AVAILABILITY AND CHEMISTRY OF GROUND WATER ON THE BRUNEAU PLATEAU AND ADJACENT EASTERN PLAIN IN TWIN FALLS COUNTY, SOUTH-CENTRAL IDAHO

By R. L. Moffatt and M. L. Jones

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CONTENTS

ILLUSTRATIONS

[Plates in pocket]

ILLUSTRATIONS--Continued

TABLES

CONVERSION FACTORS

For readers who prefer to use metric units, conversion factors for units used in this report are listed below. Chemical concentrations are expressed in mg/L (milligrams per liter) or µg/L (micrograms per liter), which are, within the range of values in this report, numerically equal to parts per million or parts per billion, respectively. Water temperatures are reported to the nearest one-half degree.

Multiply	By	To obtain
acre	4,047	square meter
acre-foot (acre-ft)	1,233	cubic meter
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
gallon per minute (gal/min)	0.06309	liter per second
inch (in.)	25.40	millimeter
micromho (µmho)	1.000	microsiemens
mile (mi)	1.609	kilometer
square foot (ft^2)	0.0929	square meter
square mile (mi^2)	2.590	square kilometer

Temperature in °C (degrees Celsius) can be converted to °F (degrees Fahrenheit) as follows:

$$°F=(1.8)(°C)+32$$

NGVD of 1929 (National Geodetic Vertical Datum of 1929): The term "National Geodetic Vertical Datum of 1929" replaces the formerly used term "mean sea level" to describe the datum for altitude measurements. The geodetic datum is derived from a general adjustment of the first-order leveling networks in both the United States and Canada. For convenience in this report, the datum also is referred to as "sea level."

AVAILABILITY AND CHEMISTRY OF GROUND WATER ON THE BRUNEAU PLATEAU AND ADJACENT EASTERN PLAIN IN TWIN FALLS COUNTY, SOUTH-CENTRAL IDAHO

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ABSTRACT

The Bruneau plateau in south-central Idaho consists of about 889,600 acres of irrigable land. About 112,200 acres have been developed for agriculture; 11,200 acres are irrigated with ground water, and 101,000 acres are irrigated with available surface water from the Snake and Bruneau Rivers and Salmon Falls Creek. On the basis of present usage, about 158,000 acre-feet per year of water are needed to develop an additional 63,000 acres. About 438,000 acre-feet per year are needed to irrigate existing and newly developed lands in dry years when streamflow in the Snake River at Milner Dam is inadequate to meet appropriated needs.

Pumping lifts of about 400-600 feet and low well yields on the Bruneau plateau preclude large-scale irrigation development solely from the local ground-water resources. Supplemental sources of irrigation water beneath the plain adjacent to the Bruneau plateau include a perched-water aquifer, a thermal aquifer that underlies a large part of southwestern Idaho, and a regional aquifer. An estimated 100,000-115,000 acre-feet per year of water from the perched and regional aquifers could be withdrawn. The amount of water that could be safely withdrawn from the thermal aquifer was not determined.

Water samples from a few wells contained concentrations of dissolved solids, pH, fluoride, chloride, or sulfate that exceeded either required or recommended drinking water limits. In general, however, most ground water in the area is suitable for domestic and stock use. High salinity in water from perched and regional aquifers beneath the Twin Falls South-Side Tract probably precludes using it to irrigate salt-sensitive crops.

INTRODUCTION

Location and Extent of Study Area

The Bruneau plateau in south-central Idaho lies south of the Snake River between Salmon Falls Creek on the east and Bruneau River on the west (shaded area, fig. 1). The plateau comprises about 1,390 mi^2 and includes parts of Owyhee, Elmore, and Twin Falls Counties. The adjacent eastern plain (locally referred to as southern Magic Valley) comprises 692 mi^2 east of Salmon Falls Creek to about 114° west longitude at Milner Dam. The entire study area, which consists of the plateau and adjacent eastern plain, comprises about 2,080 mi^2 and extends southward from the Snake River to an arbitrary boundary along the southern foothills at about 4,500 ft above sea level.

Need for Study

The Bruneau plateau consists of about 889,600 acres of irrigable land (U.S. Department of Agriculture, 1976). At present (1982), about 112,200 acres on the plateau have been developed for agriculture. Ground water is pumped to irrigate about 11,200 acres and surface water from the Snake River, Bruneau River, and Salmon Falls Creek is diverted to irrigate about 101,000 acres. Additional agricultural development can be realized, provided an economical supply of water can be made available. Presently, water is supplied to large tracts of land by means of high-lift pumping of surface and ground water, but increasing energy costs have greatly reduced the economic benefits of this method. Thus, an alternate source of water is needed to substitute or supplement existing supplies and to provide for additional agricultural development. Galinato and Packer (1981, p. 68) proposed that 63,000 additional acres be developed on the Bruneau plateau. On the basis of present usage, about 158,000 acre-ft/yr of supplemental water are needed to develop the additional 63,000 acres; about 438,000 acre-ft/yr of water are needed to irrigate existing and newly developed land in dry years when streamflow in the Snake River at Milner Dam is inadequate to meet appropriated needs.

Purpose and Approach

Purposes of this study were to: (1) Evaluate the potential for additional ground-water development on the Bruneau plateau and adjacent eastern plain; (2) determine effects of additional development on available sources of water, such as accelerated water-level declines; and (3) assess the quality of ground water as it relates to irrigation, stock, and domestic uses.

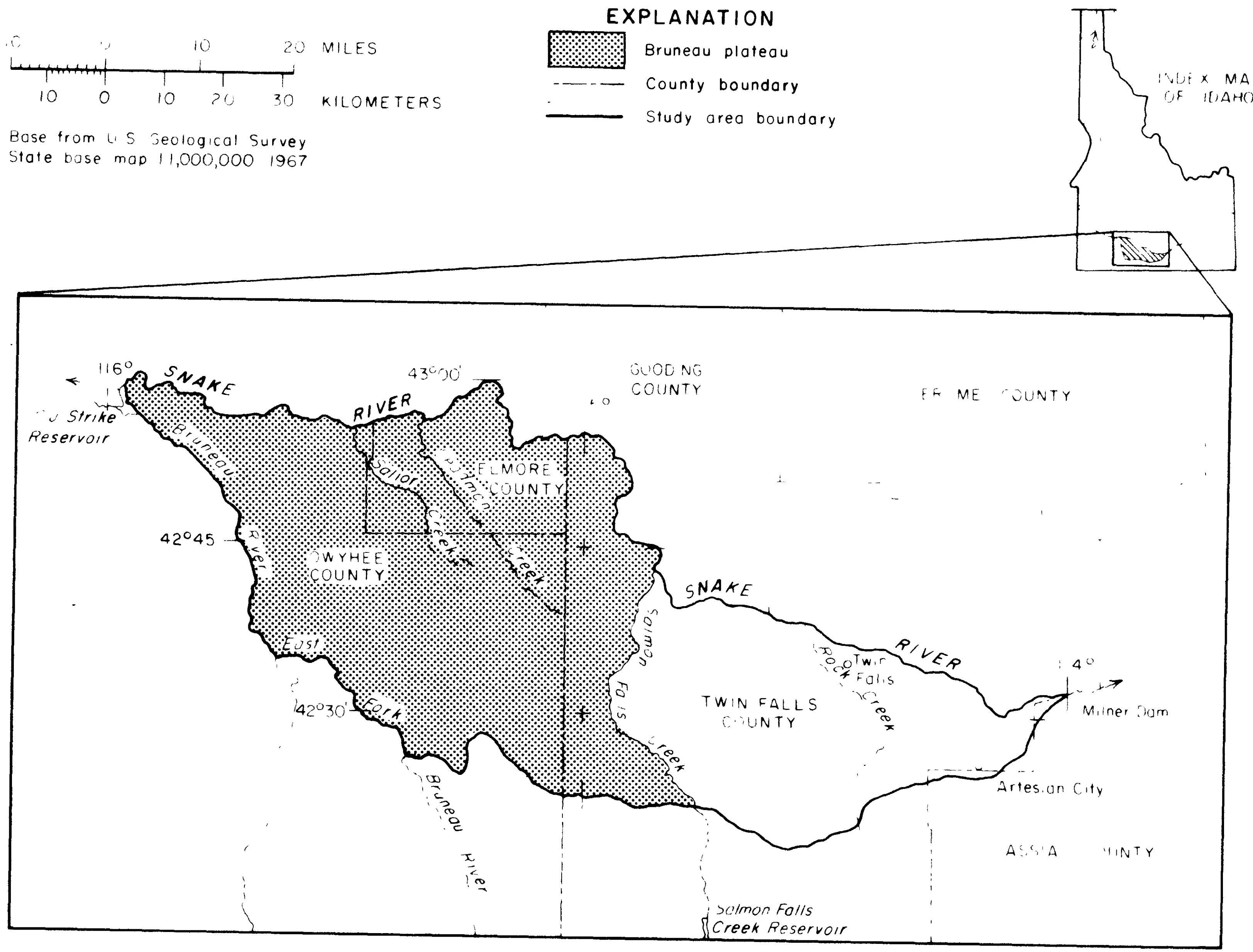

Figure 1. -- Location of study area.

Approaches were to: (1) Inventory wells throughout the study area to select observation wells for measuring water levels and update the well inventory data base; (2) describe the present level of water-resource development; (3) define the potentiometric surface of the regional aquifer; (4) evaluate seasonal fluctuations in ground-water levels; and (5) collect and analyze water samples from selected wells to describe chemical character of ground water and determine its suitability for irrigation, stock, and domestic uses. Analysis of physical or economic constraints for conveying water to the Bruneau plateau was beyond the scope of this investigation.

Previous Investigations

Several studies have been made of the occurrence, use, and chemistry of ground water on the Bruneau plateau and adjacent eastern plain. These studies have provided a basis for comparison of changes in ground-water levels since the early 1900's.

Stearns, Crandall, and Steward (1938, p. 128-135, 207-208) reported that the water table in the Twin Falls South-Side Tract rose significantly during a 28-year period as a result of flood irrigation. Their report also included a brief description of the thermal-water resources at the edge of the foothills between Salmon Falls Creek and Goose Creek.

Crosthwaite (1963) made a ground-water reconnaissance of the Sailor Creek area on the Bruneau plateau and followed with a study of water resources in the Salmon Falls Creek basin (1969b). These studies provided information about ground-water conditions in the two areas prior to 1969. Crosthwaite (1969a) also studied ground-water conditions in the vicinity of Rock Creek (fig. 1) and described aquifers and extent of ground-water withdrawals that caused water levels to decline from a few to several tens of feet.

Chapman and Ralston (1970) investigated water resources in the Blue Gulch area of the Bruneau plateau. They concluded that well yields and water-level fluctuations were extremely variable, that water levels were declining at an average rate of 5 ft/yr, and that most of the decline was thought to be the result of well discharges exceeding the rate of natural recharge.

Ralston and Young (1971) evaluated water resources of the Twin Falls South-Side Tract. They estimated that about 70 percent of the total volume of irrigation water applied annually to the tract leaves the area as surface runoff or ground-water underflow and may be a potential source of water for other irrigation projects.

Young and Lewis (1982) described the hydrology and geochemistry of thermal ground water in a broad area that extends across most of southwestern Idaho. They also defined the nature and extent of the geothermal reservoir in the vicinity of Salmon Falls Creek (fig. 1) (Lewis and Young, 1982).

Well- and Spring-Numbering System

The well- and spring-numbering system (fig. 2) used by the U.S. Geological Survey in Idaho indicates the location of wells or springs within the official rectangular subdivision of public lands, with reference to the Boise base line and meridian. The first two segments of the number designate the township (north or south) and range (east or west). The third segment gives the section number, followed by three letters, which indicate the ¼ section (160-acre tract), ¼-¼ section (40-acre tract), and ¼-¼-¼ section (10-acre tract); and a numeral, which indicates the serial number of the well within the tract.

Quarter sections are identified by the letters A, B, C, and D, which are assigned in a counterclockwise direction from the northeast quarter of each section. Within quarter sections, 40-acre and 10-acre tracts are lettered in the same manner. For example, well 10S-15E-16DDC1 is in the SW¼SE¼SE¼ sec. 16, T. 10 S., R. 15 E., and is the first well inventoried in that tract. Springs are designated by the letter "S" following the last numeral; for example, 12S-17E-31BAB1S. For the purpose of illustrating a large number of wells, a reference number was assigned sequentially to each well used in this study (table 1).

DESCRIPTION OF STUDY AREA

Topography and Drainage

The topography of the Bruneau plateau and adjacent eastern plain increases in altitude in a southerly direction from a precipice several hundred feet above the Snake River between Milner Dam and the Bruneau River. The area identified as the Bruneau plateau is broken by protruding buttes and incised by intermittent streams. The adjacent eastern plain is gently undulating and is incised principally by Rock Creek and Salmon Falls Creek. Salmon Falls Creek is the hydrologic divide between the Bruneau plateau and the adjacent eastern plain. Average altitude of the entire area is 3,800 ft.

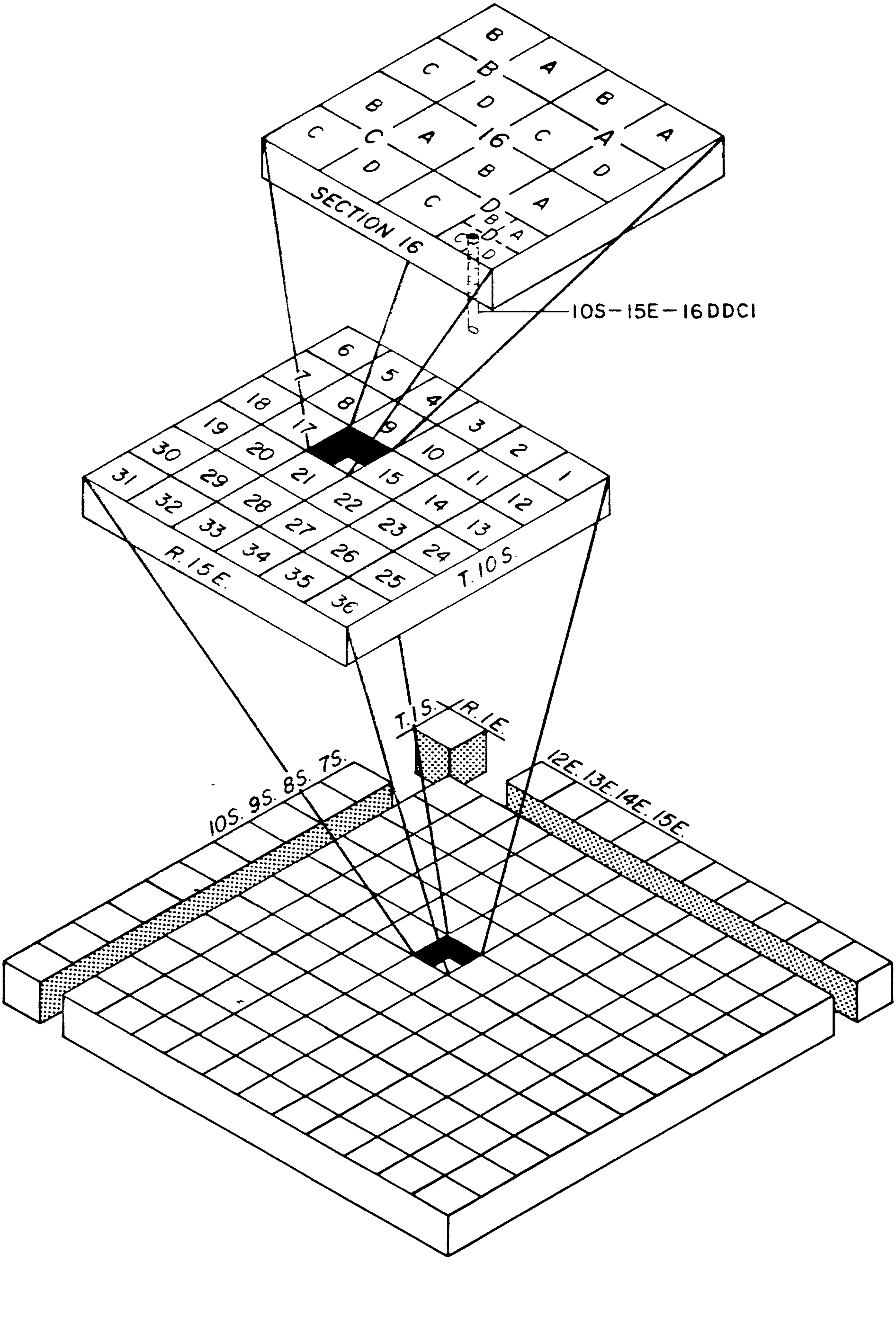

Figure 2. -- Well- and spring-numbering system.

Table 1.--Reference numbers assigned to wells

Reference No.	Well No.	Reference No.	Well No.	Reference No.	Well No.
1.	12S-20E- 3CDD1	74.	11S-16E- 6DBA1	147.	10S-12E- 1DDC1
2.	5CCD1	75.	9CCC1	148.	2CBA1
3.	6BCC1	76.	9DAC1	149.	2CBA2
4.	12S-19E- 3ACC1	77.	13BAA1	150.	11DBD1
5.	4ADD1	78.	14DAD1	151.	12ADA1
6.	6DBC1	79.	20CCC1	152.	12CDC2
7.	12S-18E- 1ACC1	80.	22ACD1	153.	9S-16E-20BDD1
8.	5BCD1	81.	27CCC1	154.	21DCD1
9.	12S-17E-16DCA1	82.	32BBA1	155.	25AAD1
10.	19BCC1	83.	11S-15E- 1BBB1	156.	25BAA1
11.	30AAD1	84.	2BBB1	157.	26BCA1
12.	12S-16E- 9BDD1	85.	3BAA1	158.	34AAD1
13.	12DBA1	86.	5CBB1	159.	9S-15E-12CCA1
14.	12DDC1	87.	7ACB1	160.	16DDD1
15.	12DDD1	88.	11S-14E- 5DAD2	161.	18CBB1
16.	22DDD1	89.	9ABA1	162.	24CBB1
17.	34BCB2	90.	19AAA1	163.	28AAB1
18.	12S-15E-10CBB1	91.	11S-13E-11BDA1	164.	30CAD1
19.	26DDD1	92.	11DDA1	165.	31CCB1
20.	35ADD1	93.	10S-19E-18CCD1	166.	31DCC1
21.	11S-20E-21ABC1	94.	22DDA1	167.	34DCC1
22.	24DDD1	95.	35DDC1	168.	36BAB1
23.	26BAA1	96.	10S-18E- 8CDD1	169.	9S-14E- 6CDA1
24.	29ADD2	97.	18DCD1	170.	13DBB1
25.	29CDD1	98.	18DCD2	171.	13DDD1
26.	30DDD1	99.	20DDD1	172.	14BDD1
27.	32ADD2	100.	28BCB1	173.	17BAB1
28.	32CCC1	101.	31BBB3	174.	21ABC1
29.	33ABC1	102.	35BCC1	175.	32BCC1
30.	33DAD1	103.	10S-17E- 2DDC1	176.	36DAC1
31.	34ABB1	104.	5DCC1	177.	9S-13E-20CCD1
32.	34ADD1	105.	14CCD1	178.	22DDD1
33.	34CCC1	106.	19CCC1	179.	25ADD1
34.	11S-19E- 3ACD1	107.	25ABB1	180.	31DDC1
35.	12BDA3	108.	26DCC1	181.	32CDD1
36.	13CDC1	109.	33BBA1	182	9S-12E-17BDC1
37.	14CDD1	110.	10S-16E- 3DDD1	183.	17CAD1
38.	17AAB1	111.	6CCB1	184.	21ABA1
39.	18ADA1	112.	7DAC1	185.	24DAA1
40.	20CBD1	113.	9CCD1	186.	27ADB1
41.	20DDD1	114.	11DAA1	187.	28CBB1
42.	21BCC2	115.	11DDA1	188.	28CCD1
43.	23CDA1	116.	15DDC1	189.	29ACD1
44.	25BDC1	117.	20BCB1	190.	35BCD1
45.	25DDD1	118.	22CBB1	191.	9S-11E-12DBD1
46.	26CDD1	119.	26CBB1	192.	8S-14E-19DDB1
47.	27CAD1	120.	29BDA1	193.	30DAD1
48.	27CDD1	121.	33ADD1	194.	32DDB1
49.	28CDD1	122.	33CDC1	195.	8S-13E-23CCD1
50.	30ADD1	123.	10S-15E- 1AAA1	196.	32ADD1
51.	31ADD1	124.	4DDD1	197.	35ACD1
52.	31CDC1	125.	8DDA1	198.	8S-12E-23DCA1
53.	32BAD1	126.	14AAB1	199.	24CCC1
54.	32CCD1	127.	16DDC1	200.	8S-11E-21BAB1
55.	32DDD2	128.	20CDD1	201.	33BCD1
56.	33DDD1	129.	24DDC1	202.	7S-13E-17CCB1
57.	35BDC1	130.	26DDA1	203.	29CBD1
58.	35BDD1	131.	27CBB1	204.	7S-12E-23BAB1
59.	36CDD1	132.	10S-14E- 1CAA1	205.	35BAA1
60.	11S-18E- 1ABB1	133.	5CBB1	206.	7S-10E-22DDD1
61.	7BAB1	134.	10ACA1	207.	7S- 9E-12CBA1
62.	17CAD1	135.	13DAA1	208.	6S-10E-12CDD1
63.	21CBB1	136.	19CAD1	209.	30CAD1
64.	23ABC1	137.	22CDD1	210.	30DBC1
65.	24ADD1	138.	33BAB1	211.	31CCC1
66.	34DCA1	139.	33BBA1	212.	6S- 9E-10BCC1
67.	35DBC1	140.	35DCC1	213.	26AAB1
68.	36BCD1	141.	10S-13E- 2DCD1	214.	27ABC1
69.	11S-17E- 3CDC1	142.	5CBD1	215.	33AAD1
70.	16BCB1	143.	11ABC1	216.	6S- 8E-33ABA1
71.	25DDD2	144.	25DDC1	217.	6S- 7E- 2CDD1
72.	28AAA1	145.	34DAA1	218.	8BBA1
73.	29BBB1	146.	10S-12E- 1ACD1	219.	12ABC1
				220.	6S- 6E- 8BBC1

Drainage is northward toward the Snake River. Many streams on the plateau are ephemeral and flow only in response to rainstorms or spring runoff. Rock Creek, Salmon Falls Creek, and East Fork Bruneau River are perennial streams that head in mountains south of the study area and drain irrigated fields throughout the study area. Diversions and return flow from irrigated lands affect streamflow quantity in some reaches of these perennial streams. Low yield from the streams is evident from computation of the median monthly discharge (from more than 20 years of record during the nonirrigation season December through May) at gages on Rock Creek near Rock Creek, Idaho; Salmon Falls Creek near San Jacinto, Nevada; and East Fork Bruneau River near Hot Springs, Idaho. These watersheds cover a 2,150-mi^2 area and have an average total unit surface runoff of 5.0 in. for the 6 months considered. The average annual water content in snowpack in tributary basins drained by the streams ranges from 11.2 to 20.4 in. (U.S. Department of Agriculture, 1975). One-quarter to one-half of the average yield from spring snowmelt appears as surface flow in streams; the balance recharges ground-water systems in the area or is consumed by evapotranspiration.

Climate

Climate of the area is semiarid (Miller, 1971, p. 125), generally characterized by hot, dry summers and cold, subhumid winters. Annual potential ET (evapotranspiration) exceeds annual precipitation. Average monthly temperatures and average monthly precipitation (National Oceanic and Atmospheric Administration, 1961-80) at four selected U.S. Weather Bureau stations are shown in figure 3. Mean annual temperatures recorded at these stations range from 47° to 57°F. Average monthly extreme temperatures for the period 1931-60 range from 18.5°F in January to 91.5°F in July (Pacific Northwest River Basins Commission, 1969, p. 11 and 23). The frost-free period is generally from early May to mid-September, although the growing season usually extends into October when potatoes and sugar beets are harvested.

Evapotranspiration is the mechanism for depleting soil moisture gained from precipitation or applied irrigation water. Potential ET is the water loss that will occur if there is no deficiency of water for use by vegetation (Thornthwaite, 1944, p. 687). Potential ET rates were computed by Allen (unpubl. data, 1982) for selected crops grown on the plateau and adjacent eastern plain. Monthly and seasonal potential ET totals for three agriculturally developed areas are shown in table 2. Average annual ET rates during the growing season for three principal crops are 47.7 in., alfalfa; 24.7 in., beans; and 29.7 in., grain.

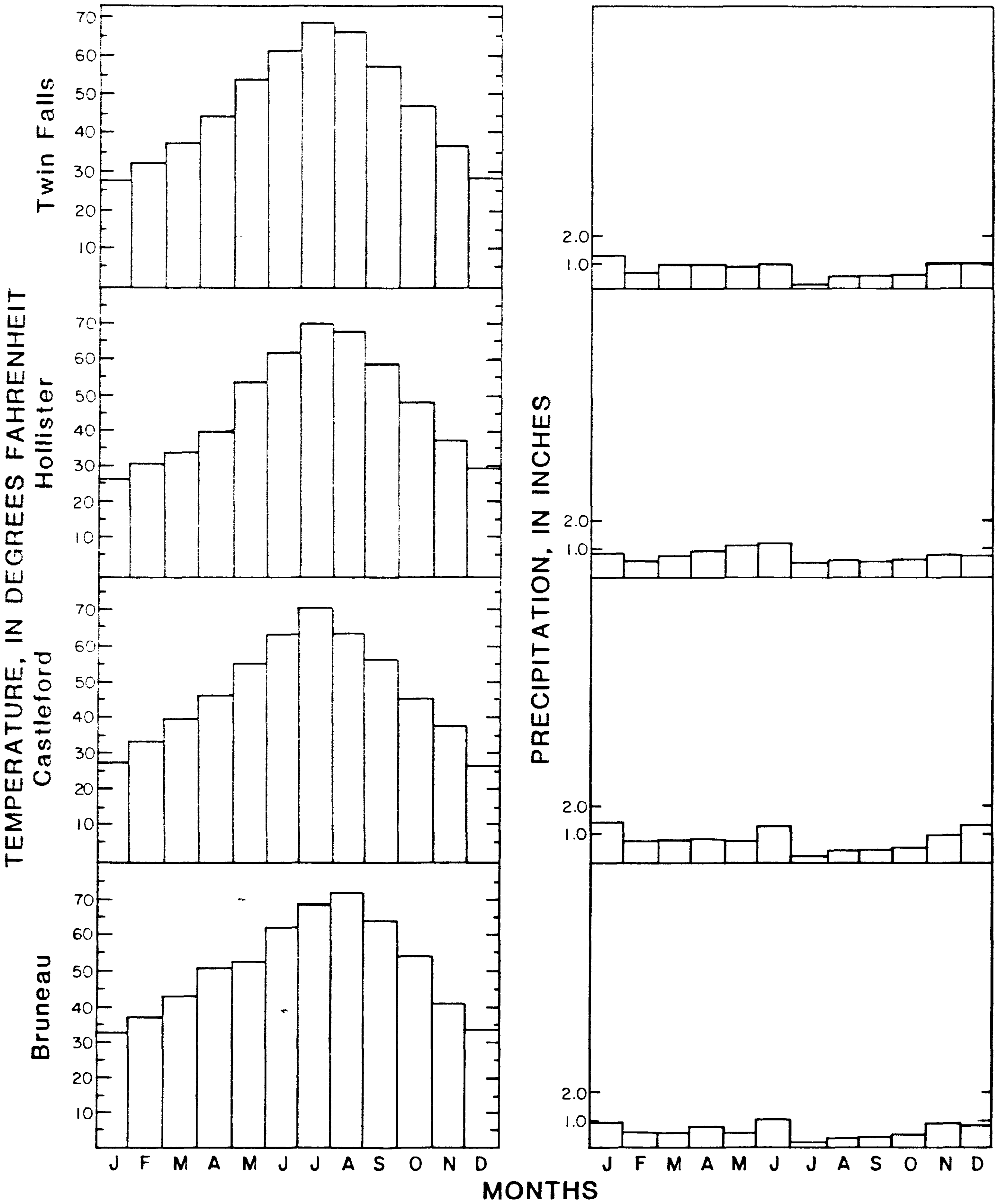

Figure 3. -- Average monthly temperature and precipitation, 1961-80, at four U.S. Weather Bureau stations, south-central Idaho.

Table 2.--Monthly and seasonal totals of potential evapotranspiration[1/] from selected field crops grown in the study area

Month	Water-development project	Potential evapotranspiration, in inches								
		Alfalfa	Beans	Corn	Pasture	Peas	Potatoes	Sugar beets	Spring grain	Winter grain
April										
	Kimberly	2.44	0.76	0.76	2.21	0.78	0.76	0.76	0.82	2.47
	Grindstone	2.79	.87	.87	2.51	.88	.87	.87	.93	2.66
	Bell Rapids	2.43	.75	.75	2.20	.77	.75	.75	.83	2.41
May										
	Kimberly	6.05	1.80	1.80	5.24	3.38	1.88	1.82	4.36	6.05
	Grindstone	7.48	2.24	2.24	6.50	4.24	2.36	2.26	5.40	7.48
	Bell Rapids	6.84	2.05	2.05	5.94	3.83	2.15	2.07	4.89	6.84
June										
	Kimberly	8.23	4.40	3.57	8.13	7.37	6.14	4.82	9.31	9.35
	Grindstone	8.22	4.55	3.66	8.23	7.35	6.31	5.01	9.41	9.44
	Bell Rapids	9.35	4.56	3.70	8.41	7.61	6.37	5.00	9.63	9.66
July										
	Kimberly	10.20	9.28	8.27	8.93	3.56	8.62	9.93	8.88	8.21
	Grindstone	12.20	11.10	9.94	10.70	4.23	10.40	11.90	10.60	9.77
	Bell Rapids	10.50	9.53	8.51	9.18	3.62	8.85	10.20	9.05	8.37
August										
	Kimberly	8.11	5.38	8.60	7.91	1.37	7.21	8.90	2.08	1.63
	Grindstone	10.10	6.81	10.80	9.90	1.68	9.02	11.20	2.57	2.09
	Bell Rapids	9.20	5.57	8.80	8.08	1.39	7.37	9.10	2.13	1.73
September										
	Kimberly	6.77	1.02	5.70	5.89	1.02	4.42	5.87	1.02	1.02
	Grindstone	8.56	1.30	7.22	7.46	1.30	5.59	7.41	1.30	1.30
	Bell Rapids	7.12	1.07	5.99	6.19	1.07	4.66	6.17	1.07	1.07
October										
	Kimberly	1.87	.34	.44	1.95	.34	.62	1.12	.34	.34
	Grindstone	2.24	.43	.54	2.46	.43	.81	1.45	.43	.43
	Bell Rapids	2.27	.41	.50	2.37	.41	.72	1.30	.41	.41
Seasonal total										
	Kimberly	43.67	22.98	29.14	40.26	17.82	29.65	33.22	26.81	29.07
	Grindstone	51.59	27.30	35.27	47.76	20.11	35.36	40.10	30.64	33.17
	Bell Rapids	47.71	23.94	30.30	42.37	18.70	30.87	34.59	28.01	30.49

[1/] Values from Allen (1982).

Mean annual precipitation (1961-80) on the plateau and adjacent eastern plain ranges from 8.0 to 10.9 in. Monthly precipitation averages 0.5-1.0 in. each month except in July, when average precipitation is less than 0.5 in. at three of the four weather stations.

Agricultural Development

Economy of the study area is based principally on farming. Lands developed under the Homestead Act of 1862 included small acreages along the Snake and Bruneau Rivers where water was readily available for irrigation, stock, and domestic supplies. Some dryfarming was attempted many years ago along the upper reaches of Sailor Creek and in the valley of Deadman Creek south of Glenns Ferry. These areas are now irrigated with ground water. Past surveys show a slow progression of development until the early 1960's, when large tracts of land were released by the Federal government for development under the Desert Land Entry Act of 1877. Large tracts like Blue Gulch, Black Mesa, Bell Rapids, and Grindstone Butte (fig. 4) were developed to include 64,000 acres (Bob Mitchell, U.S. Bureau of Land Management, oral commun., 1982). By 1966, about 82,600 acres of land on the plateau were irrigated (Idaho Water Resource Board, 1970), and by 1980, about 112,200 acres were irrigated (U.S. Bureau of Reclamation, 1980, aerial photos on file in Boise, Idaho, office). This amount constitutes about 13 percent of the Bruneau plateau.

In contrast to the plateau, nearly all the adjacent eastern plain is developed. The Twin Falls South-Side Tract, developed in 1905, and Salmon Falls Tract, developed in 1911, were released for development under the Carey Act of 1894. The tracts now comprise about 299,700 acres of irrigated land (fig. 4). This development covers about 68 percent of the eastern plain; the remaining 32 percent is undeveloped, covered by natural vegetation, and used partially for grazing.

LITHOLOGIC UNITS AND THEIR HYDRAULIC CHARACTERISTICS

Principal lithologic units are of volcanic and sedimentary origin. Surface distribution of the units is shown on plate 1, generalized from Rember and Bennett (1979). Although some wells drilled along the southeastern boundary are completed in sedimentary rocks of Paleozoic age, most of the wells drilled in the area are completed in consolidated rocks of Cenozoic age. The oldest of the Cenozoic rocks exposed in the area are the Idavada Volcanics, which consist chiefly of volcanic flows and welded tuff. They probably

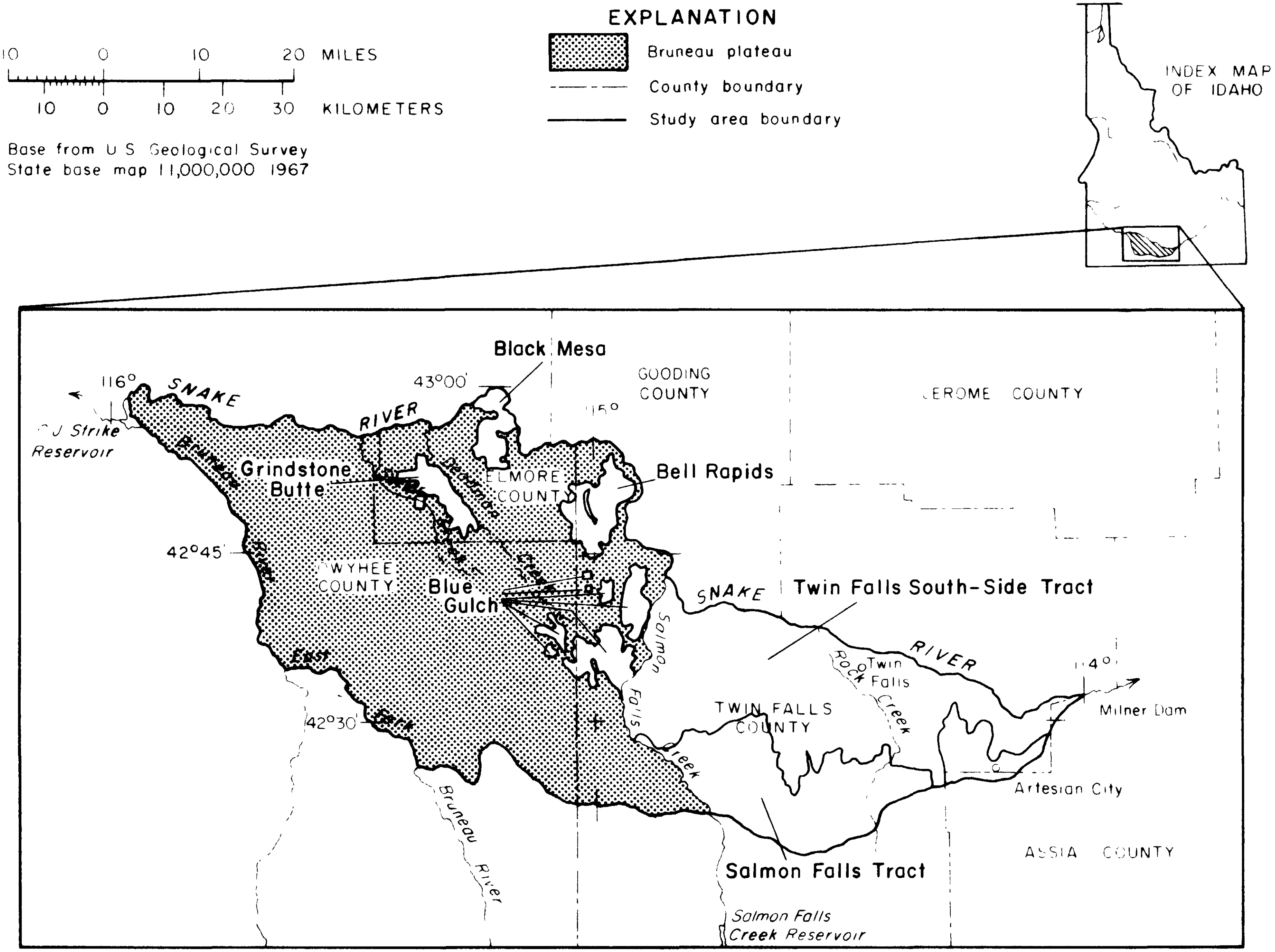

Figure 4. -- Location of major water-development projects.

overlie Paleozoic limestone and sandstone (Crosthwaite, 1969a). Overlying the Idavada Volcanics are: (1) Banbury Basalt of the Idaho Group, which consists chiefly of olivine basalt with minor interbedded sediments, and (2) younger lava flows of the Glenns Ferry Formation of the Idaho Group, also interbedded with detrital basin-fill deposits of clay, silt, sand, and gravel.

Structure of the lithologic units is a controlling factor in the movement of ground water along horizontal and vertical planes. Exposed rock units dip northward, and northwest-trending faults have displaced the Idavada Volcanics and younger formations in several places. Yields to wells drilled on either side of the faults are affected by the structure (Chapman and Ralston, 1970, p. 11, and Crosthwaite, 1963, p. 12), and water levels measured in these wells indicate different hydraulic potential.

Physical and hydraulic characteristics of the units are summarized in table 3. Hydraulic conductivity in consolidated lithologic units is a function of the degree of fracturing and extent of solution cavities and is highly variable. Wells completed in Idavada Volcanics and Banbury Basalt generally have higher yields than those completed in basalt flows of the Glenns Ferry Formation or in Quaternary sedimentary rocks. Potential yield from primary lithologic units is represented by the range of the specific-capacity index (table 3). Specific-capacity index (Davis and DeWiest, 1966) is calculated by dividing the specific capacity for a well by the saturated thickness of the aquifer penetrated by that well and is expressed in gallons per minute per square foot. Relatively higher numbers indicate a greater water-producing capability.

Wells completed in Idavada Volcanics commonly yield thermal water (temperature 30°-60°C). The Banbury Basalt unit also contains thermal water, possibly owing to higher pressure heads in the Idavada Volcanics reservoir rock, which causes upward movement of the hot water into the overlying Banbury Basalt (Lewis and Young, 1982).

DEVELOPMENT OF GROUND-WATER RESOURCES

Ground water in the study area is used principally for domestic and stock supplies, except in areas where well yields are adequate for use as a primary source for irrigation supplies. Ground water is used as a supplemental source in some areas where little surface water is available

Table 3.--Summary of physical and hydraulic characteristics of lithologic units

Period	Epoch	Lithologic unit	Physical characteristics	Hydraulic characteristics
Quaternary	Holocene and Pleistocene	Windblown deposits	Clay, silt, and fine sand of windblown origin blanket most of the area. Admixed with alluvium at some places.	Contains no ground water but transmits recharge to underlying formations.
		Alluvium	Chiefly surficial deposits of clay, silt, and sand and gravel of rhyolitic composition. Forms an apron along hills, mountain fronts, and stream channels. Older deposits form poorly sorted detrital basin fill across Bruneau plateau and consists of clay, silt, sand, and gravel and some sedimentary deposits found in the Banbury Basalt of the Idaho Group.	Yields small supplies to wells in the area. Contains perched ground water along Deep Creek, Mud Creek, and Cedar Draw. Yields adequate for small domestic and stock supplies during most years. The specific-capacity index, based on four wells completed in sedimentary rocks, ranges from 0.3 x 10^{-3} to 9.0 x 10^{-3} (gal/min)/ft^2.
Quaternary and Tertiary	Holocene and Pleistocene	Younger basalt	Olivine basalt, dense to vesicular, aphanitic to porphyritic; irregular to columnar jointing; thickness of flows variable; but average about 20-25 ft (Mundorff and others, 1964, p. 143). Includes beds of basaltic cinders, rubbly basalt, and interflow sedimentary rocks. Chiefly rocks of the Idaho Group. Crops out in much of the Snake River Plain; mantled in many places with alluvium, terrace gravel, and windblown deposits. Older unit generally defined by its thicker soil cover.	Hydraulic conductivity highly variable, may be extremely high; formational conductivity high because of jointing and rubbly contacts between numerous flows; rock conductivity low. Unit constitutes the Snake Plain aquifer east of King Hill. The specific-capacity index, based on 18 wells completed in the Glenns Ferry Formation, ranges from 0.7 x 10^{-3} to 300 x 10^{-3} (gal/min)/ft^2.
Tertiary	Miocene	Older basalt	Flood-type basalt, dense, columnar jointing in many places, folded and faulted (except for the Banbury Basalt); may include some rhyolitic and andesitic rocks; some flows of vesicular olivine basalt (Banbury); interbedded locally with minor amounts of stream and lake deposits of the Idaho Group. Includes the Miocene Columbia River Basalt Group (older) and the Miocene Banbury Basalt of Idaho Group.	Hydraulic conductivity variable, may be high in places. Locally yields small to moderate amounts of water to wells from fractures, faults, and related sedimentary zones under confined and unconfined conditions. The specific-capacity index, based on six wells completed in Banbury Basalt, ranges from 3.5 x 10^{-3} to 100 x 10^{-3} (gal/min)/ft^2.
		Idavada Volcanics	Massive, dense, reddish-brown, gray, and black silicic volcanic rocks; occur as thick flows and blankets of welded tuff with associated fine- to coarse-grained ash and clay, silt, sand, and gravel and compose most of the Rock Creek Hills and large areas of southern Bruneau plateau.	Hydraulic conductivity highly variable. Joints and fault zones in the indurated rocks yield large quantities of water at some places, but massive nonjointed units yield little water. Sand, tuff, and ash beds yield moderate quantities of water. One of two important aquifers in the area. The specific-capacity index, based on six wells completed in Idavada Volcanics, ranges from 52 x 10^{-3} to 300 x 10^{-3} (gal/min)/ft^2.

for a dependable irrigation supply. Only 41,400 acres, or 10 percent of all irrigated land in the study area, are irrigated solely with ground water. Figure 5 shows the distribution of lands irrigated with surface and ground water as of 1980 (U.S. Bureau of Reclamation, written commun., 1982).

Early development of ground-water resources in southeastern Twin Falls County depended on high yields to wells. Several wells drilled to supply irrigation water in western Twin Falls County were abandoned or used only for domestic purposes because yields were generally less than 500 gal/min.

Historically, wells drilled near Artesian City (fig. 1) yielded flowing water (Crosthwaite, 1969a, p. 31). Between 1945 and 1962, ground-water withdrawals for irrigation increased, and many of the wells ceased flowing. In 1962, part of the area was classified by the Idaho Water Resource Board as a critical ground-water area (pl. 2).

Ground water was developed for irrigation in the Blue Gulch area of western Twin Falls County because of the lack of available surface-water supplies. Wells in this area were drilled 600-800 ft deep to obtain adequate yields. Increased withdrawals from 1960 to 1970 caused significant declines in the water table, and in 1970, the entire area was classified as a critical ground-water area (pl. 2).

Thermal water in the Idavada Volcanics reservoir rock has been developed since early 1970. South of Hollister, a few wells completed in rhyolite at more than 1,500 ft have yielded thermal water of about 25°-50°C. Well yields are about 1,500 gal/min. Static water levels range from near land surface to about 200 ft below land surface. Examples of three high-yield, thermal-water wells completed in rhyolite are listed in table 4.

DEVELOPMENT OF SURFACE-WATER RESOURCES

Surface water constitutes the largest volume of water supplied for irrigation on the Bruneau plateau and adjacent eastern plain. Surface-water sources are the Snake River, Salmon Falls Creek, and Bruneau River. About 351,000 acres are irrigated totally by surface water, and about 20,200 additional acres are irrigated by surface water supplemented by ground water.

East of Salmon Falls Creek, an average 1,250,000 acre-ft/yr of water were diverted from the Snake River at Milner Dam between 1976 and 1980 to irrigate about 203,000 acres of the Twin Falls South-Side Tract. The Twin Falls Canal Company estimated onfarm deliveries averaged about

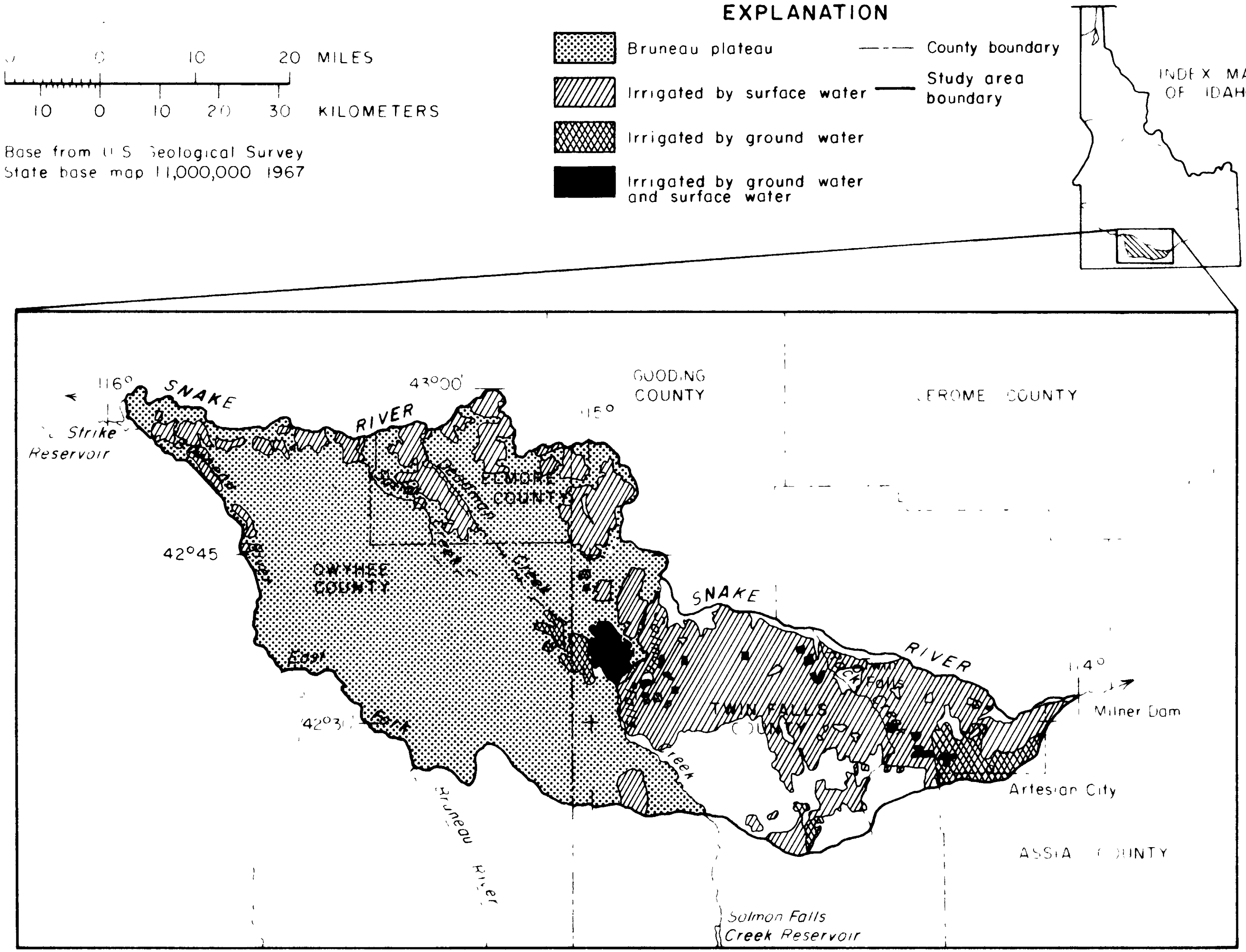

Figure 5. -- Distribution of lands irrigated with surface and ground water. (Updated to 1980 from 1975 aerial photos taken by the U.S. Bureau of Reclamation, Boise, Idaho)

Table 4.--Data for three high-yield, thermal-water wells in Twin Falls County

Well number	Depth of well (feet)	Water temperature (°C)	Well yield (gallons per minute)
9S-17E-33BBB1	750	40	6,300
10S-17E- 4CDA1	2,220	38	500
10S-13E-20ADA1	1,280	42	3,300

880,000 acre-ft/yr. Thus, an average of 370,000 acre-ft/yr were either spilled or lost from the canal system by evaporation and seepage to the ground-water reservoir.

Water diverted from Salmon Falls Creek from 1979 to 1982 to irrigate about 22,200 acres of the Salmon Falls Tract averaged 82,200 acre-ft/yr. The Salmon Falls Canal Company estimated onfarm deliveries averaged about 53,600 acre-ft/yr. This amount represents an average conveyance loss from the canal system of about 28,600 acre-ft/yr. Other areas irrigated by surface water include comparatively small sections of land south of the High Line Canal and adjacent to Rock Creek. About 2,500 acre-ft/yr (U.S. Geological Survey, 1980) of water are diverted from Rock Creek, and less than 1,800 acre-ft/yr (Crosthwaite, 1969a, p. 15) of water are diverted from small streams in the lower valleys at the base of the foothills.

About 158,000 acre-ft of water were pumped from the Snake River and 35,000 acre-ft were pumped from Salmon Falls Creek in 1980 (Bigelow and others, 1984) to irrigate lowlands along the south side of the Snake River and large tracts of land on the Bruneau plateau. Conveyance systems for irrigation projects on the Bruneau plateau consist of closed pipeline and open, unlined canals from which water is pumped to sprinklers.

In the extreme western part of the study area, an average of about 12,000 acre-ft/yr of water are diverted from the Bruneau River to irrigate lowlands along the east side of the river (U.S. Geological Survey, 1956).

GROUND WATER

Occurrence and Movement

The occurrence and movement of ground water were determined using water levels measured in March 1982 in 220 wells shown on plate 2. Ground water occurs throughout the study area under confined and unconfined conditions. Many wells in the area are cased to shallow depths and open to more than one aquifer. However, few anomalies were apparent in the water levels, even though some wells penetrate different aquifer systems. Exceptions are in the intensely faulted part of the Blue Gulch critical ground-water area and east of Salmon Falls Creek near Buhl, Idaho. Wells drilled near Buhl penetrate one or more of three hydraulic systems: a perched aquifer, a thermal-water aquifer, and the regional (cold-water) aquifer. In some cases, wells completed in more than one aquifer reflect a composite of the effects caused by confined and unconfined conditions. Water-level measurements made in these wells could not be used to determine the extent of different aquifers underlying the area. In parts of the plain east of Salmon Falls Creek, differences in hydraulic head in the confined and unconfined systems are small and the potentiometric surfaces of the two systems coincide.

Lithologic columns of three wells and the occurrence of water in each well are shown in figure 6. Drillers' logs of other wells drilled in the perched system show sequences of basalt flows at depth, which indicate that ground water may percolate vertically to the underlying regional aquifer, as well as laterally to tunnels and surface drains that convey the water out of the area. The perched aquifer is extensive (33,000 acres) and may be an additional source of irrigation water (fig. 7).

The volume of water in the perched aquifer varies seasonally, as indicated by water-level measurements made monthly during part of 1982 in two shallow wells that intercept only the perched system. The zone of saturation was located approximately by examination of drillers' logs and comparison of water-level measurements made in March 1982. Levels rose about 12 ft during the summer in response to recharge from applied irrigation water. Assuming a storage coefficient of 0.02 to 0.06 (Walton and Stewart, 1961) and change in hydraulic head of 12 ft, the potential supply of water from the perched system could be about 8,000-24,000 acre-ft/yr. The total volume of water in this system could range from 13,000 to 40,000 acre-ft. A more detailed study is needed to accurately define the extent and hydraulic characteristics of the perched aquifer, but the volume of water that could be captured from the perched system alone may be too small to develop for other than local use.

Extent of the thermal aquifer was not defined for this study; however, the occurrence of thermal water in the aquifer in parts of the study area was discussed by Lewis and Young (1982) and Young and Lewis (1982). Thermal water generally occurs in the rhyolite and older basalt flows throughout the area and moves generally northwestward. High pressure heads and well yields ranging from 500 to 6,300 gal/min indicate that this aquifer is a potential source for irrigation water.

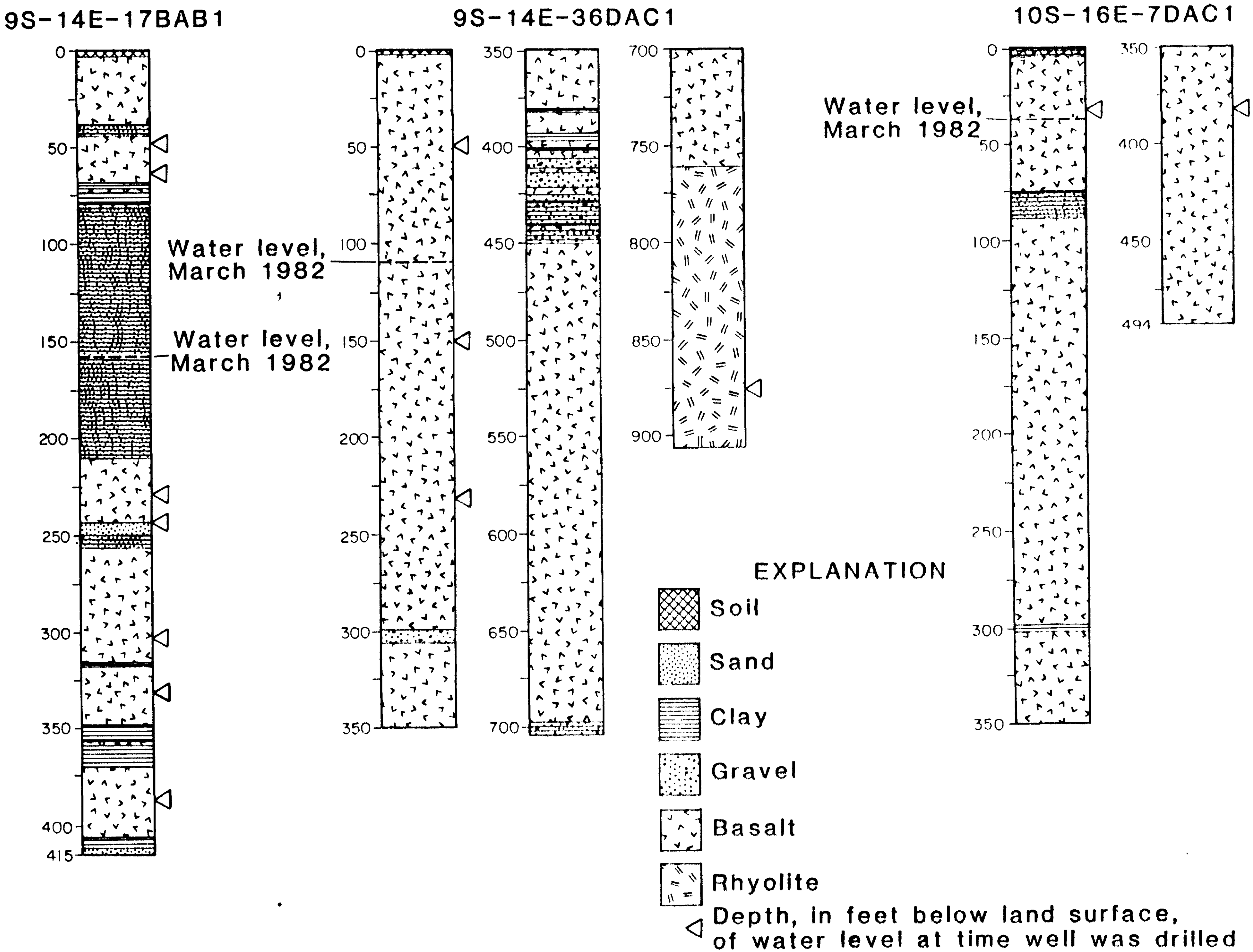

Figure 6. -- Lithologic columns of three wells drilled near Buhl. (Representations are of data from drillers' logs)

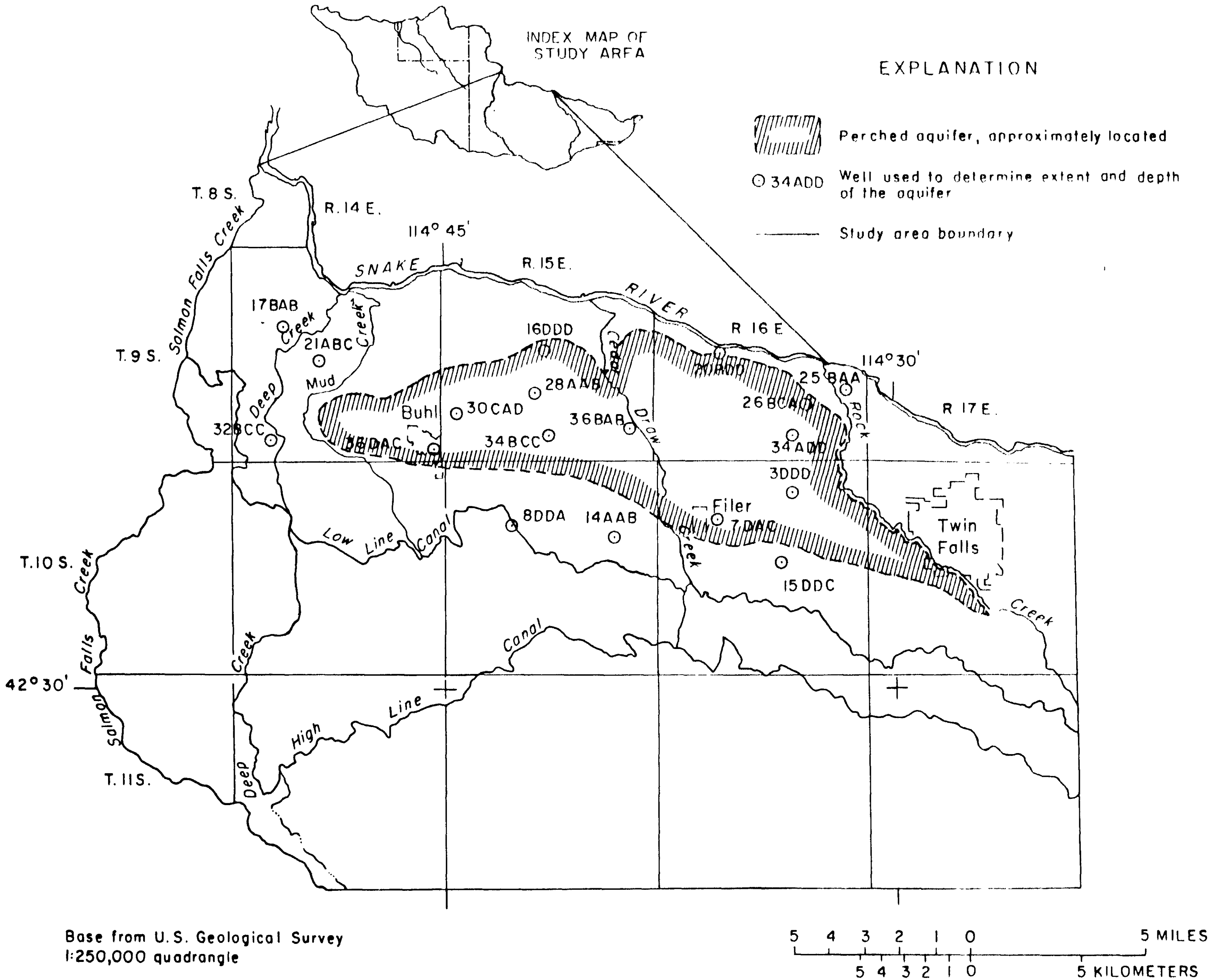

Figure 7. -- Approximate location and extent of perched aquifer.

The regional aquifer underlies the entire study area. Potentiometric-surface contours (pl. 2) were drawn on the basis of water-level measurements obtained from 234 wells in March 1982. Water levels in shallow wells that penetrate only the perched aquifer and in deeply cased wells that intercept only the thermal aquifer were not used to produce the map. Potentiometric-surface contours illustrate the hydraulic gradient and direction of movement in the regional aquifer.

Recharge

Recharge to the regional aquifer is from precipitation, leakage from unlined canals, percolation of excess irrigation water, ground-water inflow across the southern boundary of the study area, and probably upward leakage from the thermal system and downward leakage from the overlying perched system. The principal source of recharge is thought to be from unlined canals and surface-water-irrigated areas.

Hydrographs of wells in areas irrigated with surface water are shown in figure 8. Water levels begin to rise when water is released into canals and fields; reach a plateau of high levels through the summer irrigation season; begin to decline at the beginning of the growing season; and continue to an annual low just prior to the start of the next irrigation season.

Discharge

Natural discharge of ground water from the regional aquifer is by underflow northward to the Snake River and the lower reaches of Rock Creek, Salmon Falls Creek, and Bruneau River. Total discharge of ground water includes that pumped from wells and underflow northward. Only small amounts of water are pumped for domestic and stock supplies compared with those pumped for irrigation, even though the emphasis of development has been on domestic supplies. About 350 irrigation wells in the area are equipped with pumps powered by electric motors (Idaho Power Company, written commun., 1980). Pumpage from those wells can be estimated using electrical power-consumption data, but the estimates are sensitive to the value used for depth to pumping water level. Pumpage from wells equipped with petrofuel-powered pumps in the area also may be significant. A detailed survey of all pumps would be necessary to determine total pumped discharge as input to a water-budget analysis of the area's ground-water resources.

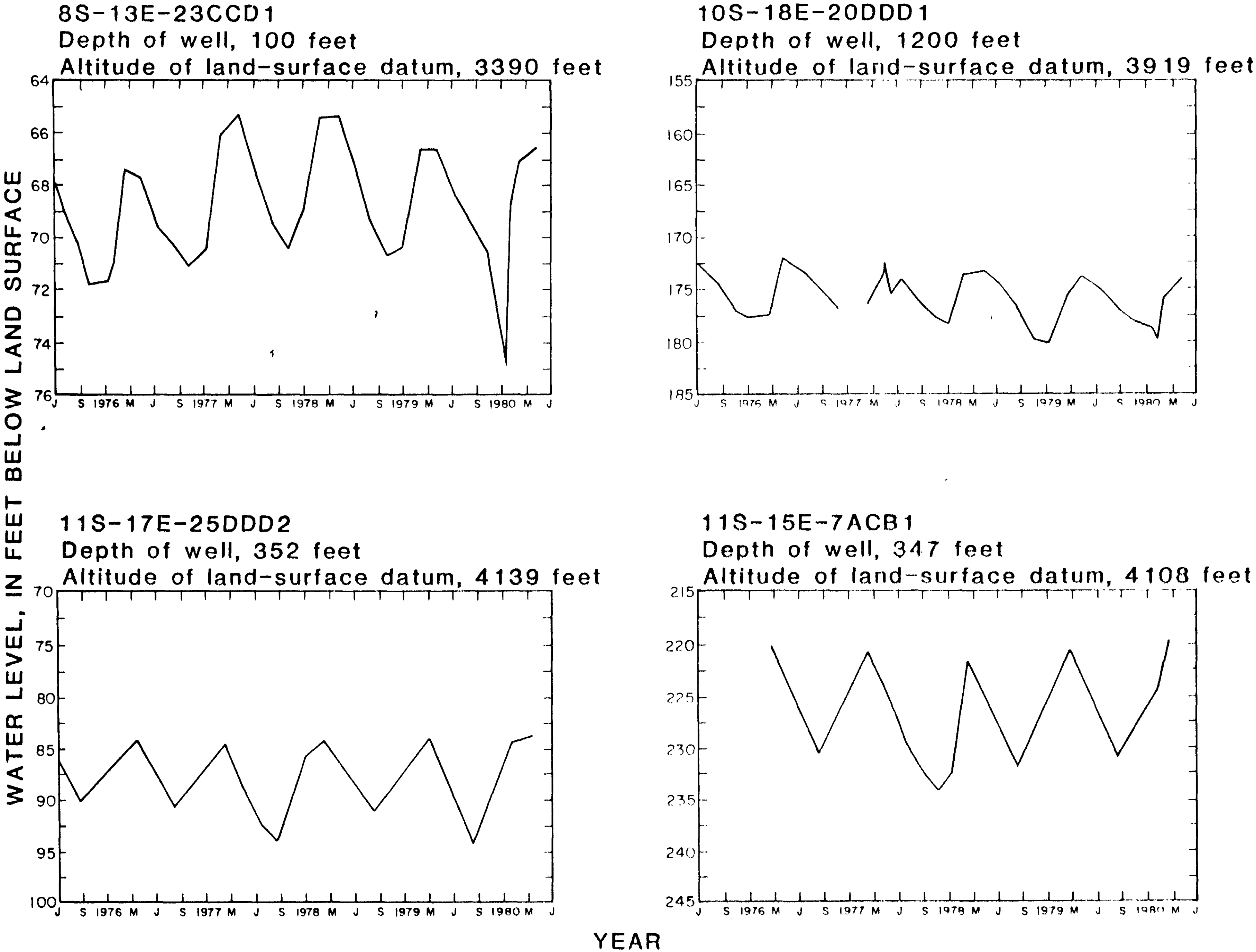

Figure 8. -- Hydrographs of wells in areas irrigated by surface-water sources.

Water-Level Trends

Long-term water-level trends in the regional aquifer are affected by ground-water withdrawals and climatic changes. Withdrawals for irrigation in the Artesian City and Blue Gulch areas have increased during the past 20-30 years and have seriously impacted ground-water resources. A nearly steady decline in water levels from 1951 to 1962, ranging from 2 to 10 ft/yr, is evident in hydrographs for three wells near Artesian City (fig. 9). This area was classified as a critical ground-water area in 1962; no additional permits to pump ground water for irrigation were approved by the State until late 1967, when control on the size of the area impacted was decreased. From 1962 to 1966, the water levels stabilized in two wells and rose in a third. The rise may have been due to recharge from leakage by the High Line Canal and reduction of withdrawals in the vicinity of the well. From 1966 to 1969, water levels again declined about 2-3 ft/yr, then rose slightly during the wet period 1970-72, after which they continued to decline at a rate of about 4 ft/yr.

Hydrographs of water levels in two wells in the Blue Gulch area (fig. 10) show that water levels continued to decline after 1970 when this area was classified a critical ground-water area. The rate of decline in the two wells averaged about 1.5-4 ft/yr until 1976, after which water levels declined at a lesser rate in one well and rose slightly in the other. This indicates that equilibrium between the rates of recharge and discharge may have been reached in the Blue Gulch area or that recharge has increased as a result of deep percolation of irrigation water pumped from Salmon Falls Creek and applied to newly developed lands in the vicinity.

Climatic changes also affect water-level trends in some wells. For example, wells 8S-13E-23CCD1 and 11S-17E-25DDD2 (fig. 8), which have relatively shallow depths to water (about 70-90 ft), exhibit a correlation between their trend in water levels and annual precipitation recorded at Hollister and Castleford (National Oceanic and Atmospheric Administration, 1961-80).

Variability of Chemical and Physical Characteristics

Variations in chemical composition of ground water depend on mineral composition of rocks through which the water moves, solubility of the minerals, length of flow path, residence time of water in rocks, and degree of mixing

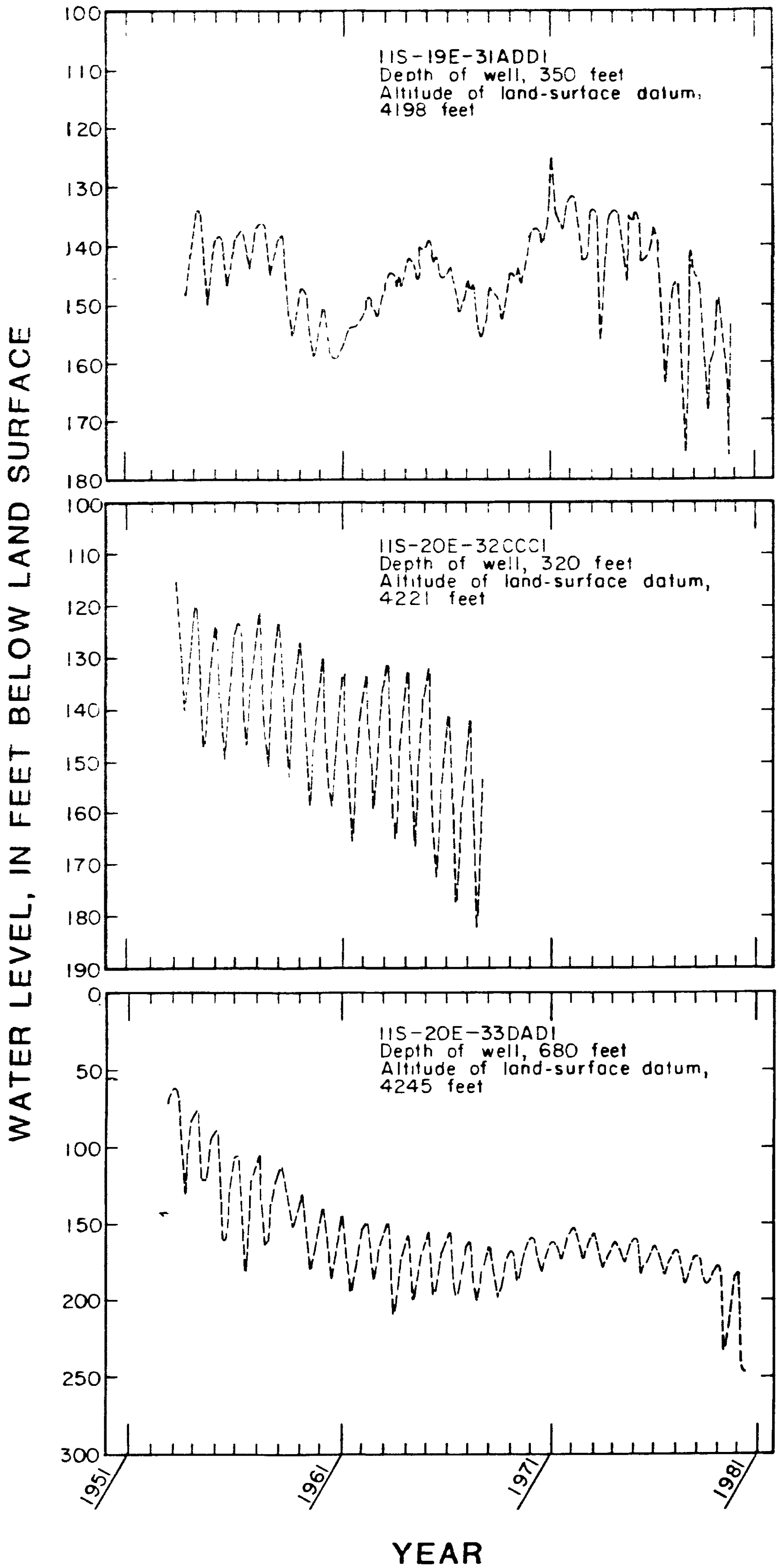

Figure 9. -- Hydrographs of wells in Artesian City critical ground-water area.

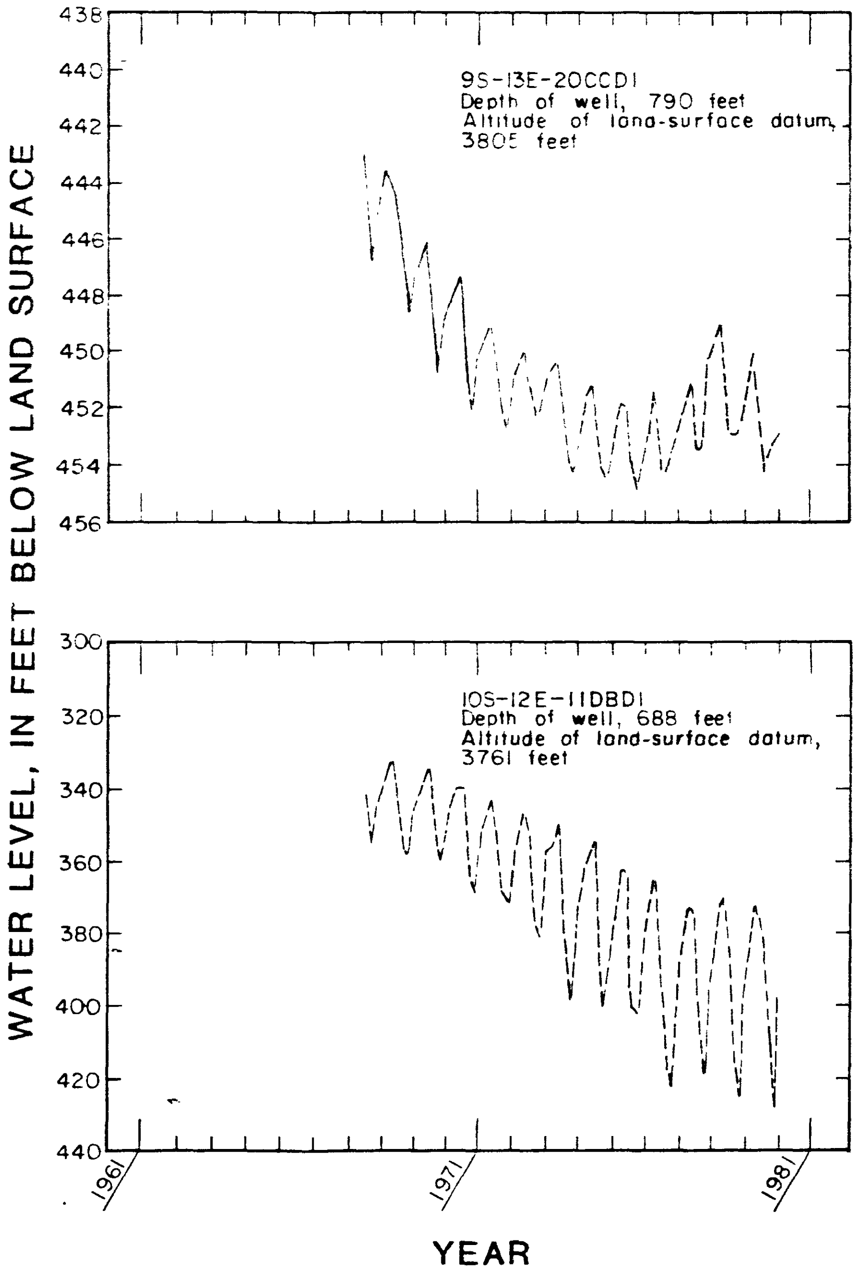

Figure 10. -- Hydrographs of wells in Blue Gulch critical ground-water area.

(Solid lines represent continuous-record measurements; dashed lines represent periodic measurements) of waters from different aquifer systems. Chemical and physical analyses of water samples collected from 29 wells throughout the study area are listed in table 5. The chemistry of ground water in the study area is highly diverse, both spatially and with respect to aquifer sources. Chemical and physical characteristics of water by subarea from selected hydraulic units is shown graphically in figure 11. Each graph illustrates the median concentrations of selected ions plotted on a logarithmic scale. Sample populations and median water temperatures are given for each aquifer graph; maximum vertical scales are variable.

Water from aquifers in the Snake River Group is similar in chemical composition throughout the eastern part of the study area. Water from subarea 1 generally is more dilute than water from subarea 2 and may indicate a shorter residence time in the aquifer than water from subarea 2. Chemical composition of water from the Banbury Basalt in subarea 3 is strongly influenced by thermal water in that area, which probably accounts for the difference in chemical composition of water in subareas 2 and 3. The thermal water ranges from 30° to 72°C and is typically sodium carbonate or bicarbonate in character with high concentrations of fluoride and low concentrations of magnesium (Lewis and Young, 1982).

Concentrations of common constituents in water from the Idavada Volcanics vary, probably owing to different residence times in the aquifer, variations in minerals in the rock, and partial mixing with local thermal waters.

Chemical composition of water from some springs in the area south of Twin Falls is similar to the chemical composition of water from nearby wells. Water from two cold springs (temperature about 12.5°C) that issue to Rock Creek is similar in chemical composition to water from wells completed in the Snake River Group and may indicate similar origin and rock environment. Water from Nat Soo Pah warm spring (12S-17E-31BAB1S) is chemically similar to water sampled in two deep wells completed in Idavada Volcanics south of the study area, which may indicate leakage from the deep aquifer upward along faults.

Because of the variability, both areally and with depth, of the water chemistry, origin of the water probably could be defined by analysis of stable isotopes. Water samples from three wells in the Bruneau plateau were analyzed for the stable isotopes ^{18}O (oxygen-18) and D (deuterium), and the data were compared with isotope analyses of

Table 5.--Chemical and physical characteristics[1] of ground water
(Analyses are reported in milligrams per liter, unless otherwise noted)

[per mil, per thousand; <, less than; ---, no data available; E, estimated]

Reference No. (see fig. 7)	Date of sample	Altitude of land surface, in feet above sea level	Total depth of well, in feet	Depth of water level below land surface, in feet	Temperature, in °C	pH units	Specific conductance, in µmho/cm at 25°C	Total dissolved solids	Alkalinity, as $CaCO_3$	Hardness, as $CaCO_3$	Dissolved calcium, as Ca	Dissolved magnesium, as Mg	Dissolved sodium, as Na	Percent sodium	Sodium-adsorption ratio (SAR)	Dissolved potassium, as K	Dissolved chloride, as Cl	Dissolved sulfate, as SO_4	Dissolved fluoride, as F	Dissolved boron, in µg/L as B	Dissolved silica, as SiO_2	Dissolved nitrogen, NO_2+NO_3, as N	Total phosphorus, as P	Deuterium, stable-isotope ratio per mil	Oxygen-18, stable-isotope ratio per mil
													Twin Falls County												
12	6-11-82	4,411	1,185	528	16.5	7.8	488	325	130	200	49	20	18	16	0.6	3.9	41	51	0.4	60	54	2.1	<0.010	---	---
60	6- 3-82	4,115	280	198	15.0	7.4	625	393	210	250	53	28	34	23	1.0	3.5	27	53	.7	110	40	6.6	.060	---	---
69	6- 3-82	4,010	243	143	14.5	7.7	991	627	240	310	64	36	90	38	2.5	5.3	70	160	.8	170	53	2.1	.020	---	---
89	6- 4-82	3,980	230	126	12.0	7.4	1,050	674	420	430	84	54	68	25	1.6	4.6	34	100	.8	220	59	5.4	<.010	---	---
90	6- 4-82	4,025	500	211	15.0	7.6	940	620	300	320	68	37	86	36	2.3	8.0	30	140	1.0	240	56	3.0	.190	---	---
94	6- 3-82	4,100	255	155	16.0	7.6	459	287	160	190	44	19	22	20	.8	3.8	19	43	.8	70	34	1.2	.070	---	---
100	6- 3-82	3,930	400	E190	14.5	7.9	851	549	300	260	54	31	86	41	2.6	5.5	36	100	.6	230	48	3.9	<.010	---	---
103	6- 3-82	3,705	80	28	13.0	7.6	1,110	738	320	400	94	39	93	33	2.2	5.7	54	190	.6	230	53	4.5	.280	---	---
110	6-11-82	3,705	105	70	14.5	7.5	937	638	290	330	73	35	81	35	2.1	4.2	43	160	1.0	220	53	4.1	<.010	---	---
119	6- 4-82	3,985	217	179	14.5	7.8	776	504	240	270	52	35	63	33	1.9	4.7	39	100	.9	170	54	2.6	.030	---	---
130	6- 4-82	4,040	245	219	14.5	7.3	850	547	310	330	78	33	53	26	1.4	4.8	34	91	.9	180	53	4.2	<.010	---	---
136	6- 4-82	3,885	240	125	13.0	7.5	3,430	2,440	370	1,400	280	170	290	31	3.4	13	430	940	1.0	560	52	10	<.010	---	---
143	6- 4-82	3,765	220	177	15.0	7.8	1,040	665	300	410	75	53	72	28	1.8	6.0	60	150	.8	180	52	4.2	<.010	---	---
145	6- 4-82	3,905	175	131	12.5	7.5	1,080	715	310	370	85	39	85	32	2.1	9.9	44	200	.9	200	57	3.9	1.10	---	---
146	6- 2-82	3,700	960	E340	26.0	7.6	499	345	110	150	45	9.1	39	35	1.5	7.3	31	64	1.3	70	65	3.8	.020	-131.0	-17.3
157	6-11-82	3,585	77	34	12.5	7.6	1,050	710	340	350	74	40	110	40	2.8	3.7	44	160	.9	280	55	5.0	.010	---	---
160	6-10-82	3,572	119	44	13.0	7.5	1,130	746	450	420	89	47	94	33	2.2	6.9	45	130	.9	270	54	3.1	<.010	---	---
166	6-11-82	3,825	179	48	15.0	7.3	996	653	340	380	87	39	80	31	2.0	5.1	48	110	.9	230	54	5.7	.060	---	---
169	6-11-82	3,400	700	108	20.0	9.6	412	325	140	3	1.0	.1	89	96	23	3.4	8.4	24	10	120	100	<.10	<.010	---	---
178	6- 2-82	3,698	575	323	22.0	7.3	373	276	100	120	34	8.9	25	30	1.1	4.0	19	38	1.2	50	72	2.8	.050	---	---
199	6-10-82	3,469	500	229	24.0	8.6	321	247	110	34	11	1.6	54	75	4.2	4.5	9.3	18	6.3	90	70	1.4	<.010	-150.0	-19.5
202	6- 2-82	3,375	720	523	26.5	9.3	191	137	75	9	3.2	.3	38	88	5.6	1.4	3.2	17	.7	80	29	<.10	.050	---	---
204	6- 2-82	3,325	398	398	24.0	9.5	226	158	83	21	7.6	.6	41	79	3.9	1.4	4.2	23	.8	90	29	<.10	.640	---	---
													Elmore County												
206	6- 1-82	3,158	735	268	25.0	9.2	421	286	92	15	5.7	.1	84	92	9.6	1.2	25	65	2.4	60	47	<.10	.340	---	---
207	6- 1-82	2,910	280	144	18.0	7.8	471	330	170	86	26	5.0	59	56	2.9	12	8.2	52	8.5	120	63	.17	2.00	---	---
211	6- 1-82	3,050	635	303	22.0	7.8	481	342	190	120	36	7.5	49	44	2.0	12	9.1	44	2.6	110	70	<.10	.220	-148.0	-19.1
													Owyhee County												
182	6- 2-82	3,432	785	245	20.0	7.4	310	267	110	100	34	4.6	24	31	1.1	8.6	17	30	1.5	70	80	.82	.120	---	---
187	6- 2-82	3,651	783	417	28.0	7.8	342	247	100	83	25	5.1	33	44	1.7	6.3	15	32	1.7	80	63	1.1	.130	---	---

[1] Recommended concentration limits in drinking water (U.S. Environmental Protection Agency, 1977a, 1977b): pH, 6.5-8.5 standard units; total dissolved solids, 500 mg/L; chloride, 250 mg/L; sulfate, 250 mg/L. Control limits for fluoride vary with average daily air temperature. For average daily air temperatures across the plateau of south-central Idaho (64°-71°F), the recommended upper limit for fluoride concentrations averages 1.8 mg/L.

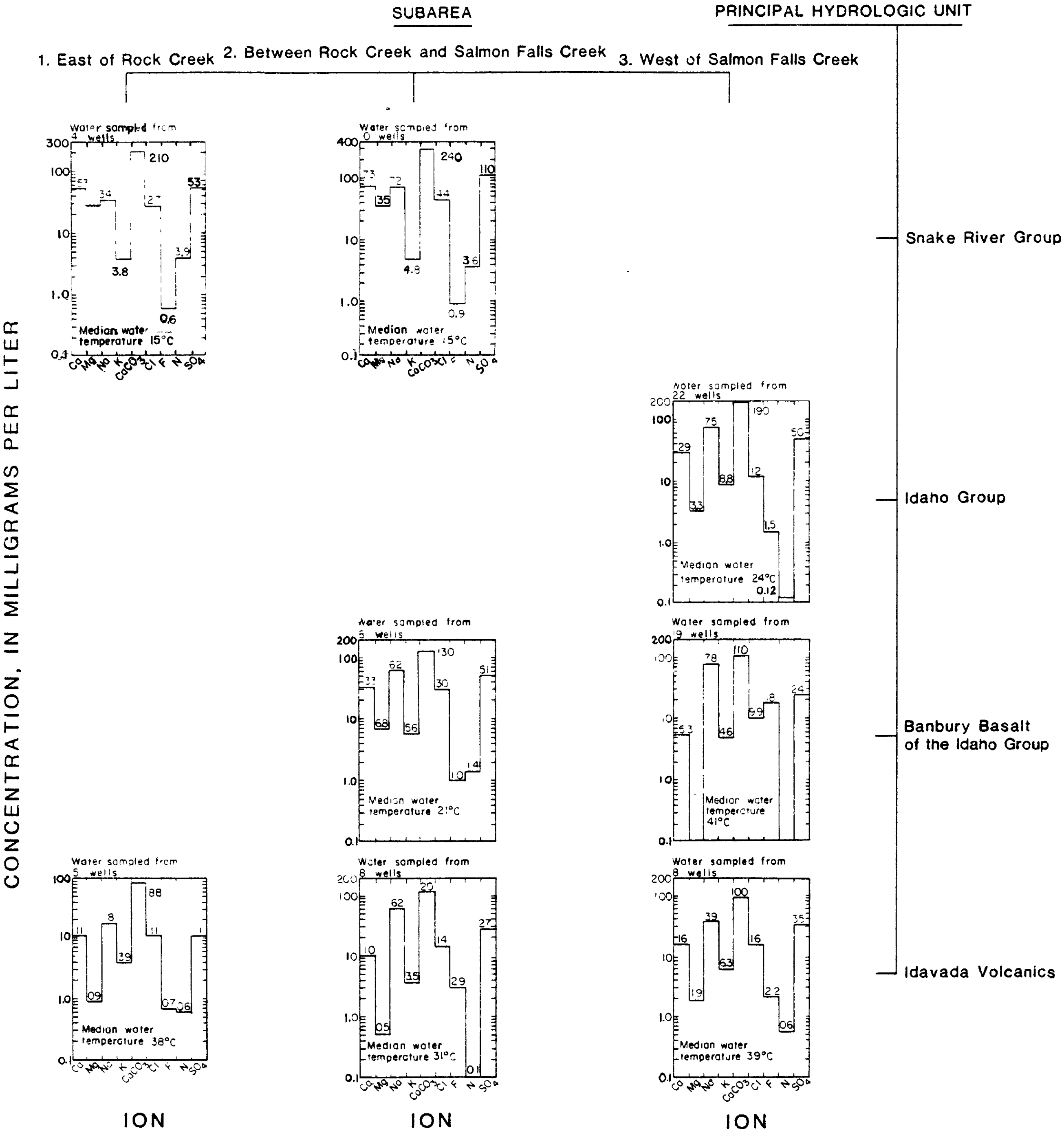

Figure 11. -- Chemical and physical characteristics of ground water, by subarea and major hydraulic unit. (Data includes chemical analysis from previous studies; alkalinity is represented as CaCO3)

other wells and springs sampled in south-central Idaho (Lewis and Young, 1982, p. 19, and Young and Lewis, 1982, p. 12).

Isotopic composition of water sampled from well 10S-12E-1DDC1 is very similar to thermal waters (temperature generally greater than 20°C) shown and may indicate a common recharge environment to the south. The lower temperature of the water and depletion in ^{18}O relative to the other waters may be indicative of a shorter residence time and contact with the rock in the aquifer. Water from wells farther east (6S-10E-31CCC1 and 8S-12E-24CCC1) are isotopically unlike any of the other waters. The depletion in ^{18}O and D relative to other waters may indicate recharge origins at some higher altitudes (Hobba and others, 1979).

Suitability of Ground Water for Irrigation

Chemical characteristics used to determine quality of ground water for irrigation are (1) total concentration of soluble salts, (2) relative proportion of sodium to other cations, and (3) concentration of boron.

Classification of irrigation water with respect to the total concentration of soluble salts is made on the basis of specific electrical conductance, using a method developed by the U.S. Salinity Laboratory Staff (1954). Figure 12 illustrates salinity hazards for selected ground-water samples from major hydraulic units in the study area.

High salinity hazards most frequently occur in water from the Glenns Ferry Formation--probably the result of salts leached from the soil zone and intercalated sediments in the aquifer. Samples from three wells completed in Banbury Basalt also have a high salinity hazard. However, the water is cooler than normally encountered in the Banbury Basalt and actually may be water from the Glenns Ferry Formation (H. R. Covington, U.S. Geological Survey, written commun., 1982).

Crop tolerance to saline water is quite variable (U.S. Salinity Laboratory Staff, 1954), and ground-water salinity may be one decisive factor in crop selection in the study area. Green beans, which have a low salt tolerance, are grown on the plateau in areas presently irrigated by surface water. Alfalfa and grains have a medium salt tolerance and are the principal crops grown on the plateau. Such crops might be affected by importation of ground water from areas east of Salmon Falls Creek, where a medium to high salinity hazard exists.

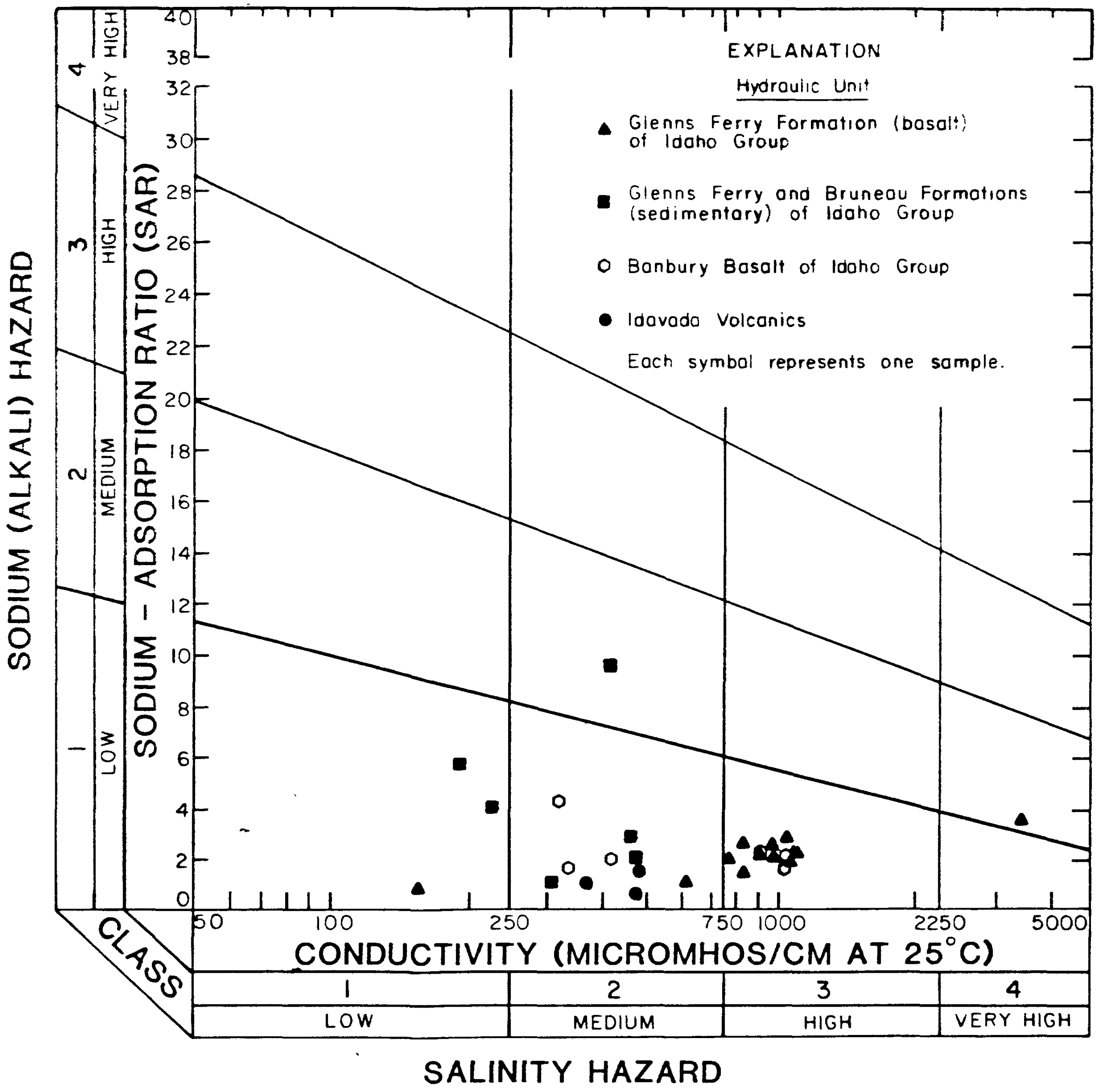

Figure 12. -- Salinity and sodium hazards of ground water.

Classification of irrigation water with respect to sodium hazard can be defined by the SAR (sodium-adsorption ratio):

$$SAR = \frac{Na^{+}}{\sqrt{\frac{(Ca^{++})+(Mg^{++})}{2}}}$$

where Na^{+}, Ca^{++}, and Mg^{++} represent the concentrations of the respective ions in meq/L (milliequivalents per liter), the milligrams of a constituent per liter divided by the atomic weight of the constituent and multiplied by the constituent charge. Alkali soils are formed by accumulation of exchangeable sodium with other cations, principally calcium and magnesium, and result in poor tilth and low hydraulic conductivity. If the proportion of sodium is high, alkali hazard is high. Conversely, if calcium and magnesium predominate, the hazard is low (U.S. Salinity Laboratory Staff, 1954, p. 72). Shown in figure 12 are four classes of SAR and the plots of SAR calculated for samples of ground water from different hydraulic units. A high sodium hazard occurs in thermal water in the Idavada Volcanics and Banbury Basalt, but no spatial distribution of concentrations is apparent from the few water samples available.

Classification of irrigation water with respect to boron can be made on the basis of relative tolerance of crops to boron (U.S. Salinity Laboratory Staff, 1954). Table 6 lists the tolerance level of selected crops and classifies water by the concentration of boron with respect to sensitive, semitolerant, and tolerant crops. Boron levels in ground water throughout the study area are generally low (mean boron concentration for the 28 analyses shown in table 5 is 1.6 mg/L). Irrigation water tolerance ratings are generally good to excellent for groups of crops shown in tables 6 and 7. Statistics available from the U.S. Geological Survey's data base for all ground water sampled and correlated with principal hydraulic units show that, of 140 ground-water samples in the study area, only two contained boron concentrations in excess of 1.0 mg/L, and they were rated permissible for crops in the semitolerant and tolerant categories.

Suitability of Ground Water for Domestic and Stock Use

Water-quality requirements and recommended limits for selected chemical constituents in domestic water supplies

Table 6.--Relative tolerance of crops to boron

[In each group, the plants first named are considered more sensitive and the last named more tolerant. Modified from U.S. Salinity Laboratory Staff, 1954, p. 81]

Sensitive	Semitolerant	Tolerant
Thornless blackberry	Lima bean	Carrot
Apricot	Sweet potato	Lettuce
Peach	Bell pepper	Cabbage
Cherry	Pumpkin	Turnip
Grape (Sultanina and Malaga)	Zinnia	Onion
	Oat	Broadbean
Apple	Milo	Gladiolus
Pear	Corn	Alfalfa
Plum	Wheat	Garden beet
American elm	Barley	Sugar beet
Navy bean	Field pea	Asparagus
Black walnut	Radish	
Pecan	Sweet pea	
	Tomato	
	Potato	
	Sunflower (native)	

Table 7.--Rating of irrigation water for various crops on the basis of boron concentration in the water

[$<$, less than; $>$, greater than; modified from U.S. Salinity Laboratory Staff, 1954, p. 81. Boron concentrations are in milligrams per liter.]

Rating	Grade	Sensitive crops	Semitolerant crops	Tolerant crops
1	Excellent	$<$ 0.33	$<$ 0.67	$<$ 1.00
2	Good	.33- .67	.67-1.33	1.00-2.00
3	Permissible	.67-1.00	1.33-2.00	2.00-3.00
4	Doubtful	1.00-1.25	2.00-2.50	3.00-3.75
5	Unsuitable	$>$ 1.25	$>$ 2.50	$>$ 3.75

are given as footnotes in table 5. Requirements (not shown) also have been established for additional constituents, which were not analyzed for this study, but were analyzed for studies previously done in the area. The majority of water sampled for this study was from domestic wells. In some cases, the same water is used for stock supplies. Toxicity levels for most chemical substances common in ground water are higher for animals than for man (Gough and others, 1979). Thus, water suitable for human consumption should generally be acceptable as a stock supply. Locally, a few wells contained concentrations of dissolved solids, pH, fluoride, chloride, or sulfate that exceeded either required or recommended drinking water limits (table 5). In general, however, most ground water in the area is suitable for domestic and stock use.

Arsenic is a toxic element to man (U.S. Environmental Protection Agency, 1976, p. 14). Concentrations of dissolved arsenic exceeded the maximum allowable limit of 0.05 mg/L in three irrigation wells in the study area (U.S. Geological Survey, unpubl. data, Boise, Idaho, 1978, 1980, and 1982).

Excessive fluoride in drinking water produces objectionable dental fluorosis at concentrations above the required public water supply limit of 1.8 mg/L (U.S. Environmental Protection Agency, 1977a, p. 5) for this area. Concentrations above 2 mg/L fluoride in water can be toxic to lambs (Case, 1974). Concentrations of fluoride in water sampled from four wells ranged from 2.4 to 8.5 mg/L.

Dissolved iron can affect the taste of beverages and can stain laundered clothes and plumbing fixtures. The required public water supply limit of dissolved iron is 0.3 mg/L (U.S. Environmental Protection Agency, 1977b, p. 3). The U.S. Geological Survey (1980, p. 374) reported a concentration of about 1.5 mg/L dissolved iron in one domestic well (6S-7E-8BBA1, not included in table 5). Chapman and Ralston (1970, p. 25) reported a concentration of about 0.58 mg/L dissolved iron in one well (8S-12E-25BC, not included in table 5).

Nitrate (NO_3) was not specifically analyzed in water samples collected for this study. It is, however, one molecular species used in combination with nitrite (NO_2) to determine total dissolved nitrogen. A concentration of 10 mg/L nitrate as nitrogen is the maximum acceptable concentration for public water supplies (U.S. Environmental Protection Agency, 1977a, p. 5). However, Fowler (1960) reported nitrate levels of more than 44 mg/L in five wells in the Salmon Falls Tract of Twin Falls County.

Excess DS (dissolved solids) are objectionable in drinking water because of their laxative effects, unpalatable mineral tastes, and corrosive properties. The recommended limit for DS is 500 mg/L (U.S. Environmental Protection Agency, 1977b, p. 3). Fourteen wells throughout the area exceeded this limit; one domestic well contained a concentration of 2,440 mg/L total dissolved solids.

Levels of pH ranging from 6.5 to 8.5 are considered permissible (U.S. Environmental Protection Agency, 1977b, p. 2). Water with a pH level below 6.5 is acidic and has a bitter taste. Water with a pH level above 8.5 is alkaline and can corrode pipes. Water from five wells in the study area contained pH levels greater than 8.5. Three of the five wells are completed in the Glenns Ferry Formation and two are completed in Banbury Basalt; water temperatures in these wells indicate some contribution of thermal water.

POTENTIAL FOR ADDITIONAL DEVELOPMENT OF GROUND WATER

It is unlikely that present needs for additional irrigation water can be met solely by developing existing ground-water supplies in the Bruneau plateau. The Blue Gulch area of the plateau already has been impacted significantly by development of ground water for irrigation, and in other areas of the plateau, low yield (less than 500 gal/min) and large pump lifts (about 400-600 ft) probably preclude large-scale development of ground water. However, potential sources for supplemental irrigation water exist in the eastern plain: (1) A perched aquifer that extends generally westward from Rock Creek to Buhl and north of U.S. Highway 30, (2) a thermal-water reservoir underlying the regional aquifer, and (3) a regional aquifer.

As previously stated, change in storage in the perched aquifer was 8,000-24,000 acre-ft in 1982, on the basis of seasonal variation of water levels monitored in two wells. Some of this water probably could be withdrawn for irrigation of farmland in the local area, relieving stress on surface-water supplies presently allocated for such areas.

Further study is needed to determine how much water can be withdrawn from the thermal-water reservoir without affecting existing wells, but yields of 1,800-6,300 gal/min and pump lifts ranging from a few feet near the Snake River to about 200 ft in the Hollister area indicate that the thermal-water reservoir is a potential source of supply.

The regional aquifer also is a potential source of water for irrigation, but further study is needed to determine availability and dependability of the supply. Ralston and Young (1971, p. 39) estimated that annual storage and dissipation of water in the Twin Falls South-Side Tract was about 100,000 acre-ft through 1969. Between February and October 1982, five wells that penetrate the regional aquifer were equipped with continuous water-level recorders; water-level hydrographs are shown in figure 13. Monthly measurements of water levels made in 43 wells from February to August 1982 show an average fluctuation of 10 ft during the irrigation season. If the +10-ft change for 1982 is applied over an area of 240,000 acres and an average storage coefficient of 0.04 is assumed, the increase in the volume of water in the regional aquifer between February and August 1982 was 96,000 acre-ft. Precipitation during 1982 was about 2 in. above normal (normal period is 1941-70), and it is not known whether similar water-level fluctuations and associated volumes of ground water can be anticipated in the ensuing years. It is further unknown how withdrawal of some part of this annual flux of water would affect long-term water levels in the regional aquifer.

EFFECTS OF ADDITIONAL DEVELOPMENT

Favorable and unfavorable effects on ground-water resources of the Bruneau plateau and adjacent eastern plain might be expected from additional development. To support this development would require an additional withdrawal of several hundred thousand acre-feet of water annually from aquifers beneath the Twin Falls South-Side and Salmon Falls Tracts and conveyance of that water to the plateau. Favorable effects would be: (1) Increased recharge on the plateau as a result of percolation from unlined canals, surface reservoirs, and irrigation; and (2) improved drainage of waterlogged fields that lie in surface depressions adjacent to Deep Creek and Mud Creek. Local citizens and Twin Falls Canal Company officials reported that such areas become waterlogged in late summer. Several tile drains and ditches have been installed to alleviate this problem, and requests to install additional drains are pending.

Unfavorable effects of large-scale development of ground water are broad in scope and areal extent: (1) Water in the perched and regional aquifers generally has a higher salinity than ground water in the plateau. Water withdrawn from these aquifers and applied to the plateau could adversely affect ground-water quality in the plateau. (2) Some soils that cover significantly large areas of the plateau have moderately low runoff and low infiltration capacities. The soils are underlain by hardpan, and water-

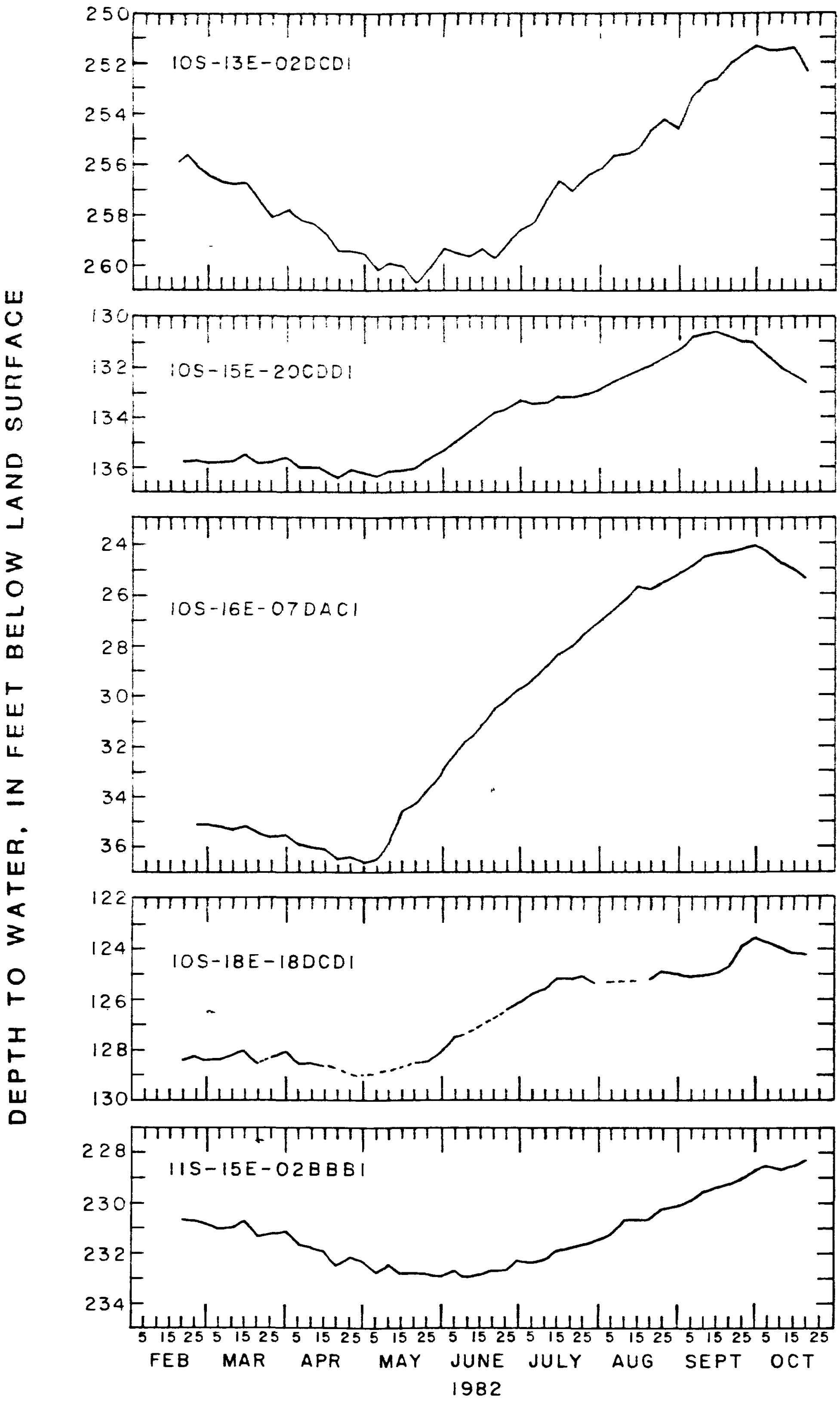

Figure 13. -- Hydrographs of wells open to the regional aquifer beneath the Twin Falls South-Side Tract. (Dashed where missing record was estimated)

logging may occur where these characteristics prevail. (3) Interaction between the regional and thermal-water aquifers is poorly understood. Thermodynamics of the aquifer systems might be affected by large-scale withdrawals from either aquifer. If new withdrawals remained constant, the most immediate effect would be a decline in water levels in the regional aquifer until equilibrium was established between recharge and discharge. The degree to which decline of the water levels would affect existing wells depends on the location of those wells with respect to a proposed well field and on how much water is withdrawn. (4) Finally, water artificially withdrawn from aquifers beneath the Twin Falls South-Side and Salmon Falls Tracts probably would result in a decrease of water in storage and capture of ground water presently discharged to streams and drains.

Ground water and surface water are closely interrelated in the Twin Falls South-Side Tract (Ralston and Young, 1971). Where and how much ground water can be developed without detrimental effects to streamflow need further study. The 233,400 acre-ft/yr of water needed to supplement existing irrigation supplies on the plateau (Galinato and Packer, 1981, p. 9) is about 3.5 percent of the average annual flow in the Snake River near Hagerman. Withdrawal of this amount from upstream sources probably would not seriously affect streamflow allocated downstream, but much of this water would be lost for any beneficial use downstream owing to ET from the plateau. Water presently considered return flow from the Twin Falls South-Side Tract could be captured and used provided that irrigation, power-production, and fish-habitat rights downstream are not affected. Present criteria (Statute 42-1736a, Idaho Code, 1978) require that a minimum instantaneous flow of 3,300 ft^3/s be maintained in the Snake River at the Murphy gaging station before appropriating rights upstream to Milner Dam.

WATER MANAGEMENT INFORMATION NEEDS

Information contained in this report could be refined through future studies to (1) improve potentiometric-surface maps, (2) develop a water budget for the area, and (3) define the interaction among different aquifer systems. To accomplish this, exploratory test holes would be needed to determine the occurrence and extent of aquifers. Pumping tests would help determine aquifer characteristics, and seepage and evaporation studies on canal systems would help define a component of ground-water recharge. Knowledge gained through these studies then could be used to produce a ground-water model for possible practical use by water-resource managers.

SUMMARY

Agricultural development in the Bruneau plateau and adjacent eastern plain has been accomplished with an adequate supply of surface water for irrigation. Presently, however, about 87 percent of the plateau is undeveloped, yet consists of irrigable land. Ground-water resources in the area are an alternate source of irrigation water but are recoverable only in relatively small quantities and are inadequate to meet projected needs of about 438,000 acre-ft/yr of water for existing and newly developed lands. Pumping lifts of about 400-600 ft and low well yields (less than 500 gal/min in many places) probably preclude large-scale development of this resource in the Bruneau plateau. Ground water throughout the area is used principally for domestic and stock supplies. Some areas of ground-water development have been seriously impacted by significant drawdowns and declining water levels.

A large volume of surface water applied to the Twin Falls South-Side Tract significantly increased water levels during the early 1900's. About 1.3 million acre-ft/yr of water presently are applied to irrigate about 202,700 acres. Large volumes of ground water either move laterally to streams and are transported from the area or percolate to recharge the aquifer. Recharge to the aquifer is evident from a seasonal rise of 5-20 ft in water levels. Water levels in the aquifer rise in the spring and decline in the fall. About 100,000-115,000 acre-ft/yr of water may be available for development from perched and regional aquifers beneath the Twin Falls South-Side Tract. However, high salinity in this water probably precludes using it to irrigate salt-sensitive field crops.

Locally, a few wells contained concentrations of dissolved solids, pH, fluoride, chloride, or sulfate that exceeded either required or recommended drinking water limits. In general, however, most ground water in the area is suitable for domestic and stock use.

High pressure heads and good yields to wells indicate that the thermal-water reservoir underlying a large part of south-central Idaho is a potential source of water for supplemental irrigation on the plateau, but the amount of water that could be safely withdrawn from this system was not determined.

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