Reconnaissance of the Hydrology of the Little Lost River Basin Idaho

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1539Q

Prepared in cooperation with the Idaho Department of Reclamation

Mundorff and others—HYDROLOGY OF THE LITTLE LOST RIVER BASIN, IDAHO—Geological Survey Water-Supply Paper 1539-Q

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By M. J. MUNDORFF, H. C. BROOM, CHABOT KILBURN

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

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By M. J. MUNDORFF, H. C. BROOM, and CHABOT KILBURN

ABSTRACT

The Little Lost River basin is one of several basins along the northwest flank of the Snake River Plain that has no surface outlet to the Snake River. The economy of the area depends almost entirely upon agriculture; and, because annual precipitation on the valley floor averages only about 10 inches, irrigation is required for production of cultivated crops.

Prior to 1954 cultivated land was irrigated almost entirely with surface water. Substantial ground-water pumping began about 1954, and in 1959 about 37,000 acre-feet of water was pumped from 63 wells to furnish about 40 percent of the total water supply for the 16,000 acres under cultivation.

The valley is flanked by high mountain ranges that receive moderately large amounts of rain and snow. Much of the runoff percolates into the porous and permeable alluvium that underlies the broad valley floor. Surface and ground water are closely related throughout the valley because of complicated interchanges and therefore constitute a single resource, not two separate resources.

The discharges of most tributary streams were measured in September 1959, and were used to estimate the annual contribution to the river from the mountainous perimeter. Discharge measurements were made also at several places along the Little Lost River for determination of channel gains and losses. An inventory was made of all irrigation wells in the area, and the data collected were used in preparing a water-table map, a hydrologic profile, well sections showing lithology, and an inventory of ground-water pumpage.

Three different methods were used to estimate the water yield of the basin. The estimates ranged from 185,000 to 200,000 acre-feet per year and averaged 190,000 acre-feet per year. Consumptive use by irrigation in the basin is estimated as 25,000 acre-feet per year, so that the outflow from the basin is on the order of 165,000 acre-feet per year. Perhaps 30 to 35 percent of the outflow could be intercepted and consumed within the basin.

INTRODUCTION

The Little Lost River drainage basin is one of several basins along the northwest flank of the Snake River Plain that have no surface outlet. The lower (south) end of the basin is approximately 50 miles west of Idaho Falls and about 80 miles northwest of Pocatello, Idaho.

The economy of the basin is based on agriculture that is largely dependent upon irrigation. Surface-water sources are completely utilized during most irrigation seasons, and in some years the supply is inadequate to meet all needs. Since 1954 there has been considerable development of ground water. Because surface and ground water are closely related in the valley and constitute a single resource, development of either source affects the total supply. Recognizing this close relation and the need for evaluating the water of the basin as a total resource, the Idaho Department of Reclamation joined with the U.S. Geological Survey in a preliminary study of the water resources of the basin. A more precise evaluation of this resource would require a much more comprehensive study.

The investigation was made during the period September to December 1959 by M. J. Mundorff and Chabot Kilburn of the Ground Water Branch and H. C. Broom of the Surface Water Branch of the U.S. Geological Survey. All irrigation wells and most of the domestic and stock wells were inventoried. Altitudes for all wells in which the water levels could be measured, altitudes of springs, and altitudes of the water surface of streams at selected locations were determined with an aneroid barometer. Data on power consumption for all irrigation wells were obtained. The discharge of every tributary stream of any appreciable size in the basin was measured, and the discharge of the Little Lost River was measured at selected locations to determine losses or gains in several reaches of the valley. A reconnaissance of geologic features controlling the ground water and of the relation between surface and ground water also was made.

NUMBERING OF STREAM-GAGING STATIONS

Stream-gaging stations, as used in this report, have been assigned arbitrary identification numbers prefaced by the letters LL (Little Lost). The arrangement and sequence of measuring sites in downstream order are in keeping with the system used in publications of streamflow records by the U.S. Geological Survey. Further explanation of this system is given in Water-Supply Paper 1217 and all other papers in the series on surface-water supply starting with paper No. 1201.

WELL-NUMBERING SYSTEM

The well-numbering system used in Idaho by the U.S. Geological Survey indicates the location of wells within the official rectangular subdivisions of the public lands, with reference to the Boise base line and meridian. The first two segments of a number designate the township and range. The third segment gives the section number and is followed by two letters and a numeral, which indicate the quarter section, the 40-acre tract, and the serial number of the well within

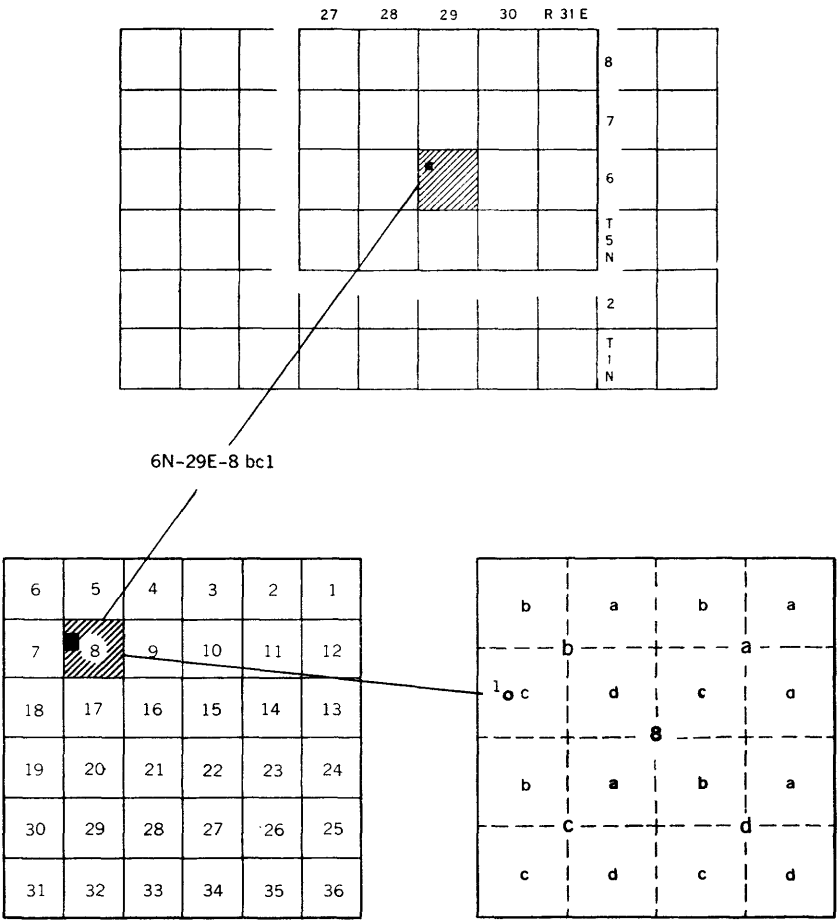

FIGURE 1.—Sketch illustrating well-numbering system.

the tract. Quarter sections are lettered a, b, c, and d in counterclockwise order, from the northeast quarter of each section (fig. 1). Within the quarter sections, 40-acre tracts are lettered in the same manner. Thus, well 6N–29E–8bc1 is in the SW¼NW¼ sec. 8, T. 6 N., R. 29 E., and is the first well visited in that tract.

ACKNOWLEDGMENTS

Acknowledgment is due residents of the valley, particularly well owners and users, for their cooperation in furnishing assistance in obtaining data and measurements. Especial acknowledgment is made to Mr. Nephi Hansen, watermaster for the valley, and Mr. Edwin True, secretary of the Hope Land and Water Co. and the Sweet Sage Development Co., for their assistance and for records furnished from their files. The Utah Power and Light Co. furnished power-consump-

tion records and the U.S. Soil Conservation Service furnished aerial photographs. All this assistance is gratefully acknowledged.

PHYSICAL SETTING

The Little Lost River basin is one of the larger basins tributary to the Snake River Plain along its northwest flank. Although the basin is part of the Snake River drainage basin, no water from it reaches the Snake River, except by underground flow.

TOPOGRAPHY AND DRAINAGE

The Little Lost River basin extends northwestward from the margin of the Snake River Plain between nearly parallel mountain ranges (pl. 1). It is roughly rectangular, about 50 miles long and 15 to 25 miles wide, and encloses a little more than 900 square miles of drainage area. It is flanked by the Lost River Range on the southwest and the Lemhi Range on the northeast. The highest peaks in these two ranges rise 11,000 to 12,000 feet above sea level, and the average height of the ridge crests probably is about 10,000 feet. The Hawley Mountains, Red Hills, Taylor Mountain, and Donkey Hills from a shorter, parallel ridge in the northern half of the basin between the main valley floor and the Lost River Range. The alluviated valley floor, which extends nearly the entire length of the basin, ranges from about 5 to 8 miles in width, and is as wide at the head of the valley as at the mouth. Large alluvial fans formed by streams from the flanking mountains at places extend more than halfway across the basin floor. The most prominent of these include Mulkey Bar, Deer Flats, Badger Creek Bar, Deer Creek Bar, the Uncle Ike-North Creek Fan, the Cedarville Canyon Fan, and the South Creek Fan.

The valley floor slopes from an altitude of about 6,500 feet at the northwest end of the basin to about 4,800 feet at the southeast end at Howe—a decline of about 1,700 feet in approximately 45 miles, or an average downvalley gradient of about 38 feet per mile. The gradient is shown on the profile, figure 4.

The Little Lost River is formed by the confluence of Sawmill and Summit Creeks on the valley floor, about 10 to 12 miles from the northwest boundary of the basin. Dry and Wet Creeks are important tributaries rising in the Lost River Range in the northwest corner of the basin. The Little Lost River flows nearly directly downvalley, and most of its tributaries enter the valley approximately at right angles and are short. The river disappears in poorly defined and ephemeral playas a few miles south of the mouth of the valley near the margin of the Snake River Plain.

GEOLOGIC FEATURES

In relation to the hydrology of the area, the rocks can conveniently be divided into three general categories: (1) the older consolidated sedimentary strata and older volcanic rocks, which form the hills and mountain ranges, (2) alluvial fill in the valleys, (3) younger volcanic rocks (basalt) in the Snake River Plain. For convenience of reference the rocks in the first group generally are referred to collectively as "the bedrock."

The Lemhi Range on the northeast and the Lost River Range on the southwest consist largely of stratified consolidated rocks including quartzite, limestone, dolomite, shale, and sandstone. The strata have been folded and faulted, and are highly jointed. The Hawley Mountains, Taylor Mountain, and the Donkey Hills consist of the same types of rock, but the Red Hills are largely silicic volcanic rocks. A belt of silicic volcanic rocks extends through the Lost River Range in the Pass Creek area, and northward along the east slope of the range. These rocks also are greatly fractured but are less affected by faulting than the consolidated sedimentary rocks, which are older. The generalized geology of the basin is shown on the geologic map of the State of Idaho (Ross and Forrester, 1947).

The broad and relatively straight valley of the Little Lost River obviously was not formed by normal erosion. It was, instead, formed by block faulting of the type characteristic of basin and range topography. Baldwin (1951, fig. 1) shows a normal fault along the southwest base of the Lemhi Range throughout the length of the valley.

The strata southwest of the fault have moved downward relative to the strata exposed in the Lemhi Range (fig. 2). Baldwin mapped several other faults in the basin, and a very brief field reconnaissance during the present investigation revealed numerous other faults not shown by him. Thus, although the Little Lost River valley might be considered as formed simply by alluviation of a trench between tilted mountain blocks (see fig. 2), in detail the structure is much more complex. To a considerable extent the structure controls the occurrence of ground water in the basin. About 11 miles upvalley from Howe, near the center of T. 7 N., R. 28 E., a low bedrock ridge projects from the Lemhi Range approximately halfway across the valley (pl. 1). It seems obvious that this ridge is of structural origin, but the nature of its relation to other structures is not known. However, regardless of the forces that may have produced it, this ridge is a very important factor in the hydrology of the basin.

The alluvial fill in the valley consists of silt, sand, gravel, and boulders. The materials are composed of limestone, sandstone, shale, and volcanic fragments—all the kinds of bedrock cropping out in the mountains.

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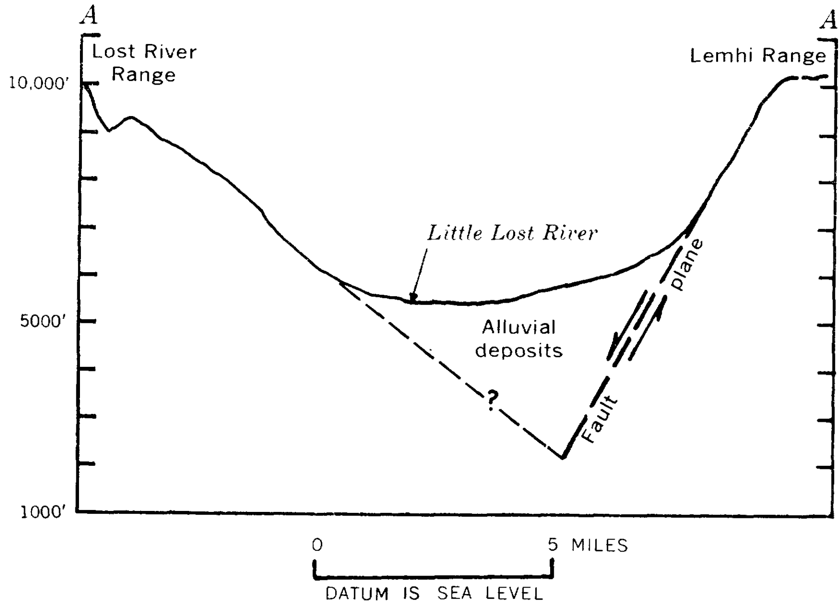

FIGURE 2.—Generalized section across the Little Lost River basin, Idaho.

The thickness of alluvial materials deposited in the trench is not known. If the slopes of the mountain ranges on either side of the valley are projected beneath the valley, as suggested in figure 2, the alluvium might be more than 3,000 feet thick. The width of the valley, between bedrock walls, ranges generally from 5 to 8 miles. At places alluvial fans extend from one or both sides; some extend to the center of the valley or beyond. Most of the alluvial fill has been brought into the valley by the tributaries entering from both flanks and deposited in alluvial fans. Along a belt, varying in width and position as the fill accumulated, the Little Lost River reworked these materials, but the quantity of material actually transported down-valley by the Little Lost River is believed to have been relatively small. The lithologic and hydraulic characteristics of the alluvial-fan deposits and of the materials reworked by the Little Lost River are significantly different. The material in the alluvial fans ranges in size from silt to boulders. Probably most of the material was moved into the valley during infrequent floods; and as the streams raced from the canyon mouths, they spread widely and dropped their loads of debris only short distances from the mouths of the canyons. Thus, there was little opportunity for sorting to occur; fine and coarse materials are mixed. The fan deposits have been reworked and stratified by the Little Lost River where it has cut into the fans toward the center of the valley. These reworked deposits are more permeable than the poorly sorted alluvial-fan deposits.

Downvalley from the constricting bedrock ridge, near the center of T. 7 N., R. 28 E., the valley is somewhat wider, averaging about 6 or 7 miles in width, and the gradient of the floor is somewhat gentler, about 33 feet per mile, as compared with about 40 feet per mile upvalley. In this wider, lower reach of the valley, alluvial fans are much less prominent. Probably less material was brought in from the sides of the valley, because the flanking streams are smaller and there is less precipitation on these drainage basins that are near the ends of the mountain ranges. The land surface in the southern two-thirds of T. 6 N., R. 29 E., and the northeastern part of T. 5 N., R. 29 E., is nearly level across the valley, but it slopes downvalley about 30 feet per mile. The surficial geology and well logs indicate that stratification of the alluvial deposits is approximately parallel to the surface. Because the stratification slopes vainly downvalley rather than toward the center, it is evident that the alluvium in this area has been either deposited or reworked by the Little Lost River.

Near the mouth of the valley, east and southeast of Howe, basalt is exposed at the surface. Logs of several wells and drillers' reports of aquifers in other wells indicate that basalt is interbedded with the alluvium in that area. As the great pile of basalt lava accumulated in the Snake River Plain, some of the tongues of lava flowed for a short distance up the Little Lost River valley. Clay and silt accumulated in playas north of the margins of the lava, and in some places overlapped the lava tongues. Thus the alluvial deposits interfinger with basalt near the mouth of the valley.

CLIMATE

The climate of the basin is characteristic of that of intermontane basins in the northwest: warm and dry in the summer, cold withprecipitation mostly as snow in the winter. However, because of the moderating influence of the Pacific Ocean, the climate is less severe than that of similar basins east of the Continental Divide.

The storms brought in by the prevailing west winds of this region are channeled by the mountain masses bordering the Snake River Plain so that the dominant regional windflow is toward the northeast. Local surface winds, however, blow down the intermontane valleys. Wind movement has an important bearing on the precipitation in the Little Lost River basin, because the valley and the flanking mountain ranges are perpendicular to the general storm path. As the air masses rise in crossing first the Lost River Range and then the Lemhi Range, they are cooled and lose much moisture as rain or snow. As they descend into the valley, the air masses are warmed and dried, so that much less precipitation falls on the valley. Thus, even though the valley is only 5 to 8 miles wide, precipitation on the mountains is several times greater than in the valley. (See tables 1 and 2). The Lemhi Range, which is slightly lower and leeward, receives somewhat less precipitation than the Lost River Range.

TABLE 1.—*Average monthly and yearly precipitation, in inches, and mean monthly and yearly temperature, in degrees Fahrenheit, at stations in and near the Little Lost River basin, Idaho, through 1958*

[From records of the U.S. Weather Bureau]

Station and altitude, in feet	Years of record	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average annual
Precipitation														
Howe, 4,820	22	0.79	0.60	0.59	0.70	0.86	1.33	0.49	0.69	0.50	0.69	0.38	0.60	8.22
Arco, 5,300	36	.96	.62	.81	.72	1.26	1.11	.55	.60	.56	.70	.60	.94	9.43
Mackay Ranger Station, 5,897	49	.83	.77	.51	.66	1.06	1.15	.85	.78	.80	.70	.51	.71	9.33

Station	Years of record	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean annual
Temperature														
Arco	25	15.0	20.1	30.5	43.1	51.5	58.1	66.8	64.8	55.3	45.1	31.4	20.0	41.8
Mackay Ranger Station	[1] 41	17.1	21.2	30.9	42.4	51.2	58.7	67.6	65.1	55.8	45.6	31.6	20.4	42.3

[1] Through 1955.

Average precipitation and mean temperature for stations in the Big and Little Lost River valleys are given in table 1. The stations at Howe and Arco (20 miles southwest of Howe) are near the mouths of the Little Lost and Big Lost River valleys, respectively. The station at Mackay Ranger Station, about 25 miles northwest of Arco, is about midway between the head and mouth of the Big Lost River valley. At Howe the average precipitation ranges from 0.49 inch in July to 1.33 inches in June; the long-term average is 8.22 inches over 22 years of complete record. At higher altitudes, the precipitation during the winter is in the form of snow. As this is an important source of runoff during the spring and early summer, five snow courses in the mountains on both sides of the valley are maintained by the U.S. Soil Conservation Service. Records of snowfall and water content for the period of record are summarized in table 2. The average annual distribution of precipitation is shown on the isohyetal map, figure 3.

Data on the length of the frost-free period at Howe and in the Little Lost River valley have not been compiled. However, the length should be similar to the length at Arco and Mackay in the Big Lost River valley, which is 94 and 105 days, respectively. At Arco the average dates of the last killing frost in the spring and first killing frost in autumn are June 5 and September 7, respectively, and are based on data from the U.S. Weather Bureau (1937).

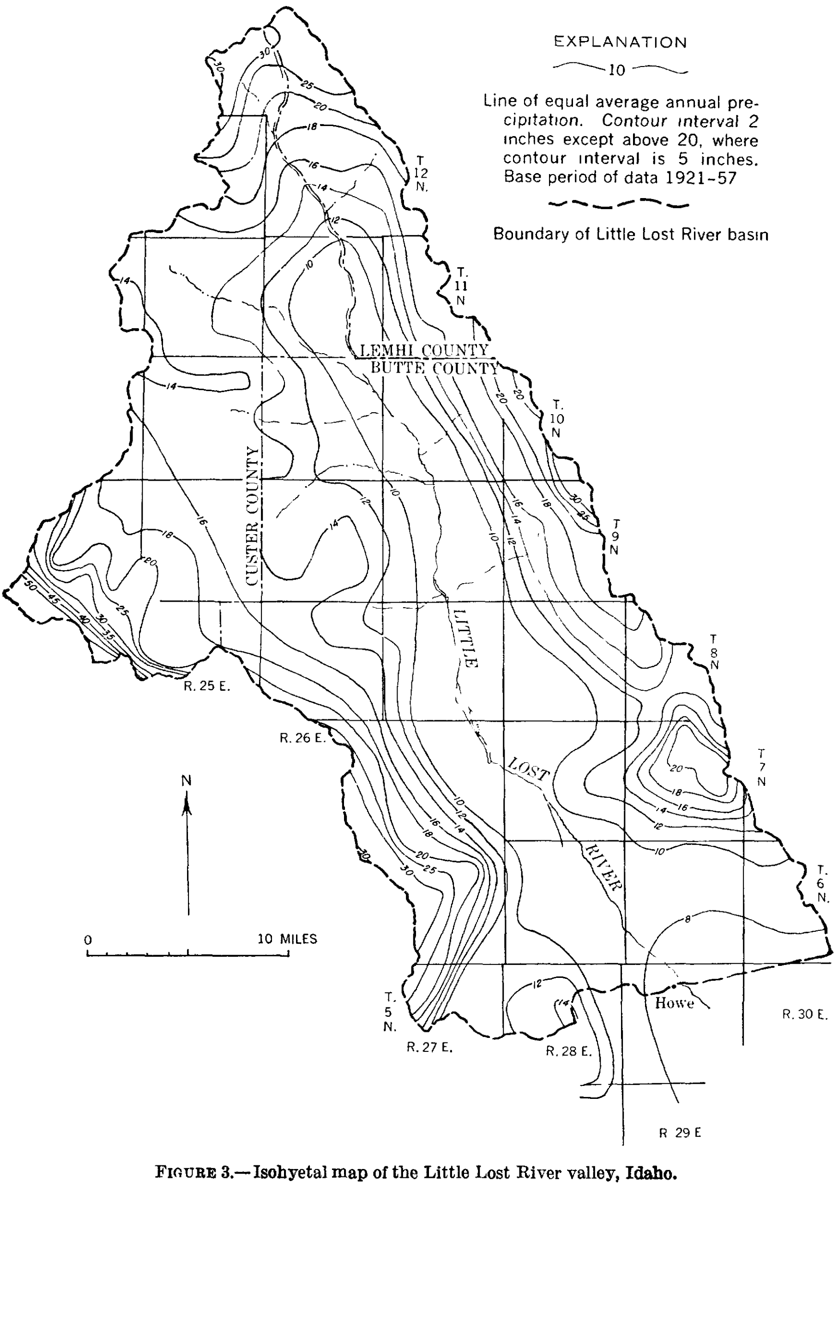

FIGURE 3.—Isohyetal map of the Little Lost River valley, Idaho.

TABLE 2.—*Summary of mean snowfall and water content of snow, in inches, at stations in the Little Lost River basin, Idaho, 1957–59*

Station	Jan. 1		Feb. 1		Mar. 1		Apr. 1	
	Snow depth	Water content	Snow depth	Water content	Snow depth	Water content	Snow depth	Water content
1	12.7	2.2	17.7	3.7	17.7	4.5	14.0	4.7
2	10.7	1.7	15.3	3.2	14.7	3.4	12.3	3.7
3	24.3	5.4	32	7.7	37	9.8	39	10.0
4	20	3.8	26	6.4	30	7.6	29	8.7
5	21	4.4	26	6.7	36	8.6	40	10.5

1. Fairview Guard station, sec. 28, T. 12 N., R. 26 E., alt. 5,850 ft.
2. Lost-Garfield course, sec. 34, T. 12 N., R. 26 E., alt. 5,700 ft.
3. Moonshine course, sec. 31, T. 13 N., R. 26 E., alt. 7,250 ft.
4. Sawmill Canyon course, sec. 17, T. 12 N., R. 26 E., alt. 6,000 ft.
5. Wet Creek Summit course, sec. 15, T. 8 N., R. 25 E., alt. 8,175 ft.

IRRIGATION DEVELOPMENT AND GROUND-WATER PUMPAGE

Though some lumbering is done in the Little Lost River basin, there is no industry of consequence. The economy of the basin is based largely upon agriculture, including farming and stockraising. To a major extent agriculture is dependent upon irrigation, which is necessary for production of row crops and cattle feed; thus an adequate water supply is of paramount importance to the economy of the valley.

Development of irrigation in the Little Lost River valley began in the latter part of the 19th century. The earliest priorities filed on surface-water rights are dated September 1, 1879. Nearly all this early development occurred in the lower part of the valley, in what is now the Howe area. Early in 1909 the area was segregated under the Carey Act of 1894 and a project was begun by the Blaine County Irrigation Co. (Swendsen, 1914). The original segregation of public lands, known as list No. 53, contained 14,690 acres in T. 6 N., Rs. 28, 29, and 30 E. The water supply for the project was to be derived from the Little Lost River and its tributaries.

According to a report of W. G. Swendsen on file at the Idaho Department of Reclamation, Boise, Idaho, the amount of water furnished to the project lands in T. 6 N., Rs. 28, 29, and 30 E., during the 1913 irrigation season was 12,500 acre-feet for irrigation of approximately 4,035 acres. The Blaine County Irrigation Co. furnished water also to several thousand acres of land in the valley above the project.

By 1950 approximately 10,000 acres was being irrigated, chiefly with surface water; however, some of the land received an inadequate supply. Supplemental irrigation with ground water began about 1948, but the development of ground-water supplies did not assume much importance until about 1954 or 1955. By 1959, there were 46 wells in use in the Howe area and 17 wells in the upper part of the valley.

Mr. Edwin True, secretary of the Hope Land and Water Co. and the Sweet Sage Development Co., states (oral communication, 1959) that in 1959 surface-water supplies became insufficient during July and had to be supplemented by pumped ground water. Records of the Utah Power and Light Co. indicate that pumping for irrigation began before May 18, 1959, and continued through October 16; some pumping continued beyond November 5, which is considerably past the end of the growing season. This late-season irrigation is done to store moisture in the soil for the next season's crops.

Water users in the area have not kept records of the amount of water pumped. However, by use of power-consumption data furnished by the Utah Power Co. and well-performance data obtained by the Idaho Department of Reclamation, a rough estimate of the pumpage was made.

The following equation was used to estimate water pumped

$$Q=\frac{0.977\times Kw\times \text{efficiency}}{\text{Head}}$$

where Q is the discharge, in acre-feet; Kw is the power consumed, in kilowatt hours; efficiency is efficiency of motor and pump, in percent; and head is the total height, in feet, that the water must be lifted. An overall efficiency of 65 percent was assumed, and the equation reduces to

$$Q=\frac{0.635\ Kw}{\text{Head}}.$$

Where actual drawdowns of water levels in wells were not known, the average drawdown in other wells in the area was used. The average drawdown in the Howe area was about 30 feet, and in the upvalley area was about 40 feet.

Power consumed, horsepower, total lift, and water pumped by each irrigation well in the valley are listed in table 3. In the upvalley area, north of T. 6 N., approximately 12,000 acre-feet of water was pumped and used for nearly 4,000 acres. In the Howe area (T. 6 N.) approximately 25,000 acre-feet of water was pumped and used for nearly 6,000 acres. It is probable that 5 to 10 additional wells will be in operation by late 1960. Records of wells and well logs are given in table 6.

TABLE 3.—*Power consumption and estimated pumpage in the Little Lost River valley, 1959*

Well	Owner	Power consumed (Kwhr)	Pump horse-power	Total lift (feet)	Water pumped (acre-feet)
	Upper valley area				
10N-27E- 7cc1	Byron Telford	190,800	75	54	2,240
19ab1	J. L. Amy and Margaret Waymire.	53,320	25	46	740
19dd1	Jess L. Amy	35,480	20	70	320
9N-27E-10cc1	Ralph Blessinger	92,480	40	92	640
21bb1	Frank E. Reed	48,160	40	62	490
28cb1	Lawrence W. Isham	98,200	40	58	1,080
8N-27E- 3ba1	Andrew D. Little	42,480	30	46	590
8N-28E-29bb1	Orville W. Nicholson	68,448	60	105	410
7N-27E-12aa1	L. R. Hawley		20		
12aa2	do	187,840	15	50	1,020
12ab1	do		40		
12ba1	do	215,760	40	53	960
12ba2	do				
12dd1	do		30		
7N-28E- 7cb1	do	235,040	25	28	3,630
7cc1	do		50		
Subtotal and average		1,268,008		60	12,120
	Howe area				
6N-29E- 8dc1	Hope Land and Water Co	143,120	50	114	800
8dd1	do	122,720	50	111	700
15cb1	Melvin L. Caldwell	68,000	50	105	410
16bb1	Hope Land and Water Co	145,920	50	110	840
17cc1	Sweet Sage Development Co	107,760	60	117	580
17cc2	do	46,880		116	260
17cd1	do	118,800	60	113	670
17dc1	do	141,168	60	110	810
18db1	Roland L. Reeves	109,040	40	122	570
19bb1	Wendell Hansen	195,760	75	112	1,110
20ba1	Philip S. York	124,720	50	118	670
20bb1	do	112,000	60	126	560
20ca1	Paul E. Harrell	80,960	60	96	540
20dd1	do	34,720	50	100	220
21aa1	Sweet Sage Development Co	148,560	60	102	920
20ab1	do	159,312	60	107	950
21ac1	do	126,880	75	97	830
21ad1	do	34,520		99	220
21ad2	Hope Land and Water Co	108,560	50	98	700
21ad3	do	154,560	75	102	960
21bb1	Al Wiseman	88,800	50	99	570
21cb1	Willard O. Bell	117,984	60	103	730
22ab1	Warren E. Stauffer	55,840	40	78	450
22ab2	William Stauffer	7,460	40	93	50
22bb1	Warren E. Stauffer	52,320	40	100	330
22cd1	John Dietrich	30,240	25	79	240
22cd2	Dan H. Levan	159,600	75	91	1,110
22da1	Jess M. Strope	63,200	40	87	460
22db1	R. Urich and Earl Wortly	85,760	50	82	660
23ad1	Hope Land and Water Co	65,360	25	65	640
23cb1	Earl Wortly	32,840	30	82	250
24bb1	Robert Urich		20	70	
24bb2	do	28,560	15	66	270
24bc1	do				
24cb1	E. L. Amos	66,120	25	76	670
24cb2	do		20	51	
26ab1	Raymond H. Ralls	110,400	30	60	1,030
26ab2	do		25	57	
26cb1	Paul R. Solem	93,740	30	66	900
27bb1	Norman G. Allen	17,560	30	77	140
28cb1	Willard O. Bell	59,440	50	95	400
28cb2	do	40,160	60	93	270
28db1	Philip S. York	87,280	50	82	680
30ab1	Tom Hocking	114,960	50	105	700
32ac1	Harley Kyle		80	95	470
32bb2	Andrew D. Little	36,000	50	99	230
Total or average:					
Howe area		3,697,584		94	24,570
Upper Valley area		1,268,008			12,120
		4,965,592			36,690

WATER SUPPLY

The water supply of the basin is derived almost entirely from precipitation. There is no appreciable underground flow of water into the basin and only one minor diversion of surface water into the basin. There is little prospect of importing additional water; thus the supply available for the basin is essentially surface and ground water originating within the basin. The surface- and ground-water features of the basin are shown on plate 2.

INTERRELATION OF SURFACE AND GROUND WATER

Surface and ground water are so closely related in this basin that neither can logically be considered a separate source of supply. The broad alluvium-filled valley serves as a ground-water conduit from near the head of the valley to its mouth, and most of the tributary streams lose a large part of their surface flow by percolation before reaching the main channel.

Summit Creek, one of the tributaries of the Little Lost River, rises in springs and seeps near the northwest margin of the main valley. From the head of the creek in Summit Reservoir to sec. 33, T. 11 N., R. 26 E., the water table is at or near the surface. From the latter locality downstream to its natural confluence with Sawmill Creek, Summit Creek is a losing stream and contributes to underground flow. Several small tributary streams from mountains to the north and southwest terminate at the margin of the valley, and undoubtedly contribute indirectly to the flow of Summit Creek. Much of the flow never appears as surface runoff, however, but moves down-valley as underflow.

Sawmill Creek, the largest tributary of the Little Lost River, rises in the extreme north corner of the basin and flows southeastward in a relatively narrow canyon for about 12 miles. The lower reach of the canyon is about half a mile wide and is underlain by alluvium. Undoubtedly there is some ground-water underflow in this reach, but underflow becomes much greater beyond the mouth of the canyon where the valley is 9 or 10 miles wide. Losses in the channel reach between the canyon mouth and the natural junction of Sawmill and Summit Creeks, a distance of about 7½ miles, were so great that water users constructed a bypass canal around the reach in an attempt to conserve as much of the surface flow as possible.

The natural confluence of Sawmill and Summit Creeks form the Little Lost River at approximately the south edge of sec. 12, T. 10 N., R. 26 E. The valley bottom from this locality downstream for 2 or 3 miles is very swampy, and many springs and seeps discharge into the river, indicating that the water table is at or near the surface (fig. 4). For the next 7 or 8 miles the water table ranges from

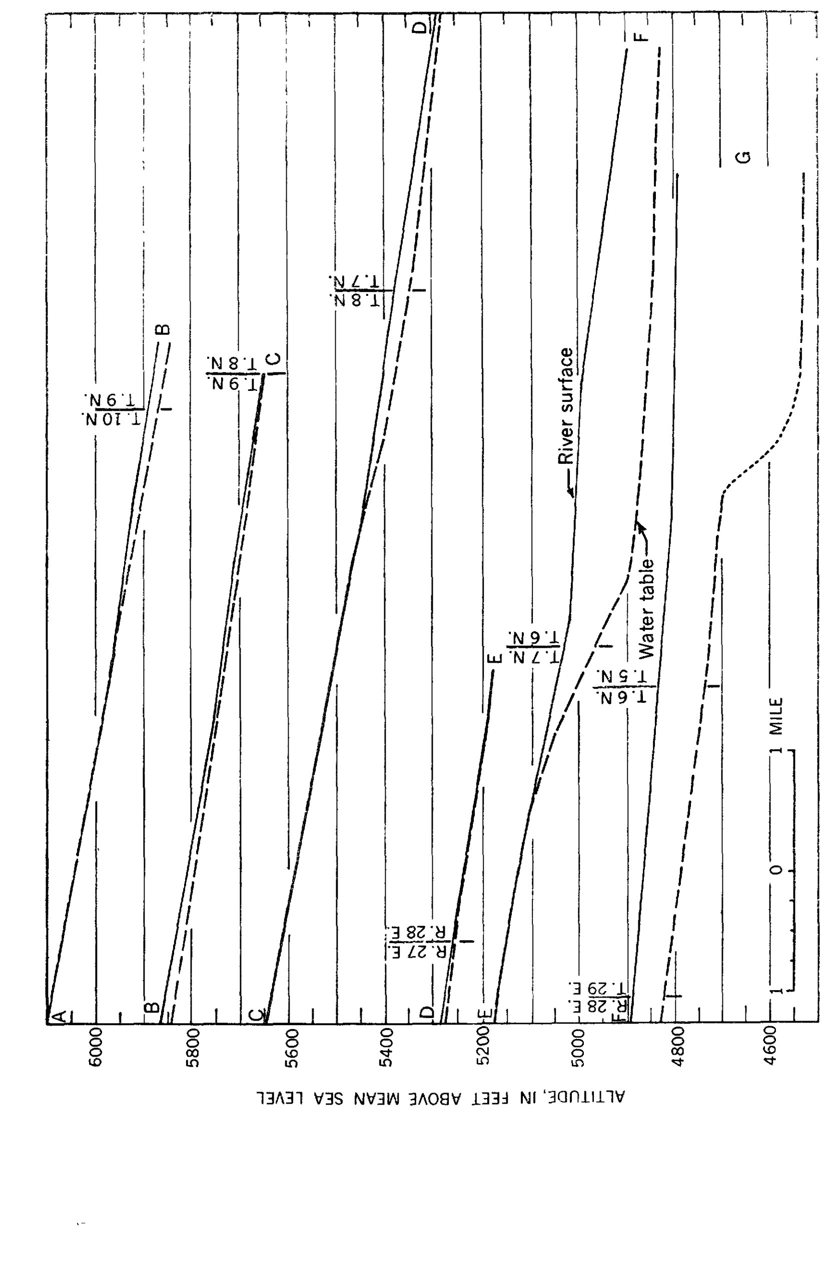

FIGURE 4.—Longitudina profile of the Little Lost River valley, Idaho, showing the water surface of the Little Lost River and the water table.

a few feet to about 15 or 20 feet below the surface. Many tributaries in this reach contribute to the underflow, but only occasionally does any appreciable surface discharge reach the river.

In sec. 3, T. 8 N., R. 27 E., a short distance downstream from the mouth of Badger Creek, the water table is again near or at the surface, and several springs discharge into the Little Lost River. Several large springs rise to form Spring Creek, which flows parallel to the river on the east side of the valley for about 10 miles before joining the river. The water table is at or near the surface along the two streams for about the next 4 miles. Near the southeast corner of sec. 23, T. 8 N., R. 27 E., the water table again drops and remains below the level of the stream to about sec. 12, T. 7 N., R. 27 E. (Knollin ranch). From this locality to about the north edge of sec. 28, T. 7 N., R. 28 E., the water table is above stream level and several springs augment the surface discharge. The water table rises to the surface in this reach, because of a constriction of the aquifer by the low bedrock ridge extending from the Lemhi Range. Downstream from this constriction, the water table drops more steeply than the river, and nowhere again does it approach the surface. Only rarely does any surface flow from tributaries below the constriction reach the river, and, except for the water diverted for irrigation, the flow from these tributary valleys percolates down to the water table.

SURFACE WATER

The Little Lost River begins at the confluence of two major tributaries, Summit Creek and Sawmill Creek, about 35 miles northwest of Howe. Summit Creek heads in Summit Reservoir near the divide between the valley of the Little Lost River and the Pahsimeroi River basin. This small stream meanders for 8 miles through a swampy spring-fed valley to a point about 4 miles above the natural confluence of Summit and Sawmill Creeks, where it is joined by the diversion channel from Sawmill Creek. Of the two major tributaries Sawmill Creek, which drains a moderately rugged area at the north end of the basin, is the larger. It flows out of Sawmill Canyon onto alluvium. Formerly, at times of low and medium stages, most or all the flow was lost between the mouth of the canyon and the confluence with Summit Creek. To reduce this loss, most of the combined flow of Sawmill Creek and Warm Creek is diverted to the fairly well sealed diversion channel that empties into Summit Creek at the point described previously, which is about 6 miles upstream from the mouth of Wet Creek at Clyde, Idaho.

Major tributaries to the Little Lost River, other than Summit and Sawmill Creeks, are Dry and Wet Creeks, which both enter from the west side of the valley above Clyde. The natural outflow channel of Dry Creek is over a great alluvial fan named Mulkey Bar, where all surface flow is lost by percolation before reaching the river channel, except during extremely high stages. A canal similar to the one used at Sawmill Creek diverts water from Dry Creek to Wet Creek, where the combined flow can be either partly diverted locally for irrigation or allowed to run freely into the Little Lost River. Wet Creek, a perennial stream, has its source in the rugged peaks of the Lost River Range. The channel is apparently sealed more tightly than some of the others in the basin, or the spring-fed flow is large enough to overcome the loss to the alluvium near the mouth even during dry years.

A few minor tributaries traverse alluvial fans to contribute occasionally to the surface discharge of the Little Lost River. Except for Warm and Badger Creeks, which enter from the east and except in the event of a flash flood, it is doubtful that any one stream would contribute more than a very minor part of the river flow at its point of entry. Many small streams flow out of the mountain canyons and become lost completely as their channels cross the alluvial fill. Some water from these streams is diverted into channels or pipelines for irrigation of lands at lower levels.

STATION RECORDS

There are two stream-gaging stations on the Little Lost River and one canal-gaging station in the basin. The upper river station, LL27A (13–1187), Little Lost River below Wet Creek near Howe, Idaho, in sec. 4, T. 9 N., R. 27 E. (pl. 2), is a relatively new station, which was installed on January 25, 1958. Discharge records of this station for 1959 when compared with records for the station near Howe indicate that the annual mean discharge is about 52 cfs (cubic feet per second) or 38,900 acre-feet, and is equivalent to runoff of 1.65 inches from the 442 square miles of drainage area above the station. No correction has been applied for bypass diversions, which probably do not exceed 1,000 acre-feet annually.

The other river station, LL39A(13–1190), Little Lost River near Howe, Idaho, in sec. 3, T. 6 N., R. 28 E. (pl. 2), has been operated since 1921, but only since 1940 are the annual records complete. The mean annual discharge for the 19 years of record since 1940 is 70.0 cfs or 50,680 acre-feet, and is equivalent to runoff of 1.35 inches from the 703 square miles of drainage area above the station. The daily discharge at this station is published in annual reports on surface-water supply (U.S. Geol. Survey, issued annually). Tabulations of annual mean discharge and runoff for the 19 complete years of record are given as follows:

Annual mean discharge, Little Lost River near Howe, Idaho

Year	Discharge		Year	Discharge	
	Cfs	Acre-feet		Cfs	Acre-feet
1941	51.5	37,290	1953	79.2	57,350
1942	57.3	41,470	1954	66.7	48,260
1943	64.0	46,320	1955	54.2	39,240
1944	72.2	52,420	1956	65.2	47,370
1945	69.1	50,010	1957	71.0	51,430
1946	72.5	52,510	1958	82.6	59,810
1947	91.6	66,310	1959	72.4	52,380
1948	75.9	55,130			
1949	69.1	49,990	Mean annual discharge, water years 1941–59	70.0	50,680
1950	69.4	50,230			
1951	70.1	50,720			
1952	75.6	54,910			

The Blaine County Investment Co. Canal, LL39b (13–1195), in sec. 11, T. 6 N., R. 28 E., represents the largest diversion in the valley and has been gaged during irrigation seasons since 1924. The average annual diversion during 19 years (1937–43, 1944–57) was about 8,200 acre-feet. Records from the gaging station are used primarily in the distribution of water.

The total irrigated area in the valley is about 16,000 acres, from the best information available in 1959. It is estimated that about two-thirds of this area, or 10,000 to 11,000 acres, is irrigated from surface-water sources. The average annual surface-water diversions for the period 1945–59 for the entire basin totaled about 43,000 acre-feet according to open-file annual reports by the district watermaster of the Idaho water district No. 9 that are on file at the Idaho Department of Reclamation, Boise, Idaho.

MEASUREMENTS OF STREAMFLOW AT SITES OTHER THAN GAGING STATIONS

Streamflow measurements were made on streams in the Little Lost River basin in mid-September 1959. The measurements were used to determine peripheral inflow to the basin and channel losses in the river itself. Results of these measurements are given in table 4, in downstream order. Also, results of several measurements made in the basin in August and September 1959 by district watermaster, Mr. Nephi Hansen, were available for reference but are not listed.

TABLE 4.—*Measurements of streamflow at sites other than gaging stations, 1959*

Station	Stream	Location	Drainage area (sq mi)	Date measured	Discharge (cfs)
LL1	Summit Creek [1]	NW¼NW¼ sec. 8, T. 11 N., R. 25 E., 100 ft downstream from Summit Lake and Dam.	9.04	Sept. 1	1.23
LL2	Summerhouse Canyon Creek.	About center of sec. 3, T. 11 N., R. 25 E., just above point at junction with unnamed tributary from north.	3.15	do	.40
LL3	Summit Creek	Near north line, on line between sec. 22 and 23, T. 11 N., R. 25 E., just below road bridge.	31.05	do	8.29
	do	do		Sept. 17	10.2
LL4	Squaw Creek	In SW¼ sec. 27, T. 12 N., R. 26 E., 100 ft above road crossing near Fairview guard station.	10.56	Sept. 3	3.82
LL5	Sawmill Creek [1]	In NE¼ sec. 3, T. 11 N., R. 26 E., at narrows one-quarter mile above road crossing at mouth of canyon.	73.40	do	19.6
LL6	Sawmill Creek	In E½ sec. 3, T. 11 N., R. 26 E., 100 ft upstream from road crossing at canyon mouth.	74.3	Sept. 17	20.4
LL7	Warm Creek	In NW¼NW¼ sec. 12, T. 11 N., R. 26 E., in canyon mouth, one-eighth mile above gully on left bank.	3.67	Sept. 15	8.71
LL8	do [1]	In NE¼NE¼ sec. 11, T. 11 N., R. 26 E., just above gully on left bank.	3.76	Sept. 3	10.8
LL9	do	In southeast corner sec. 3, T. 11 N., R. 26 E., 100 ft above mouth and Sawmill Creek.	4.76	Sept. 17	5.84
LL10	Meadow Creek [1]	On east line sec. 24, T. 11 N., R. 26 E., at canyon mouth.	3.14	Sept. 3	[2] .5
LL11	Sawmill Creek diversion canal.	In sec. 29, T. 11 N., R. 26 E., at point 300 ft above confluence with Summit Creek.		Sept. 17	20.7
LL12	Summit Creek	In SW¼ sec. 33, T. 11 N., R. 26 E., at Sawmill Canyon road crossing, and about a mile below inflow of Sawmill Creek diversion canal.	[3] 75.0	do	33.9
LL13	Little Lost River	In center sec. 12, T. 10 N., R. 26 E., in two channels at Bell Mountain road crossing.	199	do	29.5
LL14	Bell Mountain Creek. [1]	In NW¼ sec. 4, T. 10 N., R. 27 E., just upstream from Telford pipeline intake at canyon mouth.	5.39	Sept. 3	[2] 1.06
LL15	Telford inflow channel.	In SW¼ sec. 7, T. 10 N., R. 27 E., 50 ft downstream from end of Telford pipe and at pump outlet.		Sept. 17	7.26
LL16	Dry Creek [1]	Near west line sce. 31, T. 10 N., R. 25 E., at old road crossing one-quarter mile downstream from old dam site.	42.2	Sept. 1	19.1
LL17	Dry Creek	In NE¼SE¼, sec. 16, T. 10 N., R. 25 E., in canyon mouth and about 4.5 miles downstream from old dam site.	56.0	Sept. 15	46.4
LL18	Dry Creek canal	In NW¼ sec. 19, T. 10 N., R. 26 E., at point where canal leaves Dry Creek channel and about one-quarter mile downstream from head of canal.		do	28.8
LL19	Black Creek-Deep Creek inflow channel. [1]	In NW¼ sec. 20, T. 10 N., R. 27 E., at service road crossing near mouth of channel.	8.16	Sept. 17	1.09
LL20	Cedar Run Creek [1]	In SW¼ sec. 25, T. 10 N., R. 27 E., at ditch diversion at canyon mouth.	5.35	Sept. 1	[2] .38
LL21	Coal Creek	SW¼ sec. 2, T. 8 N., R. 25 E., at mouth	1.39	do	[2] .30
LL22	Wet Creek [1]	In SW¼ sec. 2, T. 8 N., R. 25 E., 50 ft above Pass Creek road crossing.	11.2	do	4.60
				Sept. 15	5.26
LL23	Big Creek [1]	in NW¼ sec. 35, T. 9 N., R. 25 E., at road ford.	10.8	Sept. 1	9.04
LL24	Squaw Creek [1]	In NW¼ sec. 23, T. 9 N., R. 25 E., at old homestead.	8.40	do	.83
LL25	Chicken Creek [1]	In N½ sec. 26, T. 9 N., R. 25 E., at indistinct road crossing.	.97	do	[2] .01
LL26	Wet Creek	In NW¼ sec. 4, T. 9 N., R. 27 E., at road crossing near Clyde School at mouth.		Sept. 17	6.13
LL27	Clyde diversion	In sec. 4, T. 9 N., R. 27 E., in field east of Little Lost River station at Clyde.		Sept. 18	3.42
LL28	Little Lost River	In NE¼ sec. 33, T. 9 N., R. 27 E., 100 ft above Knollin diversion and 0.6 mile above Deer Creek.	485	do	46.6
LL29	Deer Creek [1]	In SW¼NE¼ sec. 11, T. 8 N., R. 26 E., at canyon mouth.	6.88	Sept. 4	2.97

See footnotes at end of table.

TABLE 4.—*Measurements of streamflow at sites other than gaging stations, 1959*—Continued

Station	Stream	Location	Drainage area (sq mi)	Date measured	Discharge (cfs)
LL30	Deer Creek	In SE¼ sec. 33, T. 9 N., R. 27 E., at indistinct road crossing one-fourth mile above mouth.	18.4	Sept 18	1.90
LL31	Badger Creek [1]	In SW¼ sec. 20, T. 9 N., R. 28 E., at canyon mouth.	15.18	Sept. 4 Sept. 15	9.30 10.7
LL32	do	In SW¼ sec. 34, T. 9 N., R. 27 E., at highway crossing one-third mile above mouth.	17.75	Sept. 18	4.68
LL33	Little Lost River	In NW¼SW¼ sec. 3, T. 8 N., R. 27 E., one-quarter mile upstream from end of indistinct road at springs, and downstream from Badger Creek.	525	do	50.5
LL34	Big Spring Creek	In SE¼SW¼ sec. 11, T. 8 N., R. 27 E., 100 ft below fork.	(4)	do	15.7
LL35	Uncle Ike Creek [1]	In NE¼SW¼ sec. 24, T. 8 N., R. 28 E., at mouth of canyon and 200 ft above diversion.	7.44	Sept. 4 Sept. 14	3.51 2.90
LL36	North Creek [1]	In NE¼ sec. 31, T. 8 N., P. 29 E., at canyon mouth at diversion.	3.95	do	1.37
LL37	Little Lost River	In NE¼ sec. 20, T. 7 N., R. 28 E., 300 ft upstream from road crossing near Fallert.		Sept. 18	67.8
LL38	Teeney Creek	In NE¼ sec. 28, T. 7 N., R. 28 E., at road crossing near Fallert.	(4)	do	7.41
LL39	Wiseman Diversion	In sec. 3, T. 6 N., R. 28 E., at point of diversion of ditch.		do	1.44
LL40	East Spring Creek	In SE¼ sec. 21, T. 7 N., R. 28 E., at highway crossing near Fallert.	(4)	do	3.06
LL41	South Creek [1]	In NE¼ sec. 30, T. 7 N., R. 29 E., at canyon mouth above diversion.	9.70	Sept. 2	[2] 1.6

[1] Peripheral stream; sum of discharges of peripheral streams in the basin is 87.4 cfs.
[2] Estimate.
[3] Does not include drainage area of Sawmill Creek, the flow of which enters about a mile upstrean.
[4] Spring fed.

Gaging stations have never been operated on tributaries of the Little Lost River, and few recent miscellaneous measurements have been made. Because most tributaries lose a large part of their flow before they reach the Little Lost River, it was believed that discharge measurements made near the mouths of the canyons, where underflow is small, might give a reasonable figure for inflow to the basin. The miscellaneous measurements made during the early part of September 1959 followed a long period of fair weather so that the discharge is assumed to have come entirely from ground-water sources. Measurements made on most of the flowing streams from the peripheral area totaled 87.4 cfs. Ungaged inflow from a relatively inaccessible part of the peripheral area is believed to be small and is estimated to be about 10 percent of the measured flow. Adding this to the measured flow gives a total of about 95 cfs as the surface-water contribution to the valley. This discharge is used as the base flow in studies of basin yield described later.

It was observed that discharge reaching the river as surface water from these same streams, after traversing the alluvial-fan material, totaled about 48 cfs, or only about half that measured at the canyon mouths. Because of these losses, gaging stations on the main stem do not measure all the runoff generated in the basin.

RIVER-CHANNEL GAINS AND LOSSES

Results of the September 1959 discharge measurements of major tributaries and in the river channel indicate a substantial loss in tributary channels in the upper part of the basin, and relatively little loss in the lower part. Location of measuring sites are shown on the basin map (pl. 2) and results of measurements are given in table 5.

TABLE 5.—*Channel losses and gains in the Little Lost River basin, 1959*

[Percentages of gain or loss are rounded]

Station	Stream or diversion	Location	Miles above mouth	Discharge				
				River (cfs)	Inflow from tributary (cfs)	Diversion (cfs)	Gain or loss	
							Cfs	Percent
Sawmill Creek channel [Measurements made Sept. 17, 1959]								
LL6	Sawmill Creek	At bridge at canyon mouth.	7	20.4				
LL9	Warm Creek	Near mouth			5.84			
LL11	Sawmill Creek canal.	300 ft above mouth		20.7			−5.54	−21
Little Lost River channel [Measurements made Sept. 18, 1959]								
LL3	Summit Creek	At road crossing above Barney Hot Springs.	55.2	10.2	10.2			
LL11	Sawmill Creek canal.	300 ft above entry to Summit Creek.	51.6		20.7			
LL12	Summit Creek	At Sawmill Canyon road bridge.	49.5	33.9			+3.0	+9.7
LL13	Little Lost River	At shearing corral and Bell Mountain road crossing.	45.5	29.5			−4.4	−13.0
LL15	Telford inflow	25 ft below pump and pipe line confluence.			7.26			
LL19	Black and Deep Creeks.	At point just above entry to river			1.09			
LL26	Wet Creek	At highway crossing near mouth.			6.13			
LL27	Clyde diversion	In field near river station 500 ft below point of diversion.				−3.42		
LL27a (13-1187)	Little Lost River	Gaging station below Wet Creek at Clyde.	38.5	44.1			+3.5	+8.6
LL28	do	Above Deer Creek and above point of diversion.	33.2	46.6			+2.5	+5.7
LL30	Deer Creek	At indistinct road crossing one-quarter mile above mouth.			1.90			
LL32	Badger Creek	At highway crossing one-third mile above mouth.			4.68			
LL33	Little Lost River	Below Badger Creek and above spring on route.	31.4	50.5			−2.7	−5.1
LL34	Big Spring Creek	At point near highway in line with river measurement LL33, below tributary inflow.			15.7			
LL37	Little Lost River	Below farm near Fallert and 100 ft above Cederville Canyon road bridge.	20.0	67.8			+1.7	+2.6

See footnotes at end of table.

TABLE 5.—*Channel losses and gains in the Little Lost River basin, 1959*—Continued

[Percentages of gain or loss are rounded]

Station	Stream or diversion	Location	Miles above mouth	Discharge: River (cfs)	Discharge: Inflow from tributary (cfs)	Discharge: Diversion (cfs)	Gain or loss: Cfs	Gain or loss: Percent
		Little Lost River channel—Continued [Measurements made Sept. 18, 1959]						
LL38	Teeney Creek	At Cedarville Canyon road crossing and in line with river measurement LL37.			7.41			
LL39	Wiseman diversion.	At headgate of ditch near USGS gage.				−1.44		
LL39a (13-1190)	Little Lost River	Gaging station near Howe	16.5	74.1			+0.3	+0.4
Total or net					75.07	−4.86	+3.9	+5.5

NOTE.—Station numbers in parentheses are Geological Survey IBM numbers.

The loss in the channel and diversion canal of Sawmill Creek in the 7-mile reach from the mouth of the canyon to Summit Creek was 21 percent. The loss in the channel of Summit Creek in the 4-mile reach below the diversion inflow, or from the bridge on Sawmill Canyon road to the crossing at Bell Mountain road and the old corral, was 13 percent. The channel probably loses water for at least another mile, or to about the place where water from the Telford inflow channel enters the river. In the reach of the river between the Bell Mountain crossing and the gaging station below Wet Creek, the increase in river flow exceeded the measured tributary inflow. At the time the inflow measurements were made, direct unmeasurable seepage to the river was in evidence all along this reach.

Measurements at the four check points in the 22-mile reach between the two gaging stations showed gains and losses in the surface flow of the Little Lost River of less than 6 percent of the measured flow. The significance of differences of this magnitude is obscured by limitations in the accuracy expected of the measurements themselves and by the complicated channel conditions in the reach. Results obtained thus far are not sufficiently conclusive to serve as a basis for the determination of reliable channel transportation coefficients. A channel transportation coefficient generally varies with stage and can be applied to discharge at the head of a reach to determine the correct discharge, exclusive of inflow and diversion, at the end of the reach. Medium- and high-stage transmission factors may be greatly different, as indicated by the study of a range of discharges at the two stations. Operational difficulties during the initial period of record at the upper gage also cast some doubt on the reliability of the relation thus far developed between the two stations.

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Additional streamflow measurements of the main river, tributaries, and diversions, from below Summit Creek to the lower gaging station, are necessary to determine channel transportation coefficients more precisely. A minimum of two runs must be made, one during the freshet season and one about midway in the irrigation season. At best, only the approximate amount of water routed through this part of the channel can be determined, because of the apparent alternate loss and gain of water in some reaches.

GROUND WATER

SOURCE AND OCCURRENCE

The alluvial sand and gravel deposits in the Little Lost River valley are the most important aquifers in the basin. Except for a few wells near the mouth of the valley that obtain water from the Snake River basalt, all wells are completed in the alluvium. The consolidated rocks in the hills and mountains, however, also play an important role in the water regimen of the basin. These rocks are greatly fractured, and the fractured material, together with talus and slope wash on some of the steeper slopes and a fairly thick residuum on gentler slopes, forms a large ground-water reservoir, which is recharged during periods of rainfall and snowmelt. During periods of fair weather, discharge from this reservoir maintains the flow of the streams within the basin. There are no wells in the hills or mountains; however, numerous springs on the flanks of the highlands show that the rocks are saturated to altitudes well above the valley floor. Many of these springs are shown on topographic quadrangle maps, such as those of the Gilmore, Diamond Peak, and Hawley quadrangles. Some of the springs discharge into the streams; others discharge at the base of the mountains, and the flow from some of these percolates into the alluvium within a very short distance of the base of the mountains. Undoubtedly a considerable amount of ground water moves out of the aquifers of the hills and mountains into the valley alluvium and never appears at the surface.

Thus, the aquifer beneath the valley is recharged by (1) precipitation on the valley floor; (2) percolation from streams entering the valley; (3) percolation from springs at the margins of the valley; (4) underflow from the bedrock aquifers of the adjacent highlands, and by (5) infiltration of irrigation water.

WATER TABLE

As was previously explained, the alluvial materials are generally better sorted and are more permeable toward the center of the valley than near the valley margins. Thus, water entering the alluvial aquifer near the margins of the valley moves toward the center and gradually turns downvalley. The water-table contour lines, which are shown as nearly straight lines across the central upper two-thirds of the valley, (fig. 4) undoubtedly would swing downvalley near the margins if data were available to define them.

The downvalley gradient of the water table is fairly uniform, about 43 feet per mile from the junction of Sawmill and Summit Creeks to the bedrock ridge that constricts the aquifer in secs. 21, 22, 23, and 24, T. 7 N., R. 28 E. At this place the water table declines very steeply, dropping about 200 feet in less than 2 miles. The major drop in the water table may occur in a much shorter distance. The only controls used to determine the gradient were sites at either end of the reach—springs at the upper end in sec. 21, T. 7 N., R. 28 E., and well 6N–28E–1bc1 at the lower end. The bedrock ridge apparently acts as a partial dam. Hydraulic considerations suggest that, if the bedrock ridge visible at the surface were the only barrier to underflow, the gradient in the reach would be much gentler and the steepening of the water table would begin farther upvalley. Therefore, a buried projection is believed to extend from the visible part of the bedrock ridge westward beneath the alluvium. Ground water crosses the ridge as a sort of underground "cascade."

A map by Crandall and Stearns (1930, pl. 2) shows water-table contours in December 1929 for a small part of the basin immediately upvalley from the bedrock barrier. The map is based on water-level measurements in about 18 wells and several springs. Nearly all the wells have since been destroyed and measurements of water levels could not be made in that area in 1959; however, the appearance of the springs and the amount of discharge suggest that the depth to the water table in this area is about the same as it was in 1929. The datum used by Crandall and Stearns was chosen arbitrarily and cannot be related precisely to sea-level datum. It appears, however, that their 80-foot contour is approximately the same as the 5,250-foot contour shown on plate 2. Their map shows detail not available at the present time (1959) and therefore has been reproduced in figure 5.

The aquifer widens downvalley from the bedrock barrier, and the water-table gradient in the Howe area ranges generally from 15 to 20 feet per mile. The water table in most of this area is 40 to 100 feet below the surface. The alluvial materials in the area consist of interbedded sand, gravel, clay, and silt (pl. 3). The proportion of silt and clay apparently increases downvalley, so that east of Howe the alluvial materials are predominantly silt and clay. These materials are of low permeability and are interbedded with tongues of basalt from the Snake River Plain. They are responsible for "damming" the ground water in the Howe area so that it is held at a level nearly 200 feet higher than the water level in the basalt of the Snake River Plain only a mile or so to the south. In the transition zone between

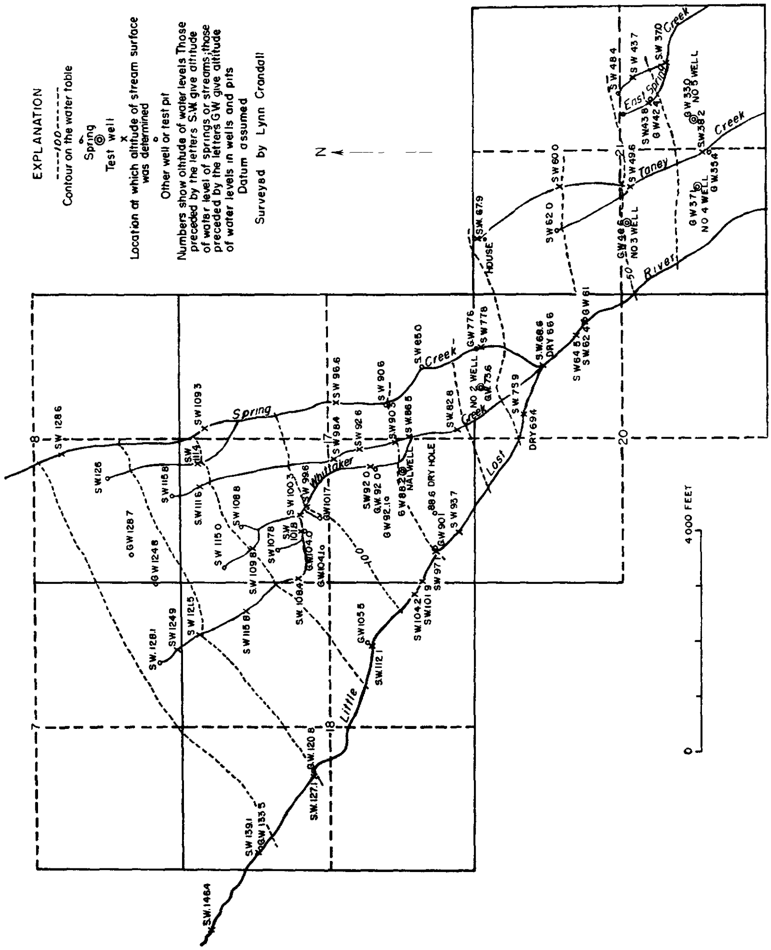

FIGURE 5.—Map showing ground-water conditions in the Spring Creek area of the Little Lost River valley, Idaho. (From Crandall and Stearns, 1930.)

the high water table in the Howe area and the lower water table of the Snake River Plain, the water level in a well may stand at progressively lower levels as successively deeper aquifers are penetrated during drilling.

UTILIZATION OF GROUND WATER

Several hundred wells, about 100 of which are described in table 6, have been dug or drilled in the valley. In 1959, about 63 of those described were used for irrigation. The deepest well known is 318 feet deep; all but about 10 of the wells given in table 6 are less than 150 feet, and many are less than 100 feet deep. Most of the wells were drilled, either from the surface or in the bottom of dug wells, but some dug wells still are in use. Most drilled domestic and stock wells are 6 inches in diameter; irrigation wells are generally 14 to 18 inches in diameter.

The discharges of 38 irrigation wells were measured by the Idaho Department of Reclamation. Of these wells, 13 discharged more than 1,500 gpm, 17 discharged between 1,000 and 1,500 gpm, and 8 discharged less than 1,000 gpm. Data from these and other pumping tests made by drillers and irrigation-equipment companies are given in table 6. The maximum discharge measured in the area was 2,475 gpm from well 10N–27E–7cc1, and the minimum was 303 gpm from well 6N–29E–24bb1. Drawdowns in the 38 wells ranged from 12 to 60 feet, and averaged about 30 feet in the Howe area and about 40 feet in the upvalley area.

The drawdown in a well includes the drawdown in the aquifer immediately adjacent to the well and entrance loss of head caused by flow, generally turbulent, through the perforations in the casing or well screen and in the casing to the pump intake. In the Little Lost River valley no well screens have been used; nearly all irrigation wells admit water through perforations in the well casing. Perforations are precut with a torch or are cut with a casing knife after the casing is set. Torch-cut perforations are usually ¼ to ⅜ inch by 12 inches, and knife-cut perforations are 5/16 inch by 2½ or 3 inches. In most wells for which construction data are available about 250 to 450 perforations are used in an interval of 40 to 60 feet. Generally the openings constitute less than 4 percent of the surface area of the casing adjacent to the aquifer in the perforated interval

How much of the drawdown in wells in the Little Lost River valley is due to entrance loss is not known. However, in other areas where the same type of construction has been used for similar aquifers, entrance loss commonly exceeds 50 percent, and in some wells exceeds 90 percent of the total drawdown. Probably an average of three-quarters of the drawdown in the Howe area is due to entrance loss.

TABLE 6.—*Records of wells in the Little Lost River valley, Butte County, Idaho*

Type of well: DD, dug and drilled; Dr, drilled; Du, dug.
Depth of well: M, measured depth.
Character of aquifer: G, gravel; S, sand; C, clay; B, basalt.
Altitude of land surface: Altitudes determined by spirit leveling are given to the nearest tenth of a foot. Altitudes determined by aneroid barometer are given to the nearest foot. Altitudes interpolated from topographic maps are indicated by an asterisk(*).
Depth to water: Measured depths to water are given to the nearest tenth of a foot. Reported depths to water are given to the nearest foot.
Type of pump: J, jet; P, piston; T, turbine; Sub, submersible.
Yield of well: Data giving yields were measured by the Idaho Department of Reclamation, except that those marked R were reported by users.
Use: I, irrigation; D, domestic; U, unused; A, abandoned; S, stock; O, observation.
Remarks: CA, chemical analysis on page 36; L, log available in files of U.S. Geological Survey. Selected well logs are given in this report. Data regarding drawdown (Dd), yield, pumping tests, and number of acres irrigated are reported.

Well	Owner	Year drilled	Type of well	Depth of well (feet)	Casing: Diameter (inches)	Casing: Depth (feet)	Character of aquifer	Altitude of land surface (feet)	Water level: Depth to water (feet)	Water level: Date	Pump: Type	Pump: Horsepower	Yield of well (gpm)	Date of measurement	Use of well	Remarks
10N-27E-7cc1	Byron Telford	1956	Dr	125	22	122	G	*6,085	13.0	12/4/59	T	75			I	Dd 80 ft at 2,475 gpm after 48 hrs; L; ± 840 acres.
19ab1	J. L. Amy and Margaret Waymire.	1949	Dr	86	16	80		*6,035	22		T	25	1,794	6/4/53	I	Dd 11 ft; 350 acres.
19bd1	C. F. Scott		Dr		6			*6,042	32.1	10/28/59	P				U	
19dd1	Jess L. Amy	1949	Dr	86	16	86		*6,030	22		T	20			I	Dd 40 ft; 160 acres.
29bc1	Lowell J. Nelson	1957	Dr	75	6	75	S,G	*5,995	14.9	9/14/59	J	½			D	L.
9N-27E-4db1	Jess L. Amy	1959	Dr	83M	16			5,874	27.3	10/28/59	None				U	Yield inadequate
9bc1	Frank E. Reed	1939	Dr	65	4 or 5	65	G		20		J	½			D, S	
10cc1	Ralph Blessinger	1952	Dr	119	16	90		5,838	45		T	40	1,319	8/7/56	I	Dd 45 ft; 140 acres.
21bb1	Frank E. Reed	1951	Dr	100	16	90	G	5,773	12		T	40	1,441	July 1956	I	Dd 50 ft; 315 acres.
22bb1	do		Dr		8				35		J	1			D, S	
28ca1	Lawrence W. Isham.	1956	Dr	70	6	70	G		16.0	9/12/59	J	½			D, S	
28cb1	do	1956	Dr	110	16	99½	G	5,717	18.5	10/28/59	T	40	2,091	7/23/58	I	Dd 47 ft at 1,800 gpm after 1 hr; L; 319 acres.
34cd1	Andrew D. Little.		Dr					5,705	51.1	10/28/59	P	1			D	
8N-27E-3ba1	do		Dr	80	16			*5,635	6		T	30	2,177	7/23/58	I	250 acres.
8N-28E-29ba1	Orville W. Nicholson.	1955	Dr	126	6	126	G	5,403	81.2	9/12/59	J	1(?)	600R		D, S	
29bb1	do	1958	DD	128	16	128	G	5,390	70.4	10/28/59	T	60	1,345	7/23/58	I	Dd 105 ft at1,345 gpm after 5 to 10 min; 200 acres.

7N-27E-12aa1	L. R. Hawley		Dr	60	16	60	C, G		25		T	20	702	8/ 2/55	I	Dd 30 ft; L. This and other wells given below irrigate 1,483 acres.
12aa2	do		Dr	80	16	80	G	5, 321	20. 1	10/28/59	T	15	972	8/ 2/55	I	L.
12ab1	do		Dr	60	16	60	C, G				T	40	1, 485	8/ 2/55	I	L.
12ba1	do		Dr	100	16	100			14		T	40	1, 998	8/ 5/53	I	Dd 36 ft.
12ba2	do		Dr	100	16	100		5, 326	12. 7	10/28/59	T	40	1, 998	8/ 5/53	I	
12dd1	do		Dr		16						T	30	1, 566	8/ 4/54	I	
7N-28E- 7cb1	L. R. Hawley		Dr	100	16	100					T	50	2, 106	8/ 2/55	I	
7cc1	do		Dr	87	16½	87	C, G	5, 280	7. 6	10/28/59	T	25	1, 323	8/ 4/54	I	Dd 18 ft at 1,350 gpm; L.
21ca1	do		Dr	318M	14			5, 179	6. 2	10/28/59	None				A	
6N-28E- 1bc1	Bob Hall	1959	Dr	215	16	215	G	5, 043	160. 7	12/ 4/59	None					Yield inadequate; L.
24ab1	L. R. Hawley		Dr	93	6			4, 938	95. 7	10/29/59	T				S	
6N-29E- 8bc1	Lewis Burgess	1953	Dr	187M	16	191	B, S	4, 942	95. 0	10/27/59	None				A	L.
8dc1	Hope Land and Water Co.		DD		36, 16		S, G	4, 921	82. 0	10/29/59	T	50	1, 193	8/ 7/56	I	Wells 8dc1, dd1 and 16bb1 irrigate approximately 360 acres.
8dd1	Hope Land and Water Co.	1956	DD	148	36, 16	148	S, G	4, 908	80. 5	9/15/59	T	50	1, 548	8/ 7/56	I	L.
15cb1	Melvin L. Caldwell		Dr	120	16	110	S, G		60	July 1958	T	50	1, 759	7/22/58	I	130 acres.
16bb1	Hope Land and Water Co.		DD	120	36, 16	120	S, G	4. 906	77. 1	10/29/59	T	50	1, 552	8/ 7/56	I	
16cd1	Sweet Sage Development Co.	1959	Dr	129M	16	131	G	4, 876	75. 9	9/ 1/59					I	L.
16cd2	do	1959	Dr	132M	16		G	4, 885	70. 2	10/27/59					I	L.
16dd1	do	1959	Dr	133M	16	131	G	4, 870	73. 2	9/ 1/59					I	L.
16dd2	do	1959	Dr	101	6	±100	S, G	4, 865	70. 7	9/ 1/59	Sub				D	L.
17cc1	do	1956	DD	152	36, 16	152	S, G		80	2/13/56	T	60			I	L. Wells in secs. 16, 17, and 21 supply water to irrigate approximately 1,000 acres.
17cc2	do	1959	Dr	136	16	136	G		76	2/28/59	T				I	Dd 52 ft at estimated 675 gpm after 6 hrs; L.
17cd1	do	1956	DD	150	36, 16	150	G		75	3/ 1/56	T	60			I	L.
17dc1	Sweet Sage Development Co.	1959	Dr	135	16	136	G	4, 896	79. 5	9/15/59	T	60			I	Dd 57 ft at 1,615 gpm after 5 hrs; L.
18db1	Roland L. Reeves.	1957	Dr	142	16	83–142	G	4, 939	94	3/15/57	T	40			I	L; 240 acres.

TABLE 6.—*Record of wells in the Little Lost River valley, Butte County, Idaho*—Continued

Well	Owner	Year drilled	Type of well	Depth of well (feet)	Casing		Character of aquifer	Altitude of land surface (feet)	Water level		Pump		Yield of well (gpm)	Date of measurement	Use of well	Remarks
					Diameter (inches)	Depth (feet)			Depth to water (feet)	Date	Type	Horsepower				
6N-29E-19bb1	Wendell Hansen	1952	DD	160	72, 20, 16	160		4,931	92.3	10/27/59	T	75	1,763	8/17/57	I	Dd 20 ft; 225 acres.
19dc1	Harry Mays	1912	Du	79M			G	4,905.1	69.3	8/29/49	P				D, S	
20ba1	Philip S. York		DD	112	16	112			72	August 1956	T	50	1,319	A 8/ 7/56	I	Dd. 38 ft. Wells 20ba1 and bb1 irrigate 306 acres.
20bb1	do		DD	140	36, 18, 16	140		4,915	85.4	10/27/59	T	60	1,354	8/ 7/56	I	Dd 54 ft.
20ca1	Paul E. Harrell		Dr	117	16	117	S, G		47	May 1952	T	60	1,512	5/20/52	I	Dd 18 ft; 240 acres.
20cd1	Mrs. G. G. Harrell.		DD		36, 6		S, G	4,886	72.9	9/ 2/59	J				D, S	Being drilled deeper; original depth, 72 ft.
20dc1	Paul E. Harrell	1913	Du	53M	40	72	S, G	4,883.8	61.4	8/29/49	P	¼			D, S	Dry 9-17-59; CA.
20dd1	do	1956	DD	108	16	58-108	G	4,877	68.0	10/29/59	T	50			I	L; about 16' acres.
21aa1	Sweet Sage Development Co.	1958-59	Dr	133	16	133	G		55	2/18/59	T	60			S	Dd 69 ft at 1,426 gpm after 4 hrs, 20 min; L.
21ab1	do	1959	Dr	133	16	131	S, G		55	2/14/59	T	60			I	Dd 69 ft at 1,579 gpm after 9 hrs; L.
21ac1	do	1956	DD	135	16	135	S, G	4,868	67.2	10/29/59	T	75			I	L.
21ad1	do		Dr								T				I	
21ad2	Hope Land and Water Co.		DD	101	36, 18, 14			4,856	67.9	9/15/59	T	50			I	
21ad3	do	1956	DD	135	36, 16	135	S, G	4,865	72.0	9/15/59	T	75			I	L.
21bb1	Al Wiseman		DD	144	16	144	S, G	4,889	77.1	9/15/59	T	50	1,230	8/ 6/52	I	Dd 30 ft; 180 acres.
21cb1	Willard O. Bell		DD	109	18	109	S, G		60	August 1954	T	60	1,337	8/ 4/54	I	160 acres.
21dc1	Unknown		Du	59M	6		S, G	4,862.2	65.2	9/17/59	J	1			D, S	
21dd1	Clifton Scott		Du	67	36			4,857.3	50.9	8/26/49	P	¼			D, S	CA.
22ab1	Warren E. Stauffer.		DD	87M	40, 16	90		4,845	62.3	9/15/59	T	40	1,351	8/ 6/52	I	Dd about 15 ft; 160 acres.
22ab2	William Stauffer.		DD	90M	36, 18			4,840	59.1	10/27/59	T	40	843	5/21/59	I	153 acres.
22bb1	Warren E. Stauffer.		DD	105M	36			4,861	64.3	10/29/59	T	40	1,049	6/21/59	I	160 acres.

22cd1	John Dietrich	1947	DD	97	44, 16	97		4,844.3	59.8	9/ 3/59	T	25	907	5/20/52	I	Dd 12 ft after 3 hrs; 87 acres.
22cd2	Dan H. Levan	1950	DD	103	36, 20	103	G	4,842	57.0	10/29/59	T	75	1,511	8/ 7/57	I	200 acres.
22da1	Jess M. Strope		DD	85	36, 18	85		4,838	57.1	9/ 3/59	T	40	1,220	8/ 4/54	I	240 acres.
22db1	R. Urich and Earl Wortley.		DD	88	36, 16	88		4,841	61.8	3/ 9/59	T	50	1,261	9/13/50	I	Dd 20 ft; 227 acres.
22dc1	Robert Urich	1926	DD	66	46, 6	66	G	4,840.7	44.8	8/26/49	J				D	
23ad1	Hope Land and Water Co.		DD		18			4,822	41.0	9/16/59	T	25			I	80 (?) acres
23cb1	Earl Wortley	1956	DD	97	42, 18, 16	87	G	4,829	50.8	10/29/59	T	30	1,113		I	L; 160 acres.
23cd1	Keith Strope		Du	43M	48			4,824.2	38.7	8/26/49						
23db1	Hope Land and Water Co.	1956	DD	86	36, 16	86	G	4,828	44.3	9/ 3/59	T	25			A	L
24aa1	Unknown		DD	98M	None		G		Dry	9/ 9/59	None				A	
24bb1	Robert Urich	1950	DD	66M	36, 16	72	G	4,826	43.7	9/ 9/59	T	20	303	6/ 4/53	I	Dd 26 ft; L. Wells 24bb1, bb2, and bc1 irrigate 80 acres.
24bb2	do		DD	67M	45, 14	69		4,821	38.3	9/ 9/59	T	15	718	6/ 4/53	I	Dd 28 ft.
24bc1	do	1957	DD	66M	36, 14	64	G	4,821	38.2	10/29/59	T		314R		I	L.
24cb1	E. L. Amos	1956	DD	73M	16	73	G, S	4,819	36.5	10/29/59	T	25	817	8/12/58	I	Dd 40 ft; L; 160 acres.
24cb2	do		DD	69M	48, 14	85		4,821	36.2	9/ 9/59	T, J	20, 1			I, D	Dd 15 ft; 160 acres.
25aa1	William Stauffer.		Du	43M	40			4,803.3	25.2	10/27/59	None				A	
25ab1	do(?)	1948	Dr	78			S, G	4,806.4	34.9	8/26/49						L; well destroyed.
25bc1	Henry Stauffer	1955	DD	40M	22, 21		G, S	4,812.2	33.7	10/27/59	T	30			I	L; unused in 1959.
25cb1	Byron Telferd	1955	Dr	253	None		S		55	May 1955					A	Location approximate. L.
29bc1	Harry Mays		Du	67M	36			4,886.7	63.5	8/29/49	P				A	
30aa1	Tom Hocking	1955	Dr	106	6	126	G	4,899	74.7	10/29/59	J	1			D	L.
30ab1	do		Dr								T	50			I	Approximately 320 acres.
26ab1	Raymond H. Ralls.	1955	Dr	76	16	76	G	4,819	[1] 59.0	9/ 4/59	T	30			I	Wells 26ab1 and 2 irrigate 240 acres.
26ab2	do	1953	DD	72	16		G	4,821	41.7	10/29/59	T	25			I	
26cb1	Paul R. Solem	1948	DD	87	36, 16	87	G				T, J	30, 1	1,230	8/ 4/53	I, D	Dd 10 ft; L; 120 acres.
26cd1	Clarence Fink	1955	Dr	96M	16	124	G	4,820	58.2	10/29/59	None				U	Original depth, 132 ft reported; L.
27bb1	Ida McGehee	1957	DD	95	36, 18, 16	89	G	4,851	58.3	10/29/59	T, J	30, ¾	1,130	7/21/59	I, D	Dd 13 ft at 1,200 gpm after 2 hrs; L; 110 acres.
28cb1	Willard O. Bell		Dr	109M	16			4,873	62.4	10/29/59	T	50			I	40 acres.
28cb2	do		Dr		16			4,865	63.1	10/29/59	T	60			I	160 acres.
28da1	P. S. York	1959	Dr	110	6	110	G				J	1			D	
28db1	do	1954	Dr	106	16	106	G	4,867	59.8	10/29/59	T	50	[2] 889 [3] 1,346	8/8/57	I	Dd 14 ft; L; 130 acres.

TABLE 6.—*Records of wells in the Little Lost River valley, Butte County, Idaho*—Continued

Well	Owner	Year drilled	Type of well	Depth of well (feet)	Casing: Diameter (inches)	Casing: Depth (feet)	Character of aquifer	Altitude of land surface (feet)	Water level: Depth to water (feet)	Water level: Date	Pump: Type	Pump: Horsepower	Yield of well (gpm)	Date of measurement	Use of well	Remarks
6N-29E-32acl	Harley Kyle	1957	Dr	133	16	128	G	4,859	65.2	10/29/59	T	80	1,139R		I	L; 50 acres.
32bbl	Andrew D. Little		Du	72M	40			4,873.2	68.1	10/29/59	P				O	Hydrograph in report.
32bb2	do	1950	Dr	104	18	104	G		65.7	5/15/50	T	50	1,220	8/ 5/53	I	L; 143 acres.
33abl	Philip S. York	1954	Dr	94M	16½	100	S, G	4,853	63.9	10/29/59	None				U	Original depth, 100 ft reported; L.
33ccl	Charles Kyle		Du	67	40	65	S, G	4,842.5	61.1	10/17/56	P				D, S	CA.
33dbl	L. L. Cowgill	1959	DD	81M	40, 18	93	B	4,843	70.5	10/29/59	T				U	L; irrigates 120 acres.
33dcl	do	±1910	Du	108M	30	90	B	4,834.1	105.6	10/29/59	P	18			O, S	Hydrograph in report.
35abl	Fred Woody		Du	68	36			4,808.0	57.8	10/17/56	P				D, S, O	
5N-29E-1bbl	Unknown		Dr	154M	16		B	4,808	120.9	10/26/59	None					Unused irrigation well.
3bcl	Charles Webb	1924	Dr	155	6	40	B	4,822.1	113.9	10/26/59	P				D, S	L.
5N-29E-3cdl	Joe O'Maley	1957	Dr	178M	6	75	B	4,813	114.9	10/26/59	None				U	L.
4dcl	Nehi Hansel	1946	Dr	220	4, 6, 8	220	G	4,818.2	188	November 1946	P	3			D, S	L.
4dd3	Charles O'Maley.		Dr	140	6	140	G	4,819	94.8	10/26/59	P				D	
15aal	J. E. Mays and Sons.	1939	Dr	540	8	520		4,805.5	268.6	10/9/59	P				D, S, O	
23cd1	U.S. Geological Survey.	1951	Dr	401M	6	401	Cinders	4,800.3	272.0	10/26/59	None				O	L.

[1] Both this well and well nearby were being pumped at time of measurement.
[2] Average.
[3] Maximum.

In sand and gravel aquifers, slotted casings of the type used in wells in the Little Lost River valley allow large quantities of silt, sand, and fine gravel to enter and partly fill a well. Sediment also may casue extensive wear on the pump and thereby decrease its operating efficiency. Head loss can be reduced and pump efficiency increased if wells are constructed with sufficient openings of the correct size in the casing or screen.

One means of comparing the water-yielding ability of wells is by comparing their specific capacities—that is, their yield per foot of drawdown. In the Howe area specific capacities of 15 wells for which data were available ranged from 12 to 123 gpm per ft and averaged about 60 gpm per ft. The specific capacities are not constant, but vary with the discharge of the well and the length of time that the well is pumped.

Specific capacities of wells can be used to make a rough estimate of the coefficient of transmissibility of the aquifer where the coefficient of storage can be estimated and all or nearly all the drawdown occurs in the aquifer. The coefficient of transmissibility is defined as the quantity of water, in gallons per day, that will flow through a vertical strip of the aquifer 1 foot wide and extend through the saturated thickness of the aquifer, under a hydraulic gradient of 100 percent, at the prevailing temperature of the water. This coefficient in turn can be used to estimate flow through the aquifer. Assuming that only one-quarter of the drawdown occurs in the aquifer and that three-quarters represents entrance loss, the average specific capacity in the area should be about 240 gpm per foot for efficient wells. The coefficient of storage is defined as the volume of water released from or taken into storage per unit surface area of the aquifer per unit change in the component of head normal to that surface. It is expressed as a decimal fraction; for nonartesian aquifers, it is approximately equal to the specific yield.

If the coefficient of storage is assumed to be 0.20, which is believed to be a reasonable assumption for gravel aquifers, a coefficient of transmissibility of about 400,000 gpd per foot can be computed (Theis and others, 1954). That this is a reasonable, and perhaps conservative, estimate is suggested by the fact that coefficients of transmissibility determined by aquifer tests in similar materials in nearby valleys are as large or larger.

EFFECT OF GROUND-WATER WITHDRAWALS

The effect that withdrawal of ground water will have on the surface-water and ground-water supply of the basin is an important consideration. No water can be pumped and consumed without lowering the water level and reducing the outflow from the basin in accordance with the consumptive use. However, because some part of the water is taken from storage during the pumping, not all the decrease in basin outflow will occur during the period of pumping. Some of the water will be obtained at the expense of outflow during the nonpumping period. The extent to which outflow is depleted by withdrawals during the irrigation season is dependent on several factors, including the distance of the place of withdrawal from an area of discharge, the depth and thickness of the aquifer, and the coefficients of storage and transmissibility.

Because ground water discharges into the river in at least three reaches upstream from the hydrologic barrier in T. 7 N., R. 28 E., pumping of ground water upvalley from that locality will reduce streamflow to some extent. In general, the greatest reduction during the irrigation season will be caused by pumping wells in areas where the water table is higher than the water in the stream, particularly if the wells are very near the area of discharge to the stream.

The effect of pumping a well on the flow of a nearby stream can be computed under idealized conditions by means of an adaptation of the Theis nonequilibrium formula (Theis, 1953), if the coefficients of storage and transmissibilty are known. By use of the assumed coefficient of 0.20 for storage and the estimated coefficient of 400,000 gpd per foot for transmissibility, the percentage of the pump discharge that is obtained from the river can be calculated for any time after pumping begins. The percentages of river water pumped from wells A and B, at distances of 0.2 mile and 2.0 miles from the stream, respectively, are shown graphically in figure 6. It can be seen from these curves that well A would obtain 80 to 85 percent of its water from the stream, either directly or by diverting water that would otherwise have reached the stream during the irrigation season. On the other hand, only 10 or 15 percent of the water pumped from well B would be taken from the stream during the irrigation season. However, this percentage represents conditions during the first irrigation season. Because of the lag between pumping well B and lowering of the water level in the discharge area, depletion of the streamflow by cyclic pumping of well B would, after several years, result in a uniform rate of depletion of the stream. For example, if 120 acre-feet of water is pumped each year from well B and consumptively used, streamflow would be reduced after equilibrium is reached by approximately 10 acre-feet per month. On the other hand, pumping 120 acre-feet of water from well A would reduce streamflow by perhaps 90 acre-feet during the period of pumping, and the other 30 acre-feet would be obtained from the stream in the nonpumping season, when storage space in the aquifer near the well is being refilled.

The depletions given are based both on postulated ideal conditions and on assumed coefficients of storage and transmissibility. Actual

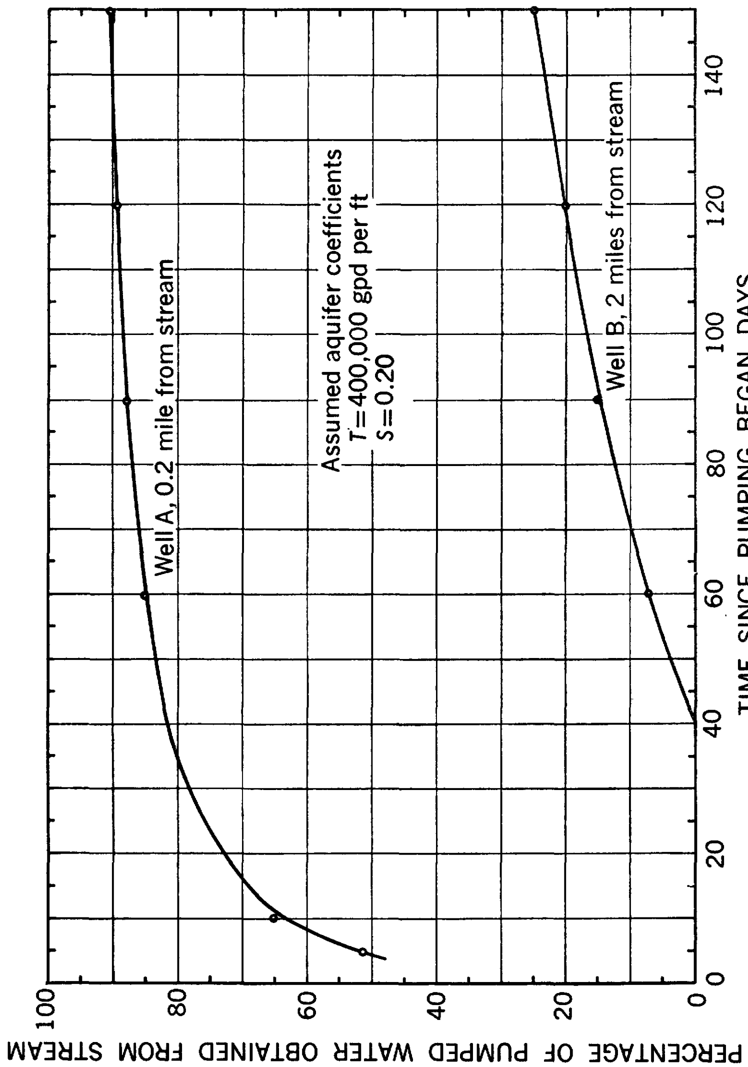

FIGURE 6.—Effect of pumping from wells on flow of a nearby stream.

conditions in the Little Lost River valley may be considerably different. Nevertheless, the computations show that a well near an area of ground-water discharge to a stream would have a much greater effect on streamflow during the irrigation season than would a well much farther away.

Furthermore, under the assumed conditions, each well would decrease basin outflow by approximately 120 acre-feet per year.

The above discussion is applicable only to the area upstream from the hydrologic barrier. Below the barrier, and especially several miles downvalley in the vicinity of Howe, pumping probably has little or no effect on streamflow. The river is perched 50 to 100 feet above the water table, and pumping will not materially increase vertical leakage. Streamflow could be diminished by pumping in this area only if the cone of depression were to expand upvalley, beyond the ground-water "cascade" into the area of ground-water discharge in secs. 17, 20, and 21, T. 7 N., R. 28 E. Such depletion of streamflow probably would not be significant and the amount of decrease would be distributed uniformly throughout the year. Thus it can be concluded that withdrawal and consumptive use of water from wells in the Howe area would be largely at the expense of ground-water flow across the hydrologic boundary east of Howe, which separates the valley from the Snake River Plain.

Water-level measurements have been made for the past 10 years in several wells in the Howe area. Hydrographs of two of these wells are shown in figure 7. Also a hydrograph of a well in the Snake River Plain, 5N–29E–23cdl, a few miles south of the mouth of the Little Lost River valley is shown in figure 7. Sharp rises shown on the hydrograph of this well were the result of flood runoff in Little Lost River, which percolated to the Snake River basalt aquifer in the vicinity of the well. The three hydrographs generally show very similar long-term trends. For the first 4 years of record, from 1950 through 1953, there was little net change in water level. In 1954 and 1955 the water level declined 1 to 2 feet in all the wells. This decline was general throughout the Snake River Plain and adjacent tributary valleys (Mundorff and others, 1960, p. 253–256) and cannot be attributed to pumping in the Howe area. During the period 1955 through 1959, ground-water levels at the wells rose slightly, even though pumping increased greatly during this period. The rise in water levels is probably attributable to an increase in recharge. More detailed analysis than this preliminary study permits would perhaps indicate quantitatively what the effect of pumping has been on the water table in the Howe area. Nevertheless, it is apparent that withdrawal and consumptive use of water in the Little Lost River valley, which in 1959 reached about 37,000 and 12,000

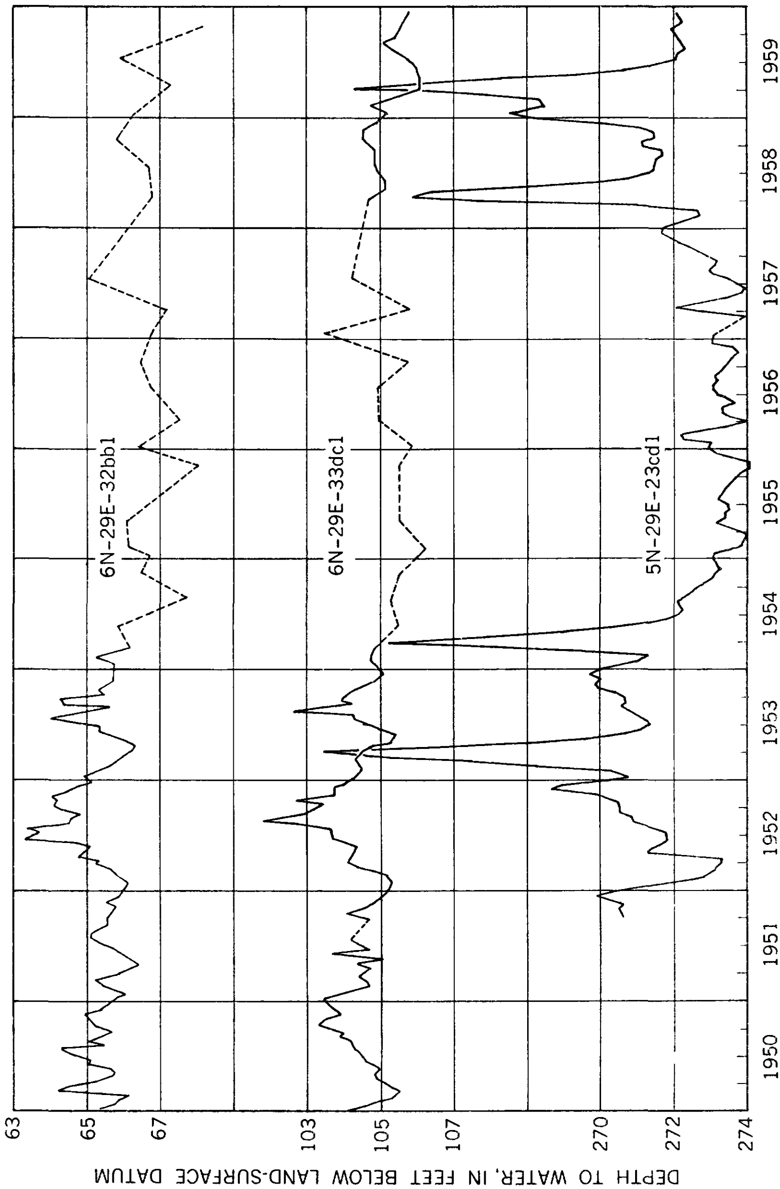

FIGURE 7.—Hydrographs of wells 6N-29E-32bb1, 6N-29E-33dc1, and 5N-29E-23cd1.

acre-feet, respectively, have not lowered the general water table more than 1 or 2 feet. The coefficients of storage and transmissibility apparently are large, and considerably more water could be utilized without a critical lowering of the water table. Increased pumping in effect would salvage ground water now leaving the Little Lost River valley as underflow to the Snake River Plain.

QUALITY OF WATER

Chemical analyses of 3 samples of water from wells and 1 sample from the Little Lost River are given in the following table. The water sampled is predominantly of the calcium and magnesium bicarbonate type, moderately hard to hard. By most frequently used criteria, the water is satisfactory for irrigation use. Some of the water is harder than desirable for domestic use but otherwise is satisfactory.

Chemical analyses of water from the Little Lost River valley, Idaho

[Results in parts per million except as noted. Analyses by U.S. Geol. Survey]

	Well			Little Lost River [1]
	6N-29E-20dc1	6N-29E-21dd1	6N-29E-33cc1	
Date of collection	1/5/50	10/18/49	10/18/49	7/22/57
Temperature (° F)	45	----------	48	62
Silica (SiO_2)	17	----------	----------	15
Iron (Fe)	.06	----------	----------	.00
Calcium (Ca)	50	----------	----------	27
Magnesium (Mg)	18	----------	----------	7.8
Sodium (Na)	27	----------	----------	3.0
		11	3.9	
Potassium (K)	2.1	----------	----------	.6
Bicarbonate (HCO_3)	244	220	264	119
Sulfate (SO_4)	26	40	15	7.1
Chloride (Cl)	14	35	6	2
Fluoride (F)	.1	----------	----------	.2
Nitrate (NO_3)	16	----------	----------	.5
Boron (B)	.02	----------	----------	----------
Dissolved solids (residue at 180° C)	290	----------	----------	123
Total hardness as $CaCO_3$ (calcium and magnesium)	199	248	232	99
Specific conductance (micromhos at 25° C)	457	534	452	202
pH	7.6	----------	----------	8.0
Percent sodium	22	9	4	6

[1] SE¼NE¼ sec. 16, T. 9 N., R. 27 E.

BASIN ANALYSIS

A precise quantitative analysis of the water supply of a basin requires detailed geologic and hydrologic data, which for the Little Lost River basin simply are not available. However, the scanty information available for this area can be used to determine the factors and the general magnitude of quantities involved.

TOTAL WATER YIELD OF THE BASIN

The total water yield of a basin is that residue of total water supply that is not consumed within the basin by natural processes. The total water supply of a basin is the total amount of water available to the basin in any form. In this area it is assumed to be derived almost entirely from precipitation. The water budget, or distribution of the water supply, for the Little Lost River basin is based on water years and was estimated by the use of three following methods.

RELATION OF PRECIPITATION TO WATER YIELD

A method of relating total precipitation to total water yield of tributary basins in the eastern part of the Snake River basin was described by Mundorff and others (1960, p. 51). In this method the measured surface-water outflow of selected basins is related to the average annual precipitation on the basin as shown on an isohyetal map. All the basins used in establishing the relation have the same general physiographic and geologic setting and geographic orientation.

Mundorff and others (1960) used an isohyetal map by the U.S. Army Corps of Engineers (1950, v. 4, app. G, pl. 4). According to Mundorff, the weighted average annual precipitation on the Little Lost River basin above its mouth is 14.7 inches; and the relation shown by Mundorff and others (1960, fig. 7 p. 68) indicates that the water yield of the basin is about 160,000 acre-feet. A more recent isohyetal map based on the period 1921–57 has been prepared in greater detail by the U.S. Geological Survey for use in a report on flood frequency in the Snake River basin (Thomas and others, written communication 1960). Data from this more recent map have been used to plot the precipitation-runoff relation shown in figure 8. From the isohyetal map (fig. 3), an annual mean precipitation of 14.8 inches is obtained for the Little Lost River basin. This value used on the curve shown in figure 8 gives a mean annual runoff of about 4 inches over the area of about 900 square miles and a water yield of 190,000 acre-feet per year. Limits of accuracy are probably plus 25 percent (+45,000 acre-feet) to minus 12 percent (−25,000 acre-feet).

The figures for average precipitation used in both the present and the earlier study are nearly identical. The difference in the yields computed was caused by the use of different basins in establishing the relation. In the earlier study, basins on both the southeast and northwest sides of the Snake River Plain were used to establish a general relation for the entire east end of the plain. In this investigation, only basins on the northwest side were used. These basins generally yield more water than those on the other side. The following table gives basins used in establishing the relation shown in figure 8.

Relation of water yield to average annual precipitation, north flank of eastern Snake River Plain

No.	Stream and gaging station	Area (sq mi)	Average annual water depth (inches over the area)	
			Precipitation	Water yield [1]
1	Pacific Creek near Moran, Wyo	160	40	21.7
2	Buffalo Fork near Moran, Wyo	378	45	20.2
3	Bear Creek above reservoir, near Moran, Wyo	77.1	31	13.0
4	Henrys Fork near Island Park	481	32	15.3
5	Henrys Fork near Ashton	3,880	29	17.5
6	Teton River at St. Anthony	890	25	11.6
7	Willow Creek near Ririe	622	17	4.7
8	Birch Creek near Reno	320	14.5	3.4
9	Big Lost River at Wildhorse, near Chilly	114	24	11.1
10	Big Lost River at Howell's ranch, near Chilly	448	24	8.4
11	Big Wood River near Ketchum	137	34	14.4
12	Little Wood River at Campbell ranch, near Carey	267	18	7.4
13	Fish Creek above dam	38	15	7.0
14	Clover Creek near Bliss	150	14	3.2

[1] Average discharge for the period 1921–57, assumed to be water yield.

PERIMETER INFLOW

In a previous part of this report (p. 17) surface inflow from the mountainous perimeter was determined to be about 95 cfs during a period of base flow when flow consisted entirely of ground-water effluent. This discharge was considered to represent the flow of a single synthetic stream in the basin and could therefore be correlated with other streams in the region. The annual discharge for 1959 was obtained from the relation (fig. 9) between discharge during the base-flow period and annual mean discharge during water year 1959. Five stations having the same general hydrologic conditions as the perimeter area of the Little Lost River were used. According to the relationship, the mean annual discharge for the perimeter of the entire basin during the 1959 water year is about 190 cfs, or 138,000 acre-feet. When this discharge is adjusted to the base period 1921–57, used for the isohyetal map, the 37-year mean annual discharge becomes 260 cfs, or 190,000 acre-feet.

It is evident that some recharge to the basin occurs from precipitation on the alluvial fans and terraces, which occupy about 250 square miles inside the perimeter. The materials underlying these areas are chiefly coarse gravel and boulders underlying scanty soil. The water table is a considerable distance below the surface; accordingly, the vegetation can utilize only the moisture retained in the soil. According to Blaney and Criddle (1949, p. 9), the evapotranspiration from arid lands having sparse native vegetation in the upper Colorado River basin consumes all precipitation in the growing season plus 50 percent, to a maximum of 3 inches, of the precipitation in the nongrowing season. The remainder of the precipitation in the nongrowing season

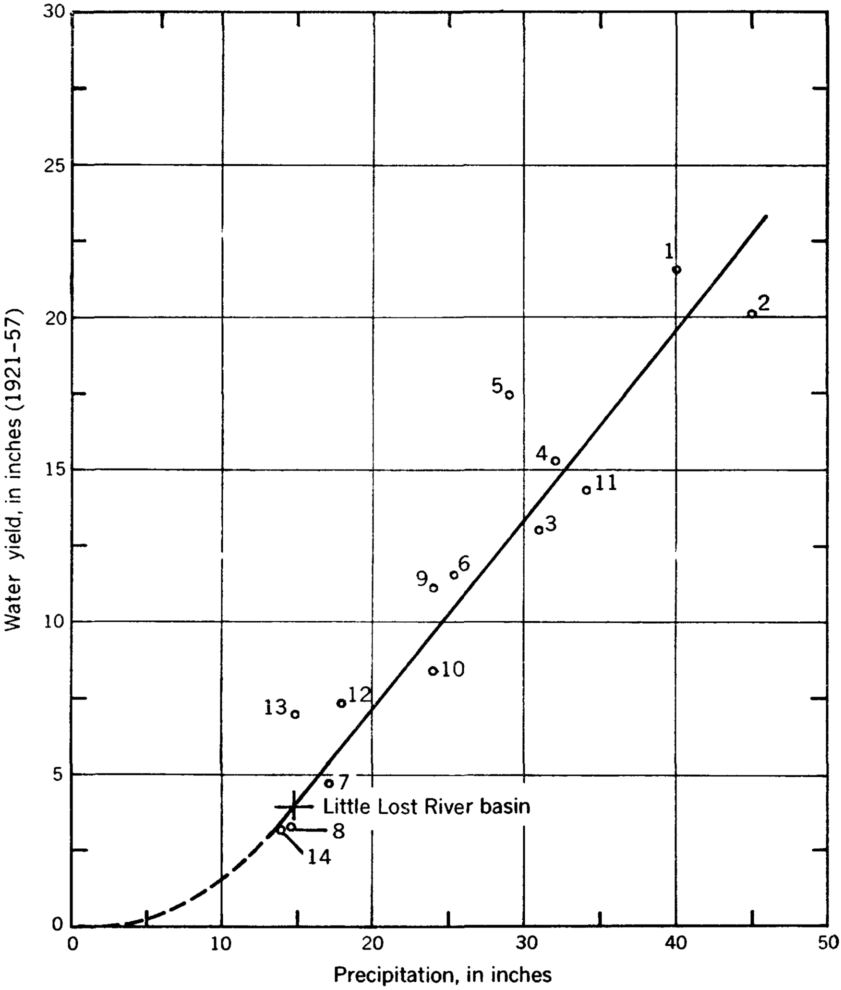

FIGURE 8.—Relation between precipitation and basin yield, upper Snake River basin, Idaho.

presumably would not be consumed and would become either surface runoff or, as in this area, ground-water recharge. The isohyetal map shows that average annual precipitation on the alluvial slopes is about 12 inches. If half of that amount is used by native vegetation from May through September as indicated by the record of monthly distribution of precipitation at Howe, the average contribution to water yield would be about 3 inches over the 250 square miles of the basin, or 40,000 acre-feet per year. As there is little or no surface discharge from these areas, most of the water must become ground-water recharge.

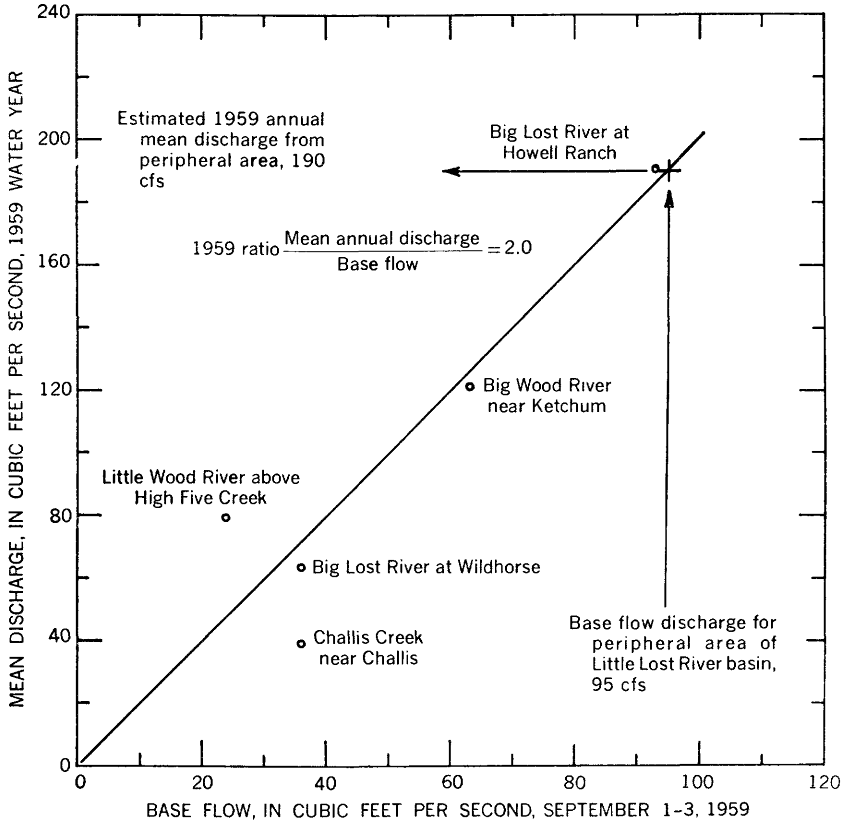

FIGURE 9.—Relation between base flow and mean annual discharge of the Little Lost River basin, Idaho.

A second method of estimating the water yield of these alluvial slopes is the precipitation-water yield relation shown in figure 8. According to the curve, an area having an average precipitation of 12 inches should have a water yield of about 2½ inches, or about 33,000 acre-feet. The average estimate from the two methods, 36,000 acre-feet, is used for determining the water yield of the basin.

Several areas along the Little Lost River, estimated to total about 20 square miles, are occupied by phreatophytes. Much more water is consumed in these areas than is contributed by direct precipitation, and therefore the difference is supplied at the expense of streamflow and underflow. This loss represents a negative entry in the water budget for the basin. In most areas phreatophytes are light to medium in density and consume roughly 24 inches of surface and ground water plus about 10 inches of precipitation. Consumptive use by phreatophytes in an estimated area of about 20 square miles is thus about 26,000 acre-feet.

The water yield of the basin thus is equal to perimeter inflow plus yield on alluvial slopes minus evapotranspiration, or 190,000+36,000−26,000=about 200,000 acre-feet.

SURFACE FLOW, UNDERFLOW, AND CONSUMPTIVE USE

A third method used to estimate water yield of the basin is to add the total outflow of both surface and ground water. Surface flow has been gaged, but underflow can only be estimated. The average annual discharge at the gaging station on Little Lost River near Howe was 70 cfs for 19 years of record. Some additional surface flow bypasses this station, as in East Spring Creek, but it probably does not exceed 5 cfs. Thus the average surface flow past the hydrologic section is about 75 cfs, or 55,000 acre-feet per year.

In another part of the report, the transmissibility of the entire thickness of aquifer is estimated to be about 400,000 gpd per ft. This figure can be used to help estimate the amount of ground-water outflow from the basin.

Because the gaging station near Howe is close to the area of the postulated hydrologic boundary, where the hydraulic gradient is not accurately known, a hydrologic section a few miles upstream from the station was selected for estimating underflow. The average hydraulic gradient is about 40 feet per mile and the aquifer is 5 to 7 miles wide. The underflow is computed to be about 96 mgd or nearly 110,000 acre-feet per year by use of a width of 6 miles, a gradient of 40 feet per mile, and a coefficient of transmissibility (T) of 400,000 gpd per ft in the equation $Q=TIW$, where Q is the underflow, in gallons per day; I is the hydraulic gradient, in feet per mile; and W is the width of the aquifer, in miles. If the coefficient of transmissibility is greater or smaller, the amount of underflow would be correspondingly greater or smaller. The total outflow past this hydrologic section of the basin, as determined by this method, is therefore 55,000 acre-feet (surface flow) plus 110,000 acre-feet (underflow), or approximately 165,000 acre-feet. Inflow from an area of more than 200 square miles to the basin between the hydrologic section and the mouth of the valley may be 10,000 to 15,000 acre-feet. The amount of water consumed by irrigated crops on 4,000 to 5,000 acres of land in the upper valley, above the gaging station and the hydraulic section, is about 7,000 acre-feet, and it also must be added to obtain the total water yield of the basin. Thus the total water yield, as estimated by this method, may be about 110,000 plus 55,000 plus 20,000 equals 185,000 acre-feet per year.

COMPARISON OF METHODS AND RESULTS

Estimates of the annual water yield of the basin obtained by the three methods are compared as follows:

Method	*Water yield (acre-feet)*
Precipitation—water-yield	190, 000
Perimeter inflow	200, 000
Surface flow, underflow, and consumptive use	185, 000
Average	[1] 190, 000

[1] Rounded.

The close agreement of the results probably is somewhat fortuitous. The data available for each method were barely adequate; more and better records would put the estimates on a much firmer basis. The precipitation-water-yield method in some ways appears to be the most satisfactory. However, the method is dependent upon the consistency of the isohyetal map. Although absolute accuracy is not necessary, the isohyetal map should show relative precipitation on the different basins. The scatter of the points on figure 8 indicates that results by this method are probably within 25 percent of the true yield.

The perimeter-inflow method is based largely on a single measurement on each stream during a period of low flow. A more dependable relation obviously could be established by making series of measurements at different rates of flow or by continuous records of flow for several perimeter tributaries. This method is based on the assumption that the ratio of base flow on a given date to the discharge for the year is the same for the sum of the many small tributaries as it is for the sum of the larger streams. It is probable that the ratio of underflow to base flow for small streams generally is larger than it is for medium-sized or large streams and that the ratio of annual yield to base flow would be larger than the 2.0 shown by the line on figure 9. Thus the perimeter-inflow method may give a somewhat low estimate of basin yield.

Records for the gaging station near Howe support the major part of the surface-flow component of the surface-flow-underflow method and are probably accurate to within 5 percent. The underflow component may be considerably in error. The hydraulic gradient is known and the assumed width of aquifer is probably reliable, but the assumed coefficient of transmissibility may be considerably in error. Several pumping tests or other aquifer tests would provide a much firmer basis for estimating transmissibility.

WATER BUDGET

The water yield estimated by three different methods ranges from 185,000 to 200,000 acre-feet. All these methods take into account water used by native vegetation. However, the total supply is depleted additionally by irrigation of about 16,000 acres of land. Irrigated crops in this basin, on the basis of data given by Jensen and Criddle (1952, p. 12), consume about 1.3 acre-feet per acre in addition to rainfall during the growing season. This is actual consumptive use by the crops during the frost-free periods. The actual growing season for some crops is longer, however, and some additional water is used by nonbeneficial vegetation along laterals and in waterlogged areas. Therefore, 1.5 acre-feet per irrigated acre, or a total of about 25,000 acre-feet for the basin, is probably a more reasonable figure. The water budget is estimated to be as follows:

Water yield (average estimate)	190, 000
Consumptive use (irrigation)	—25, 000
Estimated outflow from basin	165, 000

POTENTIAL RECOVERABLE SUPPLY

Theoretically the limit to the ultimate recoverable supply of water is the total amount available, which in this area was estimated to be about 165,000 acre-feet. However, generally it is impractical if not impossible to intercept all the underflow. Because the water table is reasonably close to the surface and because the gradient is fairly low in the Howe area, about 30 to 35 percent of the underflow, or 50,000 to 60,000 acre-feet, probably could be intercepted and consumed within the basin. Because part of the water pumped for irrigation returns to the aquifer, consumptive use of 50,000 to 60,000 acre-feet additional would require pumping of a much larger amount and would result in a considerable general lowering of the water table, especially during the irrigation season.

Near the south margin of T. 6 N., the water table drops sharply to several hundred feet below the land surface. Water percolating to the water table south of that line is beyond practical recovery in the area near Howe; depletion of supply therefore equals the amount diverted to the area south of T. 6 N., not merely the amount used consumptively.

During the winter and spring of most years, some water discharges from the Little Lost River into playas southeast of Howe, from which part of the water evaporates and part percolates to the water table. Water reaching this area is beyond recovery for the Howe area, and maximum utilization of the water supply within the basin would require some method of preventing this surface outflow. Perhaps the simplest method would be to divert surplus flows into canals above Howe, from which the water could percolate into the ground. Existing canals might be sufficient to take most of the water. Such salvage operations probably would not be necessary or profitable until the water table was drawn down somewhat to provide underground storage space for the recharged water.

CONCLUSIONS

The principal conclusions of the study are summarized as follows:

1. The water supply available for the basin is the surface-water and ground-water that originates within the basin.
2. Surface and ground water are so closely related that development and utilization of either affects the total supply.
3. The total water yield of the basin is about 190,000 acre-feet per year.
4. Depletion of the water supply by consumptive use on irrigated lands is approximately 25,000 acre-feet per year.
5. Total surface-water and ground-water outflow from the basin is about 165,000 acre-feet per year, of which, under present conditions, about 30 to 35 percent probably could be consumed within the basin.
6. Some water leaves the basin as surface runoff during the winter and spring of most years. Maximum development would require salvaging this runoff, perhaps by diversion of the water to recharge the ground-water reservoir.
7. Water pumped from wells upvalley from the hydrologic barrier near the center of T. 7 N., R. 28 E., is obtained with a corresponding decrease in streamflow. Wells drilled and pumped near areas of ground-water discharge decrease the surface supply almost immediately, and diminish streamflow during the irrigation season by an amount equal to the bulk of the water consumptively used during the same period. Wells more distant (approximately a few miles) from areas of ground-water discharge deplete the surface flow uniformly throughout the year. However, total annual depletion by wells in each catgory would be the same, if consumptive use is equal.
8. Withdrawal from the wells downvalley from the hydrologic barrier in T. 27 N., R. 28 E., have comparatively little effect on surface flow.

Because ground-water and surface-water are so closely related, it seems reasonable to conclude that optimum development of the water resources of the basin will result when the water supply is managed as a single resource.

LOGS OF WELLS

The information in the following well logs was obtained from well owners, drillers, and the files of the Idaho Department of Reclamation. The terminology in the logs is that used by the drillers, slightly modified to achieve uniformity and clarity. The log of well 5N–29E–23cdl was compiled from the examination of drill cuttings by the U.S. Geological Survey.

Logs of wells

Material	Thickness (feet)	Depth (feet)
5N–29E–4dc1		
[Nephi Hansen. Casing, 8-inch, set to 30 feet; 6-inch casing set to144 feet; 4-inch casing set to 258 feet]		
Loam, black	3	3
Gravel	15	18
Clay, yellow	12	30
Lava rock, struck water	68	98
Clay, red	43	141
Clay and gravel	3	144
Lava, gray, hard	8	152
Lava, black, soft; depth to water, 91.0 ft	2	154
Lava	21	175
Clay	25	200
Gravel	3	203
Clay	11	214
Gravel	6	220
Gravel, clean	52	272
5N–29E–23cd1		
[U.S. Geological Survey (sample log). Casing, 6-inch, set to 401 feet; perforated from 284.9 to 305.9 feet. Bottom of casing plugged with cement at 401 feet]		
Silt, tan, clayey, slightly sandy, calcareous	5	5
Basalt, gray, minutely vesicular, drusy	10	15
Basalt, light-gray to gray, finely vesicular, drusy; external coatings of calcareous tan silt from 20 to 25 feet	20	35
Basalt, gray, porphyritic	22	57
No sample	4	61
Basalt, gray to dark-gray	19	80
Basalt, gray to dark-gray, vesicular, porphyritic	20	100
Basalt, dark reddish-gray, minutely vesicular	10	110
Basalt, gray, dense; interval between 140 to 145 ft may contain calcareous ash	35	145
Basalt, gray, vesicular	12	157
Basalt, gray, dense; interval from 177 to 180 ft contains a little gravel cemented by calcareous material	23	180
Basalt, black, coarsely vesicular to scoriaceous	10	190
Basalt, red and black, scoriaceous, aphanitic	5	195
Basalt, gray, vesicular to amygdaloidal	5	200
Basalt, gray, dense	20	220
Basalt, reddish-brown, reddish-gray, coarsely vesicular to scoriaceous	12	252
Basalt, gray, dense	18	250
Basalt, gray, minutely vesicular	6	260
Basalt, gray, finely vesicular	11	271
Basalt, gray, dense	9	280
Basalt, gray, coarsely vesicular. Struck water at 283 feet	3	283
Basalt, gray, dense	12	295
Basalt, reddish-gray, coarsely vesicular to scoriaceous and amygdaloidal	10	305
Sand, light-brown, fine, angular to rounded	20	325
Silt, light-tan, reddish-tan, gray, calcareous	75	400
No sample	1	401
6N–28E–1bc1		
[Bob Hall. Casing, 16-inch, set to 215 feet; perforated from 160 to 210 feet]		
Gravel, coarse	180	180
Gravel, small	35	215

Logs of wells—Continued

Material	Thickness (feet)	Depth (feet)
6N-29E-8dd1		
[Hope Land and Water Co. Casing, 16-inch, set from 70 to 148 feet; perforated from about 74 to 148 feet]		
Dug well		74
Gravel	6	80
Cement gravel	11	91
Gravel and sand	39	130
Gravel, very clean	18	148
6N-29E-16cd1		
[Sweet Sage Development Co. Casing, 16-inch, set to 131 feet; perforated from 67 to 130 feet]		
Soil	2	2
Gravel	1	3
Clay, blue, with some gravel	5	8
Gravel	12	20
Gravel, mostly small	10	30
Gravel, fine	20	50
Gravel, small, and clay	10	60
Gravel and a little clay	10	70
Gravel, water-bearing	10	80
Gravel, coarse	20	100
Gravel	10	110
Gravel, fine, and white clay	10	120
Gravel and sand	12	132
6N-29E-17cd1		
[Hope Land and Water Co. Casing, 16-inch, set from 73 to 150 feet; perforated from about 75 to 150 feet]		
Dug well		75
Gravel, small	6	81
Cement gravel	23	104
Gravel, large, and some sand	11	115
Cobblestone gravel	15	130
Cement gravel, small	5	135
Clay, brown, with small gravel	12	147
Gravel, hard	3	150
6N-29E-20dd1		
[Paul Harrell. Casing, 16-inch, set from 58 to 108 feet; perforated from 58 to 108 feet, 180 perforations]		
Dug well		64
Cement gravel, hard	12	76
Gravel, loose, water-bearing	5	81
Gravel, hard	1	82
Gravel, softer	25	107
Clay and gravel	1	108
6N-29E-23cb1		
[Earl Wortley. Casing, 18-inch, set to 21 feet; 16-inch casing set 21 to 87 feet; perforated from 25 to 87 feet' 215 perforations]		
Dug well		47
Gravel, water-bearing	40	87
Clay	10	97
6N-29E-24cb1		
[Edwin Amos. Casing, 16-inch, set to 45½ feet; 15-inch casing set from 45½ to 75 feet; perforated from 40 to 75 feet, 235 perforations]		
Clay	4½	4½
Gravel and sand	12½	17
Sand	4	21
Clay and sand	25½	46½
Gravel, small, and sand	28½	75
Clay	25	100

Logs of wells—Continued

Material	Thickness (feet)	Depth (feet)
6N-29E-25cb1		
[Byron Telford. Casing pulled]		
Drilled well	-----------	51
Clay, sandy	32	83
Quicksand	27	110
Clay	6	116
Clay, sandy	14	130
Clay and sand	15	145
Clay and gravel	2	147
Clay	24	171
Clay and sand	9	180
Clay, soft	12	192
Clay, hard	11	203
Clay	50	253
6N-29E-26cd1		
[Clarence Fink. Casing, 16-inch, set to 124 feet; perforated from 85 to 124 feet, 220 perforations]		
Gravel, sand, and clay	32	32
Clay	4	36
Gravel	3	39
Clay	4	43
Gravel	17	60
Gravel and some clay	12	72
Gravel	8	80
Gravel, softer	14	94
Clay	5	99
Gravel, coarse	3	102
Gravel, small	26	128
Clay	4	132
6N-29E-28db1		
[Phil York. Casing, 16-inch, set to 106 feet; perforated from 66 to 106 feet, 320 perforations]		
Soil	5	5
Gravel	62	67
Clay	3	70
Gravel, water-bearing	35	105
Clay	1	106
6N-29E-30da1		
[Tom Hocking. Casing, 6-inch, set from 6 to 106 feet; perforated]		
Well pit	-----------	6
Gravel, coarse	24	30
Gravel, hard	25	55
Gravel, hard, coarse	8	63
Cement gravel	12	75
Gravel, softer, water-bearing	30	105
Clay	1	106
6N-29E-33db1		
[L. L. Cowgill. Casing, 40-inch, depth not known; 18-inch casing set from 63 to 93 feet; perforated from 63 to 93 feet]		
Clay	4	4
Sand and gravel, fine	89	93
Lava, black	-----------	----------

Logs of wells—Continued

Material	Thickness (feet)	Depth (feet)
7N-27E-12aa2		
[L. R. Hawley. Casing, 16½-inch, set to 87 feet; perforated from 37 to 87 feet, 400 perforations]		
Soil	5	5
Gravel, water-bearing	82	87
7N-28E-7cc1		
[L. R. Hawley. Casing, 16½-inch, set to 87 feet; perforated from 30 to 85 feet, 440 perforations]		
Soil	9	9
Clay and small gravel, water-bearing	58	67
Clay and large gravel, water-bearing	20	87
9N-27E-28cb1		
[Lawrence W. Isham. Casing, 16-inch, set to 99½ feet; perforated from 34½ to 99½ feet, 308 perforations]		
Clay	3½	3½
Gravel, water-bearing	58½	62
Clay and gravel	27	89
Gravel, coarse, not much clay	21	110
10N-27E-7cc1		
[Byron Telford. Casing, 22-inch, set to 122 feet; perforated from 11 to 122 feet, 960 perforations]		
Clay	2	2
Clay and gravel, water-bearing	10	12
Clay	5	17
Clay and gravel	4	21
Gravel	8	29
Clay, hard, and gravel, water-bearing	6	35
Gravel, some clay	15	50
Clay, very little gravel	3	53
Clay and gravel	11	64
Gravel and some clay, water-bearing	12	76
Gravel, coarse	4	80
Clay	6	86
Cement gravel, some clay	39	125
10N-27E-29bc1		
[Lowell Nelson. Casing, 6-inch, set to 75 feet]		
Clay	12	12
Gravel and clay, water-bearing	28	40
Sand	32	72
Gravel, small, and sand	3	75

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