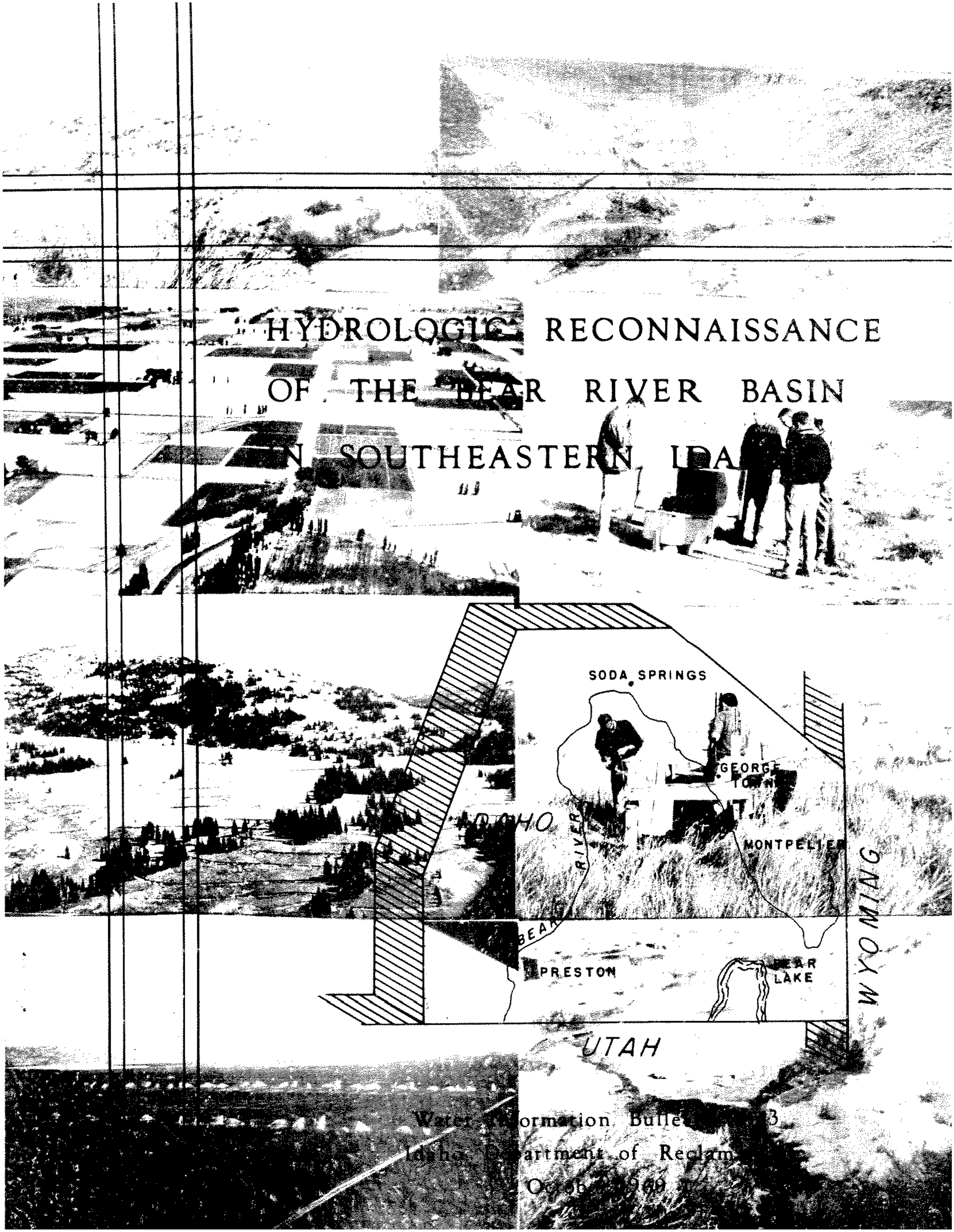
HYDROLOGIC RECONNAISSANCE OF THE BEAR RIVER BASIN IN SOUTHEASTERN IDAHO



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WATER INFORMATION BULLETIN NO. 13

HYDROLOGIC RECONNAISSANCE OF THE BEAR RIVER BASIN IN SOUTHEASTERN IDAHO

by

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Prepared by the United States Geological Survey

in Cooperation with

The Idaho Department of Reclamation

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HYDROLOGIC RECONNAISSANCE OF THE

BEAR RIVER BASIN IN SOUTHEASTERN IDAHO

By N. P. Dion

ABSTRACT

The areal distribution of precipitation in the Bear River basin is controlled chiefly by elevation, and quantities range from less than 10 inches in Bear Lake Valley to more than 45 inches on the Bear River Range. Precipitation on the basin averages about 2.3 million acre-feet per year.

Ground water occurs in the alluvium of all the valleys, the basalt of Soda Creek basin and Gem Valley, the Salt Lake Formation, the fractured bedrock, and possibly in the Wasatch Formation. The basalt and the alluvium are the most productive aquifers in the basin and are best able to withstand additional ground-water development. Reportedly, the basalt yields as much as 3,500 gpm (gallons per minute) and the alluvium as much as 2,500 gpm to wells. While many wells drilled into the Salt Lake Formation are nonproductive, those that are successful yield as much as 1,800 gpm. Because few wells have been drilled into either the Wasatch Formation or the undifferentiated bedrock, their yield capability is unknown.

The principal sources of recharge to the aquifers include precipitation, spring snowmelt and runoff, seepage of irrigation water, and losses from irrigation canals. Some additional recharge is provided by the leakage of water from Blackfoot Reservoir in the Blackfoot River basin to the Blackfoot Lava Field in the Bear River basin.

Natural discharge from the aquifers is by ground-water flow to the Bear River, by springs and seeps along the banks of the river, and by evapotranspiration in large marshy tracts. Some natural discharge into the adjoining Portneuf River basin may occur by the movement of water through a basalt in Tenmile Pass and by a northward movement of water in the vicinity of Soda Point.

The Bear River in Idaho is generally a gaining stream with the possible exception of the reach between Alexander and Grace. Ground-water contours indicate that this reach of the river is a source of recharge to the ground-water reservoir and that some of this recharge eventually returns to the river through springs issuing from the walls of Black Canyon. The average annual net surface-water contribution from the Idaho part of the Bear River basin to the Bear River is approximately 409,000 acre-feet.

Ground waters in the basin are predominantly calcium and magnesium bicarbonate in type. The surface waters of the basin are also of this chemical type but are generally lower in dissolved solids than the ground water.

The Bear River basin contains hundreds of springs that discharge water of several chemical types. These chemical types include calcium bicarbonate, magnesium bicarbonate, calcium sulfate, sodium chloride, and magnesium bicarbonate sulfate.

INTRODUCTION

The Bear River Compact, approved by Congress in 1958, established a nine-member commission that administers the distribution of Bear River water among the signatory States of Utah, Wyoming, and Idaho. In addition to establishing criteria for the distribution of direct flow and stored water for each of these States, the compact also stipulates that it is the policy of the States to encourage additional projects for the development of the water resources of the Bear River to the maximum beneficial use and with a minimum of waste. To enable maximum beneficial use of the available water, a description of the total water resources of the basin is required.

Prior to 1967, no study of the total water resources of the Bear River basin in Idaho had been made. A comprehensive hydrologic study of the Cache Valley part of the basin in Idaho and Utah was started in 1967 by the Utah District, Water Resources Division, U. S. Geological Survey in cooperation with the Utah Division of Water Resources. The hydrologic reconnaissance of the Idaho part of the Bear River basin reported on herein was started in July 1967 by the Idaho district, Water Resources Division, U. S. Geological Survey, in cooperation with the Idaho Department of Reclamation.

The author expresses his gratitude to the residents of the Bear River basin for their cooperation in furnishing information about their wells and for allowing access to their property.

Purpose and Scope

The purpose of this report on the Bear River basin in Idaho is to: (1) Describe the general distribution and availability of the basin's water resources; (2) present well data obtained during an inventory of wells in the area; (3) provide a description of the quality of the water; (4) establish a base of water-related information from which future comparisons can be made; (5) determine the effect of increased water use on the water regimen, especially the effect of increased ground-water withdrawals on the flow of streams; and (6) determine the types and locations of existing and potential hydrologic problems.

The project area covers almost 2,200 square miles in all or parts of Bannock, Bear Lake, Caribou, Franklin, and Oneida Counties in southeastern Idaho (fig. 1). For purposes of this report, the term "Bear River basin" refers only to that part of the basin that lies in Idaho but does not include the Malad River drainage basin.

Previous Work

The first comprehensive report on the geography, geology, hydrology, and mineral resources of the eastern part of the Bear River basin was written by Mansfield (1927). In that report, Mansfield described the types and occurrence of springs in southeastern Idaho and evaluated the possibility of leakage from Blackfoot River Reservoir. An unpublished report by Stearns presented a detailed account of the hydrology in the Soda Springs-Gem Valley area. (Stearns, H. T., (no date), Geology and ground-water resources of the Soda Springs area, Idaho: U. S. Geol. Survey unpublished manuscript (Boise, Idaho), 69 p.) Stearns described in detail the igneous geology of the area and traced the movement of ground water through the basalt. He was the first to suggest leakage from the channel of Bear River between Alexander and Grace. A study by Bright (1963) of Pleistocene lakes in the western part of the Bear

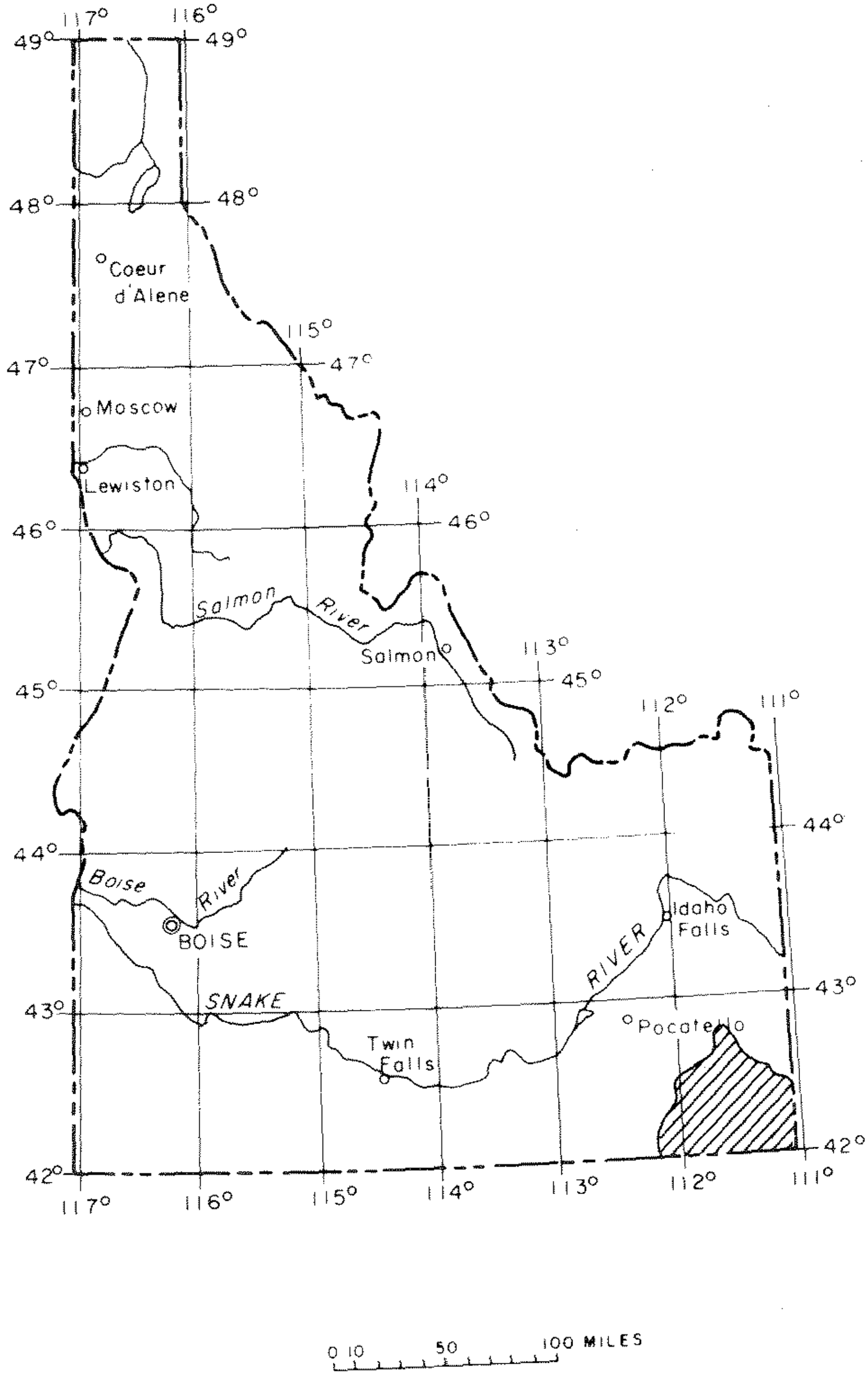

FIGURE 1.--Index map showing area covered by this report.

River basin discussed the occurrence and possible origin of Lake Thatcher, which occupied the Gentile Valley region during part of the Pleistocene Epoch.

Many parts of the area have been mapped geologically in some detail as a result of special interests, such as the search for commercial deposits of phosphate. More recently, geophysical methods have been used to determine regional geologic relationships.

Well-and Spring-Numbering System

The numbering system used in Idaho by the U. S. Geological Survey indicates the location of a well or spring in the official rectangular subdivisions of the public lands (fig. 2). The first two segments of the number designate the township and range. The third segment gives the section number and is followed by three letters and a numeral, which indicate, respectively, the quarter section, the 40-acre tract, the 10-acre tract, and the serial number of the well or spring within the tract. Quarter sections are lettered a, b, c, and d in a counterclockwise order from the northeast quarter of each section. Within the quarter sections, 40-acre and 10-acre tracts are lettered in the same manner. Thus well 14S-39E-25add1 is in the NE¼SE¼SE¼ sec 25, T. 14 S., R. 39 E., and is the first well visited in that 10-acre tract. Physical data for the wells inventoried in the Bear River basin are given in table 6.

In this report, springs are located only to the quarter section and are designated by the letter "S" following the last numeral, for example: 15S-44E-13c1S.

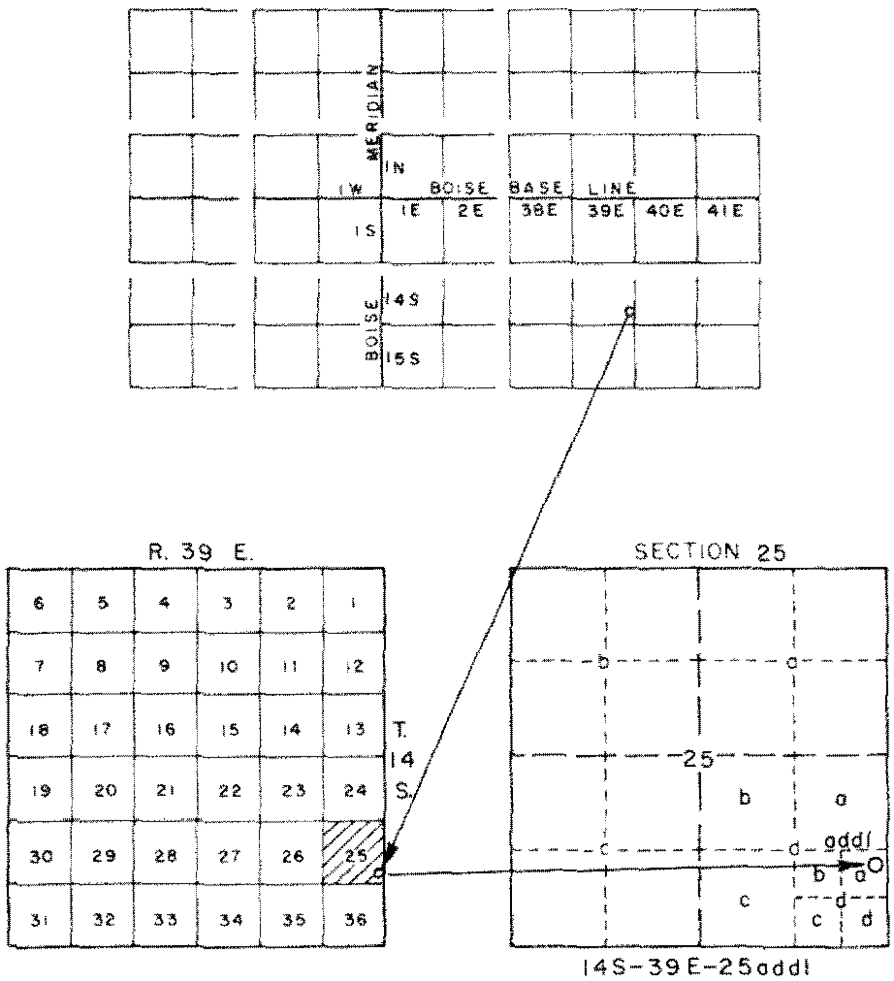

FIGURE 2.--Diagram showing the spring- and well-numbering system used in Idaho by the U. S. Geological Survey. (Using well 14S-39E-25addl).

Use of Metric Units

In this report, the units that indicate concentrations of dissolved solids and individual ions determined by chemical analysis and the temperatures of air and water are metric units. This change from reporting in "English units" has been made as a part of a gradual change to the metric system that is underway within the scientific community. The change is intended to promote greater uniformity in reporting of data. Chemical data for concentrations are reported in milligrams per liter (mg/l) rather than in parts per million (ppm), the units used in earlier reports of the U. S. Geological Survey. For concentrations less than 7,000 mg/l, the number reported is about the same as for concentrations in parts per million. Air and water temperatures are reported in degrees Celsius (^{o}C)

Table 1 will help to clarify the relation between degrees Fahrenheit and degrees Celsius.

PHYSICAL SETTING

Landforms and Drainage

Bear River is in the Basin and Range and Middle Rocky Mountains physiographic provinces and is the largest river, with respect to discharge, in the Western Hemisphere whose water does not flow to an ocean. It enters Idaho near Border, Wyo., and flows in a narrow valley around the northern edge of the Bear Lake Plateau (fig. 6). At a point near Wardboro, Idaho, water from the river is diverted through canals into Bear Lake for offstream storage. Mansfield (1927), p. 30) postulated that the lake at one time was much larger than it is today and that Bear River once flowed into the lake naturally.

Between Bennington and Soda Springs, the valley of Bear River is narrowed by several alluvial fans that flank the Aspen and Bear River Ranges. At Alexander, just west of Soda Point Reservoir, the river makes a sharp turn to the south and enters Gem Valley.

Bear River crosses Gem Valley over a series of flat basalt flows. In cutting down through the southern edge of the flows, the river has formed a long, deep canyon known locally as Black Canyon. After emerging from this canyon, Bear River crosses Gentile and Mound Valleys, flows through Oneida Narrows and enters the northern end of Cache Valley. Cache Valley was once a bay of ancient Lake Bonneville (Gilbert, 1890, pl. 12) and lake terraces occur along the margins of the valley.

Bear River leaves Idaho near Weston, Idaho, and eventually flows into Great Salt Lake in Utah. After flowing some 500 miles from its source in the Uinta Mountains of Utah and crossing state boundaries five times, Bear River terminates only 90 miles west of its source.

Major tributaries to the Bear River in Idaho include Thomas Fork, Montpelier Creek, and Georgetown Creek, which drain the Preuss and Aspen Ranges; St. Charles Creek, Bloomington Creek, Paris Canyon Creek, Liberty Creek, and Eightmile Creek, which drain the eastern slopes of the Bear River Range; Soda Creek, which drains the Fivemile Meadows area; Cottonwood Creek, which drains the Portneuf Range; Mink Creek and Cub River, which drain the western slope of the Bear River Range; and Bear Lake, which in turn is fed by springs and streams originating in the Bear River Range and on Bear Lake Plateau.

Climate

The climate of the Bear River basin may be characterized as "semiarid continental" in that winters are cold, summers are hot, and precipitation is scanty (fig. 3). The mean annual temperature at five climatological stations in the basin averages 5.9°C (degrees Celsius) 43°F. Typically the frost-free growing season lasts for about 100 days between late May and early September.

Precipitation within the Bear River basin is distributed unevenly with regard to both time and area. Most of the water available to the streams, reservoirs, and aquifers in the basin is derived from winter snow. Rainfall that occurs during the relatively short summer growing season seldom is enough to satisfy the moisture requirements of the crops grown on the lowlands. While precipitation is generally sufficient for dry farming of hardy crops such as wheat and hay, irrigation is required where a wider variety of crops are grown and higher yields obtained.

Data obtained at U. S. Weather Bureau stations at Preston, Grace, and Montpelier show that the average monthly precipitation ranges from a high of 1.93 inches in April to a low of 0.65 inches in July (fig. 3). As shown in figure 4, the range in annual precipitation at these stations is from about 8.5 inches to about 23.8 inches. This graph also shows, for example, that annual precipitation at Montpelier equals or exceeds 18 inches only 10 percent of the time, or, on the average, only 1 year out of 10.

Table 1. TEMPERATURE-CONVERSION TABLE

For conversion of temperature in degrees Celsius (°C) to degrees Fahrenheit (°F). Conversions are based on the equation, $^{\circ}F = 1.8^{\circ}C + 32$; temperatures in °F are rounded to nearest degree. Underscored equivalent temperatures are exact equivalents. For temperature conversions beyond the limits of the table, use the equation given, and for converting from °F to °C use $^{\circ}C = 0.5556$

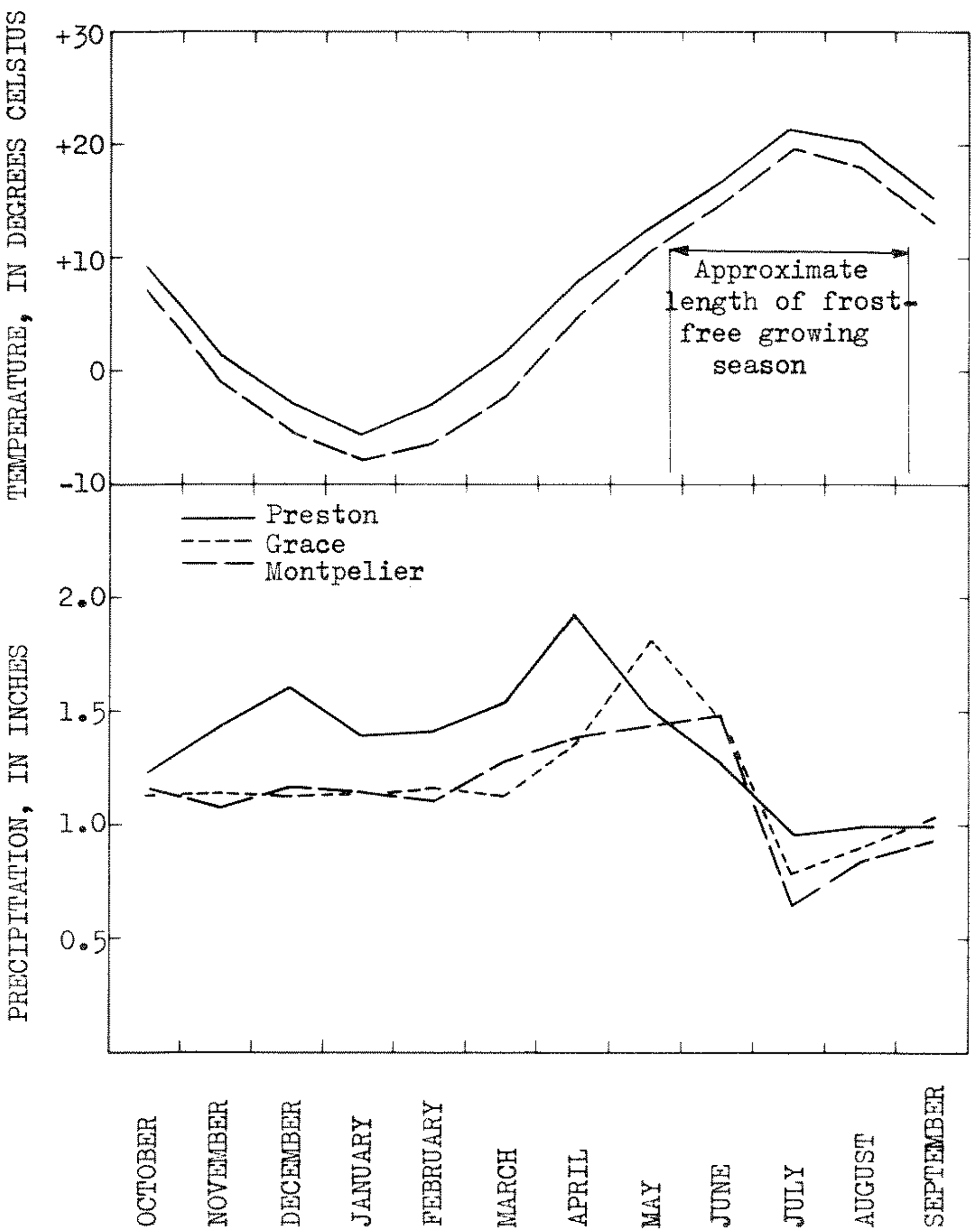

FIGURE 3.--Average monthly temperature and precipitation at selected stations, (based on data from U. S. Weather Bureau for period 1947-66).

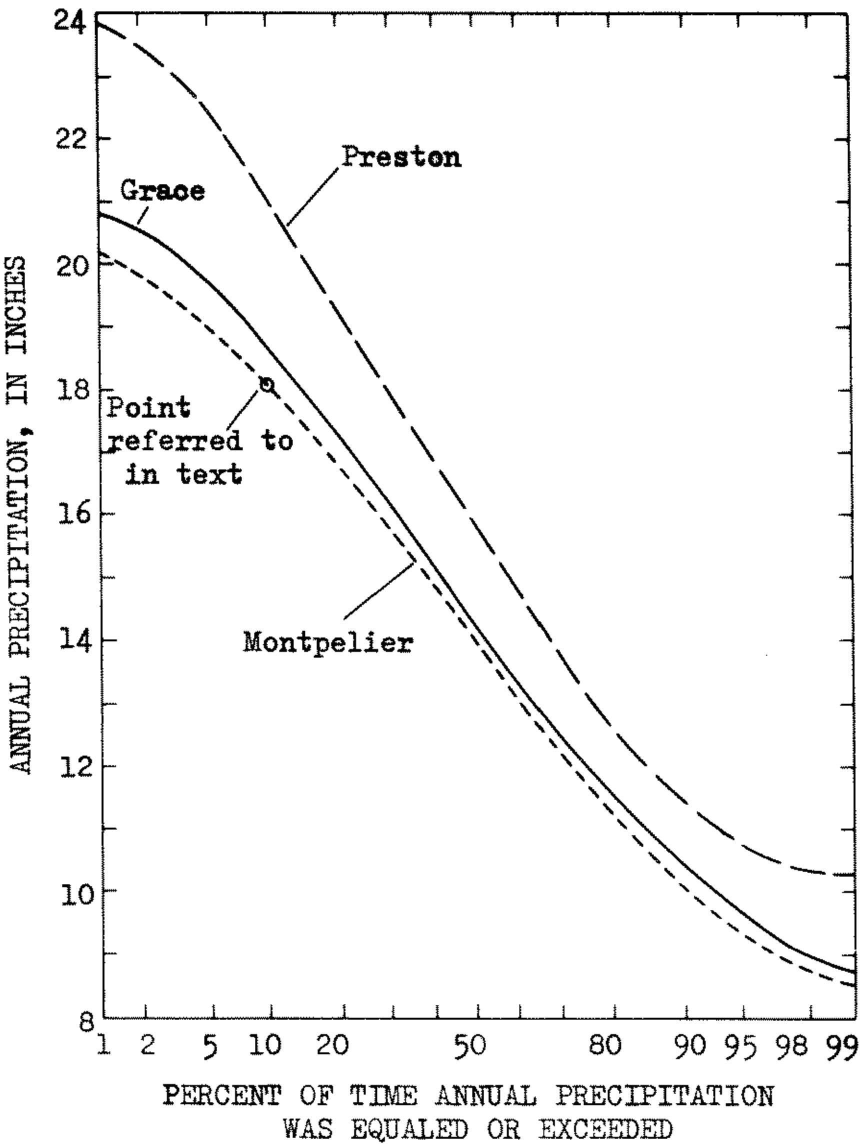

FIGURE 4.--Precipitation-duration curves for stations in the Bear River basin, (based on data from U. S. Weather Bureau for calendar years 1922-66).

($^{\circ}F$ - 32). The equations say, in effect, that from the freezing point ($0^{\circ}C$, $32^{\circ}F$) the temperature rises (or falls) $5^{\circ}C$ for every rise (or fall) of $9^{\circ}F$.

$^{\circ}C$	$^{\circ}F$	$^{\circ}C$	$^{\circ}F$	$^{\circ}C$	$^{\circ}F$	$^{\circ}C$	$^{\circ}F$	$^{\circ}C$	$^{\circ}F$	$^{\circ}C$	$^{\circ}F$	$^{\circ}C$	$^{\circ}F$
-20	-4	-10	14	0	32	10	50	20	68	30	86	40	104
-19	-2	-9	16	+1	34	11	52	21	70	31	88	41	106
-18	0	-8	18	2	36	12	54	22	72	32	90	42	108
-17	+1	-7	19	3	37	13	55	23	73	33	91	43	109
-16	3	-6	21	4	39	14	57	24	75	34	93	44	111
-15	5	-5	23	5	41	15	59	25	77	35	95	45	113
-14	7	-4	25	6	43	16	61	26	79	36	97	46	115
-13	9	-3	27	7	45	17	63	27	81	37	99	47	117
-12	10	-2	28	8	46	18	64	28	82	38	100	48	118
-11	12	-1	30	9	48	19	66	29	84	39	102	49	120

The areal distribution of precipitation (fig. 5) is controlled chiefly by elevation and ranges from less than 10 inches in Bear Lake Valley to more than 45 inches on the Bear River Range. The amount of precipitation on the entire basin averages about 2.3 million acre-feet per year.

WATER USE

The principal uses of water in the Bear River basin, in order of quantities used, are for hydroelectric power, irrigation, domestic, stock, and industrial purposes.

Bear River is highly developed for hydroelectric power. Nearly all the water downstream from Bear Lake is used nonconsumptively at one or more powerplants. A summary of data for reservoirs and powerplants on the main stem of Bear River is given in table 2. Originally, water from Bear Lake was used solely for downstream powerplants, but the lake now provides seasonal storage of water and river regulation for both power and irrigation needs. Releases of stored water are closely regulated by a pumping station at the northern end of the lake.

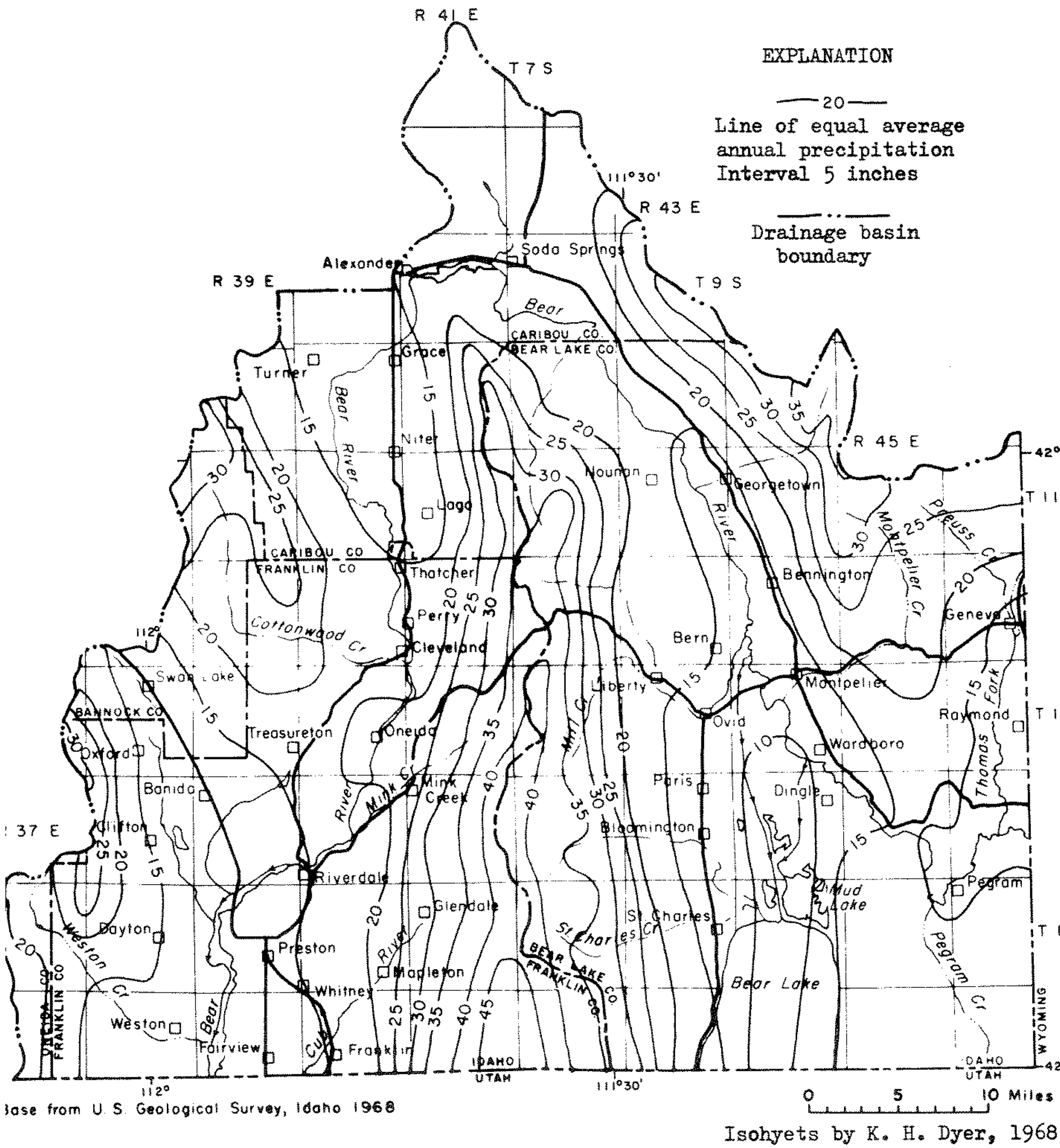

FIGURE 5.--Map of the Bear River basin showing average annual precipitation, (based on data from U. S. Weather Bureau for the period 1930-57).

Agricultural land is irrigated primarily with water from reservoirs, streams, and, when needed, from privately-owned wells. A large number of relatively small irrigation companies serve small parcels of land. Reservoirs built exclusively for irrigation purposes have a total active capacity of less than 35,000 acre-feet and are inadequate to service the approximately 150,000 irrigated acres in the basin. The quantity of water diverted from the main stem of Bear River averages more than 250,000 acre-feet annually.

Table 2. Summary of data for hydroelectric stations and reservoirs on the main stem of Bear River. (In part from University of Idaho Water Resources Research Institute, 1968, p. 211)

Reservoir or powerplant	Active reservoir capacity (acre-ft)	Powerplant capacity Hydraulic (cfs)	Powerplant capacity Generating (megawatts)	Average annual generation (megawatt hours)
Bear Lake	1,420,000	-	-	-
Soda Point	11,800	2,520	14.0	17,400
Grace	200	960	44.0	98,730
Cove	-	1,260	7.5	18,020
Oneida	11,500	3,300	30.0	42,790

The quantity of water used consumptively by irrigated crops is usually much less than the total quantity applied. Water used consumptively by evaporation and plant transpiration is lost to the basin, whereas, that part of the applied water not used consumptively percolates down to the water table and is available for reuse.

The following estimate of the quantity of applied water used consumptively by irrigated crops in Bear River basin is based on a study made by the Idaho Water Resources Research Institute (Univ. of Idaho, Water Resources Research Institute, 1968, p. 201). According to that study, the "consumptive irrigation requirement" (the consumptive use minus the contribution from rainfall) for crops grown in the basin averages about 1.10 acre-feet per acre per year and about 150,000 acres are irrigated annually in the basin. These estimates indicate that the total quantity of water used consumptively by crops in the basin is about 165,000 acre-feet per year.

Domestic- and stock-water supplies in rural areas are taken from individually-owned wells and, to a lesser extent, from springs in the surrounding hills and mountains. Municipal water supplies depend heavily on springs, but these are locally augmented by streams and high-capacity wells. The total quantity of water used for domestic and stock purposes by the approximately 25,000 people in the basin is about 8,500 acre-feet per year. About 2,100 acre-feet per year, or 25 percent, is consumed and no longer available for reuse.

Industrial demands for water, brought about by phosphate-processing plants near Soda Springs and food-processing plants in Cache Valley, are met through the use of about 15 high-capacity wells. The total quantity of water used by industry in the Bear River basin is approximately 6,900 acre-feet per year of which it is estimated that only about 170 acre-feet per year, or 2.5 percent, is actually consumed.

GROUND WATER

Occurrence and Availability

Ground water in the Bear River basin is contained in alluvium and basalt of Quaternary age, the Salt Lake Formation of Pliocene (?) age, the undifferentiated bedrock of Cretaceous and older age, and possibly in the Wasatch Formation of Eocene age. (See table 3 and fig. 6). The ages assigned to the above formations are those of Mansfield (1927, p. 49).

Although the less permeable older rocks occupy most of the surface area in the basin, the younger, more permeable basalt and alluvium ultimately receive a large part of the precipitation falling on the older rocks; and they are, therefore, capable of supplying large quantities of water to wells.

Table 3. Summary of geologic units and their hydrologic characteristics.

System	Series	Geologic unit	Availability of water: Yield (gpm)	Availability of water: Specific capacity (gpm/ft of drawdown)	Adequacy as source of water supply: Domestic and stock	Adequacy as source of water supply: Irrigation	Adequacy as source of water supply: Industrial and municipal
Quaternary	Holocene	Alluvium	500-1,500	As much as 150	Good	Good	Good
Quaternary	Pleistocene	Basalt	1,000-3,500	As much as 3,500	Good	Good	Good
Tertiary	Pliocene(?)	Salt Lake Formation	Erratic 0-1,800	Erratic 0-75	Fair	Poor	Poor
Tertiary	Eocene(?)	Wasatch Formation	Unknown	Unknown	Unknown	Unknown	Unknown
Pre-Tertiary		Undifferentiated bedrock	-	-	Fair	Poor	Poor

Alluvium of Quaternary age occupies the bottomlands of Thomas Fork, Bear Lake, Gentile and Cache Valleys. Most wells in these valleys are only 200 to 300 feet deep and do not penetrate through the alluvium. For this reason, the total thickness of the alluvial material is not known, but it may be as great as several thousand feet. Commonly, the material that is penetrated consists of alternating beds of gravel, sand, silt, and clay. Water in these beds is generally under weak artesian pressure in the lower central parts of the valleys and some wells flow at land surface. Except in the central parts of Bear Lake Valley and Gentile Valley, where water levels are within 5 feet of land surface, the depth to water in the lowlands of the basin averages about 20 to 30 feet below land surface (table 6). Wells completed in the alluvium generally yield 500-1,500 gpm (gallons per minute). An exception is the western part of Cache Valley, especially between Dayton and Oxford, where irrigation wells reportedly yield as much as 2,500 gpm. In the eastern part of Cache Valley, the alluvium is composed of finer-grained sediments and well yields mostly are correspondingly lower.

The olivine basalt flows interfingering with and overlying the alluvium in Soda Creek basin and Gem Valley are the most productive aquifers in the basin. The estimated maximum thickness of the basalt ranges from about 400 feet in Gem Valley to as much as 1,000 feet in the Blackfoot Lava Field (Mabey and Oriel, in press). The depth to water in the basalt averages 80 to 90 feet below land surface. Generally, the water occurs in fractures and joints in the basalt, in rubbly zones, and in interlying cinder beds. Yields from wells are 1,000-3,500 gpm with the larger yields generally being obtained from wells penetrating the thicker sequences of basalt.

The Salt Lake Formation consists generally of fresh-water limestone, tuffaceous sandstone, large amounts of rhyolite tuff and light-colored, poorly-consolidated conglomerate. These rocks were deposited in deep valleys and some probably blanketed the surrounding hills and mountains. Although at least 2,500 feet of these deposits have been penetrated in Bear River basin, their original thickness may have been greater than 12,000 feet (Hardy, 1957). The Salt Lake Formation crops out along the margins of the major valleys and probably underlies the alluvium (Williams, 1962, p. 136). Even though many of the water wells drilled into the Salt Lake Formation have not yielded water, drillers' logs indicate that those wells that did prove successful, yield as much as 1,800 gpm from beds of sandstone and conglomerate. Many of the wells reportedly drilled into the alluvium near the margins of the major valleys and in smaller tributary valleys may have penetrated, and may be obtaining water from, the underlying Salt Lake Formation.

The Wasatch Formation is restricted largely to the Bear Lake Plateau in the extreme southeastern corner of Idaho and to small areas northwest of Bear Lake (fig. 6). It is composed of red continental deposits consisting largely of conglomerate and sandstone and lesser amounts of shale, limestone, and tuff. The fragmental rocks within the formation are tightly cemented and it is, therefore, relatively impermeable. However, it is possible that the formation contains some secondary permeability in the form of joints or fractures, or permeable zones may exist along the contact of the relatively flat-lying formation and the underlying folded bedrock. The thickness of the Wasatch Formation is not known but Mansfield (1927) believed it does not exceed 1,500 feet on Bear Lake Plateau. The elevation of Bear Lake Plateau is about 7,000 feet above mean sea level and recharge to the Wasatch Formation is limited to precipitation that falls on the plateau. The only well known to have been drilled into the formation was on Bear Lake Plateau and reportedly penetrated "swamp gas" at a depth of about 100 feet. It was eventually abandoned as being unfit for stock use. Nevertheless, numerous springs occur along the margins of the formation and at least one produces water of excellent quality for domestic purposes. Additional drilling will be needed to evaluate the potential of the Wasatch Formation as an aquifer.

The undifferentiated bedrock that makes up the major mountain masses in the basin is composed of more than two dozen pre-Tertiary formations. The bedrock consists mostly of carbonate rocks, quartzite, shale, and sandstone. Permeability in the bedrock formations is due largely to secondary openings such as fractures and joints. Some of the Paleozoic limestones have been dissolved by water to produce solution cavaties. These give rise to innumerable springs that provide private homes and small towns a dependable source of water for domestic purposes. One of the springs yields as much as 200 cfs (cubic feet per second) during periods of peak discharge (Mansfield, 1927, p. 316). However, because only a few wells have been drilled into the bedrock, data adequate to determine its hydrologic potential are lacking.

Source and Movement

The alluvial aquifers in Bear Lake and Cache Valleys are recharged chiefly by surface streams flowing across the alluvium near the margins of the valleys. Some water may recharge and flow through the Salt Lake Formation before entering the alluvium. Other sources of recharge to the alluvium include direct precipitation over the aquifer, leakage from irrigation canals, and downward percolation of applied irrigation water.

The water-level contours in figure 7 show that ground-water movement in Bear Lake Valley is toward the Bear River. For this reason, most of the natural discharge of the ground water is into the river. In the central part of the valley where the water table is effectively at land surface, a large marshy area known as Dingle Swamp has formed. The high rate of evapotranspiration in the swamp results in large additional quantities of ground water being discharged there.

Drillers' logs of wells in Cache Valley indicate that the alluvium may contain several aquifers separated by silt and clay. For this reason, the water-level contours in figure 7 for Cache Valley probably represent a composite pressure surface for several water-bearing strata. However, the contours indicate that the general direction of ground-water movement is both toward Bear River and southward into the Utah part of the valley. The multitude of small springs and seeps along the banks of the river provides additional evidence that the ground water discharges into Bear River.

In Gentile Valley the alluvial aquifer is recharged by surface streams along the valley margins and from direct precipitation on the alluvium. Ground-water movement is toward the Bear River and discharge is through hundreds of small springs and seeps along the banks of the river.

The principal direction of ground-water flow in Soda Creek basin is to the southwest, past the town of Soda Springs, and then toward the Bear River and Soda Point Reservoir. The regional water table is above the level of Soda Point Reservoir at the eastern end and below it at the western end, suggesting that ground water discharges into the reservoir in its eastern part and that ground water seeps from the reservoir in its western part.

The basalt aquifer in that part of Gem Valley within the Bear River drainage is recharged by ground water flowing westward past Alexander, by deep percolation of irrigation water spread on croplands, by irrigation canal leakage, and probably by leakage out of the channel of the Bear River between Alexander and Grace. Few perennial streams flow into Gem Valley from the surrounding hills, therefore, natural recharge from tributaries is sporadic. The ground-water divide in the central part of Gem Valley, west of Alexander is inferred to be a broad gentle mound on the water table with ground water flowing both northward and southward away from the divide. The location of this divide can change if large amounts of recharge to, or discharge from, the aquifer occur in its general vicinity. The exact location of the crest of this mound is important in that if the crest shifts to the south, ground water formerly flowing southward will, instead, flow northward into the Portneuf drainage.

Interbasin Leakage

The possibility of leakage of water from the Blackfoot River basin into the Bear River basin has been a controversial question since the construction of Blackfoot River Reservoir in 1911 (Mansfield, 1927) Stearns, (no date) and Umpleby, J. B., (no date), Report on leakage near the head of the Blackfoot (Fort Hall) Reservoir, Idaho: U. S. Geol. Survey unpublished manuscript (Boise, Idaho), 8 p.) The relative elevations of the reservoir (about 6,100 feet above mean sea level) and Fivemile Meadows (about 6,000 feet above mean sea level) and the configuration of the water table in that area (fig. 7) indicate that leakage is taking place. The basalt in the Blackfoot Lava Field displays large structural rifts aligned generally north-south. If these rifts extend below the water table, they could provide avenues for the movement of large amounts of ground water from the reservoir to Fivemile Meadows.

In addition, some of the ground water in the area south of Blackfoot River Reservoir may be moving into the Portneuf Valley through the basalt in Tenmile Pass (see figs. 6 and 7). The elevation of the water table in the Blackfoot Lava Field is at least 500 feet higher than the water table in Portneuf Valley. The basalt in Tenmile Pass seems to be thick enough and may be permeable enough to allow a significant amount of water to move through it. However, much additional work must be done to determine the quantity, if any, of ground water moving through Tenmile Pass.

Interbasin leakage of ground water also occurs in Gem Valley. One source of recharge to the basalt aquifer in Gem Valley is ground water that flows westward past Alexander. Water-level contours in figure 7 indicate that after entering the valley from the east, some of the water flows northwestward into the Portneuf River basin and the remainder flows southward toward the Bear River. The amount of water that flows into the Portneuf drainage is not known, but has to be less than the total amount of ground water flowing past Alexander. Assuming a coefficient of transmissivity of 1,000,000 gallons per day per foot for the basalt, a water-table gradient of 100 feet per mile, and a saturated cross-sectional width of 0.5 miles, the total ground-water flow past Alexander can be estimated very roughly at 56,000 acre-feet per year. The available water-level data do not allow a determination of what percentage of this total flow goes into the Portneuf River basin.

Water-Level Fluctuations

Ground-water levels in the Bear River basin fluctuate in response to precipitation, spring runoff, application of irrigation water, and pumping. The magnitude of these fluctuations is greatest in the alluvial aquifers and least in the basalt aquifers.

Generally, water levels in wells in the Bear River basin that are unaffected by artificial discharge or recharge rise in the spring when the snow melts and runoff occurs and decline gradually through the summer, fall, and winter. Application of water for irrigation may, of course, cause water levels to continue to rise into the summer and, conversely, withdrawal of ground water for irrigation causes water levels to decline faster than they otherwise would.

The water-level fluctuations in well 13S-44E-26bad1 (figs. 7 and 8) in Bear Lake Valley are representative of ground-water conditions in the alluvial aquifer of that region. The water level began rising in early April 1968 in response to recharge from spring snowmelt and runoff and continued rising until mid-August owing to the application of irrigation water. Heavy rains in August ended the need for additional water, irrigation ceased, and the water level then began to decline. In wells not affected by irrigation, declines began in late April following the period of spring snowmelt and peak stream flow.

Well 8S-42E-17cab1 is finished in the basalt aquifer near the springs that form the headwaters of Soda Creek. There is no nearby irrigation, and direct precipitation seems to play a minor role in controlling water-level fluctuations. The water level in this well rose slightly in April in response to spring runoff and then immediately began declining.

Well 9S-40E-13acb1 is in Gem Valley just west of Alexander and is finished in basalt. Its water level began rising in April in response to spring snowmelt and runoff and continued rising through August as a result of leakage from irrigation canals and, possibly, the channel of the Bear River between Alexander and Grace. In August, it began its seasonal decline.

Water levels in Cache Valley are characterized by larger fluctuations and earlier spring rises than water levels in other parts of the basin. The water level in well 16S-40E-29cbc1 began to rise in late February, peaked in April, declined until late June, and then began rising again in response to

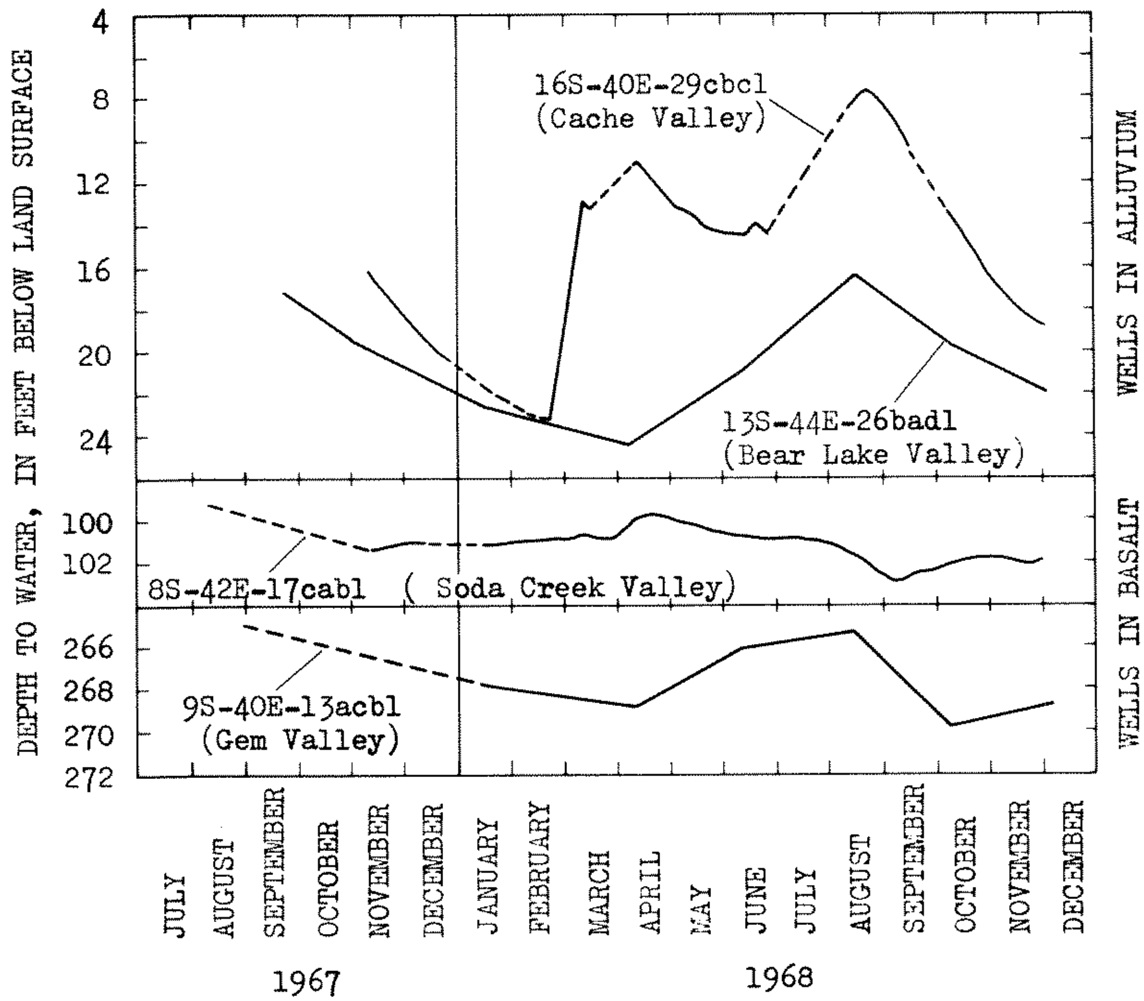

FIGURE 8.--Ground-water fluctuations in selected wells. (Locations of wells shown on Figure 7).

the nearby application of irrigation water. After irrigation was discontinued in August, the water level again declined.

Development Potential

The total number of wells in use in the Bear River basin for domestic, irrigation, and industrial purposes has increased significantly since 1950. The trend in domestic wells has been from shallow, large-diameter dug wells to deeper, smaller-diameter drilled wells. As the total cultivated acreage increased in the basin, irrigation wells were drilled to supplement the traditional surface-water irrigation system of canals and ditches. Local industries, such as vegetable packing plants in Cache Valley and mineral processing plants in Soda Creek basin, rely on the steady supply of water obtained from large-capacity drilled wells.

The hydrologic system in the Bear River basin is capable of providing increased amounts of ground water and should continue to do so, provided that future ground-water development does not exceed the sustained yield of the individual aquifer(s). Although the sustained yields of the aquifers have not been determined, some general guidelines for planning purposes can be presented.

Because of their high yields and small drawdowns when pumped, wells in the basalt aquifers of Soda Creek basin and Gem Valley are best able to supply additional quantities of ground water. A comparison of the water levels measured in 1928 (Stearns and others, 1936) with present-day water levels shown in figure 7 indicates no significant decline in the water table, despite a large increase in ground-water withdrawals in this 40-year span. However, some thought should be given to the quality requirements of the water needed, as the basalt locally contains water high in calcium, magnesium, and bicarbonate. This is especially true near the town of Soda Springs.

The alluvial aquifers generally do not yield as much water as the basalt aquifers and, therefore, are less able to withstand additional development. The alluvium in the northwestern part of Cache Valley has the greatest capability for additional development within this hydrologic unit. The wells in the alluvium of Thomas Fork Valley, Bear Lake Valley, and eastern Cache Valley have smaller yields. Because only a few high-capacity wells have been completed in the alluvium of other valleys in the basin, additional data to appraise adequately, their ground-water potential are needed. Additional ground-water development in areas previously mentioned as having high water tables might have the beneficial effect of lowering those water tables, thus drying up large areas of marshland and thereby reducing the loss of water to evapotranspiration.

The large number of unsuccessful wells drilled in the Salt Lake Formation indicate its limitation when considering it as a significant aquifer for future development. The formation undoubtedly will continue to provide ample water supplies locally, but until more information becomes available on the lithology and hydrology of the formation, its potential as a dependable source of additional water cannot be evaluated.

The Wasatch Formation and the pre-Tertiary formations generally are not regarded as having good potential for ground-water development. An exception may be found in pre-Tertiary carbonate rocks from which large springs issue in the basin.

Relation to Surface Water

As discussed previously, the aquifers in the Bear River basin are generally in direct hydraulic connection with the streams. The slope of the water table throughout most of the basin is toward the streams, and ground water is discharged from the aquifers into the streams. A hydraulic connection also exists where the basalt of the Blackfoot Lava Field is recharged by water from Blackfoot River Reservoir. Between Alexander and Grace the channel of Bear River is perched above the regional water table and direct hydraulic connection does not exist.

In areas where hydraulic connection exists, withdrawal of ground water affects the streamflow. Pumping of wells causes stream depletion by either increasing the amount of water moving from nearby streams to the wells or by decreasing the natural ground-water flow that would have discharged into the streams if the wells had not been pumped. Ground-water withdrawals in the area between Alexander and Grace, where hydraulic connection is absent, do not increase natural stream depletion in that reach of Bear River. However, these withdrawals decrease the natural ground-water flow that discharges into other reaches of the river, or into other streams.

The degree to which streamflow is affected is dependent on several factors, including proximity of the well(s) to the stream, the ability of the aquifers and the streambed to transmit water, and the quantity of water pumped. It should be noted that because only a portion of the total quantity pumped is used consumptively, some of the water withdrawn eventually returns to the stream. Therefore, the quantity of water depleted from the stream is usually less than the total quantity of water withdrawn from the wells.

No direct measurement of the reduction in streamflow resulting from ground-water withdrawals has been made in the Bear River basin. However, graphs and tables indicating the rate and volume of stream depletion both during and after the period a nearby well is pumped were described by Jenkins

(1968) for a hydrologic system in which the stream and the ground water are in equilibrium. To apply his methods, certain assumptions must be made. They are as follows: (1) Transmissivity does not change with pumping time; (2) the aquifer is isotropic, homogeneous, and semi-infinite in areal extent, with a straight, fully-penetrating stream boundary; (3) water is released instantaneously from storage; (4) the well is fully penetrating; (5) the pumping rate is steady; and (6) the residual effects of previous pumping are negligible. Geologic and hydrologic conditions in the Bear River basin are such that assumptions 1, 5, and 6 are almost fully met, while assumptions 2, 3, and 4 are only partially met. Figure 9, based on Jenkins' method, is a graph showing the percentage of the water being pumped from a well that is coming from a stream at a selected distance after a specified period of pumping. For example, if a well located 1 mile from a stream and finished in an alluvial aquifer having a transmissivity of 625,000 gallons per day per foot and a storage coefficient of 0.20 is pumped for 200 days, then at the end of that time, 50 percent of the water being pumped is coming from the stream. The values of transmissivity and storage coefficient used to draw the curves on the graph are believed to be representative of the better alluvial and basalt aquifers in the Bear River basin. It should be noted that the values obtained from these curves represent percentages, and, therefore, are unaffected by either the volume pumped or the rate of pumping. As time approaches infinity, the volume of stream depletion approaches the volume pumped.

The principal value of Jenkins' method lies in its providing a rapid, theoretical determination of pumping effects that would be extremely difficult and time-consuming to measure in the field. His method is based on

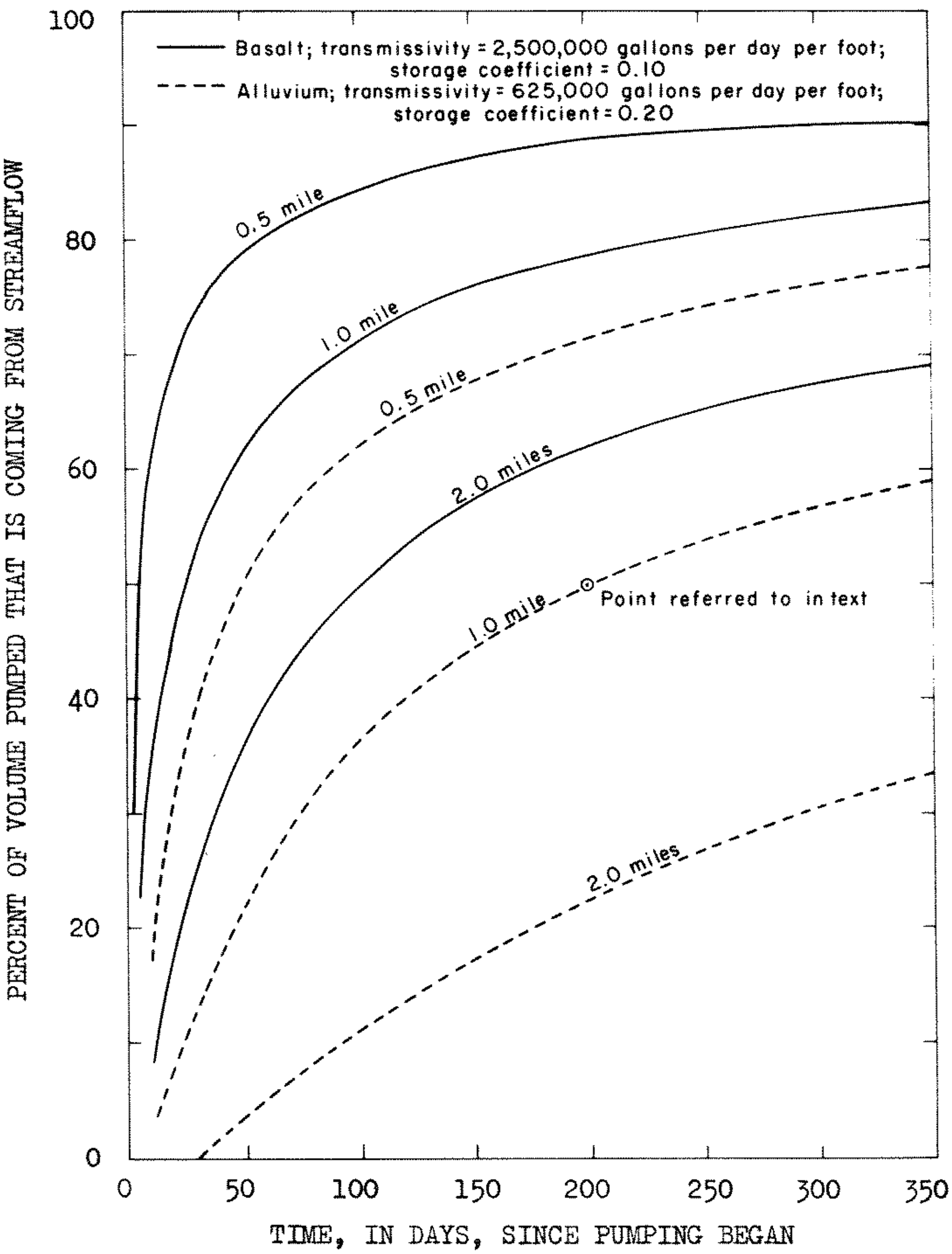

FIGURE 9.--Maximum effects of ground-water pumpage on streamflow at selected distances. (Adapted from Jenkins, 1968).

sound hydrologic principles and provides a relatively simple way of estimating effects of ground-water withdrawals, even though the assumptions made are seldom completely duplicated under natural conditions. However, the more nearly the ideal and natural conditions match, the more nearly will the theoretical answers match values measured in the field. The net result of the divergence of the actual conditions in the Bear River basin from the assumed ideal conditions would be to lessen the effects of pumping indicated by Jenkins' method. This method, therefore, provides quantitative values indicative of the maximum effect pumping from a well will have on streamflow, provided the values of transmissivity and storage used are reasonably correct.

SURFACE WATER

Figure 10 shows the average annual discharges of Bear River and some of its major tributaries as measured or extrapolated for water years 1943-67. The discharges shown on figure 10 represent measured streamflows under the present level of development; that is, they have not been adjusted for upstream storage, reservoir evaporation, or irrigation diversions.

The average annual net surface-water contribution from within the Idaho part of the Bear River basin is approximately 565 cfs, or 409,000 acre-feet. This quantity is based on an estimate by W. N. Jibson, Bear River Commission, Logan, Utah (written commun., 1969) and represents the difference between inflow to the basin from Wyoming 481 (cfs) and outflow from the basin into Utah (1,046 cfs) adjusted to the 26-year period 1943-68. Because some of the small streams and canals Jibson used in his calculations were gaged for only 1 or 2 years, the extrapolation of these records to a 26-year period can be expected to yield only approximate values of total inflow and outflow, and, therefore, an equally approximate value of net surface-water contribution from the basin.

The Bear River is generally a gaining stream in its course through Idaho. There is one section of the river channel, however, that probably is losing water--the reach between Alexander and Grace. The river channel Between Alexander and Grace is cut in fractured basalt and is perched above the regional water table. Ground-water contours (fig. 7) suggest that this reach of the river is a source of recharge to the ground-water reservoir and that some of this recharge (1) eventually returns to the river through springs issuing from the walls of Black Canyon, where the river channel is below the regional water table, and (2) some probably flows northwestward into the Portneuf River basin. To determine how much, if any, water leaks out of the channel, discharge measurements at Alexander and Grace, adjusted for canal diversions in between, should be made and compared.

Direct runoff to the streams in the Bear River basin is derived chiefly from snowmelt; hence, streamflow on unregulated streams is highest in the spring and early summer and lowest in the late fall and winter (fig. 11). Besides these relatively short-term seasonal fluctuations, there are long-term fluctuations in discharge as a result of variations in yearly precipitation (fig. 12).

The effect of stream regulation is evident on the flow-duration curves shown in figure 13. Bear River at Border is not regulated and consequently shows a much wider range in flows than stations at Alexander and Preston, where flow is regulated by upstream dams. Montpelier and Cottonwood Creeks are not regulated streams and also show wide ranges in flow.

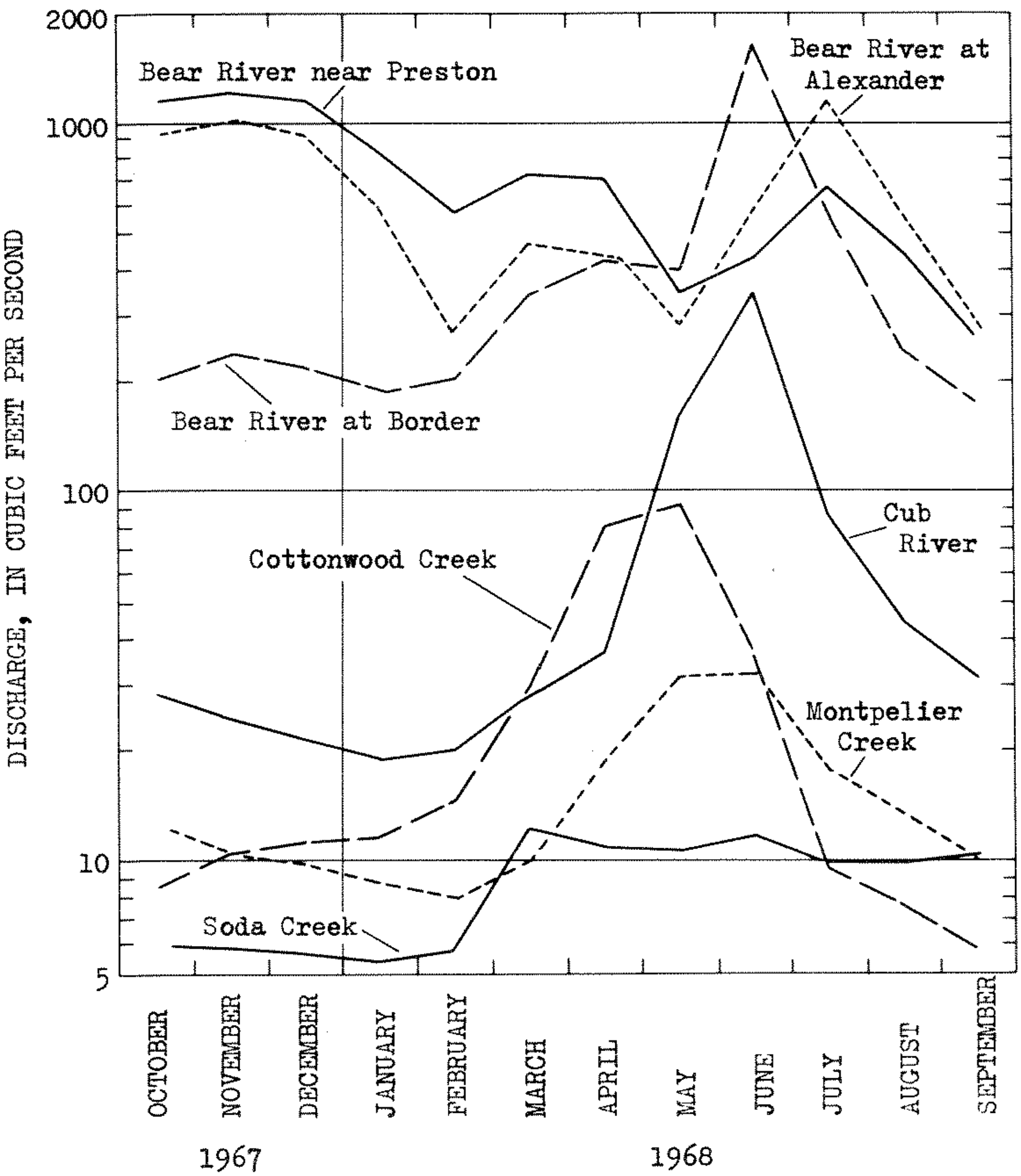

FIGURE 11.--Mean monthly discharge for water year 1968 at selected stations.

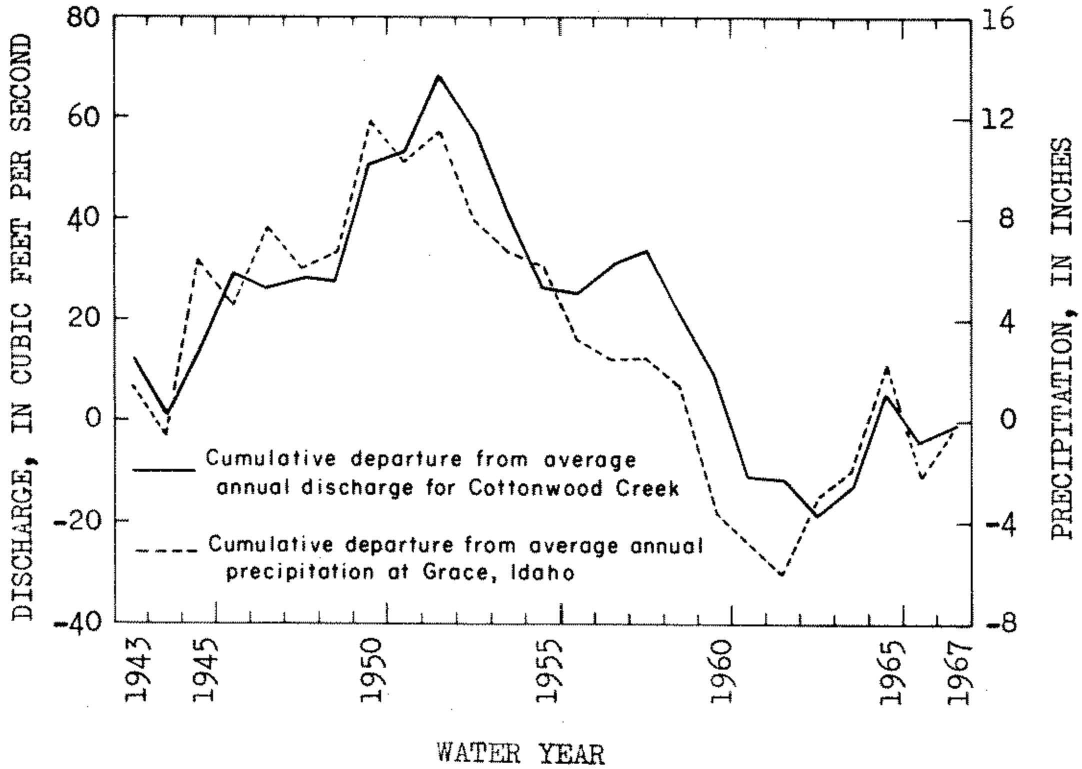

FIGURE 12.--Long-term discharge-precipitation relationship for Cottonwood Creek and Grace, Idaho.

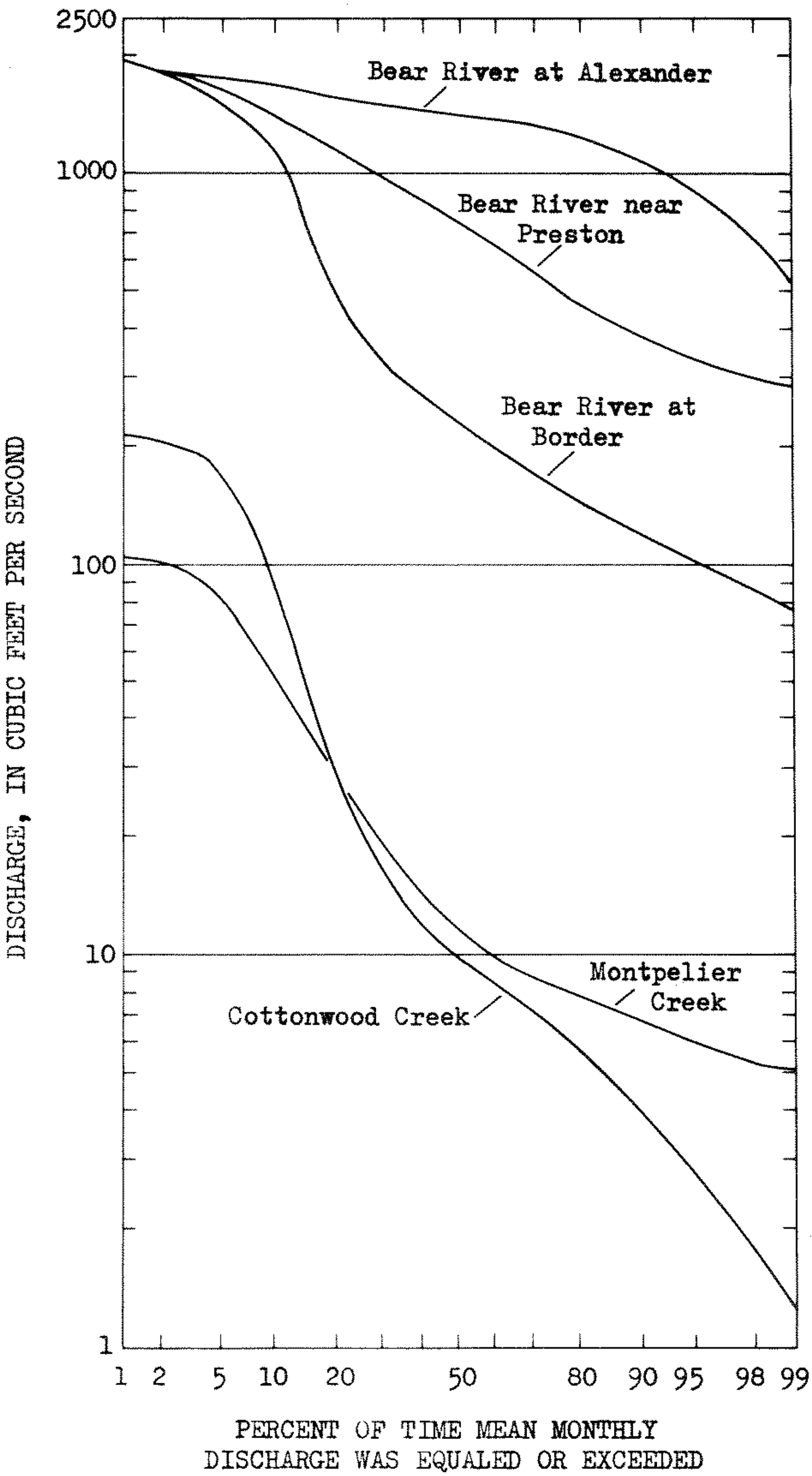

FIGURE 13.--Flow-duration curve for selected stations in the Bear River basin.

The yields from some of the tributary drainages in the Bear River basin are inconsistent with the amount of precipitation the drainage area receives. The drainage area above the gaging station on Cub River receives an average annual precipitation of about 3 acre-feet per acre. Discharge records indicate, however, that the annual runoff past this same gage averages almost 5 acre-feet per acre. The occurrence of solution cavaties in carbonate rocks along the axis of Bear River Range and numerous springs in the headwaters of Cub River, suggests that Cub River may be receiving water from adjacent drainage basins.

WATER QUALITY

Ground Water

The chemical analyses of ground water from selected wells in the basin are listed in table 4. Figure 7 contains graphical representations of chemical analyses by means of patterns (Stiff, 1951). The patterns depict the concentrations of several ions and afford a ready method to compare the areal distribution of the different types of ground water. Overall, the ground water may be classified as bicarbonate in type.

The alluvial aquifers of Bear Lake County contain calcium bicarbonate water with relatively small quantities of dissolved solids. The dissolved-solids content of the water, which is a measure of the amount of mineral matter in solution, ranges from 336 to 475 mg/l for the samples analyzed. The water temperature averages 10.6°C. (51°F)

The major valleys of Caribou County contain water of several types and quality. Most of the wells are finished in basalt and yield either a magnesium bicarbonate or calcium magnesium bicarbonate type water.

Many of the wells near Soda Springs contain water that is high in magnesium bicarbonate and that chemically resembles the water from carbonated springs in the same area. The dissolved-solids content of the water from wells sampled in the part of Caribou County that lies in the Bear River basin ranges from 422 to 998 mg/l and the water temperature averages 12.2°C. (54°F)

Ground water in the Idaho part of Cache Valley (Bannock and Franklin Counties) is heterogeneous in its chemical character. Predominant water types include calcium bicarbonate, calcium magnesium bicarbonate, sodium calcium bicarbonate, and sodium magnesium bicarbonate. The dissolved-solids content of the analyzed water ranges from 286 to 632 mg/l, which is higher than water in Bear Lake County but lower than water in Caribou County. The temperature of the water averages 13.9°C. (57°F)

In general, the ground water of the Bear River basin, with the exception of the wells near Soda Springs that produce high bicarbonate water, is suitable for most purposes. Generally, the water meets the drinking-water standards established by the U. S. Public Health Service (1962) for the constitutents analyzed, although the dissolved-solids content commonly exceeds the recommended maximum of 500 mg/l. The iron content of several springs, and possibly some wells, in the Soda Springs area also exceeds the 0.3 mg/l concentration recommended by the above-mentioned drinking-water standards. The water is quite hard, therefore, many domestic-well owners use water softeners.

The ground and surface waters in the Bear River basin are classified in figure 14 according to their suitability for irrigation. This classification, developed by the U. S. Salinity Laboratory Staff (1954), is based on the specific conductance and SAR (sodium-adsorption ratio) of the water.

Table 4.--Chemical analyses of ground water from selected wells in Bear River basin.
(Chemical constituents in milligrams per liter)

Aquifer: T - Tertiary
Q - Quaternary
A - Alluvium
I - Basalt

Analyses by: I - State of Idaho
C - Commercial
G - U.S. Geological Survey
B - U.S. Bureau of Reclamation

Well No.	Date of collection	Aquifer	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	pH	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Boron (B)	Dissolved solids		Total hardness as $CaCO_3$	Specific conductance (micromhos at 25° C)	Percent sodium (%Na)	Sodium adsorption ratio (SAR)	Analysis by
																mg/l	tons per acre-ft					
Bannock County																						
13S-38E- 3ddal	3-26-65	QA	-	91	29	-	-	7.6	-	33	78	0.25	0.5	-	-	450	0.61	342	-	-	-	I
Bear Lake County																						
11S-44E- 7ccbl	7-23-68	TA	12	74	30	5.0	1.0	7.7	310	48	3.3	0	9.1	-	0.01	350	.48	308	551	3.4	0.1	G
12S-43E-25daal	7-23-68	QA	40	61	27	16	4.6	7.8	292	30	17	.1	2.8	-	.04	351	.48	264	539	11	.4	G
12S-44E-33dccl	7-23-68	QA	12	91	30	10	1.0	7.8	336	74	6.7	.1	14	-	.02	426	.58	352	652	5.9	.2	G
13S-43E-16dccl	7-23-68	QA	23	66	20	30	1.0	7.7	340	0	27	.2	.5	-	.12	351	.48	248	576	21	.8	G
13S-44E- 3bdal	7-24-56	QA	1.8	71	28	-	-	7.4	310	70	3	.1	1.0	0.09	-	336	.46	296	-	-	-	I
13S-44E- 3bddl	7-24-56	QA	1.7	71	27	-	-	7.3	290	68	7	.1	1.0	.09	-	352	.48	294	-	-	-	I
13S-44E- 4adcl	8- 5-64	QA	-	3	-	-	-	6.4	12	106	5	.3	.5	-	-	360	.49	8	-	-	-	I
13S-46E-26bcal	7-23-68	QA	11	66	37	10	1.0	7.8	240	90	19	.1	9.1	-	.02	408	.55	316	607	6.5	.3	G
14S-43E-35bbal	7-23-68	QA	19	67	26	17	1.9	7.9	356	12	12	.1	1.9	-	.03	336	.46	276	556	12	.4	G
14S-44E-12cccl	7-23-68	QA	15	83	34	39	2.1	7.7	352	74	40	.1	4.1	-	.07	475	.65	348	765	20	.9	G
Caribou County																						
8S-42E- 7bdal	7-23-68	-	29	75	50	8.2	3.0	7.3	464	23	8.1	.3	6.4	-	.01	422	.57	392	718	4.4	.2	G
8S-42E-15bbcl	1-17-67	QI	-	176	55	48	-	7.7	-	183	81	2.3	24	3.8	-	674	.92	670	-	-	.8	I
8S-42E-31adbl	7-23-68	QI	44	88	60	48	6.9	7.6	392	147	59	1.5	9.5	-	.16	684	.93	466	1,010	18	1.0	G
8S-42E-31adcl	4- 6-67	QI	32	-	-	-	-	7.5	427	68	30	-	-	-	-	-	-	380	800	-	-	C
8S-42E-31dabl	4- 6-67	QI	27	-	-	-	-	7.3	464	84	50	-	-	-	-	-	-	420	950	-	-	C
8S-42E-32bdl	3-31-67	QI	16	115	44	-	-	7.1	537	30	13	-	-	-	-	675	.92	468	900	-	-	C
9S-40E-27dcdl	8-18-61	QI	-	69	43	31	6.3	7.8	375	61	37	-	-	-	.03	460	.63	-	764	16	.7	B
9S-40E-29cccl	8-16-61	QI	-	60	54	45	5.1	8.3	350	84	48	-	-	-	.07	508	.69	-	829	21	1.0	B
10S-40E- 3dddl	8-15-61	QI	-	84	56	50	10	8.0	468	86	58	-	-	-	.07	619	.84	-	1,007	19	1.0	B

Table 4.--Chemical analyses of ground water from selected wells in Bear River basin--Continued.

Well No.	Date of collection	Aquifer	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	pH	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Boron (B)	Dissolved solids mg/l	Dissolved solids tons per acre-ft	Total hardness as $CaCO_3$	Specific conductance (micromhos at 25° C)	Percent sodium (%Na)	Sodium adsorption ration (SAR)	Analysis by
Caribou County--Continued																						
10S-40E- 5bdd1	8-14-61	QI	-	58	53	47	5.1	8.1	367	76	51	-	-	-	0.10	500	0.68	-	830	22	1.1	B
10S-40E-12aab1	3-24-46	QI	-	70	39	-	-	7.3	-	64	38	0.3	-	-	-	492	.67	335	-	-	-	I
10S-40E-14bba1	7-22-68	-	23	59	48	34	4.9	7.8	360	51	38	.5	12	-	.03	454	.62	344	760	17	.8	G
10S-40E-24bad1	8-17-61	QI	-	67	62	50	7.8	8.1	401	96	62	-	-	-	.21	598	.81	-	974	20	1.1	B
10S-40E-36dcc1	7-22-68	QI	27	62	57	39	5.2	7.8	412	70	42	.5	13	-	.05	520	.71	390	852	18	.9	G
10S-41E-18dcc1	8-17-61	QI	-	85	34	35	4.3	7.9	352	70	42	-	-	-	.06	487	.66	-	792	18	.8	B
11S-41E-30bdd1	7-22-68	-	28	128	78	89	3.6	7.8	520	228	98	.3	27	-	.15	998	1.4	640	1,430	23	1.5	G
Franklin County																						
13S-40E-30acb1	7-19-68	QA	21	69	30	21	1.9	7.6	326	22	30	.4	13	-	0	368	.50	296	625	13	.5	G
14S-38E-22aba1	3-11-68	QA	28	69	14	-21-		7.4	279	16	19	-	5.1	-	-	303	.41	231	504	-	.6	G
14S-38E-22ccb1	7-19-68	QA	32	62	20	9.2	2.4	7.9	277	16	13	.3	1.0	-	0	286	.39	236	472	7.7	.3	G
14S-38E-26adc1	7-16-68	QA	28	75	21	15	4.0	7.7	310	17	26	.2	4.7	-	.02	340	.46	274	566	10	.4	G
14S-39E- 8ada1	7-18-68	QA	34	72	33	69	3.2	7.7	324	61	85	.7	9.8	-	.08	531	.72	314	880	32	1.7	G
14S-39E-25add1	7-22-68	QA	45	89	35	58	5.6	7.9	496	40	30	.5	4.0	-	.24	550	.75	364	866	25	1.3	G
15S-38E-11bbc1	7-19-68	TA	31	27	54	57	7.7	7.8	312	59	68	.8	4.1	-	.08	462	.63	288	779	29	1.5	G
15S-39E-23bbb1	7-18-68	-	38	68	59	29	4.0	7.8	492	24	36	.5	.5	-	.08	486	.66	414	831	13	.6	G
15S-39E-31abd1	7-21-68	QA	21	52	43	9.2	4.9	7.8	356	13	12	.3	17	-	0	333	.45	308	564	6.0	.2	G
15S-40E-32bba1	7-21-68	QA	37	46	37	23	5.4	7.7	304	27	29	.5	8.8	-	.02	369	.50	268	591	15	.6	G
16S-38E- 6aaa1	7-16-68	TA	35	95	40	62	10	7.8	372	91	95	.5	12	-	.02	632	.86	400	1,020	25	1.4	G
16S-38E-24acb1	7-16-68	QA	68	60	29	80	19	7.8	414	5.0	84	.4	.6	-	.47	533	.72	268	872	37	2.1	G
16S-40E-17bbb1	8-13-68	QA	53	34	18	111	8.3	7.8	352	11	81	1.3	.6	0.01	.10	486	.66	160	793	59	3.8	G
16S-40E-20cdc1	4-17-68	QA	35	45	21	-49-		7.8	295	12	36	-	1.7	-	-	338	.46	200	570	-	1.5	G

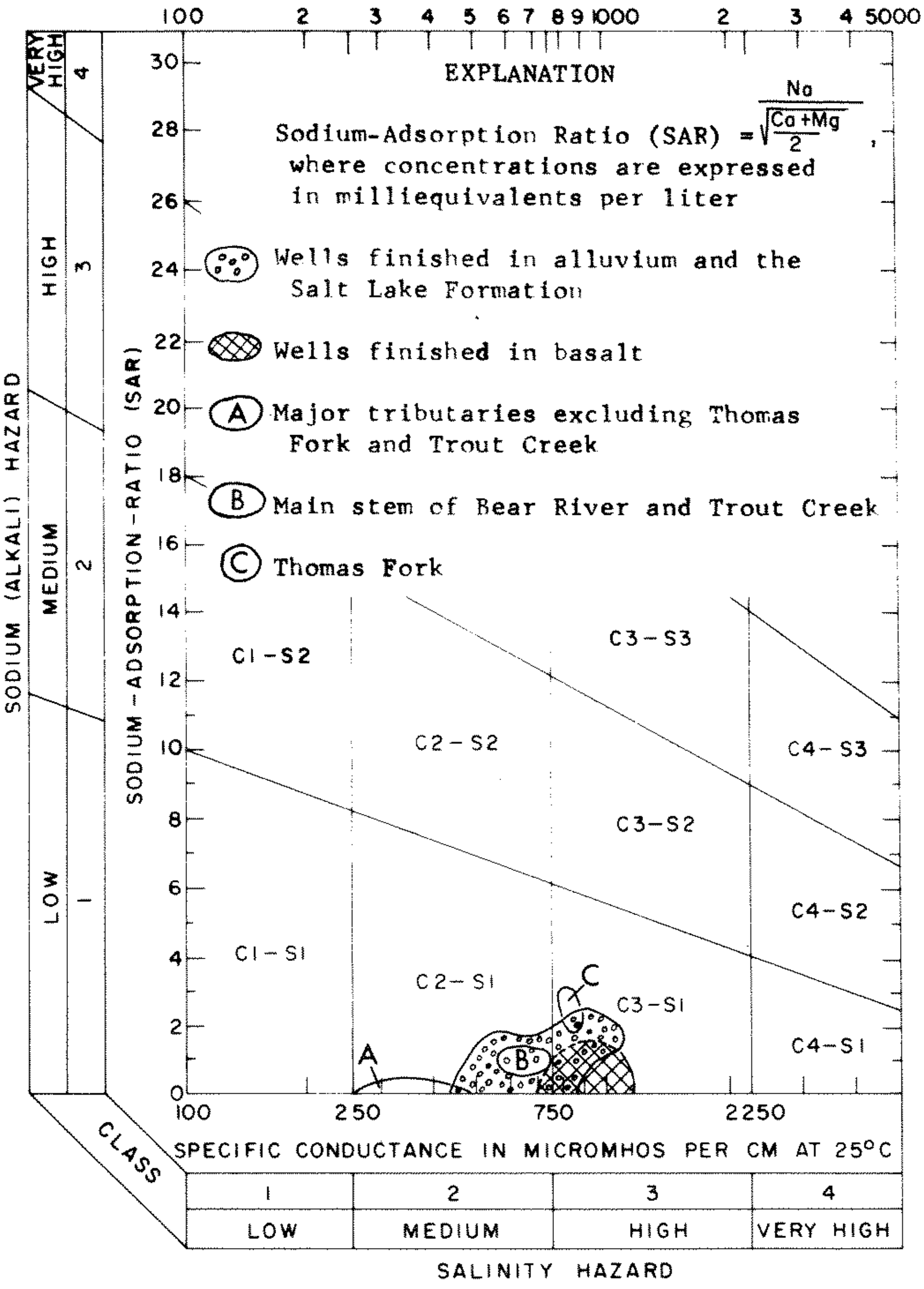

FIGURE 14.--Suitability of ground and surface water for irrigation. (From U. S. Salinity Laboratory Staff, 1954).

As shown by this figure, almost all the wells finished in basalt produce water that is low in sodium (S1) but high in salinity (C3). Because of its high salinity, this water should be used only on salt-tolerant crops and on soils having good permeability and drainage. Approximately half the wells finished in alluvium (including the Salt Lake Formation) yield water that falls into the same category as the basalt wells. The other half of the alluvial wells produces water that has only medium salinity (C2). This water is satisfactory for most crops, provided a moderate amount of leaching takes place in the soil.

Surface Water

The water of Bear River and its principal tributaries is primarily a bicarbonate type with either calcium or magnesium being the predominant cation (fig. 10). The surface water is generally lower in dissolved solids than ground water in the same basin. As in most river basins, the concentration of dissolved solids is proportionately greater at low flows than at high flows because low flows have a proportionately greater ground-water contribution. Chemical data for selected stations are given in table 5.

Prior to entering Bear Lake for offstream storage, Bear River contains a calcium bicarbonate type water that is similar to most of the large tributaries. Water that is released from the lake has a higher magnesium concentration and a higher ratio of magnesium to total cations than water entering the lake from Bear River. The increase in the total amount of magnesium is due to the fact that Bear Lake water is higher in total dissolved solids than the Bear River water entering it. The magnesium ions in the lake water are concentrated by evaporation while some of the calcium ions are removed from

Table 5.--Chemical analyses of surface water from selected streams in the Bear River basin.

Station	Date of collection	Discharge (cfs)	Silica (SiO_2)	Calcium (ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	pH	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Boron (B)	Dissolved solids		Total hardness as $CaCO_3$	Specific conductance (micromhos at 25° C)	Percent sodium (%Na)	Sodium adsorption ratio (SAR)	Analysis by
																mg/l	tons per acre-ft					
Bear River at Border	7-23-68	(355)*	10	64	32	37	3.0	7.8	316	67	32	0.3	0.2	-	0.09	404	0.55	292	707	21	0.9	G
Thomas Fork - State line	7-23-68	23	7.0	55	13	93	-	7.9	224	40	119	-	.1	0.02	-	447	.61	190	802	52	2.9	G
Thomas Fork near Border	7-24-68	33	10	69	25	88	-	8.0	272	52	132	-	2.8	.06	-	508	.69	275	887	41	2.3	G
Bear River at Harer	7-23-68	363	11	68	32	41	2.4	7.9	312	59	45	.5	1.1	.01	.06	402	.55	301	694	23	1.0	G
Rainbow Inlet Canal	7-23-68	350	11	68	32	39	2.6	7.8	324	58	41	.3	1.0	.02	.07	405	.55	301	692	22	1.0	G
Montpelier Creek	7-23-68	17	10	65	15	8.6	-	7.7	221	57	1.5	-	0	0	-	278	.38	224	442	8	.2	G
St. Charles Creek	7-25-68	50	4.7	51	17	6.7	-	7.8	248	3.2	2.6	-	.4	0	-	208	.28	196	370	7	.2	G
Bloomington Creek	7-23-68	23	5.2	46	15	1.1	-	7.9	210	4.0	1.7	-	.3	.01	-	176	.24	176	320	1	0	G
Bear Lake Outlet Canal	7-23-68	918	11	44	52	39	4.0	8.1	336	67	44	.7	.6	.01	.09	427	.56	324	722	21	.9	G
Bear River at Pescadero	5-15-68	121	8.7	57	31	33	-	8.0	258	76	35	-	1.3	.11	-	390	.53	270	633	21	.9	G
Georgetown Creek	5-14-68	37	7.1	57	15	6.3	-	7.8	220	33	1.5	-	.9	1.9	-	237	.32	204	394	6	.2	G
Eightmile Creek	7-23-68	11	5.7	53	6.4	.5	-	7.6	186	4.8	1.5	-	0	0	-	173	.24	159	293	1	0	G
Bear River at Soda Springs	7-23-68	887	11	50	43	36	3.5	7.8	316	60	38	.3	1.0	.07	.07	385	.52	302	673	20	.9	G
Soda Creek	9-11-67	3.5	25	59	46	8.0	3.2	7.8	400	25	6.5	.3	2.6	0	.02	355	.48	336	619	5	.2	G
Bear River at Alexander	7-22-68	1,110	10	54	40	34	3.5	7.7	320	55	36	.3	1.6	.08	.07	382	.52	299	665	20	.9	G
Bear River below Blk. Can.	7-22-68	75	20	52	47	38	4.9	8.1	342	62	39	2.2	3.0	.10	.08	418	.57	323	717	20	.9	G
Trout Creek	7-22-68	26	18	75	20	35	--	8.0	348	36	13	-	6.1	.40	-	383	.52	270	622	22	.9	G
Bear River at Cleveland	7-23-68	958	15	61	40	36	4.3	7.9	344	57	37	2.3	2.2	.18	.09	413	.56	316	709	20	.9	G
Cottonwood Creek	7-23-68	7.8	12	52	8.9	2.8	-	7.6	190	7.0	6.6	-	.1	0	-	188	.26	166	315	4	.1	G
Bear River below Oneida	7-23-68	1,890	13	72	33	40	-	8.1	346	59	40	-	1.9	.14	-	434	.59	315	729	22	1.0	G
Mink Creek	7-23-68	40	5.9	47	8.0	4.1	-	7.7	186	3.8	1.5	-	0.8	0.08	-	163	0.22	150	285	6	0.1	G
Bear River near Preston	12-19-67	(1,000)*	14	57	41	30	4.4	8.2	341	52	32	0.2	1.9	-	0.06	393	.53	310	692	17	.7	G
Battle Creek	7-22-68	.22	23	80	36	131	-	8.1	480	76	112	-	3.4	.30	-	698	.95	348	1,150	45	3.0	G
Deep Creek	7-22-68	2.3	15	43	38	136	-	8.0	296	66	175	-	.8	.05	-	630	.86	262	1,110	53	3.7	G
Cub River	7-23-68	65	4.6	48	9.2	2.6	-	7.8	192	3.8	1.2	-	.3	.03	-	167	.23	158	291	3	.1	G

*(n) = Mean daily discharge.

solution and precipitated as calcium carbonate. In shrinking from its maxi-size during the Pleistocene epoch to its present size, the water in Bear Lake probably became even more concentrated than it is today. The diversion of Bear River into the lake has apparently diluted the lake water and improved its quality (K. M. Waddell, oral commun., 1969). This dilution process has probably not reached an equilibrium yet, and water in Bear Lake may gradually change in quality for many years. After the water is released from the lake, Bear River is diluted by the calcium bicarbonate type water from tributaries and the percentage of magnesium in the main stem decreases.

The principal tributaries to Bear River, with the exception of Thomas Fork and Soda Creek, contain calcium bicarbonate water with relatively small quantities of dissolved solids. At low flows the water in Thomas Fork contains a fairly high concentration of sodium chloride. This salt may have been dissolved from salt beds within the Preuss Sandstone of Jurassic age, which crops out in the headwaters of Thomas Fork. Comparable salt beds were considered to be the source of saline springs in the Afton, Wyo., area (Walker, 1964, p. 168). At high flows, the percentages of sodium and chloride ions in the water are reduced and the water changes from a sodium and chloride type to a calcium bicarbonate type. Soda Creek, which is almost entirely spring fed, is the only principal tributary to Bear River that contains magnesium bicarbonate water. Most of its flow is diverted into the Soda Canal and transported to Gem Valley where it is used to irrigate crops and water stock.

The chemical analysis in figure 10 and table 5 labeled "Bear River below Black Canyon" actually represents an analysis of water discharging from the Black Canyon springs. The entire flow of Bear River is put into penstocks at the head of the canyon just north of Grace and, therefore, does not flow through the canyon. Bear River flow returns to its natural channel below Black Canyon after having passed through a hydroelectric plant. The similarity between the analysis just mentioned and the analyses for Bear River at Alexander and Bear River at Soda Springs supports the theory of leakage from the river channel between Alexander and Grace, and return to the channel by way of the Black Canyon springs.

There are streams in the basin, such as Deep Creek and Battle Creek in Cache Valley, that contain water with extremely large quantities of dissolved solids, but the discharges from these streams are so small that the overall effect on the water quality of Bear River is insignificant.

The surface water of the Bear River basin is suitable for most purposes and generally meets the drinking-water standards established by the U. S. Public Health Service (1962) for the constituents analyzed. The chloride content of Thomas Fork at times exceeds the recommended 250 mg/l limit, but this occurs only at very low flows. Figure 14 indicates that water from the main stem of Bear River and its principal tributaries, with the exception of Thomas Fork, is satisfactory for irrigating most crops, provided a moderate amount of leaching takes place in the soil. The high salinity (C3) of water from Thomas Fork limits its use for irrigation to salt-tolerant crops and soils having good permeability and drainage.

SPRINGS

The Bear River basin contains hundreds of springs. These springs can be classified according to the chemical types of the water they discharge, which are calcium bicarbonate, magnesium bicarbonate, calcium sulfate, sodium chloride, and magnesium bicarbonate sulfate. Chemical analyses of water from representative springs are given in table 6. Spring locations are shown on figure 10.

Springs having a calcium bicarbonate type water are by far the most common and represent what might be called the "normal" springs of the basin. Included are practically all the springs that issue from fractures and solution openings in the bedrock hills. Also included are Big Spring (9S-42E-18b1S) and Formation Spring (8S-42E-27c1S) that issue from basalt and travertine, respectively. Springs issuing from the bedrock have water temperatures ranging from 5^{o} to $10^{o}C$, (41^{o} to $50^{o}F$) which correspond to the mean annual air temperature.

The "soda" springs near the town of Soda Springs yield a magnesium bicarbonate type of water. Most of these springs issue from basalt, but others emerge from sources that are covered by extensive deposits of travertine. Several of the larger springs, such as 8S-41E-23a1S, constitute the headwaters of Soda Creek. The bicarbonate content of these spring waters is unusually high and carbon dioxide gas can be seen bubbling out of the water. The iron content is also high and it generally precipitates as a rusty deposit.

Soon after the construction and filling of Blackfoot River Reservoir, the discharge of the springs at the head of Soda Creek increased and many new springs developed in the Fivemile Meadows area. If the increase in spring discharge was due to reservoir leakage, the water coming from the springs today probably is a mixture of Blackfoot River water and the type of water originally issuing from the springs. The water temperature of these springs ranges from 10^{o} to $13^{o}C$.

Table 6.--Chemical analyses of water from selected springs in the Bear River basin.

Spring No.	Date of collection	Temperature (°C)	Temperature (°F)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	pH	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Boron (B)	Dissolved solids mg/l	Dissolved solids tons per acre-ft	Total hardness as $CaCO_3$	Specific conductance (micromhos at 25°C)	Percent sodium (%Na)	Sodium adsorption ratio (SAR)	Analysis by
Bear Lake County																							
15S-44E-13c1S	Aug. 1914	48.4	118	26	213	221	149	41	-	1,030	797	92	-	-	-	-	-	-	-	-	0.2	2.0	G
Caribou County																							
8S-41E-23a1S	6-28-23	12.8	55	-	151	163	-42-		-	1,298	57	11	-	-	-	-	-	-	-	-	.07	.5	G
8S-41E-36d1S	10-19-63	11.1	52	69	150	161	-48-		-	1,293	66	9.6	-	-	-	-	1,149	1.6	1,035	-	.08	.6	G
8S-42E-27c1S	7-23-68	11.7	54	10	120	49	3.8	1.2	7.8	560	32	3.3	0	0.4	-	0.01	502	.68	500	842	1.7	.1	G
8S-42E-36a1S	6-28-23	9.44	49	-	119	149	-20-		-	1,074	55	11	-	-	-	-	-	-	-	-	.04	.3	G
9S-42E- 6b1S	6-28-23	10.6	51	-	162	168	-19-		-	1,281	67	12	-	-	-	-	-	-	-	-	.03	.2	G
9S-42E-13b1S	6-28-23	13.3	55	-	165	62	-25-		-	199	537	-	-	-	-	-	-	-	-	-	.07	.4	G
9S-42E-18b1S	7-22-68	10.0	50	23	124	61	16	3.5	7.8	508	87	65	0.2	9.1	-	0	715	.97	560	1,030	5.8	.3	G
Franklin County																							
13S-41E-7a1S	7-22-68	71.0	160	52	69	31	494	76	7.8	424	255	595	.9	3.5	-	1.5	1,830	2.5	300	2,940	73	12	G
15S-39E-8b1S	3-13-68	77.0	171	72	154	18	-3,340-		7.1	704	26	5,050	-	2.6	-	-	9,180	12	460	14,900	94	68	G

In 1937, a well was drilled in the town of Soda Springs near a spring producing a magnesium bicarbonate type water. The drill stem reportedly penetrated a zone of high-pressure carbon dioxide gas at a depth of 315 feet. A control valve was installed and the well now has a pressure head of about 100 feet above land surface.

The springs in Sulphur Canyon (9S-42E-13b1S) contain a calcium sulphate type water. They were described by Richards and Bridges (1911, p. 5) as having cold water that is cloudy from the presence of free sulphur, and as giving an acidic reaction to litmus paper. Carbon dioxide and hydrogen sulphide gases bubble from the numerous spring vents and from the marshy ground surrounding the springs (Mansfield, 1927, p. 319).

At least two thermal springs having a sodium chloride type water are associated with faults. Maple Grove Hot Spring (13S-41E-7a1S) lies along a fault line at the base of the canyon wall near Narrows Plant Reservoir. The water has a temperature of 71°C (160°F) and a chloride concentration of 595 mg/l. Spring 15S-39E-8b1S is approximately 2 miles southeast of Clifton Hill, a hill composed of bedrock and surrounded by younger alluvium. Clifton Hill is probably bounded by faults along which the ascending spring water moves. The water has a temperature of 77°C (171°F) and the concentration of chloride was determined to be 5,050 mg/l. The source of the sodium chloride in the water from these springs is not known.

According to a chemical analysis published by Mansfield (1927, p. 321), the thermal springs near Mud Lake, 15S-44E-13c1S, discharge magnesium bicarbonate sulfate water. These springs, some of which are used to supply a local swimming pool, lie along a major fault on the east side of Bear Lake Valley and have water temperatures of about 49°C. (120°F)

SUMMARY AND RECOMMENDATIONS

The Idaho part of the Bear River basin receives an average of 2.3 million acre-feet of precipitation per year. The areal distribution of this precipitation ranges from less than 10 inches in Bear Lake Valley to more than 45 inches on the Bear River Range.

Ground water occurs in the alluvium of the valleys, the basalt of Soda Creek basin and Gem Valley, the Salt Lake Formation, the fractured bedrock, and possibly in the Wasatch Formation. The basalt and alluvium are the most productive aquifers and are best able to support additional ground-water development. Reported well yields are as high as 3,500 gpm from the basalt and 2,500 gpm from the alluvium. The principal sources of recharge to the aquifers include direct infiltration of precipitation, spring snowmelt and runoff, seepage of irrigation water, and losses from irrigation canals.

Basalt in the Blackfoot Lava Field is recharged, in part, by leakage from Blackfoot River Reservoir and ground water may be flowing through the basalt in Tenmile Pass into the Portneuf River basin. Basalt in Gem Valley is recharged, in part, by ground water flowing past Alexander. A portion of this water flows northwestward into the Portneuf River basin.

The Bear River is generally a gaining stream in its course through Idaho, with the possible exception of the reach between Alexander and Grace. Ground-water contours suggest that this reach of the river is a source of recharge to the ground-water reservoir and that some of this recharge eventually returns to the river through springs issuing from the walls of Black Canyon.

The average annual net surface-water contribution from within the Idaho part of the basin is about 565 cfs, or 409,000 acre-feet per year.

Ground water in the study area tends to be predominantly calcium and magnesium bicarbonate in type. The dissolved-solids content of the water sampled from wells ranges from 286 to 998 mg/l. The ground water is suitable for most purposes, but water from all the basalt wells and about half the wells that tap alluvium is saline enough that it should be used to irrigate only salt-tolerant crops grown on soils with good permeability and drainage. The surface water of the basin is also of a bicarbonate type, but generally is lower in dissolved solids than the ground water. In general, the surface water is suitable for most purposes, but low flows in Thomas Fork contain high concentrations of sodium and chloride ions, thus restricting its agricultural use.

Hundreds of springs of various sizes and having several types of water occur throughout the basin. Many of these springs are utilized for domestic water supplies.

A fuller understanding of the hydrologic intricacies and interrelations within the Bear River basin, and the hydrologic relations between the Bear, Blackfoot, and Portneuf River basins will require that several facets of the geology and hydrology of the area be studied in detail. Additional information on the hydrologic characteristics of the aquifers and the amounts of water moving through them is needed. Values of transmissivity and storage coefficient should be determined from controlled aquifer tests at selected sites. Also needed is a detailed description of the aquifer(s) within the Salt Lake Formation and a determination of whether significant aquifers exist in the Wasatch Formation and the pre-Tertiary bedrock.

A quantitative hydrologic budget of the Bear River basin should be prepared. In addition to the factors normally considered in a water budget, it would also be necessary to determine: (1) The quantity of water leaking into the Bear River basin from the Blackfoot River basin; (2) the quantity of ground water, if any, flowing through the basalt in Tenmile Pass; (3) the quantity of water, if any, being lost from the channel of Bear River between Alexander and Grace; and (4) the quantity of ground and surface water, moving from Gem Valley into the Portneuf River basin. Once the hydrologic characteristics of the aquifers and the amounts of water in each phase of the hydrologic cycle are known, an estimate of the basin's perennial yield could be made, as well as an appraisal of plans for future water development.

Finally, a detailed investigation should be made to determine the chemical effects of diverting Bear River water into Bear Lake for storage. Although Bear River water has been sampled extensively, very few samples have been taken from the lake. This investigation should be of a continuing, long-term nature and could be included as one phase of a comprehensive limnological study of Bear Lake.

RECORDS OF WELLS

Table 7 presents data on representative wells inventoried in the Bear River basin during the course of this investigation. An attempt was made to visit all the large-capacity wells and enough of the smaller wells to obtain an average of one well per square mile in the populated parts of the basin. It is believed that the resulting compilation shows good geographic distribution and is hydrologically representative.

The data were obtained by inspection in the field, interviews with well owners, and from drillers' reports submitted to the Idaho Department of Reclamation.

Table 7 - Explanation

(Boxhead explanations are abstracted from U. S. Geological Survey "Instructions for using the punch-card system for the storage and retrieval of ground-water data.")

Well number: See text

Owner: Most recent owner at time of inventory

Ownership: C County N Corp. or Co.

M City P Private

Use of water: C Commercial P Public Supply

H Domestic S Stock

I Irrigation U Unused

N Industrial

Use of well: U Unused W Withdraw

Specific Conductance: 151-300 micromhos per cm at 25°C

301-500 micromhos per cm at 25°C

501-1,000 micromhos per cm at 25°C

1,001-2,000 micromhos per cm at 25°C

2,001-5,000 micromhos per cm at 25°C

Log data: D Driller's 7 Radiation, temperature, fluid-conductivity, and

J Gamma-ray driller's logs

Depth of well: Depth, in feet below land-surface datum, as reported by owner, driller, or others, or as measured by the U. S. Geological Survey.

Depth cased: Length of casing, in feet below land-surface datum, to the top of the first perforation(s) or opening.

Diameter: Inside diameter of the well, in inches; nominal inside diameter, in inches, of the innermost casing at the surface for driller cased wells.

Well finish: F Gravel wall, perforated or slotted casing

O Open end

P Perforated or slotted casing

S Screen

W Walled or shored

X Open hole in aquifer

Method drilled: A Rotary H Hydraulic rotary

C Cable-tool V Driven

D Dug

Lift type: C Centrifugal P Piston

J Jet S Submergible

M Multiple (turbine) T Turbine

N None

Power: 1 Hand 4 Diesel engine

2 Natural gas engine M 0-50 hp

B 20-50 hp 5 Electric motor

C 50-100 hp S 0-1 hp V 15-100 hp

D 100-200 hp T 1-5 hp W 100-hp

3 Gasoline engine U 5-15 hp

Altitude of lsd: Altitude of land-surface datum, in feet, above mean sea level. Land-surface datum is an arbitrary plane closely approximating land surface at the time of the first measurement and used as the plane of reference for all subsequent measurements.

Water level: Depth to water, in feet, above (+) or below land-surface datum. Water levels given as "flow" indicate that the water level above lsd was not measured at the time of inventory.

Date measured: Month and year of the water-level measurement.

Yield of well: Yield, in gallons per minute

Drawdown: Difference, in feet, between the static water level and the pumping water level.

Pumping period: Length of time, in hours, well had been pumped when the indicated drawdown was measured.

B 15-30 minutes

C 30-45 minutes

Table 7. Records of wells in the Idaho part of the Bear River basin.

Well number	Owner	Ownership	Use of water	Use of well	Specific conductance	Log data	Depth of well	Depth cased	Diameter	Well finish	Method drilled	Year drilled	Lift type	Power	Altitude of LSD	Water level: Depth to water	Water level: Date measured	Yield of well	Drawdown	Pumping period
IDAHO - BANNOCK COUNTY																				
13S/38E-03DDA1	Swan Lake, Idaho	M	P	W	---	D	105	59	08	P	C	1953	T	U	4857			35		
13S/38E-03DDC1	Wayne Millard	P	U	U	---	DJ	382	47	16	P	C	1961	N		4835	27	7-67			
13S/38E-04AAB1	Gene Sorensen	P	H	W	---	J	94	30	08	P	C	1962	N		4795	30	7-67	90	90	
13S/38E-08ABB1	Kay Gibbs	P	I	W	405		130		12	P		1950	T	M	4917	46	7-67			
13S/38E-10CCC1	Robert Hadley	P	U	U	505	DJ	310	109	16	P	C	1965	N		4795	FLOW		3		
13S/38E-16AAA1	Albert Nordick	P	U	U	---		08		48	W	D	1862	N		4795	6	7-67			
13S/38E-17DD 1	Doug Fisher	P	I	W	390	D	232	60	14	P	C	1961	T	V	5040			450	75	30
13S/38E-18DAD1	Gene Sorensen	P	I	W	280		400		20	P	C	1961	T	W	5240			2500	159	
13S/38E-23AAA1	James Abbott	P	H	W	910		13		48	W	D		C	S	4790	1	7-67			
13S/38E-25BBC1	A. P. Allen	P	H	W	770				4				N		4747	FLOW		7		
13S/38E-26AAD1	A. P. Allen	P	S	W	780				2				N		4750	+6	7-67			
IDAHO - BEAR LAKE COUNTY																				
10S/43E-22BAD1	El Paso Nat Gas	N	H	W	395		600					1956		V	6140					
11S/43E-08DBD1	Lee Alleman	P	H	W	---		90	40	6	P	C	1948	J	S	5970					
11S/43E-12DDB1	Bartell Johnson	P	I	W	535		27		6		C		C	T	6015	12	9-67	45		
11S/43E-15CDC1	Lester Alleman	P	H	W	---		22		36	W	D	1915	C	S	5945	8	9-67			
11S/43E-21ABC1	Reed Smith	P	S	W	300				6		C		T	V	5945	FLOW		250		
11S/43E-27CDC1	Burton Ludwig	P	H	W	810		40		36	W	D	1944	C	S	5980					
11S/44E-05CDC1	El Paso Company	N	U	U	---		316	160	12	P	C	1962	T	V	6170	46	6-68	700	200	6
11S/44E-07CCB1	A. M. Thompson	P	S	W	560	D	231	63	10	P	C	1965	T	5	6025	31	9-67	500	30	6

11S/44E-18CBD1	Roy H. Robison	P	H	W	520		50		4	P	C	1942	C	T	6010	8	9-67			
11S/44E-19BBA1	Earl Tippets	P	H	W	680		211		6	P	C	1948	J	S	6020					
11S/44E-29CBB1	Andrew Jensen	P	H	W	640		63	56	6	P	C	1946	T	S	6085					
12S/43E-25CBA1	Anton Kunz	P	I	W	525	D	232		12		C	1954	T	3	5970	FLOW		900	12	5
12S/43E-25DAA1	Rebecca Buhler	P	H	W	560		66	66	4	O	C	1947	C	5	5925	FLOW				
12S/43E-35DAB1	Dean Kunz	P	I	W	420	D	241	55	16	P		1961	T	2	6010					
12S/43E-35DDC1	George Kunz	P	U	U	---		224	80	16	P	C	1962	N		5975	4	9-67			
12S/44E-05BAA1	Barker Brothers	P	U	U	---	D	311	30	18	P		1953	N		6060	40	9-67	20		
12S/44E-05DDD1	Jack Crane	P	H	W	525		56		6				C	5	6055	43	9-67			
12S/44E-16CAD1	Grant Wright	P	H	W	485		17		6				J	S	5995	1	9-67			
12S/44E-21ACD1	Lyle Stephens	P	H	W	875		140		6	P	C		C	5	5965	17	4-68			
12S/44E-23CBD1	Ross Irving	P	S	W	680	D	166	90	6	P	C	1966	P	3	6195			05		
12S/44E-33DCC1	Dave Gerber	P	S	W	695	D	52	42	6	P	C	1967	S	S	5940	5	6-68	20	1	B
12S/44E-33DDB1	David J. Gerber	P	I	W	620	D	160	20	16	P	C	1963	T	2	5940			1150	20	
12S/44E-34DDC1	Montpelier City	M	I	W	---	D	245	150	12	P	C	1964	S	V	5975			1300	18	7
12S/46E-15AAA1	Boehme Brothers	P	I	W	---	D	230	10	18	P	C	1966	T		6240	14	9-67	800	125	6
12S/46E-15ADB1	Boehme Brothers	P	U	U	---	D	167	10	12	P	C	1966	T		6230	14	9-67			
12S/46E-28AD 1	Homer Teuscher	P	I	W	750		317	26	18	P	C	1961	T	V	6190	17	9-67	500		
13S/43E-09BAA1	Udell Roberts	P	H	W	590	D	90	56	6	P	C	1956	J	5	5975			10	20	B
13S/43E-14ACD1	Dewey Johnson	P	S	W	560		110		2	P	C	1953	N		5930	FLOW				
13S/43E-14DBC1	D. Sorenson	P	H	W	1080	D	46	37	6	P	C	1966	C	5	5935			20		C
13S/43E-16CDA1	David Orr	P	H	W	910		79	79	5	O	C	1965	J	5	5955	15	9-67			
13S/43E-16DCC	Dean Roberts	P	H	W	610	D	94	85	6	P	C	1966	C	5	5960			20		B
13S/43E-20AAA1	Carl Parker	P	H	W	810	D	71	62	6	P	C	1964			5978			24	20	C
13S/43E-21ABB1	Archie Parker	P	H	W	610	D	102	92	6	P	C	1966	C	5	5960			20		
13S/43E-21ADB1	J. T. Eborn	P	H	W	625	D	89	80	6	P	C	1966			5952			20	15	B
13S/43E-21BAA1	Arnell Early	P	H	W	600	D	124	115	6	P	C	1967	S	5	5960	17	9-67	20		B
13S/43E-23BDB1	L. J. Shurtliff	P	H	W	485		64	64	5	O	C		C	5	5940					
13S/43E-26CBB1	Warner Kulicke	P	H	W	480	D	82		6		C	1958			5960			20	15	C
13S/43E-26CDC1	Harley Peterson	P	H	W	1120		165	165	6	O	C	1957	C	5	5945					
13S/43E-27ACC1	Warren Passey	P	H	W	525		54	40	6	P	C	1963	S	S	5960					
13S/43E-35CCD1	Dairy Co-op	P	U	U	---		500		10			1948	T	5	5950	17	9-67			

Table 7. Records of wells in the Idaho part of the Bear River basin (cont'd.)

Well number	Owner	Ownership	Use of water	Use of well	Specific conductance	Log data	Depth of well	Depth cased	Diameter	Well finish	Method drilled	Year drilled	Lift type	Power	Altitude of LSD	Water level: Depth to water	Water level: Date measured	Yield of well	Drawdown	Pumping period
13S/44E-02DAB1	Jnknsn & Smith	P	H	W	725	D	75	40	8	P	C	1967	S	T	6055			30	12	2
13S/44E-03ACD1	Toby Michaelson	P	H	W	---	D	100	60	6	P	C	1960	N		6005	56	6-68			
13S/44E-03BDA1	Montpelier City	M	P	W	---	D	450		10	P			T	V	5975			600	36	
13S/44E-03BDD1	Montpelier City	M	P	W	---	D	300	250	16	P	C	1944	T	V	5975			1300	30	
13S/44E-04ADC1	Montpelier City	M	P	W	610	D	188		12	P		1963	T	V	5945			1500	9	8
13S/44E-04CCB1	Glacus Merrill	P	H	W	790	D	40	32	6	P	C	1965			5930			20	12	B
13S/44E-07ACA1	Cornielsen	P	S	W	---		32		4				C	5	5925	9	6-68			
13S/44E-08BAD1	Evan Olson	P	H	W	570		77		4				C	S	5925	FLOW				
13S/44E-22AAD1	Glen Hymas	P	H	W	800	D	66	45	6	P	C				5960			20	18	B
13S/44E-23BAB1	R. K. Nelson	P	I	W	---		245		12	P	C	1961	T	4	5990	41	9-67	450		
13S/44E-26BAD1	Olean Parker	P	I	W	---	D	170	20	14	P	C	1961	T	B	5970	17	9-67	275	121	8
13S/46E-09DB 1	Norman Eschler	P	U	U	---	D	145	20	16	P	C	1967	N		6120	5	9-67	1300	50	
13S/46E-16CBC1	John Dayton	P	I	W	720	D	157	10	18	P	C	1960	T	V	6105			1000	71	6
13S/46E-21CBC1	John Dayton	P	I	W	---	D	178	18	16	F		1961	T	V	5990			500	9	4
13S/46E-22DAD1	James Saxton	P	I	W	720	D	208	83	12	P	C	1961	T	4	6140			900	30	16
13S/46E-26BCA1	Heber Boehme	P	I	W	630		320		20	P	C	1961	T	V	6145			1500		
14S/43E-14CBA1	George Painter	P	H	W	570		30	30	6	O	C	1957	C	S	5965					
14S/43E-23DCA1	Lavell Ward	P	S	W	---	D	40	34	6	P	C	1965	C	3	5950	0	6-68	20	12	C
14S/43E-35BBA1	Karel Thomas	P	H	W	580		50		6		C	1953	J	5	5955					
14S/44E-11ADD1	T. H. Spencer	P	H	W	795		30		4		C		C	5	5950					
14S/44E-12CCC1	Oscar Arnell	P	H	W	810	D	40	30	6	P	C	1964			5960			20		B
14S/44E-13ACD1	Dingle Cemetery	M	I	W	780	D	95	47	8	P	C	1960			5985			125	23	8
14S/44E-13CCD1	Cecil Quayle	P	U	U	---	D	73	56	6	P	C	1962	N		5970	22	6-68	25		

14S/45E-05AC 1	Wendell Kunz	P	I	W	720	D	160	24	16	P	C	1957	T	D	6080	16	9-67	1800	129	14
14S/45E-11AD 1	Lee Rigby	P	U	U	---		120		6	P			N		6040	42	9-67			
14S/46E-10DDD1	Calvin A. Price	P	H	W	---	D	108	100	6	P	C	1967	J	S	6050	2	7-68	20	10	C
15S/43E-02CAD1	O. E. Monson	P	H	W	1000		22	20	2	S	V	1950	C	5	5945					
15S/43E-26DAD1	Louis T. Pugmire	P	H	W	625		86	86	4	O	C	1918	P	1	5935	4	9-67			
15S/43E-35DDC1	N. Willis Hairup	P	H	W	910		48	44	6	P		1959	C	S	5970	13	9-67			
15S/44E-25BDA1	Nebeker Bros.	P	I	W	---	D	303	66	12	P	C	1962	T	V	5950	41	9-67			
15S/46E-06CAC1	Ivan K. Rigby	P	I	W	940	D	38	33	4	P		1964	S	S	6030	8	9-67	36		C
15S/46E-06CBD1	Union Pacific	N	H	W	---		38		8			1958	J	S	6030	8	9-67			
16S/43E-02DCD1	Don Perkins	P	H	W	---	D	130	120	8	P	C	1965	C	5	5950	FLOW		25	19	C
16S/43E-02DDB1	Marj Thatcher	P	U	U	---	D	96	74	8	P	C	1967	N		5955	27	9-67	20	12	
16S/43E-27DD 1	E. F. Closner	P	H	W	600	D	52	44	6	P	C	1967			5935	7	7-68	20	10	

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07S/41E-27DDD1	Elton Sorensen	P	H	W	345		184		6		C	1954	S	T	6140	171	8-67			
08S/41E-01BAA1	Merle Cellan	P	U	U	---		128		6				P	6	6093	94	8-67			
08S/41E-02DDC1	Wendell Welling	P	H	W	880	D	100	21	6	X	C	1965	S	T	6050			15		
08S/41E-25BDA1	Monsanto Chem	N	N	W	1400		18		16		C		T	V	5995	9	8-67			
08S/42E-04DCB1	Mountain Fuel	N	N	W	710		250		20	P	C	1967	T	V	6145	35	8-67	3405	4	16
08S/42E-06CDC1	Charles Skinner	P	U	U	---		37		6				P	1	5994	23	8-67			
08S/42E-07BDA1	Al Butterfield	P	S	W	740		54		6				J	T	5993	12	8-67			
08S/42E-08CBD1	Ray Gunnell	P	U	U	425		96		6		C	1925	P	1	6080					
08S/42E-09ABA1	El Paso Product	N	U	U	---		38		06				N		6150	36	8-67			
08S/42--09ABB1	El Paso Prod. Co.	N	N	W	---	D	272	50	16	P	C	1965	T	W	6145			2300	2	181
08S/42--15ACD1	J. R. Simplot	N	N	W	---	D	200		12				N		6189	7	8-67			
08S/42E-15BBC1	El Paso Product	N	N	W	---	D	280	45	20	P	C	1964	T	W	6155			1500	1	
08S/42E-15BBC2	J. R. Simplot	N	N	W	---	D	97						T	V	6145			375	3	27
08S/42E-16AAC1	J. R. Simplot	N	N	W	---	D	125	15	16	P	C		N		6135	22	8-67	300	1	8
08S/42E-17CAB1	Joe Torgeson	P	U	U	---		119		6	X			N		6096	99	8-67			
08S/42E-20BCC1	Ira Ellis	P	U	U	---		50		8				P	1	6017	38	8-67			
08S/42--20DAB1	Cove Concrete	N	N	W	950		125		6		C	1964	S	T	6045	53	8-67			

Table 7. Records of wells in the Idaho part of the Bear River basin (cont'd.)

Well number	Owner	Ownership	Use of water	Use of well	Specific conductance	Log data	Depth of well	Depth cased	Diameter	Well finish	Method drilled	Year drilled	Lift type	Power	Altitude of LSD	Water level: Depth to water	Water level: Date measured	Yield of well	Drawdown	Pumping period
08S/42E-20DAD1	Myrtle Campbell	P	H	W	930		80		04		C	1937	S	S	6045	53	9-67			
08S/42E-28CDC1	Archie Vonberg	P	H	W	---	D	90		6	X		1966	J	T	6085	54	8-67			
08S/42E-29ABA1	Tom Cellan	P	H	W	925							1949	J	T	6040	39	8-67			
08S/42E-30BDD1	Wells	P	U	U	---		120				C		P		6005	60	9-67			
08S/42E-31ADB1	Monsanto Chem	N	N	W	960	D	250	80	18	P	C	1953	M	W	5987			1000	5	
08S/42E-31ADC1	Monsanto Chem	N	N	W	800	D	200	140	16		C	1951	M	V	5987			1000	12	
08S/42E-31DAB1	Monsanto Chem	N	N	W	950	D	255	20	20	P	C	1965	M	W	5989			2000	20	
08S/42E-32BD 1	Kerr McGee Corp	N	N	W	900	D	252	90	16	P	C	1963	T	V	6023	41	8-67	450	1	
09S/39E-25BBA1	R. Christensen	P	I	W	---		122	20	18	P	C	1962	T	C	5480	42	6-68			
09S/40E-13ACB1	Ed Kessler	P	U	U	---		303		8				P		5711	265	8-67			
09S/40E-19BBA1	P. Christensen	P	I	W	1130	D	180	72	16	P		1959	T	V	5505	81	4-68			
09S/40E-20BDB1	P. Christensen	P	I	W	1350	D	243	123	16	P		1963	T	P	5568	141	8-67	1300	5	7
09S/40E-23CDA1	R. Christensen	P	I	W	1200		350	20	20	P	C	1966	T	D	5680					
09S/40E-27BBA1	Von Simonson	P	H	W	975		208		6				S	5	5620					
09S/40E-27DCD1	Lucy Gibson	P	H	W	765		180		8		C		S	5	5596	165	6-68			
09S/40E-28BCB1	Ken Christensen	P	H	W	790	D	200	18	6	X	H	1968	S	S	5576	151	5-68	12		
09S/40E-29CCC1	A. Christensen	P	H	W	830		120		8		C		S	T	5542	116	8-67			
09S/40E-31CBC1	Grant Gibson	P	H	W	---		140	122	4	P	C	1937	S	S	5517	91	8-67			
09S/40E-34AAD1	William Perry	P	H	W	700		150		6		C		P	T	5580					
09S/40E-35CCD1	Alex Olsen	P	H	W	980				6		C		S	S	5542	109	8-67			
09S/40E-36DCC1	Max Rigby	P	H	W	1175				6		C	1966	S	S	5557	48	8-67			
09S/41E-02DDA1	Merrill Balls	P	U	U	---		100	90	6	P	H	1964	N		5800	41	8-67			
09S/41E-03BAA1	Alton Maughn	P	U	U	---		185	120	14	P	C	1967	N		5900	91	8-67			

09S/41E-07AD 1	Sam Reed	P	I	W	---	D	210	03	20	X	C	1968	N		5735	27	6-68	300	120	6
09S/41E-07CDC1	Hadfield	P	U	U	---		164		4				N		5730	132	8-67			
09S/41E-07DCA1	Union Pacific	N	H	W	940	D	152	140	6	P	C	1956			5735			10	5	C
09S/41E-08CDC1	Bob Hubbard	P	I	W	1050	D	200	40	16	P	C	1962	T	V	5720	27		1300	28	6
09S/41E-08DAC1	Bob Hubbard	P	I	W	3400	D	325	18	16	P	C	1954	N		5730	10	4-68	600	50	10
09S/41E-08DAD1	Bob Hubbard	P	I	W	1390	D	200	40	16	P	C	1952	T	V	5730			1300	28	7
09S/41E-08DDC1	Bob Hubbard	P	U	U	---	D	255	108	16	X	C		N		5725	19	8-67	250	210	3
09S/41E-10ACA1	Robert Summers	P	H	W	3600		63		6		C	1966	S	5	5740	FLOW				
09S/41E-10BAA1	John Zeman	P	H	W	780				8		C	1966	S	T	5745	27	8-67			
09S/41E-11BCA1	Cedarview Club	P	C	W	2850		35		6	O	C		C	T	5730	4	4-68			
09S/41E-13BBB1	Howard Hand	P	H	W	2400	D	77	65	8	X	C	1966	S	T	5740	12	8-67			
09S/41E-13BCC1	Bill Corder	P	H	W	580	D	102		6	P	C	1967	S	S	5785	67	6-68			
09S/42E-02BBD1	Lynn Beus	P	I	W	990		350		12	P	C	1937	C	N	6180	FLOW				
09S/42E-09CAD1	Hopkins	P	H	W	---		365	215		P	C	1955	S	5	5990	191	8-67			
09S/42E-09DAC1	Dale Dunn	P	U	U	---	D	175	135	6	P	C	1965	N		6050			20	12	C
09S/42E-09DCA1	Lowell Thomas	P	H	W	740	D	150	130	6	P	C	1963	S	T	6000			15		
09S/42E-18BDD1	Stanford Steel	P	H	W	740	D	72	68		P	C	1966	S	5	5810	35	6-68	30		
09S/42E-20BCB1	Harry Steele	P	U	U	---		190						P		5825	9	8-67			
09S/42E-22AAB1	Shyrl Barker	P	H	W	780		275		6		C		P	T	6025					
09S/42E-29CDD1	Ben Call	P	H	W	460		76		6			1967	J	T	5800	20	8-67			
09S/42E-32DCB1	Keith Bennion	P	H	W	470	D	175	110	6	X	C	1965	S	T	5910	40	8-67			
10S/39E-12ABB1	Dave Revoir, Jr.,	P	H	W	780		100			P	C	1964	S	5	5505	45	8-67			
10S/39E-12DBA1	Turner Cemetery	M	I	W	900	D	170	75	6	P	C	1955	S	5	5480	54	6-68	30	38	8
10S/40E-03DDD1	Merril Hulse	P	H	W	1010		124		6				S	5	5513	91	8-67			
10S/40E-05BDD1	Everett Smith	P	I	W	830	D	208	90	16	P	C	1959	T	V	5500			1200	74	14
10S/40E-05DDD1	R. Rindlisbaker	P	H	W	940		110		6	P			S	S	5510	94	8-67			
10S/40E-06DCC1	Howard Thomas	P	H	W	1000		55	10			C	1920	S	5	5480					
10S/40E-08BBA1	Marvin Smith	P	I	W	1440	D	300	70	16	P	C	1960	T	V	5477	51	1-68	1680	203	24
10S/40E-11BAA1	Mrs. Wilker	P	H	W	1000		110		6				S	S	5505	97	8-67			
10S/40E-12AAB1	Grace Village	M	P	W	---		205	180	12	P	C		T	V	5545					
10S/40E-13ACB1	Bill Nielsen	P	H	W	840		187	18	6	X	C	1947	S	T	5525	161	8-67			

Table 7. Records of wells in the Idaho part of the Bear River basin (cont'd.)

Well number	Owner	Ownership	Use of water	Use of well	Specific conductance	Log data	Depth of well	Depth cased	Diameter	Well finish	Method drilled	Year drilled	Lift type	Power	Altitude of LSD	Water level: Depth to water	Water level: Date measured	Yield of well	Drawdown	Pumping period
10S/40E-14BBA1	Dewey Mansfield	P	H	W	740	D	225	22	6	X	A	1967	S	S	5505					
10S/40E-15DAA1	Don T. Peterson	P	H	W	840	D	170	12	6		C	1953	S	T	5475	149	8-67			
10S/40E-16DDD1	Harold Varley	P	H	W	1300	D	170	142	6	P	C	1956			5440					
10S/40E-18ACC1	R. Christensen	P	H	W	825		62		6		C		T	S	5480	58	4-68			
10S/40E-22BBB1	Junior Allen	P	H	W	1200	D	106	55		P	C	1966	S	S	5420			17		
10S/40E-24BAD1	Warren King	P	H	W	975	D	210	16	6	X	A		S	T	5510					
10S/40E-26BAA1	Don T. Peterson	P	H	W	1005		180	12		X	C	1917	S	T	5500	170	8-67			
10S/40E-34CAD1	Robert J. Burton	P	H	W	1500		52	07		X	C	1943	S	T	5140	32	8-67			
10S/40E-35BDD1	Grant Matthews	P	I	W	860		90		18				T	V	5390	66	4-68			
10S/40E-35CDD1	Everett Miles	P	H	W	1000		70		6	X	C		J	T	5372	64	8-67			
10S/40E-36DCC1	Alvin Kingsford	P	H	W	860		150		6				P	T	5410	42	8-67			
10S/41E-07CDD1	John Kirby	P	H	W	825		180	40		X	C	1907	S	S	5535	48	8-67			
10S/41E-18DCC1	Dick Smith	P	I	W	790	D	215	150	18	P		1961	T	V	5535			2700	9	3
10S/41E-31BCB1	E. F. Ziegler	P	H	W	850				6				S	S	5455	120	8-67			
11S/40E-01DBC1	Floyd Toone	P	S	W	---		80	12	8	X	C	1937	J	T	5370	74	8-67			
11S/40E-03BCB1	Dave Smith	P	H	W	1300		105		6		C	1967	S	T	5140	73	8-67			
11S/40E-10BCD1	Clem Rasmussen	P	H	W	1220		12		48	W	D	1942	S	T	5030	8	8-67			
11S/40E-24ACC1	Jay Turner	P	U	U	---		57		8	X	H	1967	N		5100	39	8-67			
11S/41E-06AAB1	Don Clegg	P	I	W	690	D	190	162		P		1964	T		5470					
11S/41E-16BDD1	Vard Harris	P	H	W	330		930		6		C	1963	S	S	5250	35	8-67			
11S/41E-18ADD1	J. Oldrenshaw	P	U	U	---		22			W	D	1965	N		5200	14	8-67			
11S/41E-19DCA1	Mel Mickelson	P	H	W	1500		22	22	8	O		1947	P	S	5050	7	8-67			
11S/41E-20CBA1	Roger Mickelson	P	H	W	820								C	S	5080	7	8-67			

11S/41E-20DDA1	Elvin Meacham	P	H	W	440		38		6		A	1964	S	S	5290	10	8-67			
11S/41E-29ABD1	Harry Steele	P	U	U	---		318		6		C	1958	N		5200	1	8-67			
11S/41E-30BDD1	Clark Mickelson	P	H	W	1500		65		6		C	1951	S	T	5050	37	8-67			

IDAHO - FRANKLIN COUNTY

12S/40E-12CCB1	Don Forsgren	P	H	W	600		07		24	W	D	1952	S	T	4950	4	7-67			
12S/40E-24AAD1	Dean Panter	P	U	U	---		27		30	W	D		N		4925	26	7-27			
12S/40E-25BAD1	Verl Neilsen	P	H	W	---		30		36	W	D		J	T	5025	12	7-67			
12S/40E-36BAD1	John Clausse	P	H	W	320		16		24	W	D		J	T	4875	1	7-67			
12S/41E-18BBC1	Arval Alleman	P	H	W	810		62		6	O	C	1963	J	T	4975	23	4-68			
13S/38E-22DDD1	B. Bosworth	P	H	W	730				8				P	1	4862	28	7-67			
13S/38E-28DDB1	Frank Beal	P	I	W	---	D	218	102	14	P			T	V	4775	FLOW				
13S/38E-33BDD1	Lavern Kendall	P	I	W	---	D	265	32	12	P	C	1961	T	V	4783	17	3-67	30		
13S/39E-24DCA1	Trsrtn Cemetery	P	I	W	---		55		8		C	1952	T	T	5050	10	3-68			
13S/39E-25DDA1	Strongarm Res.	C	I	W	---	D	234	35	16	P		1961	T	V	4985	3	7-67			
13S/40E-30ACB1	Mack Hymas	P	I	W	610		290				C	1963	T	V	5060	27	11-67			
14S/38E-04BCB1	Hyrum Ward	P	I	W	---	D	285	45	14	P	C	1962	T	U	4802	0	7-67	550		
14S/38E-12BAA1	Quent Casperson	P	H	W	800		06			W	D				4754	3	7-67			
14S/28E-14BDA1	Emil Tasso	P	I	W	690		100		8	P	C	1934	C	T	4745	3	4-67			
14S/38E-15CDC1	Lavon Porter	P	I	W	450		200		12	P	C	1937	T	V	4795	21	3-68			
14S/38E-15DBC1	Lavon Porter	P	I	W	---		200		16		C		T	V	4761	7	7-67			
14S/38E-15DCC1	Pas Martinez	P	H	W	415		190		8		C	1934	J	T	4778	15	7-67			
14S/38E-15DCC2	Pas Martinez	P	I	W	---	D	217	128	10	P	C	1963	T	U	4778			500	12	6
14S/38E-16BBA1	Dale Ralphs	P	I	W	315	D	190	48	16	P	C	1961	T	V	4835	FLOW		600	120	
14S/38E-16BBD1	Arthur Wardell	P	I	W	320	DJ	155		12			1963	N		4835	FLOW		200		
14S/38E-16BDD1	Willard Gailey	P	I	W	---	D	300	54	16	P	C	1961	T	U	4840	35	4-67	1000		
14S/38E-22ABA1	Lou McDermott	P	I	W	505	DJ	200	160	12	P	C	1967	N		4765	FLOW		800	40	
14S/38E-22BDB1	Dennis Ralphs	P	I	W	500	D	180	50	16	P	C	1959	T	V	4797	45	7-67	1740	67	
14S/38E-22BDC1	Clifton Village	M	P	W	---	D	202	117	12	P		1955	T	V	4831	71	4-67	180		
14S/38E-22BDD1	Leonard Povey	P	I	W	600	D	220	112	16	P	C	1961	T	U	4813	53	4-67	900	50	25
14S/38E-22CCB1	C. A. Mortensen	P	I	W	465	D	350	142	12	P	C	1961	T	U	4893	116	7-67	460		

Table 7. Records of wells in the Idaho part of the Bear River basin (cont'd.)

Well number	Owner	Ownership	Use of water	Use of well	Specific conductance	Log data	Depth of well	Depth cased	Diameter	Well finish	Method drilled	Year drilled	Lift type	Power	Altitude of LSD	Water level: Depth to water	Water level: Date measured	Yield of well	Drawdown	Pumping period
14S/38E-23CCC1	William Powell	P	I	W	590								T	V	4775	32	4-67	270		
14S/38E-26ADC1	Jack Choules	P	I	W	590	D	520	356	14	P	C	1960	T	V	4750			1200	30	24
14S/38E-34AAD1	Kent Howell	P	U	U	---		60		36	W	D	1951	C	T	4775	12	7-67			
14S/38E-35BCC1	Clyde Call	P	I	W	---		200	125	16	P	C	1961	T	V	4760	13	4-67			
14S/39E-01BDD1	Edward Paskins	P	H	W	680		118	85	6	P	C	1957	S	T	5025	47	7-67			
14S/39E-06DAC1	Nyel Taylor	P	U	U	---		37		10				N		4792	5	7-67			
14S/39E-07BBA1	E. Gregorson	P	S	W	890		277	179	12	P		1954	N		4760	+2	3-67	380		
14S/39E-07BBD1	E. Gregorson	P	I	W	750		631	130	12	P	C	1955	T	5	4760	1	3-67	900		
14S/39E-08ADA1	M. Hollingsworth	P	I	W	900	D	206	30	12	P	C	1961	T	V	4850	104	7-67	1100		
14S/39E-09BAD1	Dave Johnson	P	I	W	1460	D	210	95	20	P		1961	T	V	4885			1225	25	24
14S/39E-09BDA1	David Johnson	P	H	W	1700		70	40	6	P	C	1948	J	5	4812	42	3-68			
14S/39E-17AAA1	Cluff Gibson	P	H	W	2200		44	40	6		C	1955	J	T	4785	15	7-67			
14S/39E-20CDB1	Richard Ballif	P	U	U	---	D	170	146	12	P		1938	T	4	4750	61	7-67	270	123	5
14S/39E-25ADD1	Byron Tanner	P	H	W	910		125		6	X	C	1943	C	T	4750					
14S/39E-28CAB1	Allen Smith	P	H	W	2900		35		4				C	T	4760	1	7-67			
14S/39E-29BDC1	Charles Nielsen	P	H	W	1400		24		48	W	D	1957	C	T	4700	22	7-67			
14S/39E-32AAA1	Heber Swainston	P	H	W	1000		18		36	W	D		J	T	4750	7	7-67			
14S/39E-35DAD1	John Vaterlaus	P	H	W	900		16		6			1942	C	T	4530	8	7-67			
14S/39E-36AAD1	Ariel Meek	P	H	W	990		16		48	W	D	1940	J	T	4530	2	7-67			
14S/39E-36ACB1	Robt Henderson	P	U	U	---		32		8				N		4520	4	7-67			
14S/39E-36CDC1	Marv Packer	P	H	W	1100		19		36	W	D	1937	P	T	4534	3	7-67			
14S/40E-11DDD1	G. Rasmussen	P	H	W	640		24		24	W	D		J	T	4900	14	7-67			
14S/40E-18CCB1	Mrs. Robt Wells	P	H	W	700		35		48		D	1943	C	T	5020	15	7-67			

14S/40E-20BDB1	Gene Smith	P U U	---		76		6	C	1964	N	4655	61	7-67			
14S/40E-21AAC1	Curtis Bosen	P H W	490		60		8	C		J T	4645	22	7-67			
14S/40E-30ABB1	Moss Lewis	P H W	1020	D	165	50	6	P C	1962	S T	4740	53	7-67	20		
15S/37E-36AAA1	L. Bingham	P I W	---		160	75	14	P	1960	T V	5075	74	4-67	2250	7	12
15S/38E-01CBB1	Thaye Winward	P H W	680		20		36	W D		J T	4745	10	7-67			
15S/38E-02CCC1	Bruce Naylor	P U U	---		110		4			N	4830	71	7-67			
15S/38E-11BBB1	Jim Naylor	P U U	---	DJ	204	70	16			N	4818	52	7-67			
15S/38E-11BBC1	E. O. Bergeson	P H W	760	D	245	40	12	P C	1961	T V	4784	15	7-67	75	125	
15S/38E-12DBA1	John Jackson	P H W	590		68		6		1957	J T	4735	36	7-67			
15S/38E-13BDC1	Junior Jeo	P H W	800		80		24	W C	1955	J T	4733	31	7-67			
15S/38E-22DDC1	G. Housley	P I W	460	D	170	44	10	P C	1966	S U	4792	19	11-67	165	108	
15S/38E-23AAA1	Ernest Buetler	P I W	610	D	475	357	16	P C	1962	T V	4750	66	4-67	1000	126	
15S/38E-23BBD1	Dayton Cemetery	M I W	760	D	66	27	6	F C	1961	T T	4780					
15S/38E-24DAD1	Veldon Martin	P H W	---		33		36	W D	1947	C T	4710	25	7-67			
15S/38E-25DAA1	Perth Poulson	P U U	---		27		4	C	1962	N	4715	20	7-67			
15S/38E-26DDC1	T. Schuaneveldt	P H W	1000		16			W D	1954	C T	4735	6	7-67			
15S/38E-31BBC1	John King	P I W	540	D	155	80	16	P C	1961	T V	5060	54	3-68	1800	27	4
15S/38E-35BBC1	Schwartz-Robins	P I W	---		80	30	10	P C	1934	C T	4760	2	7-67	450	15	
15S/38E-35BBC2	Schwartz-Robins	P U U	---		86		2			N	4760	3	3-68			
15S/38E-36CDA1	Ward Nielsen	P H W	640		20		30	W D		S 5	4723	13	7-67			
15S/39E-04CCA1	Ivan Jorgensen	P H W	1300				36	W D		C T	4495	8	7-67			
15S/39E-09DDD1	William Hawkes	P H W	1650		14		36	D	1942	J T	4715	7	7-67			
15S/39E-11CCC1	Mark Larsen	P H W	1100		25	18	36	P D	1936	P T	4765	10	7-67			
15S/39E-15BDA1	George Eames	P H W	890		50		36	W D	1887	P T	4730	5	7-67			
15S/39E-16DAD1	A. W. Fisher	P H W	790		14		36	W D		J T	4715	5	7-67			
15S/39E-18BCC1	Martin Blau	P H W	620		85		6		1948	J T	4710	69	7-67			
15S/39E-20CDC1	Frank Mitchell	P H W	1010		09		48	W D		J T	4477	4	7-67			
15S/39E-23BBB1	Taylor	P I W	800		11		42	D	1953	P T	4727	1	3-68			
15S/39E-30DCA1	Art Stevenson	P H W	950		60		4	P	1962	J T	4710					
15S/39E-31ABD1	D. Claire	P H W	535		25		48	W D	1929	C T	4714	13	7-67			
15S/39E-34CBD1	Van E. Nelson	P S W	620		11		36	W D	1940	P 1	4655	7	7-67			

Table 7. Records of wells in the Idaho part of the Bear River basin (cont'd.)

Well number	Owner	Ownership	Use of water	Use of well	Specific conductance	Log data	Depth of well	Depth cased	Diameter	Well finish	Method drilled	Year drilled	Lift type	Power	Altitude of LSD	Water level Depth to water	Water level Date measured	Yield of well	Drawdown	Pumping period
15S/39E-35DDD1	Hesy Beckstead	P	H	W	800		14			W	D	1927	C	5	4590					
15S/40E-19CDD1	Merlin K. Larsen	P	H	W	---		22			W	D	1953	C	T	4749	8	7-67			
15S/40E-31DDD1	W. G. Reese, Jr.,	P	I	W	---	D	217	130	8	P	C	1968	T	T	4685			20		24
15S/40E-32BBA1	Whtny Wtr Works	M	P	W	600		160	125	10	P	C	1960	T	T	4770	FLOW		1280		
15S/40E-35BAD1	H. Walter Knapp	P	U	U	---		80	00	12	P	C	1954	C	T	4650	2	7-67			
16S/37E-13BBA1	K. Frederickson	P	H	W	730	D	101	50	12	F	C	1966	J	T	5250			12		
16S/38E-01CDA1	Eugene Tomasi	P	H	W	1400		20		30	W	D	1890	C	T	4662	9	7-67			
16S/38E-06AAA1	Richard Lemmon	P	I	W	1090	D	109	63	10	P	H	1961	T	T	5005	31	7-67	200	7	4
16S/38E-08BAB1	Herb Williams	P	I	W	700	D	157	14	10	P	H	1961	T	U	4940	3	3-68	450	25	8
16S/38E-08CCD1	Joseph Phillips	P	H	W	2100		20		36	W	D	1930	J	5	4945					
16S/38E-11CAB1	Gene Austin	P	H	W	1000		14		30	W	D		C	5	4757	9	7-67			
16S/38E-14BBC1	A. J. Jensen	P	H	W	610		47	25	6	P	C	1950	J	T	4795	20				
16S/38E-24ACB1	Kohler-Fonnesbk	P	I	W	850	D	548		16		C	1954	T	5	4585	57	3-68			
16S/38E-25CCB1	Mark Roylance	P	U	U	---	J	132		3				N		4560	31	7-67			
16S/39E-03CDB1	Tom Howell	P	S	W	485		06		36	W	D		J	T	4595					
16S/39E-07CAD1	Dean R. Bingham	P	H	W	760		450	300	4	P	H	1961	S	T	4565	60	7-67			
16S/39E-09CCC1	Floyd Jensen	P	H	W	---	D	205	00	12	P	C	1954	S	T	4527	4	7-67	90		
16S/39E-11ADA1	Henry Egbert	P	S	W	2500		35		48	W	D	1965	J	T	4535	8	7-67			
16S/39E-17DDD1	Barnard Inglet	P	H	W	1090		17	14	2	S	V	1945	C	T	4470					
16S/39E-18CAC1	Douglas McKay	P	U	U	---	7	450	229	14	P		1961	N		4570	55	10-67	1350	60	
16S/39E-18CDA1	Owen Maughn	P	I	W	---	D	462	204	14	P		1961	T	V	4550	32	7-67	1350	54	
16S/39E-19DBA1	Serge Benson	P	H	W	830		265	12	4	P	C	1957	S	T	4536	38	7-67			
16S/39E-30CAD1	C. D. Butler	P	H	W	2000		12		36	W	D	1931	C	5	4526	10	7-67			

16S/40E-15BDD1	Paul Woodward	P	H	W	650		115		6		C	1961	S	5	4950	54	7-67			
16S/40E-16ABB1	Marlow Woodward	P	S	W	565		170						C	5	4520	FLOW				
16S/40E-16CAC1	Orval Rallison	P	I	W	440	D	80	69	6	P	C	1954		5	4512	FLOW		80		
16S/40E-17BBB1	Davis Foster	P	I	W	760	D	180	104	12	P	C	1954	T	V	4548	8	2-67	400	8	3
16S/40E-18ABD1	Larrel Hobbs	P	U	U	---	J	91	09	12	P		1960	N		4556	13	7-67			
16S/40E-20ACC1	W. P. Hobbs	P	I	W	680		250		12		C	1963	T	V	4480	FLOW		210		
16S/40E-20CDA1	Frnkln-Cub Rivr	N	I	W	---	DJ	236	111	12	P	C	1934	N		4475	FLOW		55		
16S/40E-20CDC1	Frnkln-Cub River	N	U	U	570	DJ	215		12			1934			4475	FLOW		160		
16S/40E-20DCA1	Calif. Packing	N	N	W	---	D	315	187	12	P		1929	T	V	4498	33	7-67			
16S/40E-20DCA2	Calif. Packing	N	N	W	---	D	400	171	12	P		1943	T	V	4498	34	7-67	332	70	3
16S/40E-21AAC1	Pioneer Irr. Co.	N	U	U	---	J	77		12			1948	N		4590	8	7-67			
16S/40E-21CDC1	Unknown	P	S	W	510				20				N		4500	+3	3-67			
16S/40E-28DBC1	Birch Comish	P	H	W	525		65		6		C	1960	J	T	4526	4	7-67			
16S/40E-29CBC1	Franklin Cemtry	M	U	U	---	J	82		10	P	C	1950	N		4508	15	7-67			
16S/40E-30ABB1	Ivan Woodward	P	H	W	520		85		8		C	1945	C	T	4513	FLOW				

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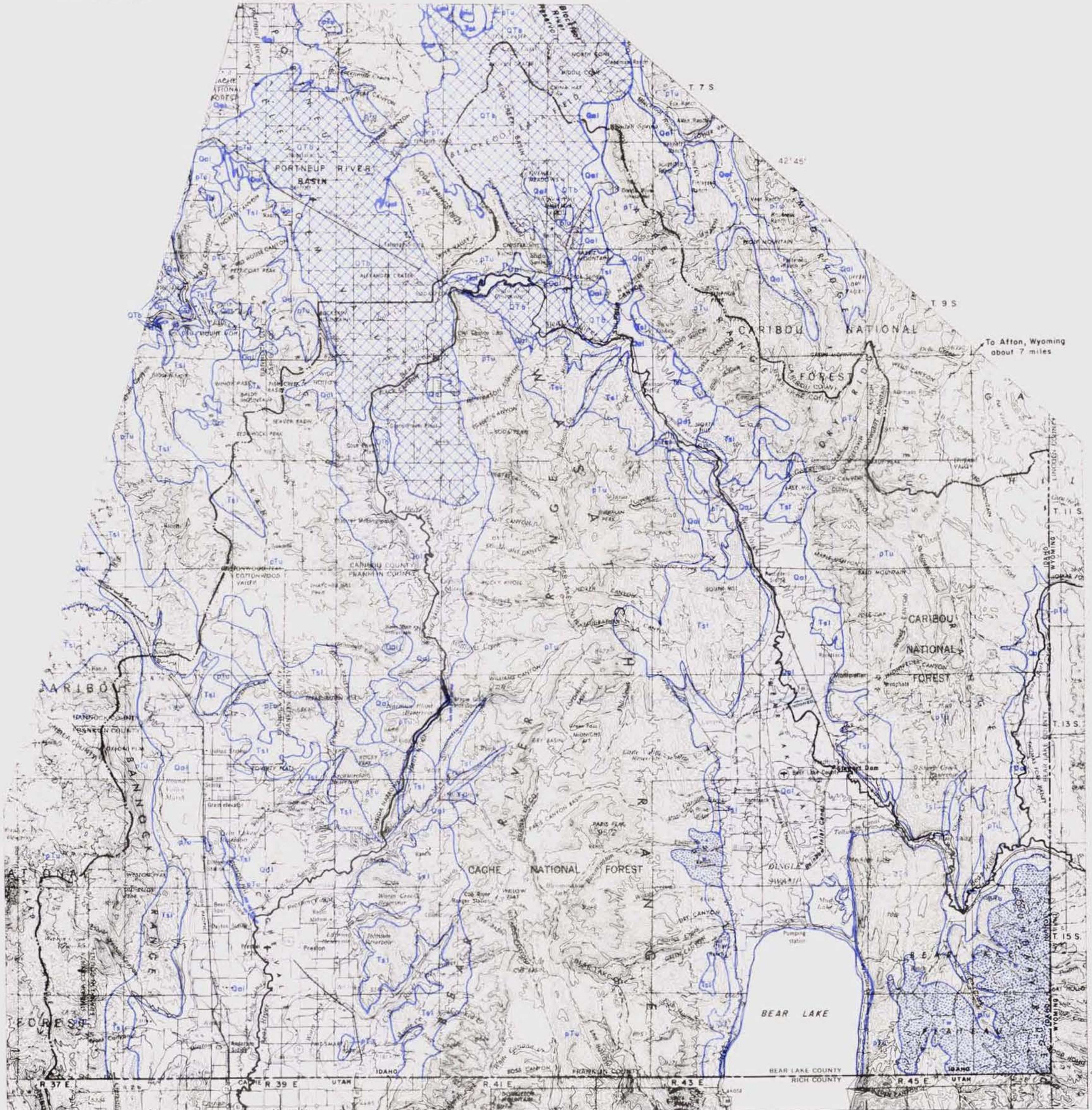

EXPLANATION

Qal	Alluvium	QUATERNARY
QTb	Basalt	TERTIARY AND QUATERNARY
Tsl	Salt Lake Formation	TERTIARY
Tw	Wasatch Formation	TERTIARY
pTu	Sedimentary rocks, undifferentiated	PRE-TERTIARY

Contact

Fault
Dashed where approximately located
Although numerous faults occur in the Bear River basin, only those referred to in this report are shown

Drainage basin boundary
The boundary in Gem Valley was drawn on the hydrologic-areas boundary adopted by the Idaho Department of Reclamation

Base from U.S. Geological Survey Pocatello, 1954; Preston, 1955; Brigham, 1954; and Ogden, 1954, Utah, Wyoming, and Idaho.

10 Miles
Datum is mean sea level
Contour interval 200 feet

Geology by N. P. Dion, 1969, based in part on a compilation by S. S. Oriel

FIGURE 6.--Generalized geologic map of the Bear River basin and adjacent areas in Idaho.

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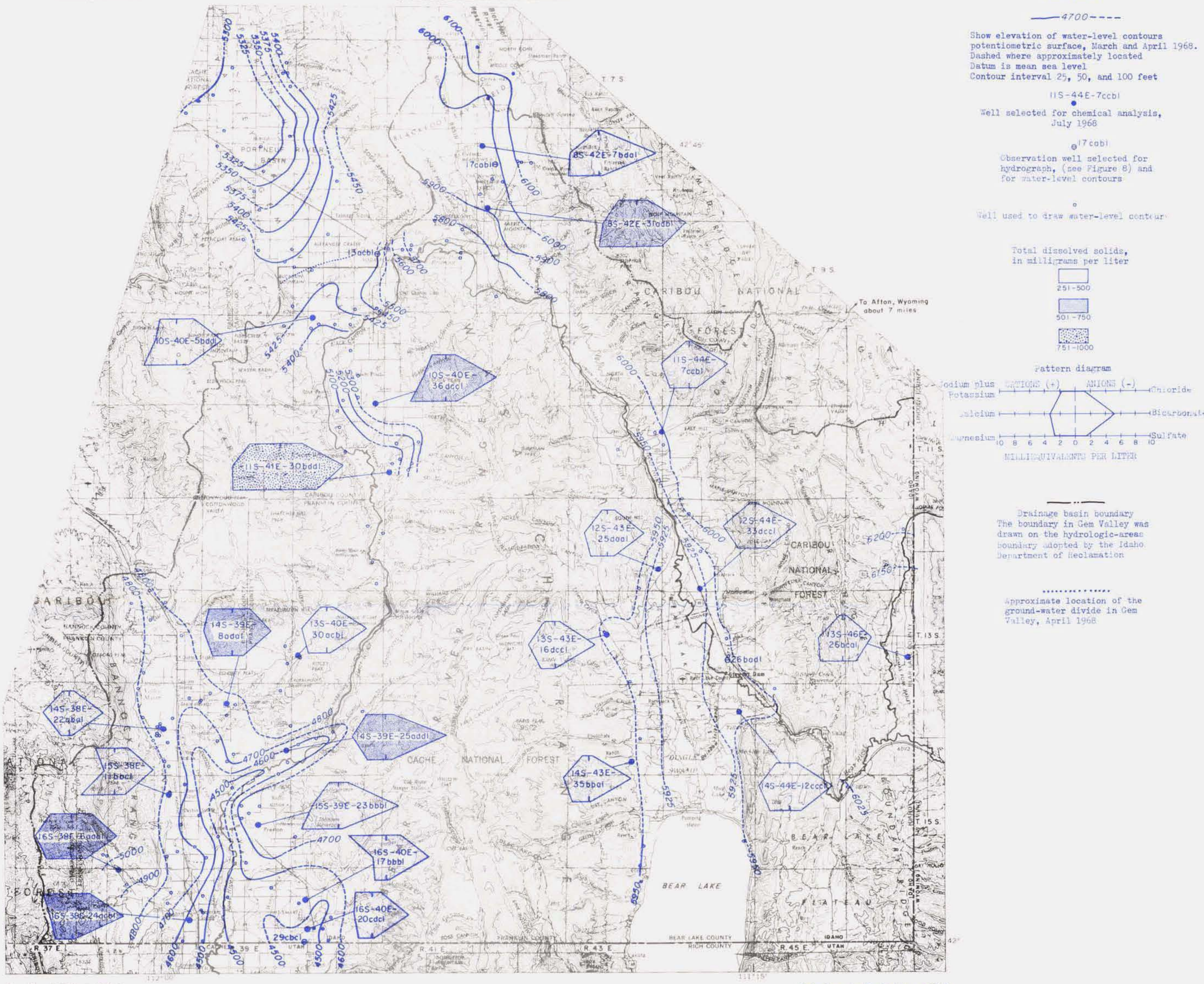

FIGURE 7.--Map of the Bear River basin showing chemical character of the ground water, water-level contours, and location of selected observation wells.

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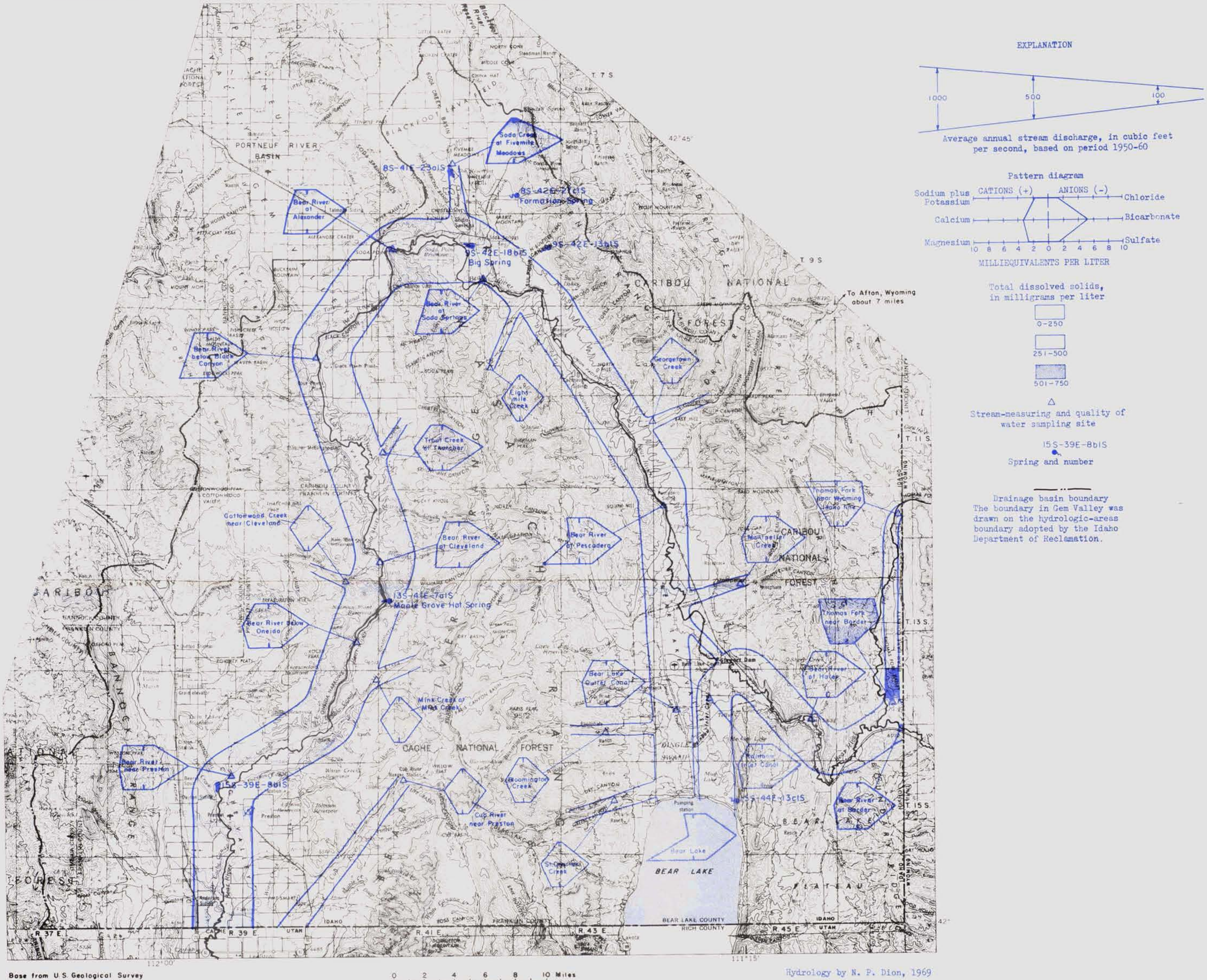

Base from U.S. Geological Survey Pocatello, 1954; Preston, 1955; Brigham, 1954; and Ogden, 1954, Utah, Wyoming, and Idaho.

Datum is mean sea level
Contour interval 200 feet

Hydrology by N. P. Dion, 1969

FIGURE 10.--Map of the Bear River basin showing average annual stream discharge, chemical character of the surface water, and the location of selected springs.