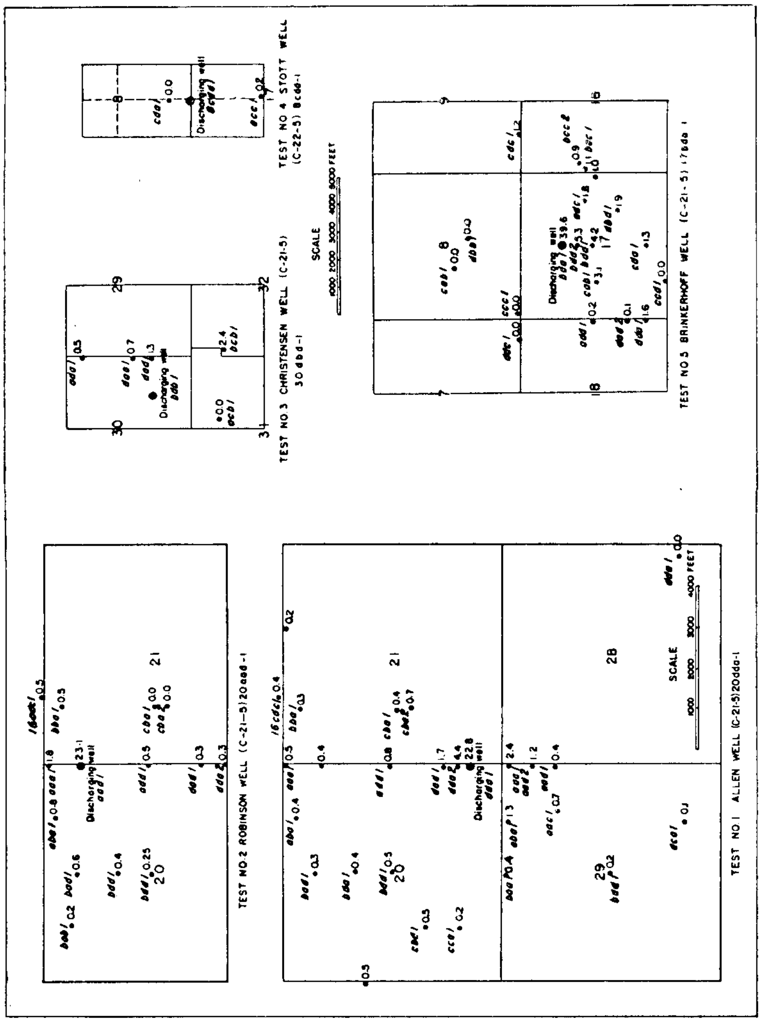

Figure 11—Location of affected wells, and pressure reduction (in feet) during interference tests.

to their distances from the discharging well. The maximum distance at which the effect of the discharging well could be detected was somewhat more than one mile, where pressures were reduced .2 to .5 foot. The pressure recovery data obtained when the discharging well was closed were used to calculate the permeability of the aquifer at this point by the Theis graphical method. Using 35 feet as the thickness of the aquifer, based on logs of adjacent wells, this coefficient is about 1,500 gallons per day per square foot.

In test No. 2 the J. L. Robinson well (C-21-5)20aadl was opened at 12 noon on November 14, 1943, and closed at 10:20 a.m. on November 15. The average discharge of the well during this period was about 480 gallons a minute and the drawdown 23.1 feet. The pressure reduction in adjacent wells ranged from 1.8 feet in a well less than a quarter of a mile away to about .2 foot in wells three-quarters of a mile away. The permeability calculated from the recovery data, using the logged thickness of 25 feet for the aquifer, is about 1,600 gallons per day per square foot.

In test No. 3 the J. C. Christensen well (C-21-5)30dbdl was opened at 2:30 p.m. on November 16, 1943, and closed at 10:45 a.m. on November 17. The flow during the period was about 440 gallons a minute with a drawdown of 41.7 feet. There are only six wells close enough to show a measurable effect from its opening and the water level could not be measured in one of these. The reduction in pressures in the five other wells ranged from 0 to 2.4 feet and the magnitudes of the effects were not directly proportional to the distances from the discharging well. Well (C-21-5)31acbl is presumably in an entirely different aquifer not connected with that penetrated by the discharging well, but well (C-21-5)32bcbl evidently draws from the same aquifer as the discharging well. The three wells in section 30 appear to be in aquifers only partially interconnected with that of the discharging well. The permeability determined from the recovery curve is about 900 gallons per day per square foot assuming the aquifer to be 25 feet thick.

In test No. 4 the Stott well (C-22-5)8cddl was opened at 9:30 a.m. on November 17, 1943, and closed on the same day at 4:50 p.m. The flow during the period was about 120 gallons a minute. The discharging well is reported to be 460 feet deep and its flow caused a decline of .2 foot in the Blake well (C-22-5)17accl, which is 375 feet deep and located ½ mile to the south. Well (C-22-5)8cdal less than a quarter of a mile north, reported to be 270 feet deep, was unaffected.

In test No. 5 the Brinkerhoff well (C-21-5)17bdal was opened at 12:10 p.m. on November 21, 1944, and closed at 2:00 p.m. on November 22. The flow during the period was about 600 gallons a minute with a drawdown of 39.6 feet. Perhaps the most significant result of this test was the absence of any measurable effect on any of the wells to the northwest although the four wells in that direction are no more distant than wells which were affected in other directions. These results indicate that aquifers are not continuous between the Brinkerhoff well and the wells to the northwest, which are in the Pavant district. The permeability at the Brinkerhoff well as determined by the graphical method is about 1,500 gallons per day per square foot, assuming the aquifer to have a thickness of 43 feet, similar to that in well (C-21-5)17bdd2.

Three of the wells used in determining permeability are located near the center of the Flowell district and in all three tests the permeability was about 1,500 gallons per day per square foot. Here the Flowell district is about 6 miles wide, the total thickness of the aquifers as determined by well logs is probably at least 100 feet and the average hydraulic gradient in the non-irrigation season is about 15 feet per mile. Using these approximate figures, the yearly inflow of artesian water to the Flowell district is at least 15,000 acre-feet and may be somewhat greater due to steepening of the gradient in the irrigation season, when interference effects prevent accurate determination of the piezometric surface.

GROUND-WATER INVENTORY

The means by which water is added to or discharged from the Pavant Valley ground-water reservoir have been outlined in preceding pages: increments are received by seepage from streams, irrigation ditches, and irrigated tracts, by underflow through permeable rock materials in canyons and gullies, and by direct penetration of rainfall upon permeable ground; and water leaves the reservoir by discharge from wells and springs, transpiration and evaporation and by underground movement through permeable beds that extend westward beyond the limits of the valley. If the total yearly inflow to the reservoir exceeds the total outflow, ground-water storage increases, and conversely, if the annual inflow is less than the outflow, there is a decrease in storage, which is shown by a corresponding change of water levels in wells.

Quantitative estimates can be made with reasonable accuracy of some of the factors involved in the ground-water equation, but other factors can be eestimated only within rather wide limits because of the inadequacy of available data. More information has been obtained concerning the ground water in the Chalk Creek alluvial fan, embracing the Fillmore and Flowell districts, than for the rest of the valley; the inventory of ground water in that fan is derived from these data, and rough estimates for the other districts are thereafter made on the basis of meager data, and analogy with the Fillmore and Flowell districts.

FILLMORE AND FLOWELL DISTRICTS

Estimate of inflow. The principal inflow to this area is provided by Chalk Creek, which discharged 32,900 acre-feet in 1944, with rainfall at Fillmore 1 inch above normal, and may be assumed to discharge about 32,000 acre-feet when rainfall is normal. Pine Creek, North Canyon, and other canyons not tributary to Chalk Creek have about 30% of the drainage area of Chalk Creek, most of which, however, is on the lower and intermediate portions of the Pavant Range. Flow and underflow in these canyons, plus underflow in Chalk Creek, is estimated to be about 25% of the measured discharge of Chalk Creek, giving a total estimated drainage from the Pavant Range of about 40,000 acre-feet in a normal year. Direct penetration of rainfall may occur over most of the Fillmore district, where surface materials include a considerable proportion of permeable sand and gravel. Farther west, in the Flowell district, very little if any rainfall is presumed to enter the ground-water reservoir, because of the prevalent fine-textured materials at the surface, and this water would in any case not reach the artesian aquifers but would remain in the shallow zone of unconfined water. Precipitation upon the Fillmore district would be about 35,000 acre-feet in a normal year. Thus the total water falling on or flowing into the area of recharge of the ground-water reservoir in the Fillmore and Flowell districts is of the order of magnitude of 75,000 acre-feet per year when the rainfall is average.

Only a minor fraction of this water actually enters the ground-water reservoir, because large quantities are transpired by plants and evaporated from soils. A rough estimate can be made of the proportion which enters the ground-water reservoir by comparison with total outflow during years of normal precipitation. 1938 was a year in which precipitation at Fillmore was slightly below normal, and it followed a year when precipitation was approximately normal. In the absence of any stream-flow records, it is assumed that the total amount of water available to the area was approximately as deduced above for a normal year—40,000 acre-feet drainage from the Pavant Range, and 35,000 acre-feet precipitation upon the Fillmore district. The water level in the State well (C-21-5)21abal rose to approximately the same maximum in the spring of 1939 as in 1938, indicating that there was no significant change in storage in the artesian reservoir (a similar condition in the overlying shallow-water reservoir is assumed on the basis of reports that these shallow-water levels remain fairly constant or fluctuate through small ranges). Therefore the total inflow to the ground-water reservoir during the year must have been approximately equal to the total discharge from the reservoir. As detailed in following paragraphs, the discharge from the ground-water reservoir in 1938 is estimated to have been 12,700 acre-feet from flowing wells, 1,000 acre-feet by evapo-transpiration, and probably about 12,000 acre-feet from Clear Lake Springs. Thus the total flow into the reservoir was about 26,000 acre-feet, or about ⅓ of the total quantity of water flowing into and falling on the recharge area.

Discharge from artesian wells. Between 1928 and 1943 the discharge of the majority of wells in the Flowell district has been measured a dozen times during irrigation seasons. These measurements appear in an accompanying table. Several wells were missed during each period of measurements, but their discharge in most cases can be estimated with fair reliability by comparison with records of adjacent wells, or with records of the particular well for other periods. These estimated flows are included in the estimated total flow which appears at the bottom of the tabulation. The total estimated discharge based on these series of measurements, has ranged from 16,000 gallons a minute in May 1929 to 10,500 gallons a minute in September 1939; in each irrigation season the discharge is greater in the early months (April and May) and decreases to a minimum in July, August, or September.

Comparison of the total estimated discharge with the water level in the State well (C-21-5)21abal at the time of the discharge measurements reveals a close relationship. If the total discharge is plotted graphically against the

Measured Discharge, in Gallons a Minute, of Artesian Wells in the Flowell District

Well No.	May 1928†	July 1928†	May 1929†	June 1930†	Sept. 1930†	Sept. 1931†	June 1938‡	June 1939‡	Aug. 1939‡	Sept. 1939‡	Apr. 1941‡	Sept. 1943§
(C-21-5)16adal	....	....	....	....	....	....	10	0	0	....	....	....
bcbl	....	....	....	....	....	....	75	60	35	35	260	....
bccl	15	....	....	....	....	....	....	....	....	....	70	125
bcc2	....	....	....	....	....	....	70	75	45	55	330	100
cabl	25	0	....	....	....	....	....	....	....	....	....	....
cdcl	175	75	50	10	....	....	....	....	....	....	....	....
17adcl	....	....	....	....	....	....	....	125	120	120	145	135
addl	....	....	490	....	....	....	335	330	....	....	....	255
add2	....	....	....	....	....	....	....	105	....	....	135	65
bdal	....	....	380	370	....	320	275	265	270	....	340	320
bddl	340	310	320	230	220	190	230	205	190	180	230	220
bdd2	....	285	230	210	210	170	....	80	90	85	100	120
cabl	380	285	270	250	230	230	215	210	175	170	205	185
ccdl	190	120	120	120	120	120	110	100	100	100	140	....
cdal	....	....	....	....	....	....	80	195	185	190	195	185
cddl	360	....	310	310	....	200	205	180	190	190	205	195
dadl	280	190	200	200	140	200	170	155	165	165	....	190
dbdl	280	....	....	....	....	....	200	190	185	175	....	200
dddl	410	....	....	....	....	....	200	170	150	160	....	....
18adal	....	....	....	200	....	....	20	15	10	15	....	15
addl	115	120	70	70	70	70	45	45	30	25	....	25
dad2	115	120	120	95	80	80	40	55	70	70	....	60
ddal	370	310	290	270	220	200	120	100	105	105	....	165
dddl	30	....	50	0	0	0	100	55	55	51	45	10
19aadl	170	140	140	140	140	130	135	110	105	100	....	110
adal	60	40	55	55	50	40	....	60	45	50	....	50
daal	390	360	....	....	280	270	240	220	....	....	240	110
daa2	....	....	....	....	....	....	40	35	30	35	....	25
dcdl	55	35	....	15	....	45	50	45	35	40	....	30
dcd2	35	....	....	15	....	....	....	70	75	75	85	70

Measured Discharge, in Gallons a Minute, of Artesian Wells in the Flowell District—(Continued)

Well No.	May 1928†	July 1928†	May 1929†	June 1930†	Sept. 1930†	Sept. 1931†	June 1938‡	June 1939‡	Aug. 1939‡	Sept. 1939‡	Apr. 1941‡	Sept. 1943§
(C-21-5)20aaa1	290	240	440	380	420	330	....	220	180	180	290	280
aadl	460	385	320	320	280	270	300	310	260	245	345	285
abal	....	....	270	....	....	....	230	230	210	210	....	210
addl	310	220	220	220	220	170	175	170	145	155	200	185
babl	140	70	140	120	115	105	65	60	65	65	90	65
bad1	220	190	200	200	200	200	160	150	130	135	160	....
bdal	....	....	....	....	....	....	160	170	150	150	215	160
bddl	190	170	170	170	140	140	150	135	135	135	155	145
cbdl	140	120	140	115	110	140	110	110	105	105	....	120
ccal	190	170	200	200	170	120	175	160	170	160	175	180
dad1	230	210	210	210	180	160	200	190	160	165	215	210
ddal	540	480	500	500	450	420	430	370	325	295	435	410
dda2	95	50	60	60	50	30	15	20	25	20	30	40
21bbal	210	150	115	115	145	....	80	....	....	....	165	105
cbal	240	180	150	150	115	100	55	100	75	65	210	185
cba2	215	150	150	150	115	85	95	85	65	65	175	140
29aaal	190	140	70	120	140	120	110	115	105	105	140	100
aab1	220	170	170	190	170	140	150	130	....	....	125	115
aacl	230	210	210	210	170	160	140	155	135	140	175	165
aadl	330	300	260	260	230	210	225	240	215	210	255	185
aad2	280	250	270	270	230	230	175	175	155	155	230	240
abal	250	160	210	210	210	180	180	165	140	145	200	160
baal	130	130	120	120	95	80	....	90	100	95	135	105
bddl	180	150	145	145	150	140	120	120	130	120	140	110
caal	140	120	120	120	120	115	110	110	115	105	130	115
cadl	300	285	300	270	250	250	300	230	215	200	245	200
cddl	380	285	340	380	340	290	....	....	....	....	150	290
dcal	440	440	....	....	....	....	270	255	200	210	290	....
dcdl	330	330	375	....	....	....	270	225	210	215	275	240
dddl	420	420	460	375	....	....	....	....	....	....	....	250

Measured Discharge, in Gallons a Minute, of Artesian Wells in the Flowell District—(Continued)

Well No.	May 1928†	July 1928†	May 1929†	June 1930†	Sept. 1930†	Sept. 1931†	June 1938‡	June 1939‡	Aug. 1939‡	Sept. 1939‡	Apr. 1941‡	Sept. 1943§
(C-21-5)30ada1	125	125	120	120	120	120	65	75	80	80	100	85
daa1	...	...	...	...	...	...	...	50	50		80	55
dadl	90	70	75	75	75	...	55	55	55	55	70	60
dbcl	...	...	...	120	120	110	60	60	55	65	125	70
dbdl	...	...	...	...	...	...	90	85	95	95	125	105
31acbl	...	...	...	...	...	...	25	35	25	25	...	25
cdal	...	230	220	220	180	...	...	160	165	...	210	195
cddl	...	...	...	...	...	...	150	...	...	...	280	160
32aadl	...	280	355	350	...	...	135	130	105	110	155	125
acbl	...	...	...	...	...	...	...	...	95	95	100	85
bcbl	250	180	210	210	160	...	90	100	100	100	115	105
bcdl	...	...	...	...	...	...	110	100	105	100	140	100
ccdl	...	...	...	...	...	...	415	260	270	270	330	300
ddal	...	...	...	...	...	...	...	130	...	...	175	175
33bcbl	...	420	415	...	...	...	215	170	125	135	220	240
bccl	...	...	...	...	...	...	10	10	5	5	10	5
bcc2	...	...	30	30	...	...	55	235	190	195	275	190
cdcl	...	...	310	240	...	...	...	...	...	...	...	155
dccl	...	...	...	...	...	...	...	490	490	490	...	...
(C-22-5)5acal	...	...	...	...	...	...	...	...	20	20	...	40
bba1	...	...	...	...	...	...	400	380	370	320	325	305
bcal	...	...	...	...	...	...	270	...	345	285	340	315
bcd1	...	...	...	...	...	...	...	...	...	...	...	20
6acdl	...	...	...	...	...	...	...	...	15	10	...	...
Estimated total discharge of all wells in Flowell district	17,200	16,500	16,000	15,200	13,900	12,800	12,300	11,400	10,800	10,500	14,600	12,200
Water level in State well (C-21-5)21abal at time of measurements (feet below land surface datum)				16.2	17.7	19.5	19.9	19.5	20.9	21.4	16.5	18.7

†Measured by Utah Agricultural Experiment Station.
‡Measured by Utah State Engineer.
§Measured by U. S. Geological Survey.

position of the water level in the well, the points fall approximately along a straight line, indicating a direct proportion between discharge and water level, so that for every foot of decline or rise in water level in the State well there is a respective decrease or increase of about 850 gallons a minute in the total flow from wells. The proportionality of this total flow with respect to the hydrostatic head in the State well suggests that that well furnishes a good index of changes in regional hydraulic gradient of the Flowell district. Available information is insufficient to demonstrate whether this approximately direct relationship between pressure head and flow during irrigation seasons holds throughout the range of recorded water levels in the State well. If it does, the discharge from all wells at the time of lowest recorded water level in that well—September 1935—would be about 8,000 gallons a minute; and in April 1945, when the water level in the State well was 16 feet higher than in September 1935, the total discharge would approach 21,000 gallons a minute, provided all wells in the district were flowing free throughout the month. However, such proportionality applies only if all wells are flowing freely and in any case cannot be assumed without further data as to the effect of friction in the wells, and more important, the effect of alternate methods of discharge from artesian aquifers as the pressure varies. Additional and more complete measurements of flow at various positions of the water level in the State well and at various times during irrigation seasons are needed to establish with certainty the value of that well as an indicator of artesian discharge from the district.

Since 1930 the water levels in the State well during the irrigation seasons have generally been within the range of depths (16.2 to 21.4 feet below land surface datum) that have been correlated with discharge measurements. The discharge of the artesian wells during irrigation seasons since that time, therefore, may be at least roughly estimated on the basis of the indicated direct relationship to these water levels, as given in the following table:

Estimated Discharge from Wells in Flowell District 1930 to 1945

Year	Average discharge (gallons a minute)	April to September 6-month total (acre-feet)	October to March 6-month total (acre-feet)	Annual total (acre-feet)
1930	15,000	12,100	3,500	15,600
1931	13,300	10,800	3,200	14,000
1933	9,900	8,000	2,300	10,300
1934	10,500	8,500	2,500	11,000
1936	10,100	8,200	2,400	10,600
1937	11,900	9,600	2,800	12,400
1938	12,100	9,800	2,900	12,700
1939	11,900	9,600	2,800	12,400
1940	11,300	9,100	2,700	11,800
1941	12,500	10,100	3,000	13,100
1942	14,600	11,800	3,500	15,300
1943	14,300	11,600	3,400	15,000
1944	14,000	11,300	3,300	14,600
1945	17,700	14,300	4,200	18,500

The winter discharge is based on Livingston and Maxey's estimate[12] that in the winter of 1943-44 the total flow from wells in the district averaged 4,200 gallons a minute, which amounts to 3,400 acre-feet in the 6-month period. It is assumed that the winter flow each year would be proportional to the flow during the irrigation season, and would increase as artesian pressures increase, or decrease as they decline. The annual estimated discharge has averaged about 13,400 acre-feet during the 14 years covered by these estimates, which is about 20% of the quantity estimated to be available for recharge in normal years.

Subsurface discharge from artesian aquifers. Livingston and Maxey[13] estimated that in April and May 1943, artesian wells in the Flowell district were discharging about 600 gallons of water a minute through perforations or leaks into the shallow zone of unconfined water. This leakage doubtless increases during the non-irrigation season when most wells are capped and artesian pressures are greater. Nevertheless, the total annual loss is small, and is estimated to be not more than 1,500 acre-feet per year. The loss can be eliminated by repair of the leaking wells.

Some water undoubtedly moves upward from the artesian aquifers through the overlying beds of clay, and eventually reaches the shallow zone of unconfined water, especially in the eastern part of the artesian reservoir

[12] Livingston, Penn. and Maxey, G. B. Underground leakage from artesian wells in the Flowell area near Fillmore, Utah: Utah State Engineer Technical Publication No. 1, p. 31, 1944.
[13] Ibid, p. 31.

where sediments are prevailingly coarser because of the lesser distance to the mountain front. Although no experiments have been conducted in Pavant Valley, Israelsen and McLaughlin[14] have demonstrated that water moves upward from artesian aquifers under similar conditions in another valley in Utah, and that the overlying compact clays are therefore not absolutely impermeable although they are far less permeable than the gravel and sand of the artesian aquifers. The quantity so lost from the artesian reservoir is not known, but it is possible that a substantial contribution is made to the shallow reservoir, greatest when artesian pressures are highest and decreasing as pressures decline. The loss is not preventable while artesian pressures exist; the water may be partly recovered, however, by pumping from the shallow zone of unconfined water.

Some water may also leave the artesian reservoir by movement westward through the aquifers and entry into the Sevier Desert basin. The quantity involved is considered to be small for several reasons. First, the aquifers are known from well logs to be composed of progressively finer materials from east to west across the Chalk Creek fan; textures may be presumed to become still finer farther west, until silt and clay-sized particles predominate. Second, the existence of high artesian pressures in the Flowell district is indicative that there is no sizable outlet for these aquifers to the west. Third, several wells have been drilled in the Sevier Desert basin west of the Flowell district near Clear Lake railroad station deep enough to intercept the equivalent of the Flowell artesian aquifers; these wells yield little water either by pumping or artesian flow, suggesting that very little water can move through the strata and that the artesian pressure is largely dissipated in the fine-grained materials.

There remains the possibility that the artesian aquifers may furnish by westward movement under the lava flows some of the water that is discharged at the Clear Lake springs. The source of the water in these springs could not be determined from the data collected during the present investigation. A detailed study of the Clear Lake area, to determine direction and rate of movement of water and fluctuations in spring discharge, must be made before estimates can be made of the amounts of water derived respectively from shallow or artesian sources.

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[14] Israelsen, O. W. and McLaughlin, W. W. Drainage of land overlying an artesian ground-water reservoir. Utah Agricultural Experiment Station Bull. 259, 31 pp., November, 1935.

The shallow ground-water reservoir. The shallow zone of unconfined water in the Flowell district represents a collecting ground for water from various sources. Part of the water moves westward from the Fillmore district in stream channels or irrigation ditches, or underground through permeable materials overlying the clay beds that roof the artesian aquifers. Part moves upward from the deeper artesian aquifers and through intervening beds of fine-textured material, and some may also move downward from the land surface due to deep penetration of rainfall or excessive irrigation. The quantities of inflow involved are not measurable except by exhaustive study requiring considerable time and equipment, which is not warranted at present because no economic use is made of this shallow water.

Throughout most of the Flowell district the shallow water is too deep to discharge water by evaporation from the water table, but in the western part of the area some water may be discharged by transpiration. White[15] estimated in the Escalante Valley, Utah, that annual transpiration losses amounted to about 2 acre-inches per acre in areas covered by greasewood, rabbit brush, and shadscale where the water table was more than 8 feet beneath the land surface. At this rate, the loss by transpiration in the Flowell district would be somewhat less than 1000 acre-feet a year.

The principal means of discharge of the shallow water appears to be by westward movement into the volcanic materials bordering the valley. An adequate outlet is available, for large inflows such as the flood flow of Chalk Creek into the "Sink" are quickly drained away, and no artesian pressure is built up in the portions of the shallow zone that are overlain by impermeable clays. Because of the ease of westward discharge, it is postulated that the shallow water constitutes the principal source of Clear Lake springs, which probably discharge about 10,000 to 15,000 acre-feet a year.

MEADOW DISTRICT

The discharge of Meadow Creek averages about 20% of that of Chalk Creek and is estimated to average about 7000 acre-feet yearly. Walker Creek and other canyons tributary to the Meadow district have about 50% of the

[15] White, W. N. A method of estimating ground-water supplies based on discharge from plants and evaporation from soil; U. S. Geol. Survey Water-Supply Paper 659-A, p. 87, 1932.

drainage area of Meadow Creek. It is estimated therefore that the total inflow to the Meadow district from the Pavant Range is about 25% of that which enters the Fillmore district, or 10,000 acre-feet in a normal year. Precipitation on the upper part of the Meadow district would amount to about 7,000 acre-feet in a normal year, so that the total water flowing into or falling on the recharge area of the ground-water reservoir in the Meadow district would average about 17,000 acre-feet a year.

According to measurements by the State Engineer, the rate of discharge of artesian wells in the Meadow district was about 1,700 gallons a minute in August and 1,600 gallons a minute in September, 1939. In September 1943 the wells discharged at a rate of about 2200 gallons a minute. This is 15 to 18% of the rate of discharge from wells in the Flowell district in the same periods. The total flow during the 1939 irrigation season is estimated to have been about 1,500 acre-feet and the yearly total to have been something less than 2,000 acre-feet. Assuming that natural conditions, well construction, and the practices of well owners in the Meadow and Flowell districts are roughly comparable, the annual discharge from wells in the Meadow district may be estimated by analogy to have ranged from 1500 to 3000 acre-feet in recent years. Water in artesian aquifers which is not discharged from wells in this district moves northward into the Flowell district.

Shallow water is discharged over a large area in the western part of the Meadow district, by springs and seeps, and by transpiration and evaporation. The flow from many of the easternmost springs enters the Meadow Slough, which has a discharge of 4 to 5 second-feet where it leaves the Meadow district, or an annual runoff of 3000 to 3500 acre-feet. Numerous springs and seeps farther west discharge water over the surface of a broad meadowland and playa area, where it disappears by evaporation and transpiration. No attempt was made to measure these springs, but it is estimated that evapo-transpiration losses in the western part of the Meadow district may total about 4,000 acre-feet a year, based on White's conclusions that yearly evapo-transpiration is about 5 acre-inches per acre for lowlands occupied chiefly by greasewood, rabbit brush and shadscale with water less than 8 feet below the surface, and 12 acre-inches per acre for meadowlands occupied by salt grass and pickleweed with depth to water less than 5 feet.[16]

[16] White, W. N. op. cit, pp. 86-87.

KANOSH AND HATTON DISTRICTS

The discharge of Corn Creek is estimated to average about 60% of that of Chalk Creek, or about 18,000 acre-feet in a normal year. The flow of Sunset and Cottonwood Creeks, Dry Wash and smaller intermittent streams, plus underflow in all canyons, is estimated to average an additional 7,000 acre-feet annually. Precipitation upon the higher parts of the district, where coarse, permeable sediments predominate, may amount to about 12,000 acre-feet. Thus the total water available to the recharge area of the ground-water reservoir is about 37,000 acre-feet in a normal year.

Four wells have been pumped for irrigation in the Hatton district to supplement irrigation water from streams and they are used chiefly in dry years. Annual discharge from these wells probably does not exceed 500 acre-feet, and in years of greater than normal rainfall and runoff practically no water is pumped.

No attempt was made to measure the discharge of all the numerous springs and seeps in the western part of the Hatton district. Warm Spring has a fairly constant flow of about 35 gallons a minute, and Devils' Ridge Spring varies from a seep in early spring to 150 gallons a minute in midsummer. The flow of these and other springs is dissipated in an area of shallow ground water where discharge by evapo-transpiration is large. Based on White's figures the total loss from this area is considered to be about 3,000 acre-feet a year.

PAVANT DISTRICT

No major stream enters this district but the portion of the Pavant Range tributary to it exceeds 50 square miles, chiefly at intermediate altitudes, although several peaks along the range crest exceed 9,000 feet altitude. The annual inflow to the district from this range is estimated to be 10,000 to 15,000 acre-feet. Precipitation upon the extensive bajada at the base of the range may total an equal amount in a normal year.

According to measurements by the State Engineer between November 1937 and May 1941, wells in the Pavant district yield water at the rate of 900 to 1100 gallons a minute. Of the 67 flowing wells, one—the Turner well (C-20-5)9daal—discharges 150 to 200 gallons a minute, and nine others each flow 20 to 100 gallons a minute. The remaining 57 wells discharge a total of only 350 to 400 gallons a minute; most of these are allowed to flow throughout the year for stock-watering and waste. The total yield of wells in the Pavant district is estimated to be about 1000 acre-feet a year.

The rest of the water that enters the ground-water reservoir in the Pavant district is presumably discharged by evapo-transpiration in the western part of the district, or by westerly movement toward the Sevier Desert basin. No data are available upon which to base an estimate of the quantities of water so discharged.

SUMMARY

The outflow on the ground-water reservoir in Pavant Valley is summarized in the following table, based on estimates as developed in preceding paragraphs.

Estimated Average Annual Outflow of Pavant Valley Ground-water Reservoir

(Quantities in acre-feet)

	Fillmore and Flowell Districts	Meadow District	Kanosh and Hatton Districts	Pavant District	Total
Discharge from wells	13,400	2,200	500	1,000	17,100
Discharge from springs		3,300	†	‡	3,300+
Discharge by evapo-transpiration	1,000	4,000	3,000	‡	8,000+
Discharge underground to Sevier Desert		15,000			15,000
Total discharge					43,400+

†Included in total discharged by evapotranspiration.
‡Not estimated.

The total water flowing into and falling on the recharge areas of the ground-water reservoir in the valley is estimated to be about 140,000 acre-feet per year. However, as previously pointed out and as indicated by the preceding table, only about one-third of this water actually reaches the reservoir. The remainder is evaporated from the soil zone and transpired by plants.

WELLS IN PAVANT VALLEY

HISTORY OF DEVELOPMENT

The streams issuing from the canyons of the Pavant Range have been of paramount importance in the development of Pavant Valley, for they have furnished water for domestic use, stock-watering, and irrigation of crops. Beginning with the settlement of Fillmore in 1851, the principal towns were located near the base of the mountain range along these streams, water was diverted for irrigation of adjacent cultivated fields, and the remainder of the valley was used principally for pasture. Water for domestic use was obtained originally from streams, but subsequently the several towns have constructed pipelines to springs located near the base of the range or in the canyons of the principal streams.

By 1908[17] there were approximately 50 wells in Pavant Valley, chiefly in the villages of Holden, Meadow, and Hatton. All of these were dug or drilled to the shallow zone of unconfined water, and were used primarily for stock-watering or domestic purposes. Irrigation had been attempted from one of these wells, dug 40 feet deep in the Pavant district about 4 miles west of Holden, but was apparently unsuccessful. Between 1911 and 1914 seven wells were drilled in the eastern part of the Flowell district, which yielded small quantities of water by artesian flow.

The first artesian well to yield water in sufficient quantities for irrigation was drilled in 1915 on the Brigham Tompkinson ranch in the Flowell district. This well, No. (C-21-5)21cbal, drilled 279 feet deep, is reported to have discharged about 600 gallons a minute through its 7½-inch casing. Following this successful development, twelve additional wells were completed by the end of the year, and by the end of 1922 there were 65 flowing irrigation wells in the Flowell district, chiefly in the northern and eastern parts. In succeeding years the development was extended to the southwest, and by 1931 practically all the existing wells had been completed.

The artesian pressures and rates of flow declined sharply as new wells were drilled, and by 1927 some of the wells along the eastern edge of the Flowell district—including the Bartholomew well (C-21-5)21abal—had ceased to flow. The flow of the Tompkinson well (C-21-5)21cbal decreased from an initial 600 gallons a minute in 1915 to 180 gallons in July 1928 and to 100 gallons a minute in September 1931. The decrease of artesian pressures is shown by the record of the State well (C-21-5)21abal from 1929 to 1931 (fig. 8), when the yearly maximum water levels declined more than 8 feet, although precipitation in the valley was only slightly below normal. In order to prevent further decline and ultimate loss of artesian flows,

[17] Meinzer, O. E., op. cit. pp. 86-94.

the well owners of the district, organized in 1935 as the Flowell Water Users' Association, have worked first with county authorities and later with the State Engineer to prevent winter waste from existing wells and to protect existing rights by restricting further development. As a result, only 3 wells have been drilled in the Flowell district in the last 10 years, and the water from those wells is used only for stock watering and domestic purposes. Through agreement among the members of the Water Users' Association, wells in the Flowell district are not pumped, except that well (C-21-5)21bbal, one of the early wells located along the edge of the area of artesian flow, is pumped intermittently during the summer. All other irrigation wells flow by artesian pressure. Generally the water from two or three wells is impounded in shallow earth-banked reservoirs until the quantity is sufficient to provide an "irrigating stream." This water is then released to irrigate individual fields. The soil in the southwestern part of the district is too poor for most crops, and water from wells in that area is transferred to fields several miles to the north.

Development in other parts of Pavant Valley has paralleled that of the Flowell district. In the Meadow district half a dozen irrigation wells were drilled during 1915, and by 1920 there were more than 20 flowing wells in that area. Flows from these wells were generally smaller than those obtained in the Flowell district, and most of the wells were used chiefly for stock watering, the discharge of Meadow Creek being sufficient for irrigation in most years. In the Pavant district also, several flowing wells were completed prior to 1920, although the majority were drilled in the following decade. Only nine wells are located in the Fillmore district; most of these were dug or drilled prior to 1928, and they are used only for domestic purposes or stock watering. In the Hatton district, five wells have been drilled for irrigation by pumping, the first being completed by the Drought Relief Administration in 1934. These have been used to advantage to supplement supplies from streams, but have remained idle much of the time during years of abundant rainfall.

STATUS OF DEVELOPMENT IN 1945

All known wells in Pavant Valley are listed in the accompanying tabulation. Of the 297 listed, 113 are in the Flowell district, 109 in the Pavant district, 34 in the Meadow district, and 30 in the Hatton district. About 110 are used primarily for irrigation, and all but 5 of those are wells 6 to 8 inches in diameter which yield water by artesian flow. About 150 wells are used primarily for stock or domestic purposes, of which about 50 are equipped with windmills, or hand or electric pumps, and most of the remainder flow by artesian pressure. About 40 wells are unused or abandoned.

The methods of well construction in the Flowell district have been described by Livingston and Maxey and details concerning the source and underground leakage of water from individual wells have been presented.[18]

POSSIBILITIES OF FURTHER DEVELOPMENT

The estimates of the total ground-water discharge from Pavant Valley (pages 68-80) indicate that less than half is discharged from wells, and only about one-third is put to economic use. The importance of utilizing more fully the underground storage possibilities of the valley is accentuated by the fact that there are no favorable sites for surface storage of the flood waters of the streams. Fuller utilization of the ground-water resources of the valley may be achieved by (1) increasing the inflow to the ground-water reservoir; (2) eliminating the waste of water from existing wells; and (3) reducing the amount of water which is currently discharged by springs, evapo-transpiration, and movement out of the valley.

Inflow to the ground-water reservoir, and particularly the artesian reservoir, may be increased by increasing the proportion of stream-flow spread over the higher slopes of the bajada along the eastern margin of the valley. Utilization of flood waters on these slopes to produce crops that do not require later irrigation will provide greater recharge to the artesian reservoir, and thus permit a larger percentage of the lower areas to be irrigated from wells.

The elimination of waste from existing wells can be achieved at very little expense if all well owners will expend the effort, and will result in a saving of about 3,500 acre-feet a year if existing wells are adequately controlled, and an additional saving of about 1,600 acre-feet a year if leaking wells are repaired and controlled. This water could then be put to economic use. It is conceded that stopping of the winter flow from all wells will raise artesian pressures somewhat and induce some increase in natural discharge, but a large proportion of the water saved will be returned in higher rates of flow when the wells are opened in the

[18] op. cit., pp. 6-31.

following spring and summer. The State Engineer has offered to provide equipment to assist well owners in plugging wells that leak badly around the casing and to permit construction of replacement wells. In this manner, several wells of dubious value can be exchanged for productive wells which will permit full economic use to be made of their flow.

Natural loss of water from artesian aquifers by westward movement out of the valley or by upward movement through the confining clay beds can be reduced only by reducing artesian pressures. This can be accomplished by increasing the number of wells or by pumping the existing artesian wells, which will eventually result in cessation of discharge by natural flow. The residents of the valley can thus obtain a greater yield of water from wells, but must probably bear the expense of pumping the bulk of it. Pumping from a small number of large irrigation wells near the flow line where the materials of the aquifer are most permeable, and use of existing flowing wells for domestic purposes only, would make for more efficient use of the water by eliminating the need for storage ponds where transpiration losses are high, and by providing water in sufficient quantities for rapid irrigation methods.

It is believed to be possible to develop successful irrigation wells by pumping from the shallow water zone. The permeable lava and associated gravel beds at a depth of about 60 feet in the Flowell district offer sufficient promise to be worthy of a test. Pumping the shallow water in that district would salvage water which has been lost to the artesian reservoir by upward movement. Lowering the water table would increase the flow upward from the artesian reservoir and thus decrease the artesian pressure, but this decrease would presumably be small and probably not discernible.

In the Hatton district a part of the shallow water may recharge the artesian aquifers of the Meadow district, but inasmuch as large quantities of the shallow water from the Hatton and Meadow districts move westward to be discharged in the spring and seep area south of White Mountain, it appears that much greater utilization of that water for irrigation in the Hatton district is possible.

Wells in Pavant Valley

Well Number	Owner or Name	Claim or Application Number	Date Completed	Depth of Well (feet)†	Diameter of Well (inches)	Altitude of Land Surface Datum	Water Level: Above (+) or below (—) Land Surface Datum	Water Level: Date of Measurement
		Pavant District						
(C-19-4) 31acd1	Stephenson and Hurst	C-19445	....	30	2		—	
31bcc1	Union Pacific R. R.	C-4263	1923	178	6	4778	—17.2	2-12-40
31dbb1	Federal Land Bank	C-8475	1930	200	4		—	
(C-19-5) 4aba1	Lawrence Clark	C-16402	....	......	6		—22.2	2-12-40
4dda1	Lawrence Clark	C-16405	1925	250	6		—33.2	2-12-40
20aca1	Cleveland Mitchell	C-12277	1934	315	2		+ 9.3	3- 2-43
20cda1	Cleveland Mitchell	C-12278	1934	371	2		+	
21bba1	Manhard and Paxton	C-12167	1922	217	6		+17.3	11- 9-37
21cbb1	Frank Badger	C-12166	1918	300	10		+	
21dda1	Frank Badger	....	....	......	8½		+ 7.3	11- 9-37
21ddd1	Frank Badger	....	....	......	8		+ 3.2	8-11-38
22acb1	State of Utah		....	......	4		—17.2	2-12-40
22ccb1	State of Utah	C-13814	1922	230	6		+	
25add1	L. C. Callister	C-19967	....	......	8		—	
26ccc1	J. A. Stevens	C-5687	1929	116	4		+25.5	11- 9-37
27cdb1	J. A. Stevens	C-5685	1929	192	4		+ 8.2	8-11-38
28aaa1	Frank Paxton	C-6584	1916	200	8		+	
28aaa2	Frank Paxton	C-6580	1925	180	8		+ 7.2	8-11-38
28aad1	Frank Paxton	C-6585	1927	185	8		+	
28bda1	Richard Nixon	C-11962	1920	220	10		+	
31cdb1	U. S. Grazing Service	....	1935	......	....			
33dcb1	Richard Nixon	C-11963	1928	265	4		+ ‡	
35cda1	J. A. Stevens	C-5686	1930	198	4		+ 6.4	3-23-40
35daa1	Kenney Bros.	C-7686	1918	294	8		+12.4	3-23-40
36bba1	Millard County	....	....	......	8		—13.3	11- 5-37
36cbd1	Kenney Bros.	C-7687	1921	187	6		+ 2.5	3-23-40
36ccd2	G. B. Kenney	C-17506	1921	180	6		+ 4.8	1-19-40

Wells in Pavant Valley—(Continued)

Well Number	Owner or Name	Claim or Application Number	Date Completed	Depth of Well (feet)†	Diameter of Well (inches)	Altitude of Land Surface Datum	Water Level: Above (+) or below (—) Land Surface Datum	Water Level: Date of Measurement
(C-19-5)36dca1	Ben Kenney	C-7690	1919	440	8		+	
(C-20-4) 6bcd1	A. W. Burton	C-17390	1930	154	6		—	
7bba1	Grant Stevens	C-19629	1931	98	5		—	
7bbb1	Marion Stevens	....	....	......	5		—	
7bda1	Ren Stevens	....	....	......	48		—25.7	11- 6-37
7cab1	Millard County	....	....	......	6		—	
7cca1	Hart Johnson	....	....	......	....		—25.7	10-12-39
11bda1	E. T. DeWitt	C-19630	1898	......	....		—	
(C-21-4) 7bbc1	A. M. Brunson	C-17867	1888	73	6		—	
10bdd1	C. H. Day	C-19632	1932	42	24		—	
(C-20-5) 1baa1	Kenney Bros.	C-7689	1921	213	4		+ 5.5	3-23-40
1caa1	G. W. Kenney	C-19719	1921	184	6		+	
1dca1	G. W. Kenney	C-19720	1922	178	6¼		+	
2aba1	Kenney Bros.	C-7688	1920	187	8		+ 1.4	3-23-40
2ada1	Hunter Bros.	C-12174	1915	182	6		+ 8.8	2-23-40
2baa1	J. B. Stephenson	C-11965	1921	190	4		+ 7.1	2-24-40
2daa1	Kenney Bros.	C-17507	1920	182	6		+ 7.1	3-20-40
2ddd1	Kenney Bros.	C-7691	1924	197	5		+10.2	3-20-40
3bdd1	Richard Nixon	C-11964	1924	......	6		+18.1	3-20-40
4adb1	Marion Nixon	C-4728	1925	220	6		+32.1	3-16-40
9acc1	J. A. Stevens	C-5684	1929	231	4		+29.0	3-19-40
9ada1	W. E. Turner	C-4732	1924	211	5		+26.2	12-19-39
9daa1	W. E. Turner	C-4731	1919	330	6¼		+37.6	3-19-40
10abb1	Alma Stevens	C-19515	1920	90	6½		+ 0.1	3-19-40
10ada1	Alma Stevens	C-4736	1919	......	5		+ 5.1	3-19-40
10bda1	Alma Stevens	C-4737	1916	347	7½		+48.4	3-19-40
10ccb1	Alma Stevens	C-19516	1920	80	4		— 0.3	3-16-40
10dbd1	John Wood	C-9087	1925	196	5		+21.8	3-19-40

Wells in Pavant Valley—(Continued)

Well Number	Owner or Name	Claim or Application Number	Date Completed	Depth of Well (feet)†	Diameter of Well (inches)	Altitude of Land Surface Datum	Water Level: Above (+) or below (—) Land Surface Datum	Water Level: Date of Measurement
(C-20-5) 11aaa1	Elmer Cummings	C-19633	1921	198	8		+11.5	3-19-40
11aad1	Elmer Cummings	C-19634	1930	213	6		+15.6	3-20-40
11bad1	Emily Wade	C-7676	1927	334	6		+ 3.8	3-19-40
11bad2	Emily Wade	C-7677	1922	296	6¼		+ 4.4	3-19-40
12bba1	State of Utah	C-10618	1933	245	6		+ 6.8	3-20-40
12dda1		....	....	......	4		—12.1	10-12-39
13dad1	C. H. Day	....	....	175	5		—47.0	2- 3-40
16dad1	Byron Stephenson	C-17694	1920	......	5		+10.8	3-18-40
17baa1	George Rowley	C-7670	1919	350	6		+18.0	2-20-40
21abc1	L. B. Smith	C-9064	1920	325	6¼		+ 5.0	3-18-40
21add1	M. S. Cummings	C-4720	1917	325	8		+ 7.1	3-16-40
21dad1	D. E. Peterson	C-13534	1918	339	5½		+ 9.8	3-16-40
21dbc1	D. E. Peterson	C-13532	1925	325	4		+14.2	4-14-41
21dbd1	D. E. Peterson	C-13533	1924	330	6		+14.5	4-14-41
21dcc1	Jane and Agnes Wilson	C-12172	1929	420	6		+17.4	2-19-40
22bcc1	Mary Rowley	C-7671	1919	400	5½		+ 6.6	2-12-40
22cbb1	C. H. Erickson	C-1407	1928	352	6		+ 4.9	3-16-40
22cbb2	C. H. Erickson	C-1408	1928	451	4		— 8.3	10-30-37
22cbb3	C. H. Erickson	C-1409	1921	435	4		— 6.8	3-16-40
24bad1		....	....	......	....		—	
26bcd1	Gene Ashby	C-17531	1917	200	6		—	
26bda1	John Starley, Jr.	C-4727	1923	62	6½		—	
26ccd1	W. J. Anderson	C-9917	1924	90	2		—	
26cdc1	C. H. Anderson	C-15412	1920	80	8		—	
27bcb1	C. H. Erickson	C-8203	1934	601	12		+ 7.8	3-18-40
27cbb1	John Roberts	....	1930	286	4	4672.06	+ 2.5	3-16-40
27dba1	Walter Paxton	C-17436	1926	190	5½		—	
28acb1	V. E. Wilson	C-12169	1926	380	4		+ 8.2	3-18-40

Wells in Pavant Valley—(Continued)

Well Number	Owner or Name	Claim or Application Number	Date Completed	Depth of Well (feet)†	Diameter of Well (inches)	Altitude of Land Surface Datum	Water Level: Above (+) or below (—) Land Surface Datum	Water Level: Date of Measurement
(C-20-5)28ada1	V. E. Wilson	C-12168	1937	350	5½		+ 3.6	10-29-37
28cdd1	C. W. Manhard	C-12173	1931	354	4	4658.95	+ 9.9	3-18-40
28daa1	J. W. Payne	C-7680	1923	330	4¾		+ 3.2	3-16-40
28ddd1	Arthur Gull	C-4011	1932	309	4	4665.6	+ 2.0	3-16-40
31dcd1	Dora Kiser	C-18736	1919	508	6	4633.93	+23.7	11-16-44
32aaa1	Otis Welch	C-6620	1926	490	6½	4640.1	+17.7	3-16-40
33ada1	C. A. Brunson	C-16682	1915	55	6		—	
33bba1	S. W. Smith	C-13657	1930	325	6	4648.5	+11.8	3-18-40
33bba2	S. W. Smith	C-13658	1930	325	5	4647.96	+12.7	2-16-40
33bda1	Robert Saguine	....	....	360	6	4651.05	+10.8	3-18-40
34aad1	Charles Lambert	C-17391	1898	115	6		—	
34acb1	H. S. Mitchell	C-18665	....	......	6		—22.5	11- 1-37
34bbb1	C. H. Lambert	C-17392	1925	300	6		— .07	3-16-40
35bab1	Morris Lambert	C-17549	1917	85	6		—	
(C-21-5) 1bdb1	M. S. Cummings	....	....	......	8		—	
3bbb1	Dal Huntsman	....	....	......	5	4677.51	—21.7	3-16-43
4ccd1	A. R. Beauregard	C-16536	1927	350	8	4681.49	—24.1	3-16-43
5cbc1	Andrew and Emery Rogers	C-7679	1915	412	7	4642.47	+16.3	3-16-43
5dbc1	M. A. Tompkinson	A-16131	1945	400	....	4652.06	—18.3	7-11-45
6dba1	D. V. Dimick	C-11967	1928	400	6	4636.21	+18.3	3-16-45
7ddc1	Ansel Robinson	A-15390	1944	324	4	4655.97	+ 9.8	9-21-44
8add1	Hazel Day	....	....	......	6	4688.29	—	
8bab1	State of Utah	C-16511	1924	455	6	4652.85	+ 5.7	1- 6-40
8bdc1	L. B. Owens	C-1374	1917	320	6	4661.41	+ 5.8	1- 6-40
8caa1	J. A. Robinson	C-16623	1914	513	8		+	
8cab1	Melvin Robinson	C-16622	1911	318	8	4668.85	— 5.6	3- 1-43
8ccc1	Wells Johnson	....	1943	272	3	4660.76	+ 7.0	7-15-43
8dbb1	Hazel Day	....	....	19	6	4679.61	—14.0	3- 1-43

Wells in Pavant Valley—(Continued)

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		Fillmore District						
(C-21-4) 7bbd1	Arthur Brunson	C-17867	1888	73	6	4909.85	—53.6	3-19-43
7cba1	Frank Partridge	....	....	69	36	4934.07	—53.9	3-19-43
9bbd1	John Carling	....	1943	160	6		—34.3	3-25-41
12bad1	T. C. Hatton	C-18478	1928	120	6		—76.7	3-17-43
12bdc1	Earnest Carling	....	....	63	8	4881.67	—45.1	3-29-43
27aaa1	O. L. Robinson	....	....	147	8	4825.64	—90.7	5-27-43
35bab1	W. H. Reay	....	1926	120	4	4836.32	—96.2	3-27-43
35cda1	C. A. Davies	C-12131	1926	120	4	4834.47	—95.3	3-19-43
(C-22-5) 2bca1	R. R. and M. S. Hoyt	....	....	134M	8	4839.59	—100.2	3-29-43
		Flowell District						
(C-21-5) 9cdc1	John Carling	C-6221	1916	300	7	4715.33	+ 9.9	3- 1-43
15aac1	State of Utah	C-13805	1919	450	6		—	
15dbb1	Martin Hansen	....	....	400	8	4785.58	—40.28	3-19-43
15dcc1	John Carling	A-12785	1938	114	6	4785.07	—	
16ada1	Frank Holbrook	C-17224	1928	109	6	4763.23	—36.0	3- 9-44
16bcb1	O. E. Brower	C-15148	1928	296 238M	6	4703.85	+19.0	2-15-41
16bcc1	O. E. Brower	C-15149	1928	230 138M	6	4705.36	+16.1	2-15-41
16bcc2	O. E. Brower	C-15150	1927	254	6	4706.34	+17.9	2-15-41
16cab1	O. E. Brower	....	....	335	6	4725.42	+ 2.7	2-15-41
16cdc1	J. C. Christensen	C-2560	1920	295	7¾	4722.26	+	
16dac1	Millard County	....	....	......	7	4748.87	—11.6	12-28-42
16dcc1	J. C. Christensen	C-17226	1916	280	6¼	4743.30	—11.7	2-29-40
17adc1	Provident Ins. Co.	C-8774	1917	324 236M	7½	4693.81	+24.4	2-15-41
17add1	Provident Ins. Co.	C-8776	1918	270	6¼	4697.07	+25.5	2-15-41

Wells in Pavant Valley—(Continued)

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(C-21-5) 17add2	Noall Bros. Farm Co.	C-8775	1918	268	6¼	4698.67	+ ‡	
17bda1	D. A. Brinkerhoff	C-4718	1928	344	6	4679.44	+39.6	4-10-43
17bdd1	D. A. Brinkerhoff	C-11209	1917	393M	6	4679.37	+40.9	2- 4-43
17bdd2	D. A. Brinkerhoff	C-11208	1928	371	6¼	4677.97	+40.0	11-20-43
17cab1	J. C. Christensen	C-2663	1922	430	6	4672.42	+35.8	2-17-41
17ccd1	H. A. Johnson	C-2664	1919	347	6¼	4672.12	+31.0	1-23-41
17cda1	J. C. Christensen	C-1375	1931	420	6	4676.66	+41.5	2-17-41
17cdd1	J. C. Christensen	C-1376	1919	315M	6¼	4680.82	+31.5	2-17-41
17dad1	S. A. Brower	C-3332	1917	305	6½	4701.60	+22.2	2-15-41
17dbd1	Provident Ins. Co.	C-8773	1928	306	6	4687.23	+34.5	2-15-41
17ddd1	J. A. Allen	C-4616	1925	281	6	4701.78	+23.4	3-11-41
18ada1	Ova Peterson	C-2667	1930	453	6	4664.88	+26.6	3-11-41
18add1	Ova Peterson	C-2217	1919	508	6	4663.10	+20.4	11-20-43
18dad2	Brinkerhoff Estate	C-7673	1918	425	6¼	4664.58	+14.1	3- 5-40
18dda1	E. C. Jackson	C-4714	1921	456	6¼	4668.52	+24.1	2-18-41
18ddd1	Nolin Jackson	C-4715	1918	376	6½	4667.87	+25.3	1-29-41
19aad1	Alonzo Huntsman	C-13528	1918	540 455M	6¼	4668.25	+35.1	1-12-41
19ada1	Alonzo Huntsman	C-13525	1918	350	5½	4667.92	+30.7	3-10-41
19daa1	Alonzo Huntsman	C-13526	1917	520 403M	8	4668.87	+ ‡	
19daa2	Alonzo Huntsman	C-13527	1915	520 232M	7½	4668.00	+27.8	3-10-41
19dcd1	T. C. Hatton	C-2665	1917	425 330M	7½	4664.48	+26.7	1-25-40
19dcd2	Samuel Utley	C-6228	1918	334M	7½	4663.27	+27.6	2- 1-40
20aaa1	Mary Robinson	C-150	1916	340	7½	4701.80	+27.4	2-28-41
20aad1	Mary Robinson	C-149	1918	272	6½	4701.10	+27.5	2-24-41

Wells in Pavant Valley—(Continued)

Well Number	Owner or Name	Claim or Application Number	Date Completed	Depth of Well (feet)†	Diameter of Well (inches)	Altitude of Land Surface Datum	Water Level: Above (+) or below (—) Land Surface Datum	Water Level: Date of Measurement
(C-21-5)20aba1	J. A. Allen	C-2219	1926	341	6	4690.55	+30.8	2- 8-41
20add1	J. L. Robinson	C-151	1917	296	6¼	4703.02	+26.8	2-28-41
20bab1	J. D. Bushnell	C-6333	1925	445	6¼	4671.99	+25.5	3-10-41
20bad1	J. D. Bushnell	C-6621	1921	395	6¼	4677.38	+39.3	3-10-41
20bda1	J. D. Bushnell	C-6623	1919	324	7	4681.18	+36.6	3-10-41
20bdd1	J. D. Bushnell	C-6622	1921	343M	6¼	4683.70	+36.3	2-26-41
20cbd1	F. M. Christensen	C-1378	1919	355	5½	4675.50	+38.8	2-26-41
20cca1	F. M. Christensen	C-1377	1925	563 488M	5½	4673.80	+36.4	2-26-41
20dad1	Millard County School	C-6992	1926	295M	6	4702.08	+29.0	2-28-41
20dda1	Oren Allen	C-3808	1915	335	7½	4705.93	+27.5	2-28-41
20dda2	Oren Allen	C-3809	1915	200 145M	7	4704.65	+15.0	2-24-41
21aba1	State of Utah	....	1917	246	6¼	4742.90	— 9.3	3- 1-41
21bba1	W. D. Tompkinson	C-7683	1918	292	7½	4716.30	+14.9	2-28-41
21cba1	Eleanor Tompkinson	C-7684	1915	279	7½	4715.55	+15.4	2-28-41
21cba2	Eleanor Tompkinson	C-7685	1915	256	7½	4715.71	+16.2	2-28-41
21dba1	A. E. Trimble	C-12960	1915	176	8		+ 3.8	12-29-42
22bbb1	Francis Melville	C-17508	1926	65M	6	4765.98	—37.3	3-19-43
22cdb1	Edward Davies, Jr.	C-7682	1913	74	6¼	4774.51	—	
22dbc1	Edward Davies, Jr.	....	....	230	6	4785.14	—45.0	3- 3-43
27ccc1	Adelia Robinson	C-13529	1915	200	8	4749.69	—11.4	3- 3-43
28dda1	Adelia Robinson	C-13530	1915	200	8	4746.74	—10.0	12-24-42
29aaa1	Samuel Utley	C-6225	1922	269M	6½	4699.46	+28.7	2-24-41
29aab1	Samuel Utley	C-6233	1922	336 302M	6	4696.97	+ ‡	
29aac1	Samuel Utley	C-6231	1922	336	6	4694.22	+35.1	2-24-41
29aad1	Samuel Utley	C-6223	1922	300	6½	4702.77	+26.9	2-24-41

Wells in Pavant Valley—(Continued)

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(C-21-5) 29aad2	Samuel Utley	C-6224	1922	334M	6	4702.90	+29.2	2-24-41
29aba1	Flowell Farms, Inc.	C-14346	1922	330	6	4691.81	+34.5	2-24-41
29baa1	Von Utley	C-6222	1919	224	6	4679.45	+33.9	2-26-41
29bdd1	Ras and May Rasmussen	C-2670	1916	320	7½	4687.07	+32.5	2-28-41
		....	....	207M				
29caa1	Ras and May Rasmussen	C-2669	1917	325	6¾	4686.89	+40.6	2-28-41
29cad1	Ras and May Rasmussen	C-2668	1926	450	6¾	4689.18	+37.9	2-24-41
29cdd1	J. C. Christensen	C-3334	1921	368	9½	4690.24	+ ‡	
29dca1	Flowell Farms, Inc.	C-14347	1927	380	6	4699.28	+33.2	2-28-41
29dcd1	Flowell Farms, Inc.	C-14348	1927	266	6	4699.30	+30.4	2-28-41
29ddd1	Flowell Farms, Inc.	C-14350	1927	277	6	4710.70	+21.9	2-28-41
30ada1	Samuel Utley	C-3299	1925	470	8	4669.34	+53.5	3- 8-41
30caa1	J. C. Christensen	....	1944	350	3		+30.9	11-15-44
30daa1	L. R. Stephens	C-3330	1930	437	6	4670.85	+48.3	3- 8-41
		....	....	322M				
30dad1	Zimmerman & Hunter	C-3301	1928	434	6½	4673.26	+44.4	3- 8-41
30dbc1	J. C. Christensen	C-3335	1929	304M	6	4665.74	+48.3	3- 8-41
30dbd1	John Carling	C-3333	1929	350	6	4667.15	+46.0	3- 8-41
		....	....	313M				
31acb1	Roy Sweeting	C-7674	1931	390	6	4668.37	+46.7	3- 8-41
31cda1	Samuel Utley	C-6235	1922	330M	6	4674.46	+39.0	3- 8-41
31cdd1	Samuel Utley	C-6236	1926	336	6	4676.85	+ ‡	
		....	....	252M				
32aad1	Flowell Farms, Inc.	C-14349	1927	296	6	4711.31	+21.0	3- 7-41
32acb1	Flowell Farms, Inc.	C-18884	1935	266	10	4694.42	+24.8	3- 7-41
32acc1	Flowell Farms, Inc.	C-18885	1935	256	10	4694.77	+ §	
32bcb1	H. F. Robinson	C-2666	1927	291	6	4680.40	+41.3	3- 7-41
				254M				

Wells in Pavant Valley—(Continued)

Well Number	Owner or Name	Claim or Application Number	Date Completed	Depth of Well (feet)†	Diameter of Well (inches)	Altitude of Land Surface Datum	Water Level: Above (+) or below (—) Land Surface Datum	Water Level: Date of Measurement
32bcd1	Flowell Farms, Inc.	C-3300	1931	310	8	4685.70	+35.4	3- 7-41
(C-21-5)32ccd1	John Allen	C-73	1927	284M	6	4691.50	+35.5	3- 7-41
32dda1	E. L. Hart	C-3297	1923	244	6½	4712.75	+19.4	3-26-41
33add1	Frank Sweeting	C-13535	1915	200	7½	4747.44	+	
33bcb1	Flowell Farms, Inc.	C-14343	1927	264	6	4711.70	+20.1	3- 7-41
33bcc1	Flowell Farms, Inc.	C-14345	1927	245	6	4711.20	+19.6	3- 7-41
33bcc2	Flowell Farms, Inc.	C-14344	1927	318	6	4711.20	+22.0	3- 7-41
33cdc1	John B. Tope	C-6335	1926	228	6½	4720.89	+ 8.4	12- 5-39
33cdd1	Andrew Dahlquist	C-11978	1916	134	5	4728.70	+	
33dcc1	Andrew Dahlquist	C-71	1915	200	8	4733.93	— 1.2	3-26-41
34baa1	Frank Sweeting	C-17381	1913	190	8	4772.87	—34.1	3- 3-43
34bbb1	W. E. Black	C-11977	1915	200	8	4748.80	—12.0	12-24-42
34bdd1	R. W. Sweeting	C-4722	1916	190	8	4777.87	—41.3	3-25-41
		....	....	126M				
34bdd2	Frank Sweeting	C-17382	1913	190	8	4777.87	—	
34ccc1	W. H. Reay	C-4723	1915	250	8	4756.09	—20.7	3-18-41
(C-21-6)25dab1	Ras Rasmussen	....	....	20M	36	4657.29	—13.7	3-17-43
36ddd1	U. S. Geol. Survey	....	1943	14M	2		— 8.7	9-24-43
(C-22-5) 4aba1	J. B. Tope	C-6336	1918	190	9	4736.56	—	
4baa1	J. B. Tope	C-6334	1931	10	60	4756.58	—	
4daa1	J. B. and LeRoy Davies	C-12961	1919	218	8	4755.83	—18.3	3-19-43
5aca1	J. B. Tope	C-11975	1920	248M	6¼	4708.40	+20.0	2-28-41
5bba1	R. A. Utley	C-6324	1928	280	6	4693.19	+34.7	3- 1-41
5bca1	R. A. Utley	C-6326	1928	288	6	4694.54	+33.5	3- 1-41
5bcd1	R. A. Utley	C-15852	1929	350	6	4695.20	+29.7	3- 1-41
6acd1	Samuel Utley	C-6232	1916	319	8	4688.67	+31.6	3- 1-41
		Meadow District						
(C-22-5) 4ccd1	Dell Hasler	C-2218	1926	284	6	4730.18	+ 3.0	3- 8-40

Wells in Pavant Valley—(Continued)

Well Number	Owner or Name	Claim or Application Number	Date Com-pleted	Depth of Well (feet)†	Diameter of Well (inches)	Altitude of Land Surface Datum	Water Level: Above (+) or below (—) Land Surface Datum	Water Level: Date of Measure-ment
(C-22-5) 4dcc1	Ed Elwin	....	....	.....	4	4743.0	+	
7bdd1	Leo Stott	C-11971	1915	390	7½	4693.66	+47.0	3- 1-41
7caa1	U. S. Geol. Survey	....	1943	13	2		— 7.9	8-25-43
7cad1	Leo Stott	C-11972	1915	176	7½	4698.18	+ ‡	
8aad1	Wilford Watts	C-11230	1924	325M	6		+ 7.3	2- 2-42
8cda1	R. E. Stott	C-10474	1919	270	8	4721.63	+13.0	3- 6-43
8cdd1	R. E. Stott	C-10473	1927	460	6	4723.90	—33.0	3-26-41
8cdd2	R. E. Stott	C-10475	1927	380	6	4722.40	+27.8	1- 2-40
9dbc1	Roy Sweeting	C-2232	1915	196	11	4751.32	— 3.8	3-19-43
10bbb1	Elmer Duncan	....	....	.....	5	4763.40	—28.9	11-19-37
17abd1	Stott and Ferguson	C-2220	1916	422	8	4732.67	+23.7	4-17-41
17acc1	Wm. Blake	C-3296	1926	375	6¼	4729.80	+29.8	3- 4-41
17acd1	L. N. Nickle	C-12112	1918	270	10	4736.96	+ ‡	
17bdd1	Wm. Blake	C-8202	1919	375	8	4726.90	+31.8	3- 4-41
17cdd1	Wasatch Loan & Livestock Co	C-15317	1916	260	8	4737.30	+23.4	3- 4-41
17dbd1	McBride & Wilson	C-12170	1919	350	7½	4740.09	+	
17dcd1	McBride & Wilson	C-12171	1921	350	7½	4740.44	+18.5	3- 4-41
19ddd1	Raymond Stott	C-12959	1926	216	8	4753.00	+12.2	3- 5-41
20aad1	G. H. Beckstrand	C-11970	1918	280	8	4759.29	+ 3.3	3- 5-41
20aba1	L. M. Nickle	C-12113	1921	263	7½	4742.45	+18.6	3 5-41
20abd1	State of Utah	C-7104	1920	260	7½	4743.38	+ ‡	
20acc1	Velma Stott	C-6626	1917	255	8	4748.40	+	
20acd1	Velma Stott	C-6627	1919	255	8	4748.6	+	
20acd1	Thelma Fisher	C-11974	1918	280	6	4756.44	+ 6.7	3- 5-41
20baa1	Isaac Stewart	C-7681	1915	260	8	4738.80	+22.7	3- 5-41
20bdd1	Charles Swallow	C-13531	1917	300	8	4745.46	+16.6	3- 4-41
20ccc1	R. E. Carlson	C-8642	1915	282	6	4752.10	+12.9	3- 5-41
20ccd1	P. L. Greenhalgh	C-5011	1925	282	7	4752.26	+12.7	3- 5-41

Wells in Pavant Valley—(Continued)

Well Number	Owner or Name	Claim or Application Number	Date Completed	Depth of Well (feet)†	Diameter of Well (inches)	Altitude of Land Surface Datum	Water Level: Above (+) or below (—) Land Surface Datum	Water Level: Date of Measurement
(C-22-5)20dbb1	P. L. Greenhalgh	C-5012	1925	280	8	4750.92	+12.1	3- 5-41
20dbc1	W. H. Reay	C-6332	1915	260	7½	4754.29	+ 6.8	3- 5-41
21bcb1	Clifford Stewart	C-20156	1917	350	8		— §	
21cdd1	M. H. Beckstrand	C-11969	1916	165	2½		—	
22adc1	Meadow Irrigation Co.		1934	155	8		—	
Hatton District								
28bcc1	H. N. Bushnell	C-7675	1924	70	8	4778.31	—18.0	3- 6-43
28cdb1	Claude Huff	C-6629	1921	60	6¼		—	
28dbd1	Charles Swallow	C-16860	1928	112	8	4812.47	—38.6	3-21-43
29cda1	Beckstrand and Bennett	C-11976	1926	85	8	4775.96	—11.5	4-19-41
29cdd1	O. E. Beckstrand	A-13159	1940	151	12½	4781.00	— 9.7	3- 6-43
29ddd1	E. J. Bushnell	A-13270	1940	175	12		—	
32abc1	Genevieve Paxton	C-6586	1926	275	8	4786.60	—	
32ada1	N. M. Stewart	C-20155	1908	130	2		—	
32dac1	Frank Paxton	C-19631	1912	185	8	4806.22	—34.9	1-19-41
32dad1	A. L. Kimball	C-17880	1924	116	4		—	
32dbd1	Frank Paxton	A-12492	1937	182	12		—	
33aba1	Claud Huff	C-6628	1920	85	8	4817.49	—	
33abb1	Leffel Fisher	C-11975	1927	100	5	4815.26	—	
33bca1	N. M. Stewart	C-20157	1918	80	6		—	
33cdd1	A. L. Kimball	A-13367	1940	152	12½	4834.69	—62.5	3- 6-41
(C-23-5) 4bcb1	C. E. Christensen	C-16688	1927	68	6		—	
5abb1	Orson Whitaker	....	....	......			+	
5bcb1	....	....	....	......	6		—	
6caa1	J. C. Whitaker	....	1928	70	8		—	
6cab1	Harold Whitaker	....	1928	60	6		—	
6cab2	Ennis Robinson	....	1854	......	5		—	
6cba1	Hyrum Robinson Est.	C-6351	1900	70	2		—	

Wells in Pavant Valley—(Continued)

Well Number	Owner or Name	Claim or Application Number	Date Completed	Depth of Well (feet)†	Diameter of Well (inches)	Altitude of Land Surface Datum	Water Level: Above (+) or below (—) Land Surface Datum	Water Level: Date of Measurement
(C-23-5) 6cba2	Noah Stowe	C-16561	1928	67	6		—	
6cba3	W. H. Robinson	....	1928	60	6		—	
6daa2	Leslie Robinson	C-18918	1929	85	6		—	
6daa3	Ellen Bird		1928	177	8		—	
6dab1	F. M. Bird	C-11966	1928	65	8		—	
6dba1	Earl Whitaker	C-17622	1927	60	1¼		—	
6dda1	Hatton Well Co.	C-8201	1934	212	12		—50.2	2- 3-43
(C-23-6) 1abd1	....	....	....	25	42		—18.2	3- 6-43
1cad1	Waldo George	A-12538	1941	146	6		—48.6	2- 3-43

†As reported by owner unless followed by M, indicating measured depth. Both reported and measured depths are shown where they differ by than 25 feet.
‡Well leaks around casing.
§Casing filled with debris.

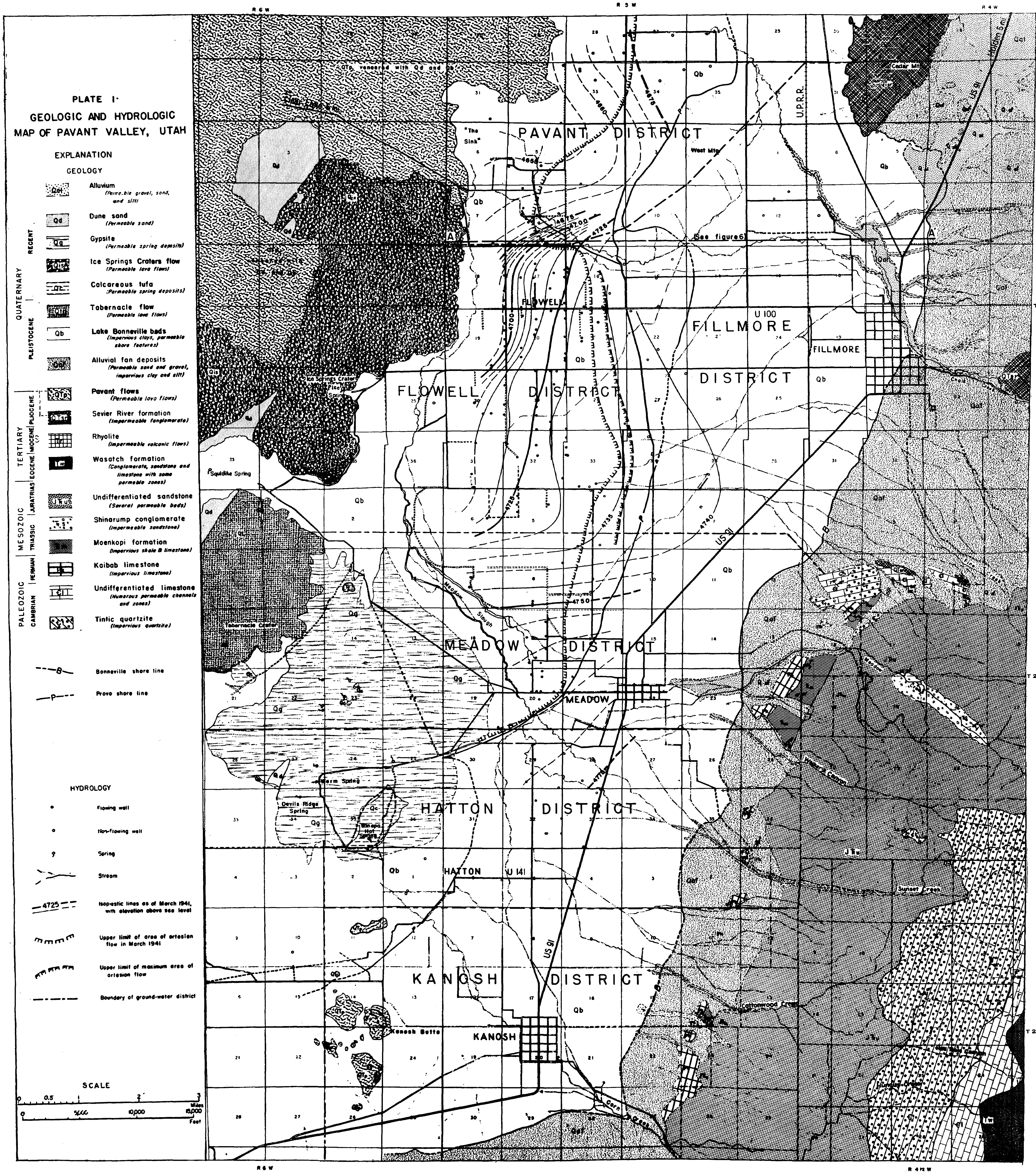

PLATE 1
GEOLOGIC AND HYDROLOGIC MAP OF PAVANT VALLEY, UTAH
EXPLANATION
GEOLOGY
Alluvium (Permeable gravel, sand, and silt)
Dune sand (Permeable sand)
Gypsite (Permeable spring deposits)
Ice Springs Craters flow (Permeable lava flows)
Calcareous tufa (Permeable spring deposits)
Tabernacle flow (Permeable lava flows)
Lake Bonneville beds (Impervious clays, permeable shore features)
Alluvial fan deposits (Permeable sand and gravel, impervious clay and silt)
Pavant flows (Permeable lava flows)
Sevier River formation (Impermeable fanglomerate)
Rhyolite (Impermeable volcanic flows)
Wasatch formation (Conglomerate, sandstone and limestone with some permeable zones)
Undifferentiated sandstone (Several permeable beds)
Shinarump conglomerate (Impermeable sandstone)
Moenkopi formation (Impervious shale & limestone)
Kaibab limestone (Impervious limestone)
Undifferentiated limestone (Numerous permeable channels and zones)
Tintic quartzite (Impervious quartzite)
QUATERNARY
RECENT
PLEISTOCENE
TERTIARY
PLIOCENE
MIOCENE (?)
EOCENE
MESOZOIC
JURATRIAS
TRIASSIC
PALEOZOIC
PERMIAN
CAMBRIAN
Bonneville shore line
Provo shore line
HYDROLOGY
Flowing well
Non-flowing well
Spring
Stream
Isopiestic lines as of March 1941, with elevation above sea level
Upper limit of area of artesian flow in March 1941
Upper limit of maximum area of artesian flow
Boundary of ground-water district
SCALE
Miles
Feet
PAVANT DISTRICT
FLOWELL DISTRICT
FILLMORE DISTRICT
MEADOW DISTRICT
HATTON DISTRICT
KANOSH DISTRICT
FLOWELL
FILLMORE
MEADOW
HATTON
KANOSH
Kanosh Butte
Ice Springs Craters
Tabernacle Crater
Squidike Spring
Devils Ridge Spring
Warm Spring
Cedar Mt
West Mtn
"The Sink"
See figure 6
U.P.R.R.
US 91
U 100
U 141
R 6 W
R 5 W
R 4 W
R 4 1/2 W
T 21 S
T 22 S
T 23 S