WATER RESOURCES OF TETON COUNTY, WYOMING, EXCLUSIVE OF YELLOWSTONE NATIONAL PARK

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 95-4204

Prepared in cooperation with the WYOMING STATE ENGINEER

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by Bernard T. Nolan and Kirk A. Miller

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Cheyenne, Wyoming
1995

U.S. DEPARTMENT OF THE INTERIOR
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CONVERSION FACTORS, VERTICAL DATUM, ABBREVIATIONS, AND ACRONYMS

Multiply	By	To obtain
acre	4,047	square meter
acre	0.4047	hectare
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
foot per day (ft/d)	0.3048	meter per day
foot squared per day (ft^2/d)	0.0929	meter squared per day
gallon per minute (gal/min)	0.06309	liter per second
inch (in.)	2.54	centimeter
mile (mi)	1.609	kilometer
million gallons per day	0.04381	cubic meter per second
square mile (mi^2)	2.59	square kilometer

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

$$°F = 9/5\ (°C) + 32$$

$$°C = 5/9\ (°F - 32)$$

In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called *Sea Level Datum of 1929.*

Abbreviated water-quality units used in t1his report:

me/L	milliequivalents per liter
mg/L	milligrams per liter
µg/L	micrograms per liter
µS/cm	microsiemens per centimeter at 25 degrees Celsius
µm	micrometer

Acronyms and Abbreviations used in this report:

USGS	U.S. Geological Survey
TDEM	Time-domain electromagnetic
USEPA	U.S. Environmental Protection Agency
ohm-m	ohm-meters
Ma	Mega-annum (10^6 years)

WATER RESOURCES OF TETON COUNTY, WYOMING, EXCLUSIVE OF YELLOWSTONE NATIONAL PARK

By Bernard T. Nolan *and* Kirk A. Miller

ABSTRACT

Surface- and ground-water data were compiled and analyzed to summarize the water resources of Teton County, exclusive of Yellowstone National Park. This study, prepared in cooperation with the Wyoming State Engineer, is one in a series describing the water resources of Wyoming counties.

The wells and springs inventoried in the Teton County study area most commonly were completed in or issued from unconsolidated deposits of Quaternary age, and rocks of Tertiary, Mesozoic, and Paleozoic age. The largest discharges measured, reported, or estimated were from Quaternary unconsolidated deposits (3,000 gallons per minute), the Bacon Ridge Sandstone of Cretaceous age (800 gallons per minute), and the Madison Limestone of Mississippian age (800 gallons per minute). Discharges from all other geologic units differed but most wells and springs yielded 25 gallons per minute or less.

A time-domain electromagnetic survey of Jackson Hole indicated that the depth of the Quaternary unconsolidated deposits ranged from about 380 feet in the northern part of Antelope Flats to about 2,400 feet near the Potholes area in Grand Teton National Park. Electrical resistivity, a general indicator of grain size in subsurface rock, ranged from 2 to 380 ohm-meters. The low values are assumed to represent less permeable (fine-grained) materials such as claystones, shales, siltstones, or fine-grained sandstones, and the higher values are assumed to represent coarse-grained materials such as sand and gravel.

Streamflow in the study area is both perennial and intermittent. Most streams originate in the mountains and are perennial, although some streams are intermittent along a particular reach in some years. The Gros Ventre River at Zenich flowed intermittently for brief periods in 1988 and 1992.

Ground water is recharged by infiltration of precipitation, streamflow leakage, irrigation water, and inflow from other aquifers. Ground water is discharged through pumped wells and is naturally discharged by springs and seeps, by evapotranspiration, and by discharge to streams and other geologic units. In a gain-and-loss study of the Snake River, the estimated ground-water discharge for a stream reach between streamflow-gaging stations near Moran and south of the Flat Creek confluence was 395 cubic feet per second

Geostatistical methods were used to generate water-level contours from 137 water-level measurements in selected Quaternary unconsolidated deposits and 118 stream altitudes. The water-level contours indicate that ground water flows from topographically high areas toward the Snake River and southwest through the valley in the general direction of the river.

Water levels were deeper in October than July 1993, in all but 1 of 27 wells completed in Quaternary unconsolidated deposits and remeasured in October 1993. The median change was -1.76 feet.

Dissolved-solids concentrations in water samples from Quaternary unconsolidated deposits and rocks of Tertiary, Mesozoic, and Paleozoic age ranged from 80 to 1,060 milligrams per liter. A water sample collected from a rhyolite flow of Quaternary age had the lowest dissolved-solids concentration (22 milligrams per liter) in the study area. The largest nitrite-plus-nitrate concentrations were found in water samples collected from Quaternary landslide deposits (7.50 milligrams per liter) and the Bear River Formation of Cretaceous age (9.70 milligrams per liter). Water type varied between lithologic groupings.

INTRODUCTION

Teton County is located in northwestern Wyoming (fig. 1) and has an area of 3,608 mi^2. The topography in the county is mostly mountainous and includes the Teton Range, the Washakie Range, the Mount Leidy Highlands, the Gros Ventre Range, and the Snake River Range (fig. 1). The Snake River flows through Jackson Hole, the valley bounded by the previously mentioned ranges. Land-surface altitudes range from 13,770 ft above sea level in the Teton Range to 5,800 ft along the Snake River south of Jackson.

The county population in 1990 was 11,172, about 40 percent of whom lived in Jackson (Wyoming Department of Administration and Fiscal Control, 1989). Additionally, large numbers of people visit Grand Teton National Park and nearby Yellowstone National Park each year. In 1988, about 2,076,700 people visited Grand Teton National Park and about 2,219,130 people visited Yellowstone National Park. Continued urban development and the large number of visitors to the parks could affect water quantity and quality in the county.

Water in the county is used mostly for commercial and domestic applications, irrigation, and public supply (Cox, 1976, sheet 2). To obtain information needed to plan and manage the increased demands for water by the growing population, the U.S. Geological Survey (USGS), in cooperation with the Wyoming State Engineer, conducted a study to characterize the water resources of the study area. Additional hydrologic and geophysical data were collected at locations where such data were lacking or considered inadequate.

Purpose and Scope

This report describes the water resources of the Teton County study area--that part of Teton County located south of Yellowstone National Park (fig. 1). The information presented can be used in future management of the resources, including planning and designing new water supplies and related economic development. Surface water is described first, but ground water is emphasized in this report. The relation of ground water to geology is described, as well as ground-water recharge, movement, and discharge, changes in water levels, and water quality. Discussion of surface water is limited to streamflow data and characteristics. Discussion of lake characteristics is beyond the scope of this report.

Surface- and ground-water sites were inventoried and sampled during this study (1991-93) to improve data coverage in the study area. In 1992, stream discharge was measured at 11 sites on the Snake River and its tributaries (Ground Water section, table 7). Two water-quality samples were collected from Fish Creek in 1993. During 1991-93, water-quality samples were collected from 74 wells and springs throughout the study area and analyzed for major ions or trace elements, or both. In July 1993, water levels were measured in 137 wells in Jackson Hole.

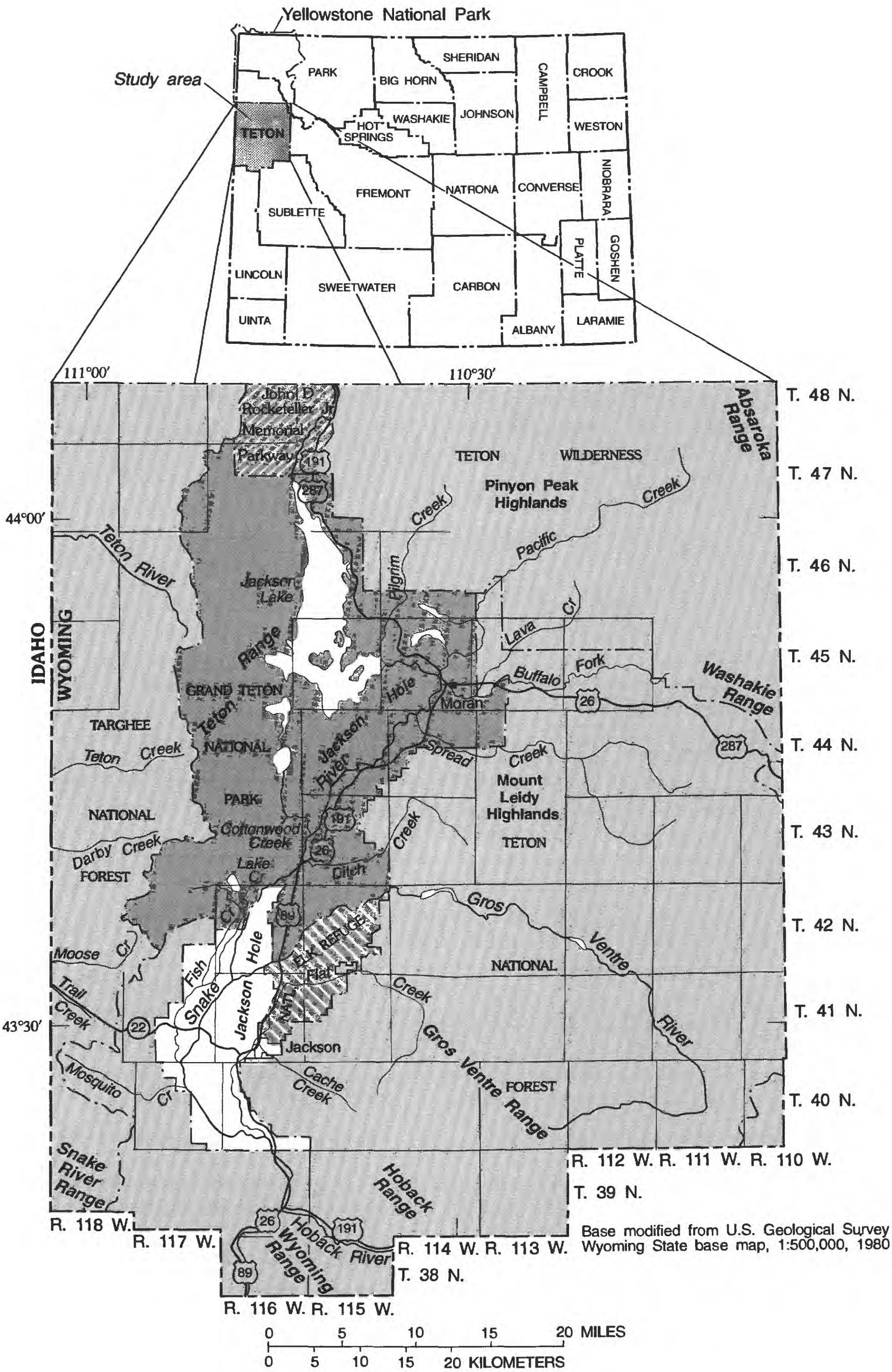


Figure 1. Location and physiography of Teton County study area, Wyoming.

Climate

Climate in Teton County varies in response to altitude and changing seasons. The highest altitude in the Teton Range is 13,770 ft, and the altitude of the Jackson weather station is 6,230 ft. Mean annual precipitation during 1951-80 was about 60 inches in the Teton Range, whereas precipitation in Jackson Hole was about 16-20 in. (fig. 2). The precipitation estimate for the Teton Range is based on correlations of annual precipitation with snowpack measurements and terrain factors, and should be regarded with caution (Martner, 1986, p. 78). The estimates are included to show potential precipitation changes in response to large changes in altitude that are common to the study area.

Temperature in Teton County varies mainly in response to changing seasons. At Moran, mean monthly air temperature ranged from 13.0 °F in January to 59.2 °F in July for the 1951-80 period of record (Martner, 1986, p. 377). Mean monthly air temperature in Jackson ranged from 16.0 °F in January to 60.8 °F in July, for the same period (Martner, 1986, p. 354).

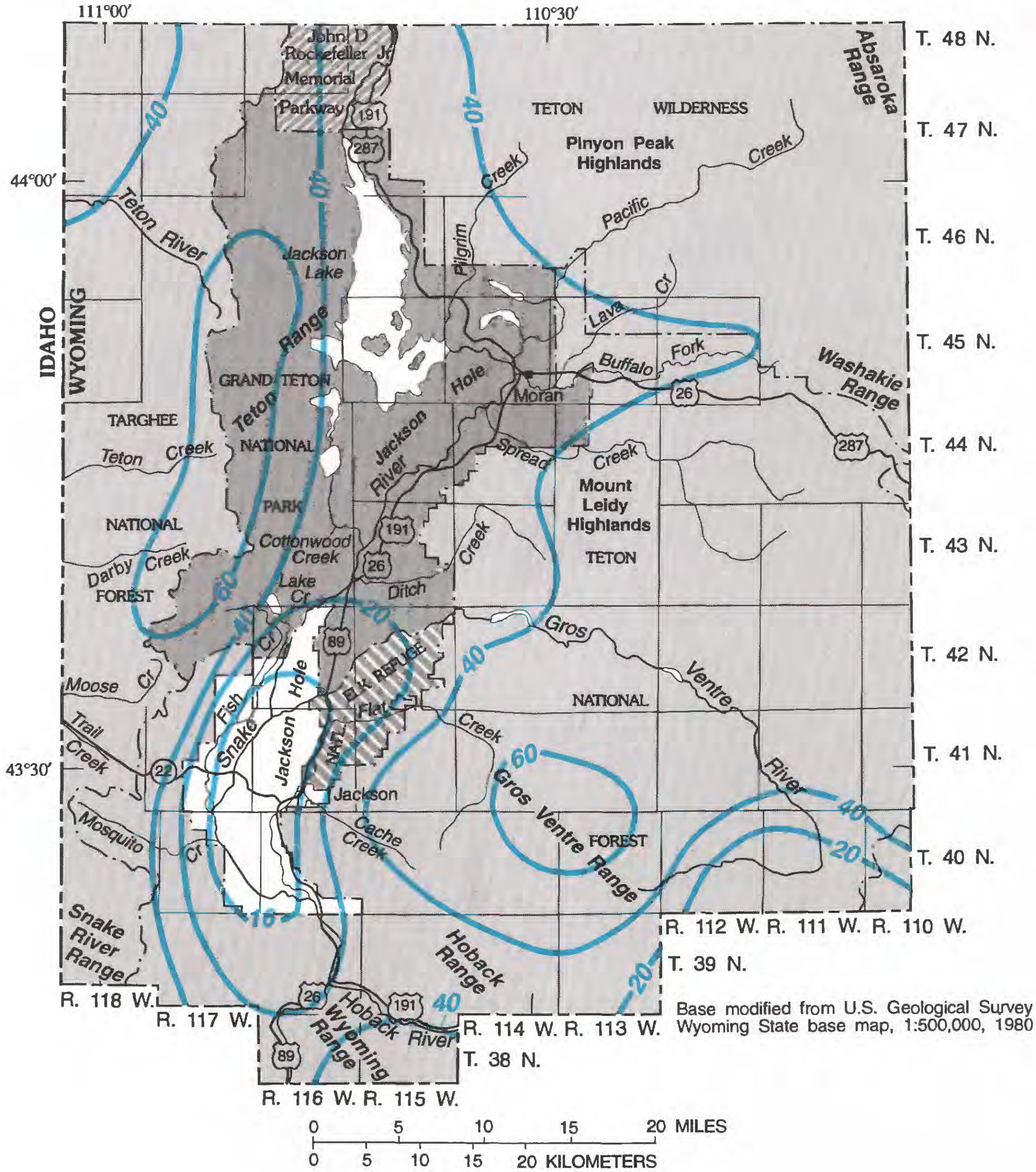
Generalized Geology

The physiography and surficial geology of Teton County, located in the Middle Rocky Mountain physiographic province, is the result of geologic processes beginning during the Laramide orogeny and continuing through recent times. Bedrock crops out throughout the study area (pl. 1). In the northern part of the study area, a high-altitude plateau was created by volcanic rhyolite flows of Quaternary age originating in the Yellowstone area (Love and Reed, 1968, p. 103; Love and Christiansen, 1985). The southern part of Teton, Snake River, Hoback, Salt River, and Wyoming Ranges compose the thrust belt south of the study area. The Washakie Range and Absaroka Range are located in the northeastern part of the study area. The Washakie range consists of thrust-faulted, asymmetric anticlines, and the Absaroka Range consists of andesitic and volcaniclastic rocks of Tertiary age. The Pinyon Peak and Mount Leidy Highlands, also in the northeastern part of the study area, include conglomerates of late Cretaceous and early Tertiary age (Love, 1973, p. 33). The Gros Ventre Range, located in the southeast part of the study area, is composed of thrust-faulted sedimentary rocks of Mesozoic and Paleozoic age. The Teton Range is an upthrown, tilted fault-block in the western part of the study area. Jackson Hole, in the center of the study area, is a structural basin as much as 3.1 mi deep (Behrendt and others, 1968, p. E3) formed by a tilted, downthrown fault block hinged to the east (Love and Reed, 1968, p. 37).

The oldest rocks exposed in the study area are metamorphic and igneous rocks of Precambrian age in the Teton, Washakie, and Gros Ventre Ranges (pl. 1). The largest outcrop is predominantly metamorphic and is in the Teton Range (Bradley, 1956, p. 34-42). Intrusive granites in the layered gneisses and schists of the Teton Range are an estimated 2.5 to 2.8 billion years old (Love and Reed, 1968; Love and others, 1972).

Sedimentary rocks of Paleozoic age occur along the flanks of major uplifts in the study area (pl. 1). Dolomites, limestones, sandstones, and shales typify the shallow marine and near-shore depositional environments of the Paleozoic age. More than 5,000 ft of sediments were deposited during the Paleozoic era (Love and others, 1972). Rocks deposited during all of the Paleozoic except those of the Silurian are exposed on the west flank of the Teton Range (Love and Reed, 1968, p. 66). During late Silurian time, northwestern Wyoming was part of a broad uplift causing all Silurian rocks to be eroded from the Teton region (Love and others, 1972). Other Paleozoic rocks crop out in the Washakie, Gros Ventre, Wyoming, and Snake River Ranges.

Sedimentary rocks of Mesozoic age are exposed in the Gros Ventre Range (pl. 1). About 8,000 ft of sediments were deposited during the Mesozoic Era (Love and others, 1972). Rock lithology differs, owing to the depositional and transitional nature of the shallow seas and the near-shore and continental environments. Mesozoic rocks consisting of marine shale crop out in the northeastern part of the study area.



EXPLANATION

—40— LINE OF EQUAL MEAN ANNUAL PRECIPATION--
Intervals 4 and 20 inches

Figure 2. Mean annual precipitation for Teton County study area, Wyoming, 1951-80 (modified from Martner, 1986, figure 6.1).

Sedimentary and volcanic rocks of Cenozoic age are exposed in much of the study area (pl. 1). Tertiary rocks include thick nonmarine conglomerates eroded from rapidly uplifted blocks and volcanic rocks derived from the Yellowstone and Absaroka Range volcanic areas (Love and Reed, 1968, p. 98). Quaternary deposits, the youngest units in the study area, include volcanic rocks and unconsolidated fluvial, glacial, and terrace deposits of variable thickness. Quaternary deposits in central-western Jackson Hole are an estimated 4,000-7,000 ft thick (Pierce and Good, 1992, p. 4), and Holocene deposits in Jackson Hole are an estimated 400 ft thick (Behrendt and others, 1968).

Water-Right Administration

By Richard G. Stockdale, Wyoming State Engineer's Office

According to article 8, section 1 of the Wyoming State constitution, "The water of all natural streams, springs, lakes or other collections of still water, within the boundaries of the state, are hereby declared to be property of the state." Anyone desiring to use water beneficially in Wyoming must apply for and obtain an approved permit from the State Engineer to appropriate water prior to initiating construction of water-diversion structures, such as dams, headgates, spring boxes, and wells. Once a permit to appropriate water has been obtained from the State Engineer, the permittee may proceed with construction of the water-diversion works and with beneficial use of the diverted water for the purposes specified in the permit. Such diversion and beneficial use must be made in accordance with statutory provisions. After the permittee has beneficially used the diverted water for all of the permitted uses at all of the permitted point(s) or area(s) of use, proof of beneficial use is filed, and the water right is adjudicated (finalized). The adjudication process fixes the location of the water-diversion structure, the use, quantity, and points or areas of use for the water right.

Wyoming water rights are administered using the Doctrine of Prior Appropriation, commonly referred to as the "First in time, first in right" system. Article 8, section 3 of the Wyoming constitution states: "Priority of appropriation for beneficial uses shall give the better right." The priority date of an appropriation is established as the date when the application for permit to appropriate water is received in the State Engineer's Office.

Water-right administration is conducted by the State Engineer and the Water Division Superintendents. Article 8, section 5 of the Wyoming constitution provides for the appointment of a State Engineer, and section 4 provides for the creation of four Water Divisions in the State and the appointment of a superintendent in each division. The State Engineer is Wyoming's chief water-administration official and has general supervision of all waters of the State. The superintendents, along with their staff of hydrographers and water commissioners, are responsible for the local administration of water rights and the collection of hydrologic data in their respective divisions.

Deviations from the standard water-right administrative system of "First in time, first in right" might exist. Such deviations might be caused by conditions in compacts, court decrees, and treaties or through the creation of special water-management districts. Virtually every stream exiting the State is subject to a compact, court decree, or treaty that dictates to some degree how the appropriations on that specific stream are administered. While the interstate nature of ground water and the interconnection of ground water with streams are recognized, the development of interstate agreements on use of water from aquifers is still in its infancy. The reason that few ground-water compacts exist is twofold. First, there is a lack of sound technical data on which to base appropriate administrative allocations of ground water between adjoining states, and second, there is not sufficient competition between Wyoming and adjoining states to require binding interstate agreements or allocations of ground-water resources.

Acknowledgments

The authors gratefully acknowledge the generous assistance of numerous ranchers and landowners in the county who provided access to their property, wells, and springs.

SURFACE WATER

The principal stream in Teton County is the Snake River, which generally flows southwestward from Jackson Lake in the north-central part of the study area (fig. 1). Major tributaries to the Snake River include Buffalo Fork and the Gros Ventre River. Buffalo Fork drains much of the northeastern part of the study area, and the Gros Ventre River drains the central part. Additional tributaries include Flat Creek, which drains the south-central part of the study area, and Fish Creek, which drains the area between the Teton Range and the Snake River. Only streamflow data and characteristics are described in this section; description of lake characteristics is beyond the scope of this report.

Streamflow Data

Streamflow data often are required to plan, design, or manage water uses and developments associated with streams. Streamflow-gaging or sampling stations commonly are installed and operated on principal streams to obtain needed data. Streamflow data are collected at the stations continuously or periodically.

Streamflow data generally are collected at continuous-record gaging stations, where water-level sensing equipment and a recorder are housed in a streamside shelter. A continuous record of stage is obtained with the water-level sensing equipment (Carter and Davidian, 1989, p. 2). Discharge is measured at various stages to define the relation between stage and discharge. The discharge record commonly is compiled to express mean daily, monthly, or yearly discharge rates or volumes. Instantaneous peak flows and total runoff for a particular period also can be determined from the records. The locations of current streamflow-gaging stations are shown on plate 2, and selected flow characteristics are presented in table 1.

Streamflow data are sometimes required for locations lacking streamflow-gaging stations. Determination of water gain or loss from seepage in a particular stream reach requires measurements of discharge at several locations along the reach. Locations where only one or a few measurements have been obtained are designated miscellaneous streamflow sites. Locations of miscellaneous streamflow sites are shown on plate 2, and related information is presented in table 2.

Additional information about the streamflow-gaging stations and miscellaneous streamflow sites in the county can be obtained from the computer files and published reports of the U.S. Geological Survey. Inquiries should be directed to the District Chief, U.S. Geological Survey, WRD, 2617 E. Lincolnway, Suite B, Cheyenne, Wyoming 82001.

Streamflow Characteristics

Most streams in Teton County originate in the mountains and are perennial, although some streams are intermittent along a particular reach in some years. Streams classified as perennial flow throughout the year, whereas streams classified as intermittent cease to flow occasionally or seasonally because evaporation and leakage to ground water exceed the available water supply (Lapedes, 1976, p. 765). Streamflow hydrographs can be used to determine stream types. Perennial streams are indicated by seasonal responses to snowmelt runoff, followed by a period of sustained flow. Regulated perennial streams, which have dams or are diverted for irrigation use, have unnatural-looking hydrographs that lack responses to individual rainfall events and periods of snowmelt runoff. Sporadic-flow pulses resulting from snowmelt runoff or rainfall usually indicate intermittent streams. Assigning a stream type can be somewhat arbitrary because it depends on the stream reach being considered and the length of time the stream has been observed (Lowham, 1985). A stream might be perennial in upstream reaches and intermittent in downstream reaches.

Table 1. *Selected streamflow-gaging stations and records of peak and mean discharges in the Teton County study area, Wyoming*

[Site number: simplified site number used in this report to identify location of streamflow-gaging stations. Station number: assigned by U.S. Geological Survey to locations where streams are regularly measured or sampled. The first two digits identify the major basin in which the station is located. The remaining six digits identify the relative location. mi^2, square miles; ft^3/s, cubic feet per second]

Site number (pl. 2)	Station number	Station name	Drainage basin area (mi^2)	Period of record: Daily or monthly discharge (calendar years)	Period of record: Instantaneous annual peak discharge (water years)	Instantaneous peak discharge for period of record: Date	Instantaneous peak discharge for period of record: Discharge (ft^3/s)	Mean discharge for period of record (ft^3/s)
1	13010065	Snake River above Jackson Lake, at Flagg Ranch	486	1987-present	1984-92	5/31/84	11,000	803
2	13011000	Snake River near Moran	807	1903-present	1904-67; 1971-92	6/12/18	15,100	1,438
3	13011500	Pacific Creek at Moran	169	1906; 1917-18; 1944-75; 1978-present	1918; 1945-75; 1978-92	5/29/83	5,350	261
4	13011900	Buffalo Fork above Lava Creek, near Moran	323	1965-present	1966-92	6/09/81	6,540	534
5	13015000	Gros Ventre River at Zenith[1]	683	1917-18; 1987-present	1917; 1988-92	6/07/91	3,400	--[2]
6	13018000	Flat Creek near Jackson[1]	40.7	1933-41; 1989-present	1933-41; 1989-92	6/15/35	438	--[2]
7	13018300	Cache Creek near Jackson	10.6	1962-present	1945-92	6/24/71	225	12.9
8	13018350	Flat Creek below Cache Creek, near Jackson[1]	129	1989-present	1989-92	6/16/91	233	--[2]
9	13018500	Flat Creek near Cheney[1]	144	1917-18; 1989-present	1918; 1989-92	6/13/18	500	--[2]
10	13018750	Snake River below Flat Creek, near Jackson	2,627	1975-present	1978-92	6/06/86	25,600	3,511

[1]No winter record, data based on available records.

[2]Not calculated because no winter record exists.

Table 2. *Miscellaneous streamflow sites in Teton County study area, Wyoming*

[Site number: simplified site number used in this report to identify miscellaneous streamflow sites. Miscellaneous streamflow site number: assigned by U.S. Geological Survey to locations where only one or a few measurements or samples have been obtained. The first six digits designate latitude of the site, the next seven digits designate longitude, and the last two digits are sequence numbers to distinguish between several sites that may be in close proximity of one another: mi, miles]

Site number (pl. 2)	Miscellaneous streamflow site no.	Location (degrees, minutes, seconds)		Site name
		Latitude	Longitude	
11	435017110304201	43 50 17	110 30 42	Buffalo Fork at Moran, east of Highway 191/89
12	434730110322101	43 47 30	110 32 21	Spread Creek at Highway 191/89
13	434050110425001	43 40 50	110 42 50	Cottonwood Creek 1.75 mi. north of Moose, east of Teton Park Road
14	433931110424001	43 39 31	110 42 40	Snake River 0.25 mi. north of Moose at historic ferry crossing
15	433555110414201	43 35 55	110 41 42	Gros Ventre River 2.5 mi. east of Gros Ventre Junction
16	433005110521301	43 30 05	110 52 13	Fish Creek at Wilson, where Wilson-North Road crosses Fish Creek
17	432813110522701	43 28 13	110 52 27	Fish Creek 2 mi. south of Wilson, east of Wilson-Fall Creek Road at wooden bridge
18	432752110515801	43 27 52	110 51 58	Fish Creek 2.5 mi. south of Wilson, east of Wilson-Fall Creek Road
19	432628110515001	43 26 28	110 51 50	Mosquito Creek at Wilson-Fall Creek Road

The Snake River above Jackson Lake, at Flagg Ranch (site 1) is an example of a nonregulated, perennial stream (fig. 3). The hydrograph shows responses to rainfall events and also the characteristic period of snowmelt runoff from April to June 1992, followed by sustained flow. In contrast, the hydrograph for the Snake River near Moran (site 2) indicates a flow-dampening effect resulting from the pattern of streamflow regulation at Jackson Lake Dam. The sudden increase in streamflow in May for site 2 indicates release of additional water for irrigation and recreational uses.

The Gros Ventre River at Zenith (site 5) flowed intermittently at various times in water years 1988 and 1992. (A water year, which begins October 1 and ends the following year on September 30, is designated by the year in which it ends.) There was no flow at this location during September 9-17, 1988, and during September 1-13, 1992 (Druse and others, 1993, p. 457). An example of a period of intermittent flow is shown for water year 1992 in the hydrograph presented in figure 3. Several factors might have caused the Gros Ventre River to flow intermittently at the Zenith location in water years 1988 and 1992. The county has received less precipitation than normal since 1988. Water is diverted from the Gros Ventre River west of Kelly to supply irrigation water to the southern part of Jackson Hole. Additionally, the Gros Ventre River is a losing stream at site 5, southwest of Gros Ventre Junction.

Data are insufficient to determine whether flows were intermittent before 1987 in the Gros Ventre River at Zenith. Besides the current record (1987-present), the only years of record for this gaging station are 1917-18. In 1917-18, streamflow data were collected only during July-September. The minimum observed flow during the 1917-18 period was 121 ft^3/s, which occurred on September 6, 1918.

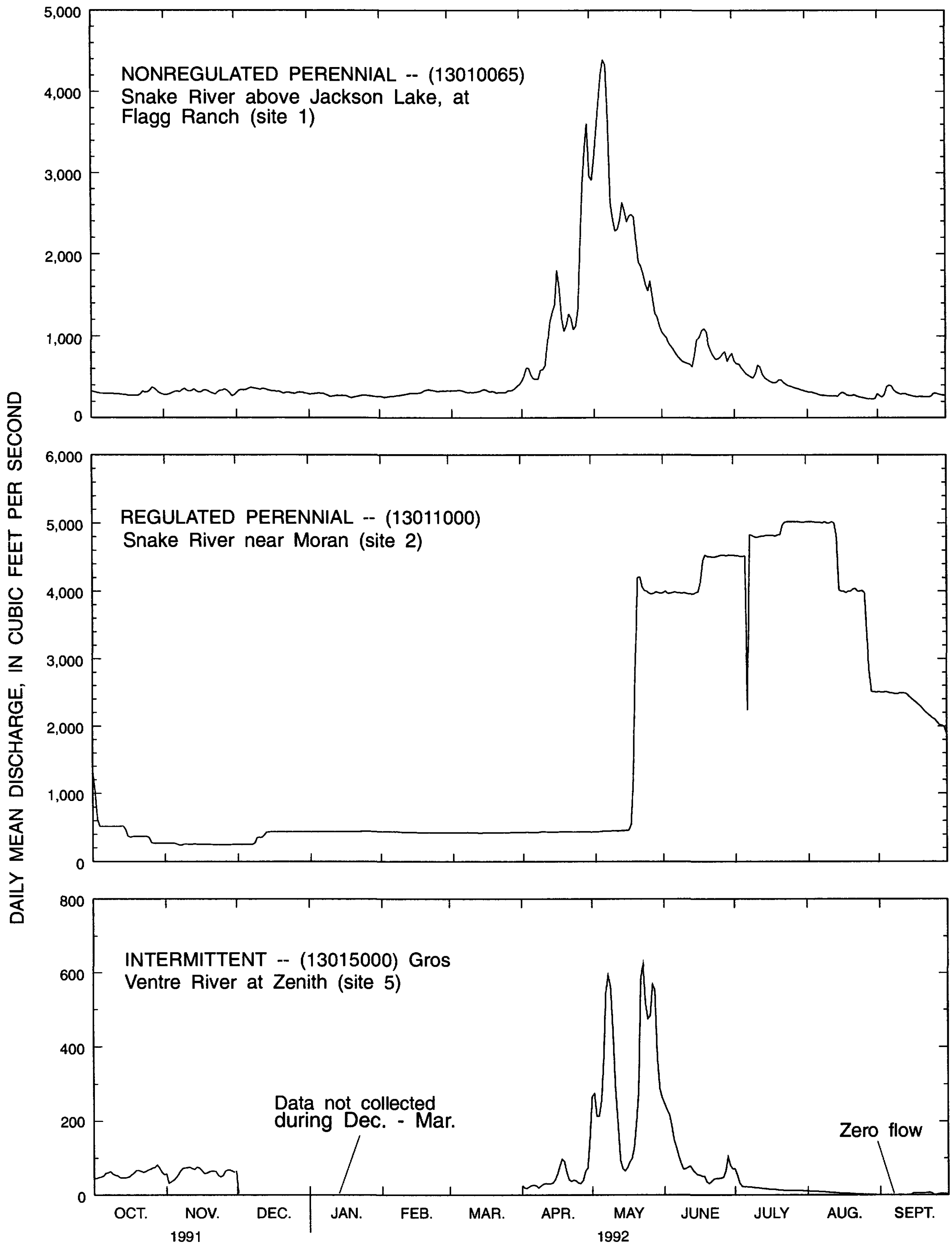


Figure 3. Daily mean discharge for selected nonregulated and regulated perennial and intermittent streams in Teton County study area, Wyoming, water year 1992.

Flow Duration

Flow-duration curves were used to evaluate streamflow variability for the Snake River above Jackson Lake, at Flagg Ranch (site 1) and near Moran (site 2), and for Buffalo Fork above Lava Creek, near Moran (site 4). The flow-duration curve is a cumulative-frequency curve that shows the percentage of time that daily mean discharges were equalled or exceeded during a particular period (Searcy, 1959, p. 1). The curve does not account for the chronological sequence of hydrologic events, but combines the flow characteristics of a stream throughout its range of discharge. The flow-duration curve applies only to the period of record on which it is based. Streamflow records for complete years of record were used to develop the flow-duration curves. Although the years need not be consecutive, the records used typically represent periods when human influences such as reservoir storage and irrigation diversions remain unchanged.

The shape of a flow-duration curve indicates streamflow variability (Searcy, 1959, p. 22). A flat slope on the curve indicates the presence of surface- or ground-water storage, whereas a steeper slope on the curve indicates flow primarily is from direct runoff.

The slope of the flow-duration curve also indicates the degree of streamflow variability. Streamflow variability depends on variations in the climate, physiography, geology, and land use of a drainage basin. The distribution of high flows is controlled primarily by the climate, physiography, and land use of the basin, whereas the distribution of low flows is controlled primarily by the geology of the basin. The effect of variable precipitation is reduced by storage, either as surface or ground water.

The flat slope in the high-flow section of flow-duration curves for the Snake River above Jackson Lake, at Flagg Ranch (site 1) and near Moran (site 2), and for Buffalo Fork above Lava Creek, near Moran (site 4) indicates that high flows come primarily from snowmelt (fig. 4). The flat slope in the low-flow section (probability greater than about 50 percent) of the curves for the Snake River above Jackson Lake, at Flagg Ranch and Buffalo Fork above Lava Creek, near Moran indicates continuous ground-water discharge to the streams. In contrast, the steep slope in the low-flow section of the curve for the Snake River near Moran, a regulated perennial stream, indicates greater streamflow variability over the period of record analyzed (1918-92). The variability at site 2 might have resulted from changing patterns of water release from Jackson Lake Dam. Because the pattern of water release is changing, the flow-duration curve for this site is not reliable for indicating future streamflow characteristics.

High Flow

Perennial streams in the study area generally have a period of high flow in April, May, and June as snowpack melts in the mountains. Daily fluctuations in flow are typical during snowmelt periods, with successive daily flows increasing as daylight hours lengthen and temperatures increase. This pattern, if uninterrupted by changing weather conditions, continues until peak flow occurs. Weather conditions can have a significant effect on snowmelt runoff, thus making prediction of peak flows difficult.

High flows on regulated streams or streams with diversions are affected by several factors. Maximum flows may be the result of snowmelt runoff, rainfall runoff, reservoir release, or a combination of these factors. Diversions can reduce flows during the irrigation season, thereby reducing peak discharges.

Maximum instantaneous (peak) discharges recorded at streamflow-gaging stations in the county are given in table 1. The table also lists drainage area upstream from the station and period of record. For stations currently in operation (water year 1993), the peak discharge listed in table 1 is based on records that are complete through water year 1992, ending September 30, 1992.

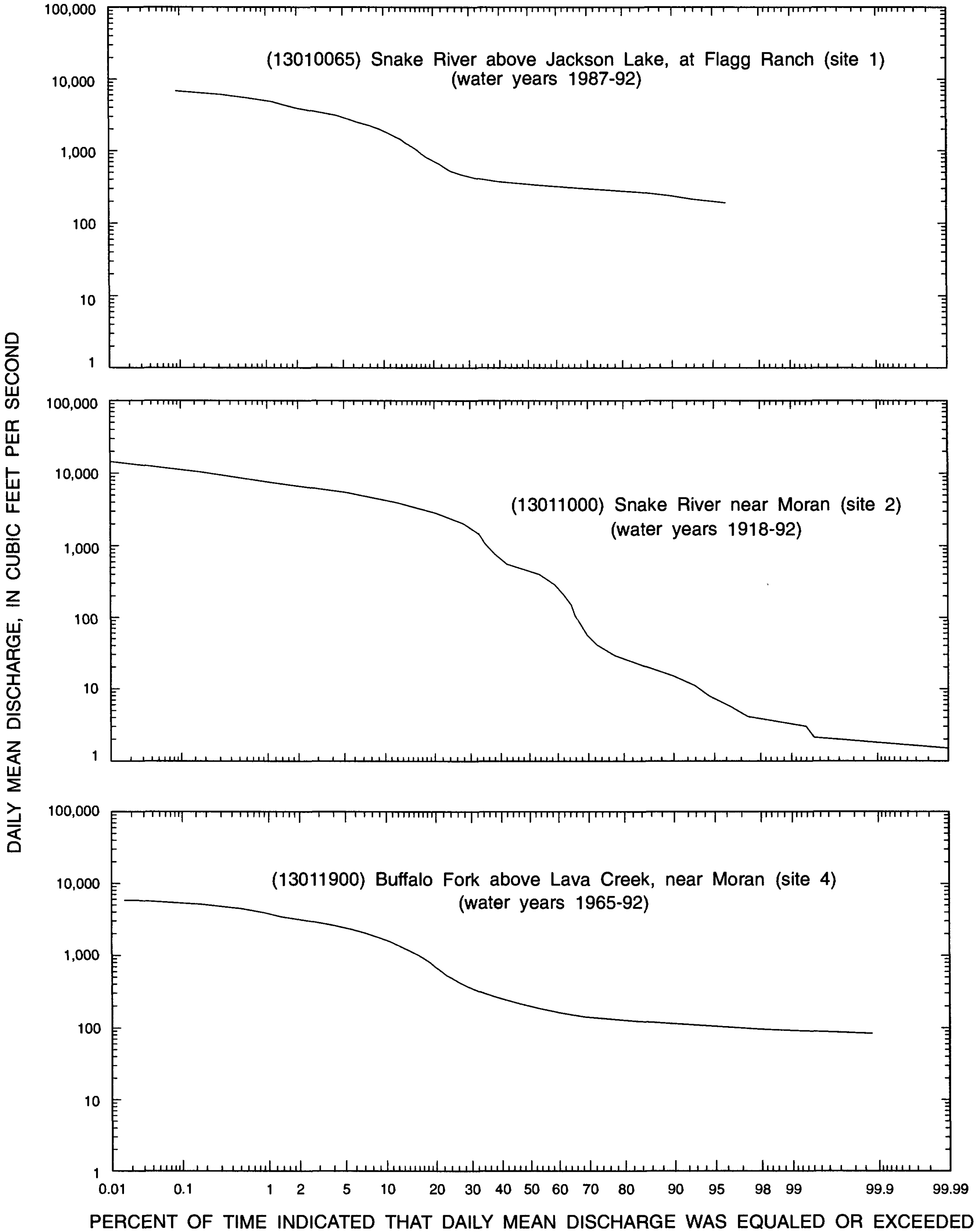


Figure 4. Flow-duration curves for selected surface-water stations in Teton County study area, Wyoming. (Period of record for each curve is indicated in water years.)

Annual peak discharge on the Snake River near Moran (site 2) for water years 1904-92 are presented in figure 5. The discharges were graphed for this period to help determine the effect of dam regulation on high flow. The data indicate that annual peak discharge generally decreased after water year 1918. The apparent reduction in annual peak discharge is consistent with the history of Jackson Lake Dam. A concrete-gravity dam with earth-embankment wings was built in 1917 (U. S. Army Corps of Engineers, 1989, p. 5). The dam was reconstructed and restored in 1988.

Because high flows on the Snake River have been attenuated by streamflow regulation at Jackson Lake Dam, related statistics were not compiled in this study. High-flow statistics can be developed using streamflow data (indexed in table 1) for daily mean discharge. Individual annual maximum discharges are needed for flood-frequency analysis. These data are available in the streamflow records. The interested reader is referred to Lowham (1988) and Peterson (1988).

Low Flow

Frequency analysis of low-flow data yields information on the adequacy of water supplies for irrigation, municipal, industrial, and waste-disposal uses, and instream fisheries (Riggs, 1989, p. 1). Low-flow statistics were compiled for streams in the study area because irrigation is one of the main uses of surface water in Teton County. Water is diverted from the Snake River, Buffalo Fork, and Gros Ventre River for irrigation use.

An index used to describe low-flow characteristics of streams is the lowest mean discharge averaged over 7 consecutive days and having a recurrence interval of 20 years or less. This index is referred to as the 7-day low-flow discharge. Seven-day low-flow discharges and corresponding recurrence intervals and nonexceedance probabilities are shown for selected streams in table 3. The low-flow statistics were compiled only for streams having more than 20 years of record. This length of record is considered desirable when defining the 20-year recurrence-interval annual-minimum flow (Riggs, 1989, p. 6).

An example is Buffalo Fork above Lava Creek, near Moran (site 4). This site will have 7 consecutive days with daily mean discharge of 102 ft^3/s or less once in 2 years, on average, and 7 consecutive days with daily mean discharge of 87.3 ft^3/s or less once in 10 years, on average. The probability of occurrence of the 7-day low-flow discharge is the inverse of the recurrence interval, and vice versa. There is a 50-percent chance (0.50 probability) that the 2-year, 7-day low flow will occur in any given year, and a 10-percent chance (0.10 probability) that the 10-year, 7-day low flow will occur in any given year.

In the case of regulated streams, computation of recurrence intervals from nonexceedance probabilities is appropriate only if the pattern of streamflow regulation has been consistent for several years. The Snake River near Moran (site 2) is regulated by the Jackson Lake Dam. Because the pattern of streamflow regulation by the dam apparently has changed with time, recurrence intervals need to be regarded with caution.

GROUND WATER

The quantity and quality of ground water in the Teton County study area varies within and between geologic units according to the physical and geochemical properties of the rocks. Porosity, a measure of void space in rock, and permeability, the ability of a porous medium to transmit fluids, are important physical properties affecting the amount of water stored in and yielded by a geologic unit. The lithology and water-yielding characteristics of geologic units exposed in the study area are described in table 4, and the spatial distribution of these units is shown on plate 1. Results of water-quality analyses of samples collected from wells completed in and springs issuing from geologic units in the study area are described in the water-quality section of this report.

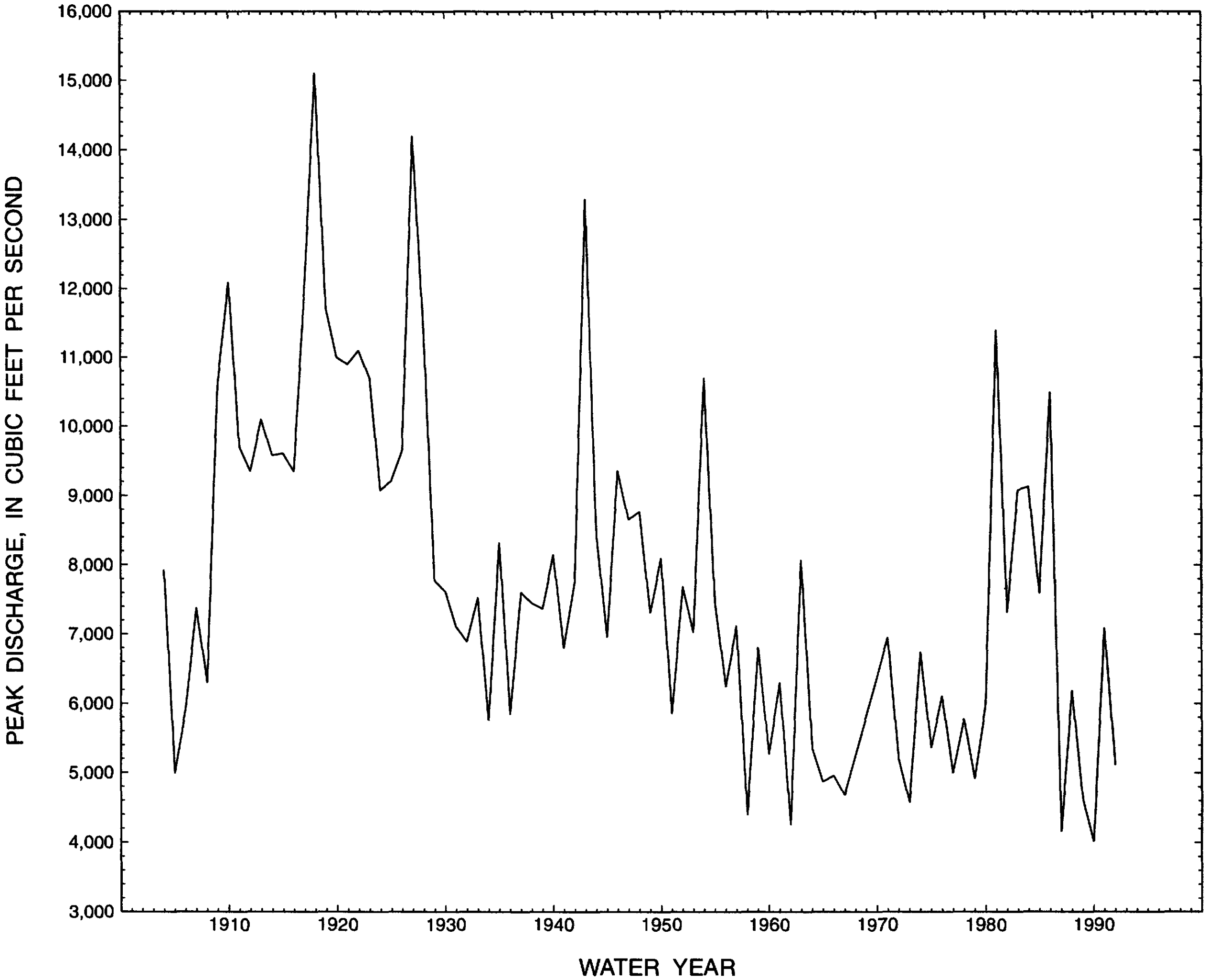


Figure 5. Annual peak discharge on the Snake River near Moran, Wyoming (site 2), water years 1904-92.

Table 3. *Seven-day low-flow discharges through 1992 for selected streamflow-gaging stations in Teton County study area, Wyoming*

[Site number: simplified site number used in this report to identify location of streamflow-gaging stations. Station number: assigned by U.S. Geological Survey to locations where streams are regularly measured or sampled. The first two digits identify the major basin in which the station is located. The remaining six digits identify the relative location. mi^2, square miles; ft^3/s, cubic feet per second]

Site number (pl. 2)	Station number	Station name	Drainage area (mi^2)	Length of record (years)	Seven-day low-flow discharge (ft^3/s) for indicated recurrence interval (years); (nonexceedance probability)							
					1.01 (0.99)	1.25 (0.80)	2 (0.50)	5 (0.20)	10 (0.10)	20 (0.05)	50 (0.02)	100 (0.01)
2	13011000	Snake River near Moran[1]	807	88	1,700	134	34.1	9.20	4.74	2.77	1.53	1.04
3	13011500	Pacific Creek at Moran	169	47	61.7	43.8	36.1	29.7	26.8	24.6	22.4	21.0
4	13011900	Buffalo Fork above Lava Creek, near Moran	323	26	129	111	102	92.1	87.3	83.4	79.1	76.2
7	13018300	Cache Creek near Jackson	10.6	29	4.29	3.94	3.49	2.88	2.51	2.20	1.86	1.64

[1]Recurrence intervals need to be regarded with caution because the pattern of streamflow regulation by the dam apparently has changed with time.

Table 4. *Lithologic and water-yielding characteristics of geologic units in Teton County study area, Wyoming*

(Series, geologic unit, and lithology modified from Love and Christiansen, 1985 unless otherwise noted)

[ft, feet; gal/min, gallons per minute; <, less than; >, greater than; --, no data; Ma, millions of years]

Erathem	System	Series	Geologic unit (pl. 1)	Approximate thickness (ft)	Lithology	Water-yielding characteristics[1]	Reported[1], estimated, or measured water yield
Cenozoic	Quaternary	--[2]	Alluvium and colluvium	0->[3]400	Unconsolidated clay, silt, sand, and gravel. Alluvium associated with modern streams and includes flood-plain, fan, and terrace deposits. Colluvium derived from underlying and adjacent units generally associated with slope deposits.	Yields as much as several gal/min from some springs.[4]	Reported yields ranged from a few to 3,000 gal/min per well. Smallest measured well yield was 1.3 gal/min.
Cenozoic	Quaternary	--[2]	Gravel, pediment, and fan deposits	--	Unconsolidated locally derived sand and gravel. Includes some glacial deposits and may include Tertiary gravels.	--	Reported yields ranged from a few to 1,650 gal/min per well.
Cenozoic	Quaternary	--[2]	Glacial deposits	0->[5]200	Unconsolidated till and outwash of clay, silt, sand, gravel, and boulders. Till generally unstratified and poorly sorted. Silt as much as 50 ft thick in local depressions in outwash south of Jackson Lake.[6]	--	Estimated spring yield was 5 gal/min. Measured well yield was 80 gal/min.
Cenozoic	Quaternary	--[2]	Landslide deposits	0-[4]100	Unconsolidated poorly sorted deposits ranging from clay to boulders. Includes intermixed landslide, glacial, talus, and rock-glacier deposits.	Probably would not yield more than a few gal/min per well. Yields water to numerous springs.[4]	--
Cenozoic	Quaternary	--[2]	Undifferentiated surficial deposits	--	Mostly alluvium, colluvium, and glacial and landslide deposits.	--	--
Cenozoic	Quaternary	--[2]	Basalt flows and intrusive igneous rocks	--	Medium- to light-gray basalt containing moderately abundant plagioclase phenocrysts.[7]	May yield a few tens of gal/min per well from brecciated zones and fractures.[4]	--

Table 4. *Lithologic and water-yielding characteristics of geologic units in Teton County study area, Wyoming--Continued*

Erathem	System	Series	Geologic unit (pl. 1)	Approximate thickness (ft)	Lithology	Water-yielding characteristics[1]	Reported[1], estimated, or measured water yield
Cenozoic	Quaternary	Pleistocene[6]	Rhyolite flows, tuff, and intrusive igneous rocks	[6]at least 700	Lava Creek Tuff of the Yellowstone Group is gray to brown, welded rhyolite ash-flow. Lewis Canyon Rhyolite is devitrified flow containing phenocrysts of quartz, plagioclase, sanidine, and clinopyroxene.[6]	May yield a few tens of gal/min per well from porous and fractured zones.[4]	--
Cenozoic	Quaternary and/or Tertiary	Pleistocene and/or Pliocene	Conglomerate	[6]as much as 400	Paleozoic clasts in a lithified carbonate matrix.	May yield a few tens of gal/min per well.	--
Cenozoic	Tertiary	Pliocene	Huckleberry Ridge Tuff of Yellowstone Group	0-[6]1,500	Lavender to grayish-brown, welded and devitrified rhyolitic ash-flow tuff containing abundant phenocrysts of quartz, sanidine, and sodic plagioclase, sparse opaque oxides, clinopyroxene, and fayalitic olivine.[6]	May yield a few tens of gal/min per well from porous and fractured zones.	Estimated yield ranged from 3 to 5 gal/min for 2 springs.
Cenozoic	Tertiary	Pliocene and Miocene	Intrusive and extrusive igneous rocks	0-[6]800	Includes gray, porphyritic andesite flows; light-gray to tan, fine-grained rhyolite intrusions; and medium- to dark-gray fine-grained dacite flows.[6]	Probably would not yield more than a few gal/min per well.	Measured well yield was 50 gal/min.
Cenozoic	Tertiary	Pliocene	Heart Lake Conglomerate	--	Abundant gray limestone and dolomite clasts and sparse rhyolite and quartzite clasts in a talc and clay matrix.	--	--
Cenozoic	Tertiary	Pliocene	Shooting Iron Formation	[6]>100	Greenish-gray to pink, tuffaceous, lacustrine and fluviatile claystone and siltstone, fine-grained sandstone, and conglomerate.	--	--
Cenozoic	Tertiary	Lower Pliocene[6] and Miocene	Conant Creek Tuff	0-[6]300	Gray to buff and pale-lavender, phenocryst-poor, welded rhyolite tuff.[6]	--	--
Cenozoic	Tertiary	Miocene	Teewinot Formation	[6]>6,000	White to light-gray, porous limestone, claystone, and pumicite. Upper part is thin-bedded claystone, marlstone, and tuff; middle part is conglomerate of limestone, quartzite, and obsidian clasts as much as 110 ft thick; lower two-thirds is nodular porous limestone in beds 100-200 ft thick interbedded with pumicite beds 20-75 ft thick.[6]	--	Yields as much as 120 gal/min per well from fractures and solution channels in limestone.[4] Estimated spring yield was 5 gal/min and measured well yield was 17.4 gal/min.

Table 4. *Lithologic and water-yielding characteristics of geologic units in Teton County study area, Wyoming--Continued*

Erathem	System	Series	Geologic unit (pl. 1)	Approximate thickness (ft)	Lithology	Water-yielding characteristics[1]	Reported[1], estimated, or measured water yield
Cenozoic	Tertiary	Miocene	Camp Davis Formation	[8]about 5,200	Upper part is red, well-consolidated, calcareous conglomerate; middle part is poorly consolidated, calcareous conglomerate interbedded with silty and sandy mudstone; lower part is brownish-gray, well-cemented, calcareous, sandy conglomerate.[8]	May yield a few tens of gal/min per well from conglomerate.[4]	--
Cenozoic	Tertiary	Miocene	Colter Formation	[4]<7,000	Upper part is light-gray, green, and brown tuff, sandstone, claystone, and mafic volcanic conglomerate; lower part is light-gray tuffaceous, massive to irregularly bedded, poorly cemented sandstone.[6]	May yield a few gal/min per well from conglomerate, sandstone, and fractures in basalt and andesite.[4]	Estimated yield of spring was 1 gal/min.
Cenozoic	Tertiary	Eocene	Intrusive igneous rocks	--	Felsic and mafic igneous bodies.	--	--
Cenozoic	Tertiary	Eocene	Wiggins Formation (Thorofare Creek Group, Absaroka Volcanics Supergroup)	0-[6]70	Light-gray, volcanic conglomerate, white tuff, and yellow, white, red, green, and pink bentonitic claystone.[6]	Probably would not yield more than a few gal/min per well.	
Cenozoic	Tertiary	Eocene	Tepee Trail Formation[9] (Thorofare Creek Group, Absaroka Volcanics Supergroup)	--	Green and olive-drab, hard andesitic conglomerate, sandstone, and claystone.	Probably would not yield more than a few gal/min per well.	Estimated yield of spring was 50 gal/min.
Cenozoic	Tertiary	Eocene	Two Ocean and Langford Formations (Thorofare Creek Group, Absaroka Volcanics Supergroup)	--	Dark-colored, andesitic volcaniclastic rocks and flows underlain by light-colored, andesitic tuffs and flows.	Probably would not yield more than a few gal/min per well.	--

Table 4. *Lithologic and water-yielding characteristics of geologic units in Teton County study area, Wyoming--Continued*

Erathem	System	Series	Geologic unit (pl. 1)	Approximate thickness (ft)	Lithology	Water-yielding characteristics[1]	Reported[1], estimated, or measured water yield
Cenozoic	Tertiary	Eocene	Aycross Formation (Thorofare Creek Group, Absaroka Volcanics Supergroup)	--	Variegated, bentonitic claystone and tuffaceous sandstone grading laterally into greenish-gray sandstone and claystone.	Probably would not yield more than a few gal/min per well.	--
Cenozoic	Tertiary	Eocene	Trout Peak Trachyandesite (Sunlight Group, Absaroka Volcanics Supergroup)	--	Regional lithologic description of this unit not available.[10]	Probably would not yield more than a few gal/min per well.	--
Cenozoic	Tertiary	Eocene	Hominy Peak Formation (Absaroka Volcanics Supergroup)	[6]as much as 2,000	Mafic, volcaniclastic conglomerate and tuff. Upper part is sparse claystone; base is gold-bearing quartzite conglomerate.	Probably would not yield more than a few gal/min per well.	--
Cenozoic	Tertiary	Eocene	Volcanic conglomerate	--	Dark-brown to black, poorly bedded conglomerate consisting of basalt clasts in a basaltic tuff matrix.	--	--
Cenozoic	Tertiary	Eocene	Wind River Formation	--	Variegated, red and white claystone and siltstone. Upper part is tuffaceous; lenticular coal unit in middle of unit.	--	--
Cenozoic	Tertiary	Paleocene	Hoback Formation	[4]<15,000	Interbedded gray sandstone and claystone containing thick red and gray conglomerate.	May yield a few tens of gal/min per well from sandstone.[4]	--
Cenozoic	Tertiary	Paleocene	Devils Basin Formation	--	Light-gray sandstone interbedded with green and gray claystone, sparse coal, and carbonaceous shale.	--	--
Cenozoic and Mesozoic	Tertiary and Cretaceous	Paleocene and Upper Cretaceous	Pinyon Conglomerate	0-[6]3,800	Rusty-brown conglomerate composed of quartzite roundstones in matrix of rusty coarse-grained sandstone containing gold flakes. Sporadic boulders of older conglomerate and quartzite are 5-8 ft in diameter.[6]	May yield a few tens of gal/min per well.[4]	--

Table 4. *Lithologic and water-yielding characteristics of geologic units in Teton County study area, Wyoming--Continued*

Erathem	System	Series	Geologic unit (pl. 1)	Approximate thickness (ft)	Lithology	Water-yielding characteristics[1]	Reported[1], estimated, or measured water yield
Mesozoic	Cretaceous	Upper Cretaceous	Harebell Formation	[6]as much as 10,000	Conglomerate consisting of quartzite roundstones in matrix of brown gold-bearing sandstone; brown, gray, and dull green, silty, hard, tuffaceous sandstone, rich in magnetite; gray, dark green, black and mustard yellow, silty, tuffaceous claystone; and marine or brackish-water fossils in some horizons.[6]	May yield a few tens of gal/min per well from conglomerate and sandstone.[4]	Measured discharge of well was 12 gal/min.
Mesozoic	Cretaceous	Upper Cretaceous	Meeteetse Formation	[6]about 1,000	White to gray sandstone interbedded with yellow, green, and dark-gray carbonaceous shale, claystone, white tuff, thin coal beds, and yellow to gray bentonite beds.[6]	May yield a few tens of gal/min per well from sandstone.[4]	--
Mesozoic	Cretaceous	Upper Cretaceous	Mesaverde Formation	0-[6]1,000	White, massive to thick-bedded, porous, medium- to coarse-grained sandstone interbedded with thin gray shale and sparse impure coal and bentonite beds. Sections southwest of Moran Junction contain conglomerate beds of as much as 50 ft thick.[6]	May yield a few tens of gal/min per well from sandstone.[4]	--
Mesozoic	Cretaceous	Upper Cretaceous	Sohare Formation	[6]as much as 2,400	Gray and brown, lenticular, fine-grained sandstone interbedded with light- and dark-gray shale and siltstone and containing thin coal beds. Largely nonmarine.[6]	May yield a few tens of gal/min per well from sandstone.[4]	--
Mesozoic	Cretaceous	Upper Cretaceous	Bacon Ridge Sandstone	1,000-[6]1,500	Tan to gray, thick-bedded, fine-grained sandstone containing abundant marine fossils. Interbedded with gray, marine and brackish-water shale and siltstone and thick coal beds. Contains thin bentonite beds in upper and lower parts. Quartzite boulder conglomerate in lower part intertongues with marine strata.[6]	May yield a few tens of gal/min per well from sandstone.[4]	Estimated spring discharge was 800 gal/min.
Mesozoic	Cretaceous	Upper Cretaceous	Cody Shale	1,400-[6]2,200	Dull-gray marine shale interbedded with lesser amounts of gray siltstone and gray, fine-grained, glauconitic sandstone and bentonite.[6]	Probably would not yield more than a few gal/min per well.[4]	--
Mesozoic	Cretaceous	Upper Cretaceous	Steele Shale	--	Gray marine shale containing numerous bentonite beds and thin lenticular sandstone.	--	--

Table 4. *Lithologic and water-yielding characteristics of geologic units in Teton County study area, Wyoming--Continued*

Erathem	System	Series	Geologic unit (pl. 1)	Approximate thickness (ft)	Lithology	Water-yielding characteristics[1]	Reported[1], estimated, or measured water yield
Mesozoic	Cretaceous	Upper Cretaceous	Frontier Formation	[4]1,000	Gray, fine- to coarse-grained sandstone. Upper part is pebbly, highly glauconitic, and interbedded with gray and black shale and thin coal beds; lower part contains bentonite beds.[6]	May yield a few tens of gal/min per well from sandstone. Yields a few gal/min to individual springs in the Gros Ventre Range.[4]	Estimated discharge of spring was 3 gal/min.
Mesozoic	Cretaceous	Lower Cretaceous	Mowry Shale	500-[6]700	Dark-gray to black, very hard, silicified, thin-bedded shale. Contains several cream-colored bentonite beds. Secondarily silicified, fine-grained sandstone common.[6]	--	--
Mesozoic	Cretaceous	Lower Cretaceous	Thermopolis Shale	55-[6]200	Black, fine-grained, soft shale. Rusty-brown to gray Muddy Sandstone Member. Upper part interbedded with black and gray siltstone and shale as much as 100 ft thick.[6]	May yield a few tens of gal/min per well from sandstone beds in Thermopolis Shale.[4]	--
Mesozoic	Cretaceous	Lower Cretaceous	Aspen Shale	[6]about 1,500	Dull-green to black, tuffaceous shale and claystone interbedded with gray and greenish-gray, hard, siliceous sandstone and dull-green claystone.[6] Contains bentonite beds.	--	--
Mesozoic	Cretaceous	Lower Cretaceous	Bear River Formation	[6]about 1,000	Greenish-gray calcareous sandstone interbedded with dark-gray to black shale. Base of unit is rusty sandstone.[6]	--	Reported discharge of well was 30 gal/min.
Mesozoic	Cretaceous and Jurassic	Lower Cretaceous and Upper and Middle Jurassic	Cloverly Formation	[4]<650	Green to gray, weathering to rusty sandstone; underlain by brightly variegated bentonitic claystone. Chert-pebble conglomerate occurs locally at base.	Cloverly and Morrison Formations undivided and probably would not yield more than a few tens of gal/min well.[4]	--
Mesozoic	Cretaceous and Jurassic	Lower Cretaceous and Upper and Middle Jurassic	Morrison Formation	[4]<650	Dully variegated claystone, nodular limestone, and gray silty sandstone.		--

Table 4. *Lithologic and water-yielding characteristics of geologic units in Teton County study area, Wyoming--Continued*

Erathem	System	Series	Geologic unit (pl. 1)	Approximate thickness (ft)	Lithology	Water-yielding characteristics[1]	Reported[1], estimated, or measured water yield
Mesozoic	Cretaceous and Jurassic	Lower Cretaceous and Upper and Middle Jurassic	Sundance Formation	[4]<700	Upper part is greenish-gray, glauconitic, very calcareous sandstone; lower part is gray, calcareous shale, clayey limestone, and red shale.	Sundance and Gypsum Spring Formations undivided and may yield a few gal/ min per well from sandstone and from limestone fractures and solution channels.[4]	--
Mesozoic	Cretaceous and Jurassic	Lower Cretaceous and Upper and Middle Jurassic	Preuss Sandstone[9]	--	Purple, maroon, and reddish-gray sandy siltstone and claystone. Some sections contain thick beds of salt and gypsum.		Estimated spring discharge was 10 gal/min.
Mesozoic	Cretaceous and Jurassic	Lower Cretaceous and Upper and Middle Jurassic	Twin Creek Limestone[9]	[6]<900	Greenish-gray shaley limestone and limy siltstone. Includes Gypsum Spring Member.		--
Mesozoic	Cretaceous and Jurassic	Lower Cretaceous and Upper and Middle Jurassic	Gypsum Spring Formation	[6]<150	Interbedded red shale, gray dolomite, and white gypsum.		--
Mesozoic	Jurassic and Triassic	Jurassic and Triassic	Nugget Sandstone	0-[6]560	Light-tan to salmon-pink, fine-grained, cross-bedded sandstone with large, frosted quartz grains in a finer matrix.[6]	May yield a few tens of gal/min per well.[4]	--
Mesozoic	Jurassic and Triassic	Jurassic and Triassic	Chugwater Formation	935-[6]1,760	Popo Agie Member is purple claystone, red shale, purple limestone conglomerate, and red siltstone. Crow Mountain Sandstone Member is red to pink, porous sandstone. Alcova Limestone Member is gray and purple, thin-bedded limestone and dolomite interbedded with white gypsum. Red Peak Member is red gypsiferous siltstone and sandstone with shale partings.[6]	Chugwater and Dinwoody Formations undivided and probably would not yield more than a few gal/min per well.[4]	--
Mesozoic	Jurassic and Triassic	Jurassic and Triassic	Dinwoody Formation	200-[6]600	Brownish-gray to olive-drab, thin-bedded dolomitic siltstone.[6]		--
Paleozoic	Permian	Permian	Phosphoria Formation and related rocks	180-[6]260	Upper part of Phosphoria Formation is black, phosphatic shale. Middle part is mudstone, carbonate rock, gray, cherty dolomite, and sandstone. Base is black phosphorite, mudstone, and shale.[6]	May yield as much as 10 gal/min per well from sandstone and from dolomite fractures and solution channels.[4]	--

Table 4. *Lithologic and water-yielding characteristics of geologic units in Teton County study area, Wyoming--Continued*

Erathem	System	Series	Geologic unit (pl. 1)	Approximate thickness (ft)	Lithology	Water-yielding characteristics[1]	Reported[1], estimated, or measured water yield
Paleozoic	Pennsylvanian and Mississippian	Pennsylvanian and Upper Mississippian[5]	Tensleep Sandstone	400-[4]450	Light-gray, fine-grained sandstone weathering yellowish-brown. Middle and lower parts are gray, fine-grained limestone and dolomite.	May yield a few tens of gal/min per well from sandstone.	Yields as much as 100 gal/min to individual springs in the Gros Ventre Range.[4] Estimated spring discharges were 2-20 gal/min.
Paleozoic	Pennsylvanian and Mississippian	Pennsylvanian and Upper Mississippian[5]	Amsden Formation	305-[6]700	Red, reddish-brown, and green shale and siltstone interbedded with white to pink dolomite and limestone. Bottom part is gray to brownish-pink, fine- to medium-grained, porous Darwin Sandstone Member as much as 100 ft thick.[6]	May yield a few tens of gal/min per well from sandstone.	Yields as much as 100 gal/min to individual springs in the Gros Ventre Range.[4] Measured well discharge was 40 gal/min.
Paleozoic	Mississippian and Devonian	Mississippian and Upper Devonian	Madison Limestone	1,100-[6]1,500	Upper part is light- to dark-gray, thick-bedded to massive limestone; middle part is thin-bedded, dolomitic limestone; brown, vuggy, cherty, dolomite occurs near bottom of unit; base of unit is black, thin, discontinuous shale.[6]	May yield several hundred gal/min per well from limestone solution channels.[4]	Yields as much as 4,000 gal/min to individual springs.[4] Estimated spring discharges were 500 and 800 gal/min.
Paleozoic	Mississippian and Devonian	Mississippian and Upper Devonian	Darby Formation	285-[6]450	Upper part is yellow, gray, pink and black, thin-bedded dolomitic siltstone and shale; lower part is brown, fetid, vuggy, siliceous dolomite with thin limestone and sandstone beds.[6]	Probably would yield no more than a few gal/min per well.[4]	Estimated spring discharge was 35 gal/min.
Paleozoic	Ordovician and Cambrian	Upper and Middle Ordovician and Upper and Middle Cambrian	Bighorn Dolomite	200-[6]500	Light- and dark-gray, siliceous dolomite.[6]	May yield as much as 100 gal/min per well from fractures and solution channels.[4]	Estimated spring discharge was 30 gal/min.
Paleozoic	Ordovician and Cambrian	Upper and Middle Ordovician and Upper and Middle Cambrian	Gallatin Limestone	[4,6]200-[6]250	Dark-gray limestone weathering tan with yellow splotches. Middle part is green shale; lower part contains glauconitic conglomerate beds.[6]	May yield several hundred gal/min per well from limestone solution channels.[4]	Yields as much as 400 gal/min to individual springs in the Gros Ventre Range.[4]

Table 4. *Lithologic and water-yielding characteristics of geologic units in Teton County study area, Wyoming--Continued*

Erathem	System	Series	Geologic unit (pl. 1)	Approximate thickness (ft)	Lithology	Water-yielding characteristics[1]	Reported[1], estimated, or measured water yield
Paleozoic	Ordovician and Cambrian	Upper and Middle Ordovician and Upper and Middle Cambrian	Gros Ventre Formation	[4]<600	Park Shale Member is green, micaceous shale, with thin limestone conglomerate beds. Death Canyon Limestone Member is blue to dark-gray with brown and tan splotches. Middle part is thin-bedded limestone with green shale. Wolsey Shale Member is green to gray-green micaceous shale with glauconitic lower part.[6]	Probably would yield no more than a few gal/min per well.[4]	--
Paleozoic	Ordovician and Cambrian	Upper and Middle Ordovician and Upper and Middle Cambrian	Flathead Sandstone	[6]200-[4,6]300	White, tan, brown, and maroon sandstone. Upper part is green micaceous shale.[6]	May yield a few tens of gal/min per well.[4]	--
Middle and Early Proterozoic	Precambrian		Mafic intrusive rocks	--	--	May yield a few tens of gal/min per well from fractures or from weathered zone at top of unit.	Estimated spring discharges were 5-12 gal/min.
Late Archean	Precambrian		Granite gneiss	--	Webb Canyon Gneiss is medium- to coarse-grained biotite- and hornblende-bearing quartz monzonite gneiss. Contains allanite.[6]	May yield a few tens of gal/min per well from fractures or from weathered zone at top of unit.	--
Late and Middle Archean	Precambrian		Metasedimentary and metavolcanic rocks.	--	Amphibolite, hornblende gneiss, biotite gneiss, quartzite, iron-formation, metaconglomerate, marble, and pelitic schist.[11]	May yield a few tens of gal/min per well from fractures.	
Late and Middle Archean	Precambrian		Metamorphosed mafic and ultramafic rocks	--	Teton Range contains gray to dark-green, coarse-grained Rendezvous Metagabbro with clots of green hornblende in matrix of light-gray plagioclase.[6] Gros Ventre Range contains hornblende, gneiss, and serpentinite.	May yield a few tens of gal/min per well from fractures or from weathered zone at top of unit.	Yields as much as 200 gal/min to individual springs in the Teton Range.[4] Estimated spring discharges were 5-12 gal/min.

Table 4. *Lithologic and water-yielding characteristics of geologic units in Teton County study area, Wyoming--Continued*

Erathem	System	Series	Geologic unit (pl. 1)	Approximate thickness (ft)	Lithology	Water-yielding characteristics[1]	Reported[1], estimated, or measured water yield
Late Archean	Precambrian		Granitic rocks of 2,600-Ma age group	--	Teton Range contains light colored, medium- to fine-grained Mount Owen Quartz Monzonite with muscovite- and biotite-bearing pegmatite.[6] Gros Ventre and Washakie Ranges contain granitic rocks.	May yield a few tens of gal/min per well from fractures or weathered zone at top of unit.	--

[1]Reported and typical well yields do not necessarily reflect potential aquifer yields.
[2]Sequence in table does not indicate age in relation to other Quaternary entries.
[3]Behrendt and others, 1968.
[4]Cox, 1976.
[5]Outwash at south end of Jackson Lake (Pierce and Good, 1992).
[6]Love and others, 1992.
[7]Christiansen and others, 1978.
[8]Schroeder, 1974.
[9]Sediments not extensive enough to be shown on plate 1, but have been verified.
[10]A trachyandesite is defined as "an extrusive rock, intermediate in composition between trachyte and andesite, with sodic plagioclase, alkali feldspar, and one or more mafic minerals (biotite, amphibole, or pyroxene)" (Bates and Jackson, eds., 1984).
[11]Love and Christiansen, 1985.

Ground-Water Data Network

Ground-water data were collected and compiled from selected wells and springs throughout the study area (table 5). Compiled data include local number, site type, primary use of water, and discharge. The locations of selected wells and springs are shown on plate 2.

Wells and springs are identified in this report by location, according to the Federal township-range system of land subdivision and assigned a local number. An example of a local number used in this report is 40-116-27cca01 (fig. 6). The first number (40) denotes the township (T), the second number (116) denotes the range (R), and the third number (27) denotes the section. The first letter following the section number denotes the quarter section (160-acre tract), the second letter denotes the quarter-quarter section (40-acre tract), the third letter, if shown, denotes the quarter-quarter-quarter section (10-acre tract), and the fourth letter, if shown, denotes the quarter-quarter-quarter-quarter section (2.5-acre tract). These subsections are designated a, b, c, and d in a counter-clockwise direction beginning in the northeast quarter. The last two characters in the local number are a sequence number indicating the order of inventory. Well 40-116-27cca01 is the first well inventoried in the northeast quarter of the southwest quarter of the southwest quarter of section 27, T. 40 N., R. 116 W.

Some sites visited during this investigation are located in remote areas outside of surveyed lands. Sites outside of surveyed lands were assigned local numbers based on the latitude and longitude of the site location. For example, lat-long 431925110260601 refers to the first site inventoried at a location having a latitude of 43 degrees, 19 minutes, and 25 seconds, and a longitude of 110 degrees, 26 minutes, and 6 seconds.

Relation of Ground Water to Geology

The lithology and water-yielding characteristics of geologic units in the Teton County study area are summarized in table 4, and the surface distribution of most of these units is shown on plate 1. Well yields reported in table 4 and discussed in the following sections do not necessarily reflect potential water yields from a geologic unit. Well yield can be affected by pump capacity, well diameter, saturated interval penetrated, aquifer transmissivity, and time since pumping began.

Plafcan and Ogle (1994) grouped geologic units into aquifer systems on the basis of areal extent, hydrologic properties, and recharge-discharge characteristics. A similar scheme has been used in this report to organize discussions of water-yielding units and water quality. Geologic units in the study area were grouped as Quaternary unconsolidated deposits, Quaternary and Tertiary volcanic rocks, Tertiary rocks, Mesozoic rocks, Paleozoic rocks, and Precambrian metamorphic rocks.

Quaternary Unconsolidated Deposits

Quaternary unconsolidated deposits include alluvium and colluvium; gravel, pediment, and fan deposits; and glacial, landslide, and undifferentiated surficial deposits occurring in Jackson Hole and along the Snake River. The unconsolidated deposits consist of clay, silt, sand, and gravel. Alluvium and colluvium in the study area are found primarily along the Snake and Gros Ventre Rivers, Buffalo Fork, and Pilgrim and Pacific Creeks (pl. 1). Quaternary glacial deposits (drift) in the study area are the result of at least three Pleistocene glaciations (Pierce and Good, 1992, p. 4). Glacial drift in the study area is composed of clay, silt, sand, gravel, and boulders in till and outwash deposits. Till is nonstratified, nonsorted to poorly-sorted drift deposited by glaciers without reworking by fluvial processes (Bloom, 1978). Outwash is stratified detritus removed from a glacier by meltwater streams. Glacial drift occurs as discontinuous deposits along the west and east margins of Jackson Hole, throughout the Buffalo Fork valley, and around Jackson Lake (Love and others, 1992).

Table 5. *Records of selected wells and springs in Teton County study area, Wyoming*

[Local number: See text describing well numbering system in the section titled Ground Water. Site type: W, well; S, spring; X, test hole. Primary use of water: H, domestic; P, public supply; U, unused; I, irrigation; C, commercial; S, stock; Q, aquaculture; F, fire; Z, other; T, institutional. Altitude of land surface, in feet: determined by interpolation of contours on U.S. Geological Survey topographic maps (1:24,000 scale). Discharge: M, measured; R, reported.; E, estimated; ft, feet; gal/min, gallons per minute]

						Static water level		Discharge		
Local number	Site type	Well depth	Year drilled	Primary use of water	Altitude of land surface (ft)	Below land surface (ft)	Date	Gal/min	Type	Date
				Quaternary alluvium, colluvium, and gravel, pediment, and fan deposits						
39-116-11bab01	W	150	--	H	5,960	20.88	07-20-93	--		--
39-116-32ccc01	W	85	--	P	5,850	--	--	--		--
[1]39-116-32dbc01	W	--	--	H	5,860	26.75	07-20-93	--		--
40-116-05ccc01	W	157	1990	H	6,120	16.91	07-22-92	60	M	1990
						10.58	07-15-93			
40-116-06aaa01	W	58	04-01-77	U	6,125	6.96	07-16-93	40	R	04-01-77
40-116-06acc01	W	151	02-06-80	I	6,110	4.31	07-16-93	--		--
40-116-06adb01	W	42	1972	H	6,110	8.04	07-12-91	15	M	1973
40-116-07cba01	W	--	--	H	6,090	3.12	07-19-93	--		--
[2]40-116-17acb01	W	--	--	H	6,120	75.02	07-21-93	--		--
[2]40-116-17bbb01	W	--	--	C	6,073	93.44	07-19-93	--		--
40-116-17cdd01	W	50	--	H	6,050	4.57	07-24-92	--		--
						4.39	07-13-93			
40-116-17dbd01	W	--	08-17-79	H	6,090	31.59	07-19-93	--		--
40-116-17dbd02	W	111	02-27-81	H	6,090	33.23	07-19-93	--		--
40-116-17ddb01	W	60	--	H	6,100	52.15	07-21-93	--		--
40-116-18cbb01	W	--	--	H	6,065	7.3	07-19-93	--		--
40-116-18dca01	W	--	--	H	6,060	2.92	07-19-93	--		--
40-116-19bac01	W	--	--	H	6,050	8.73	07-16-93	--		--
40-116-19cbc01	W	30	1961	H	6,015	--	--	--		--
40-116-19dbb01	W	--	--	H	6,040	13.36	07-19-93	--		--
[2]40-116-20aaa01	W	180	--	C	6,160	157.26	07-13-93	25	M	1980
40-116-20ada01	W	--	--	H	6,120	96.62	07-21-93	--		--
40-116-27cca01	W	53	--	P	5,980	23.49	07-23-92	22	M	1970
						18.91	07-13-93			
40-117-01aaa01	W	--	--	H	6,117	3.67	07-16-93	--		--
40-117-01aba01	W	100	--	H	6,110	6.91	07-16-93	--		--
						14.61	10-19-93			
40-117-01aba02	W	--	--	H	6,110	7.25	07-16-93	--		--
						14.73	10-19-93			

Table 5. *Records of selected wells and springs in Teton County study area, Wyoming--Continued*

Local number	Site type	Well depth	Year drilled	Primary use of water	Altitude of land surface (ft)	Static water level: Below land surface (ft)	Static water level: Date	Discharge: Gal/min	Discharge: Type	Discharge: Date
Quaternary alluvium, colluvium, and gravel, pediment, and fan deposits--Continued										
[3]40-117-01bba01	W	80	--	H	6,100	2.98	07-16-93	--		--
						6.40	10-19-93			
40-117-01bdc01	W	--	--	H	6,100	2.06	07-16-93	--		--
40-117-01cdb01	W	--	--	H	6,098	4.15	07-16-93	--		--
40-117-01cdc01	W	--	--	H	6,095	6.5	07-16-93	--		--
40-117-02dcc01	W	--	03-20-93	H	6,075	3.90	07-19-93	--		--
40-117-03cdb01	X	--	--	U	6,090	3.22	07-20-93	--		--
40-117-03dcb01	X	--	--	U	6,090	5.02	07-20-93	--		--
40-117-12dbc01	W	--	--	H	6,080	17.45	07-16-93	--		--
40-117-12dbd01	W	--	--	H	6,100	13.88	07-16-93	--		--
[4]40-117-15dab01	W	--	--	H	6,200	55.4	07-20-93	--		--
41-111-30adb01	S	--	--	H	7,575	--	--	2	E	08-09-91
41-115-03baa01	S	--	--	--	6,700	--	--	--		--
41-115-18aba01	W	115	11-16-72	H	6,360	44.35	07-20-92	--		--
						34.7	07-16-93			
41-115-18ccc01	W	--	--	H	6,310	16.98	07-16-93	--		--
41-115-18dcc01	W	86	1983	H	6,350	46.85	07-20-92	50	M	1983
						36.16	07-16-93			
41-116-02bcc01	S	--	--	U	6,360	--	--	--		--
41-116-03bbb01	W	--	--	S	6,320	10.73	07-21-93	--		--
41-116-09acd01	W	50	--	H	6,270	5.3	07-23-92	10	M	1969
						2.51	07-21-93			
41-116-09cac01	W	--	--	I	6,260	4.62	07-21-93	2,000	R	07-21-93
						12.51	10-18-93			
41-116-11abb01	W	90	--	Q	6,260	--	--	--		--
41-116-16cbd01	W	--	--	S	6,240	3.63	07-21-93	--		--
41-116-22bab01	W	--	--	P	6,240	5.37	07-25-92	100	M	1988
						6.55	07-13-93			
[2]41-116-26bdb01	W	--	--	S	6,230	3.85	07-16-93	--		--
41-116-33cab01	W	148	1985	P	6,171	5	08-16-85	2,300	M	08-16-85
								3,000	M	08-16-85
						16.56	07-13-93			
41-116-33cba01	W	--	05-10-65	P	6,172	9.96	07-21-92	--		--
						11.67	07-13-93			

Table 5. *Records of selected wells and springs in Teton County study area, Wyoming--Continued*

Local number	Site type	Well depth	Year drilled	Primary use of water	Altitude of land surface (ft)	Static water level: Below land surface (ft)	Static water level: Date	Discharge: Gal/min	Discharge: Type	Discharge: Date
Quaternary alluvium, colluvium, and gravel, pediment, and fan deposits--Continued										
41-117-02dab01	W	--	--	H	6,220	0.82	07-15-93	--		--
						1.63	10-18-93			
41-117-11adc01	W	--	--	U	6,200	2.57	07-19-93	--		--
						4.17	10-18-93			
41-117-11ccc01	W	80	--	H	6,180	3.82	07-17-93	--		--
41-117-11dab01	X	--	--	U	6,200	3.38	07-19-93	--		--
						5.14	10-18-93			
41-117-11dab02	X	--	--	U	6,200	3.53	07-19-93	--		--
						5.23	10-18-93			
41-117-12abc01	W	400	--	F	6,210	6.41	07-20-93	--		--
41-117-12dca01	W	55	--	H	6,200	5.03	07-20-93	--		--
41-117-13bbb01	W	--	--	P	6,180	4.69	07-28-92	--		--
						5.51	07-14-93			
41-117-14acb01	W	--	--	P	6,180	--	--	--		--
41-117-14bdc01	X	--	--	U	6,180	2.27	07-19-93	--		--
						5.49	10-18-93			
41-117-14bdc02	X	--	--	U	6,180	2.41	07-19-93	--		--
						5.84	10-18-93			
41-117-14bdd01	X	--	--	U	6,180	4.07	07-19-93	--		--
						7.01	10-18-93			
41-117-14bdd02	X	--	--	U	6,180	2.59	07-19-93	--		--
						5.78	10-18-93			
41-117-15adc01	W	60	--	H	6,180	--	--	40	M	1984
41-117-15adc02	W	--	--	H	6,180	3.39	07-14-93	--		--
41-117-22cda01	W	--	--	P	6,140	3.25	07-17-93	--		--
[3]41-117-22dbb01	W	--	--	U	6,145	1.37	07-17-93	--		--
41-117-22dcb01	W	60	--	P	6,140	1.14	07-19-93	--		--
						1.98	10-18-93			
41-117-26cbb01	W	60	--	H	6,130	4.65	07-19-93	--		--
						6.49	10-19-93			
41-117-27ada01	W	--	--	H	6,140	3.28	07-19-93	--		--
41-117-34acb01	W	--	--	H	6,115	2.21	07-20-93	--		--
41-117-34ddd01	X	--	--	U	6,100	3.31	07-20-93	--		--

Table 5. *Records of selected wells and springs in Teton County study area, Wyoming--Continued*

Local number	Site type	Well depth	Year drilled	Primary use of water	Altitude of land surface (ft)	Static water level: Below land surface (ft)	Static water level: Date	Discharge: Gal/min	Discharge: Type	Discharge: Date
Quaternary alluvium, colluvium, and gravel, pediment, and fan deposits--Continued										
41-117-35dac01	W	--	--	H	6,110	3.29	07-16-93	--		--
						5.35	10-19-93			
42-113-17aab01	W	105	1984	P	7,020	--	--	35	M	1984
42-114-03bbc01	W	117	1984	P	6,980	57.4	08-09-91	10	M	1984
								1.3	M	1984
42-115-09bdb01	W	--	1964	P	6,590	21.93	07-23-92	--		--
						19.84	07-14-93			
42-115-10aab01	W	--	--	C	6,660	52.5	07-19-93	--		--
42-115-10ada01	W	--	--	--	6,660	27.72	07-19-93	--		--
42-115-11aad01	W	76	--	H	6,720	19.98	08-10-91	20	E	08-10-91
42-116-14bdd01	W	--	--	--	6,420	38.24	07-14-93	--		--
42-116-14caa01	W	81	1991	C	6,410	35.57	07-22-92	100	E	1991
						33.41	07-13-93	80	E	1991
42-116-14cab01	W	--	--	Z	6,410	35.43	07-14-93	--		--
42-116-14cca02	W	--	--	U	6,410	31.7	07-14-93	--		--
42-116-20bad01	W	--	--	P	6,320	2.76	07-15-93	--		--
42-116-21abd01	W	48	--	I	6,340	12.71	08-10-91	20	M	1982
								15	E	08-10-91
42-116-27dcc01	W	--	--	I	6,350	15.58	07-14-93	--		--
42-116-32bcc01	W	--	--	P	6,265	5.61	07-16-93	--		--
						7.5	10-18-93			
42-116-34bda01	W	101	--	P	6,340	12.05	07-22-92	--		--
						8.51	07-21-93			
42-117-24dac01	W	--	1973	--	6,290	--	--	200	M	1976
								300	R	07-20-92
42-117-25aac01	W	--	--	U	6,275	6.17	07-19-93	--		--
42-117-25abb01	W	--	--	Z	6,280	4.3	07-15-93	--		--
						13.61	10-18-93			
42-117-25abb02	W	--	--	Z	6,280	.95	07-15-93	--		--
						9.44	10-18-93			
42-117-25abb03	W	--	--	U	6,280	8.48	10-18-93	--		--
43-115-20ccc01	W	--	--	H	6,565	75.92	07-20-93	--		--
43-115-20ccd01	W	--	--	H	6,565	74.3	07-20-93	--		--
43-115-29bbb01	W	--	--	U	6,565	73.93	07-20-93	--		--
43-115-29bbc01	W	--	--	U	6,560	65.2	07-20-93	--		--

Table 5. *Records of selected wells and springs in Teton County study area, Wyoming--Continued*

Local number	Site type	Well depth	Year drilled	Primary use of water	Altitude of land surface (ft)	Static water level: Below land surface (ft)	Static water level: Date	Discharge: Gal/min	Discharge: Type	Discharge: Date
Quaternary alluvium, colluvium, and gravel, pediment, and fan deposits--Continued										
43-115-29bcc01	W	--	--	--	6,560	48.13	07-20-93	--		--
43-115-29dad01	W	118	1981	H	6,607	76.94	07-21-92	--		--
						71.24	07-14-93			
43-115-30acb01	W	--	--	H	6,510	35.67	07-19-93	--		--
43-116-11dbc01	W	88	--	H	6,660	30.13	07-21-92	--		--
						11.56	07-12-93			
43-116-14abc01	W	160	09-29-81	P	6,620	39.0	06-03-89	60	M	10-09-81
						39.33	07-22-92			
						35.92	07-12-93			
43-116-25caa01	W	43	06-01-76	U	6,462	14.8	09-08-88	--		--
						13.18	07-12-93			
43-116-25dbd01	W	49	--	U	6,460	15.4	09-08-88	--		--
						13.12	07-14-93			
43-116-25dcd01	W	--	--	C	6,485	36.02	07-20-93	--		--
44-112-13dad01	S	--	--	--	8,400	--	--	2	E	06-25-92
44-114-08dda01	W	--	--	H	6,795	13.86	07-13-93	--		--
						12.20	10-19-93			
44-114-08dda02	W	--	--	H	6,780	2.63	07-13-93	--		--
						2.71	10-19-93			
44-114-08dda03	W	--	--	H	6,785	5.48	07-24-92	--		--
						5.27	07-13-93			
						5.55	10-19-93			
44-114-08dda04	W	--	--	H	6,783	5.08	07-13-93	--		--
						5.43	10-19-93			
44-114-08dda05	W	--	--	H	6,775	9.07	07-24-92	--		--
						9.15	07-13-93			
						10.78	10-19-93			
44-114-20bac01	X	--	--	U	6,870	45.87	07-20-93	--		--
44-115-36aac01	W	--	--	U	7,041	91.43	07-15-93	--		--
44-116-13abd01	W	--	--	P	6,900	233.91	07-12-93	--		--
44-116-26daa01	W	250	06-29-82	P	6,795	112.4	07-23-92	65	M	08-11-82
						81.87	07-12-93			
44-116-26ddd01	W	95	1940	H	6,770	46.31	07-21-92	--		--
						26.97	07-12-93			

Table 5. *Records of selected wells and springs in Teton County study area, Wyoming--Continued*

Local number	Site type	Well depth	Year drilled	Primary use of water	Altitude of land surface (ft)	Static water level: Below land surface (ft)	Static water level: Date	Discharge: Gal/min	Discharge: Type	Discharge: Date
Quaternary alluvium, colluvium, and gravel, pediment, and fan deposits--Continued										
44-118-19adc01	W	220	--	H	6,400	98.53	08-07-91	12	E	08-07-91
45-112-23aab01	W	--	--	P	6,940	20.31	07-15-93	9	E	06-26-92
45-112-31abc01	W	--	--	H	6,880	43.76	07-15-93	--		--
45-112-31bca01	W	75	--	P	6,880	36.69	07-15-93	14	R	06-22-92
45-113-07dbd01	W	45	1987	H	6,860	6.98	06-24-92	12	E	06-24-92
45-113-27bca01	W	--	--	H	6,800	4.62	07-15-93	--		--
						6.06	10-19-93			
45-113-27bca02	W	--	--	S	6,800	2.3	07-15-93	--		--
						3.66	10-19-93			
45-113-27dac01	W	--	--	--	6,800	4.26	07-26-92	25	M	1969
						3.31	07-15-93			
						4.98	10-19-93			
45-113-29bcd01	W	--	--	H	6,820	1.85	07-15-93	--		--
45-113-33aab01	W	31	1983	H	6,790	5.78	07-24-92	30	M	1983
						5.99	07-13-93			
45-113-34bba01	W	--	--	--	6,800	3.67	07-13-93	--		--
45-113-34bbd01	W	40	06-10-81	H	6,790	4.36	07-24-92	20	M	06-12-81
						4.35	07-13-93			
45-113-36aadb01	W	--	--	U	6,860	11.45	07-15-93	--		--
45-113-36aadc01	W	65	--	H	6,880	12.11	07-15-93	--		--
45-114-23ccd01	W	--	--	P	6,730	16.9	06-03-89	--		--
						12.5	07-13-93			
45-115-02aabd01	W	--	--	U	6,820	8.18	07-14-93	--		--
46-114-29db01	W	200	--	U	6,982	13.8	06-02-89	--		--
						21.33	07-14-93			
46-114-29db02	W	250	--	P	6,977	19.7	06-02-89	--		--
						[5]35.88	07-14-93			
46-114-31ca01	W	175	--	P	6,905	3.98	06-02-89	--		--
						[5]11.15	07-14-93			
[1]48-115-16cc01	W	27	--	U	6,859	21.5	06-02-89	--		--
						21.55	07-13-93			
[1]48-115-21bb01	W	--	--	P	6,846	6.81	06-02-89	--		--
						28.86	07-13-93			

Table 5. *Records of selected wells and springs in Teton County study area, Wyoming--Continued*

Local number	Site type	Well depth	Year drilled	Primary use of water	Altitude of land surface (ft)	Static water level: Below land surface (ft)	Static water level: Date	Discharge: Gal/min	Discharge: Type	Discharge: Date
Quaternary alluvium, colluvium, and gravel, pediment, and fan deposits--Continued										
[1]48-115-21bc01	W	37	--	U	6,837	26.7	09-07-88	--		--
						23.88	07-13-93			
LAT-LONG-431648110353701	W	--	1977	P	6,190	--	--	--		--
LAT-LONG-434528110570101	W	70	--	P	6,860	--	--	--		--
Quaternary glacial deposits										
[3]41-117-25dca01	W	143	1987	I	6,160	6.84	07-23-92	80	M	1987
						6.17	07-21-93			
						6.51	10-18-93			
[6]41-117-27bba01	W	--	--	H	6,140	2.92	07-20-93	--		--
41-117-27bba02	W	--	--	H	6,140	3.05	07-20-93	--		--
[6]41-117-27cba01	W	48	--	P	6,130	6.42	07-21-92	--		--
						6.45	07-14-93			
41-117-28aac01	W	109	11-02-73	H	6,200	77.19	07-24-92	15	M	1974
						75.9	07-14-93			
[6]41-117-28aad01	W	--	--	H	6,180	45.43	07-24-92	--		--
						43.84	07-14-93			
41-117-34cca01	W	--	--	H	6,160	40.26	07-27-92	--		--
						37.83	07-17-93			
45-111-33cbb01	S	--	--	--	8,620	--	--	5	E	06-25-92
[6]45-114-19abb01	W	--	--	H	6,810	73.56	07-24-92	--		--
						66.43	07-12-93			
[6]45-115-36bcc01	W	118	--	U	6,860	96.7	09-08-89	--		--
						105.44	07-12-93			
[4]45-115-36bcd01	W	119	--	U	6,880	112	09-08-88	--		--
						105.39	07-13-93			
46-115-23ccc01	W	--	--	P	6,829	71.1	06-02-89	--		--
						67.82	07-14-93			
47-118-04dbd01	W	--	--	P	6,440	--	--	--		--
Quaternary landslide deposits										
39-116-23cca01	W	147	--	P	5,940	57.24	07-27-92	--		--
						54.87	07-13-93			
Quaternary rhyolite flow										
48-117-16ccc01	S	--	--	--	6,960	--	--	--		--

Table 5. *Records of selected wells and springs in Teton County study area, Wyoming--Continued*

Local number	Site type	Well depth	Year drilled	Primary use of water	Altitude of land surface (ft)	Static water level: Below land surface (ft)	Static water level: Date	Discharge: Gal/min	Discharge: Type	Discharge: Date
					Tertiary extrusive igneous rocks					
[4]41-117-25baa01	W	75	1979	H	6,200	7.04	07-22-92	50	M	1979
						5.33	07-15-93			
46-118-34caa01	S	--	--	S	7,440	--	--	5	E	08-08-91
47-118-34abc01	S	--	--	U	6,510	--	--	3	E	08-08-91
					Teewinot Formation					
43-115-12cbd01	S	--	--	--	7,340	--	--	5	E	06-25-92
44-114-31bbc01	W	160	1973	P	7,090	101.56	07-21-92	17.4	M	07-26-92
						37.99	07-14-93			
LAT-LONG-440601110355201	S	--	--	--	9,160	--	--	--		--
					Camp Davis Formation					
38-115-05dcd01	S	--	--	--	6,320	--	--	--		--
39-115-18bcd01	W	140	12-06-79	S	6,170	17.09	07-12-91	--		--
						14.08	07-13-93			
LAT-LONG-432031110260701	W	135	1982	P	6,770	32.70	07-10-91	--		--
LAT-LONG-432118110263901	S	--	--	P	6,880	--	--	--		--
					Colter Formation					
46-114-20ada01	S	--	--	--	7,380	--	--	1	E	06-24-92
					Tepee Trail Formation					
LAT-LONG-434709110062401	S	--	--	--	9,320	--	--	50	E	06-28-92
					Hoback Formation					
LAT LONG-431925110260601	S	--	--	H	6,850	--	--	--		--
					Harebell Formation					
46-113-20aac01	W	130	06-02-87	P	7,040	--	--	12	M	06-23-92
					Bacon Ridge Sandstone					
42-112-28dac01	S	--	--	U	7,360	--	--	800	E	08-09-91
					Frontier Formation					
42-112-33bdb01	S	--	--	P	7,520	--	--	3	R	1985
					Aspen Shale					
[6]39-116-14aca01	W	--	--	H	5,942	33.03	07-24-92	--		--
						37.25	07-14-93			
40-117-20cba01	S	--	--	--	7,120	--	--	--		--

Table 5. *Records of selected wells and springs in Teton County study area, Wyoming--Continued*

Local number	Site type	Well depth	Year drilled	Primary use of water	Altitude of land surface (ft)	Static water level: Below land surface (ft)	Static water level: Date	Discharge: Gal/min	Discharge: Type	Discharge: Date
Aspen Shale--Continued										
LAT-LONG-432324110505501	W	127	1989	H	6,500	44	07-11-91	--		--
Bear River Formation										
39-116-14cad01	W	--	--	P	5,920	--	--	30	M	07-23-92
39-116-26bac01	W	80	1966	H	5,950	28.27	07-11-91	--		--
LAT-LONG-432108110495101	W	97	1979	H	6,485	91.35	07-09-91	--		--
Preuss Sandstone										
LAT-LONG-433200111011801	S	--	--	P	6,960	--	--	10	E	08-05-91
Undifferentiated Mesozoic rocks										
42-112-23bac01	S	--	--	U	8,060	--	--	50	E	08-09-91
42-113-17abb01	W	100	1984	P	7,020	4.72	07-22-92	20	M	1984
44-113-25cda01	W	--	--	S	8,540	--	--	1	E	06-22-92
45-113-22cbb01	W	154	--	P	6,880	42.5	06-24-92	20	E	06-24-92
Twin Creek Limestone										
LAT-LONG-431501110464301	S	--	--	P	5,960	--	--	--		--
Tensleep Sandstone										
41-115-01bba01	S	--	--	--	7,200	--	--	2	E	06-22-92
LAT-LONG-433317111014201	S	--	--	U	7,080	--	--	3	E	08-05-91
LAT-LONG-433401111020801	S	--	--	U	6,800	--	--	20	E	08-05-91
LAT-LONG-434018111020201	S	--	--	U	6,680	--	--	10	E	08-05-91
Darwin Sandstone Member of the Amsden Formation										
41-116-18bcb01	W	180	07-01-64	H	6,285	67.51	07-21-92	40	M	07-20-64
Madison Limestone										
LAT-LONG-433957110572001	S	--	--	U	8,920	--	--	800	E	08-06-91
LAT-LONG-434029110593001	S	--	--	T	6,900	--	--	500	E	08-06-91
Darby Formation										
38-115-03bcb01	S	--	--	--	6,140	--	--	--		--
LAT-LONG-434103110572601	S	--	--	U	7,180	--	--	35	E	08-06-91

Table 5. *Records of selected wells and springs in Teton County study area, Wyoming--Continued*

Local number	Site type	Well depth	Year drilled	Primary use of water	Altitude of land surface (ft)	Static water level: Below land surface (ft)	Static water level: Date	Discharge: Gal/min	Discharge: Type	Discharge: Date
Darby Formation--Continued										
LAT-LONG-434721110572701	W	--	--	P	7,940	--	--	--		--
Bighorn Dolomite										
[6]41-116-32add01	W	--	--	P	6,190	21.83	07-28-92	--		--
						23.55	07-13-93			
LAT-LONG-432219110263501	S	--	--	U	7,200	--	--	--		--
LAT-LONG-434646110583201	S	--	--	S	7,320	--	--	30	E	08-07-91
Undifferentiated Cambrian rocks										
41-115-16cca01	S	--	--	--	7,060	--	--	--		--
46-111-33add01	S	--	--	--	7,420	--	--	2	E	06-26-92
Precambrian metamorphic rocks										
LAT-LONG-434537110545701	S	--	--	P	7,370	--	--	12	E	08-07-91
LAT-LONG-435358110561401	S	--	--	U	8,280	--	--	5	E	08-08-91

[1]Site within boundary describing Quaternary alluvium, colluvium, and gravel, pediment, and fan deposits on pl. 1; but site outside of contoured area, so removed from water-level map.

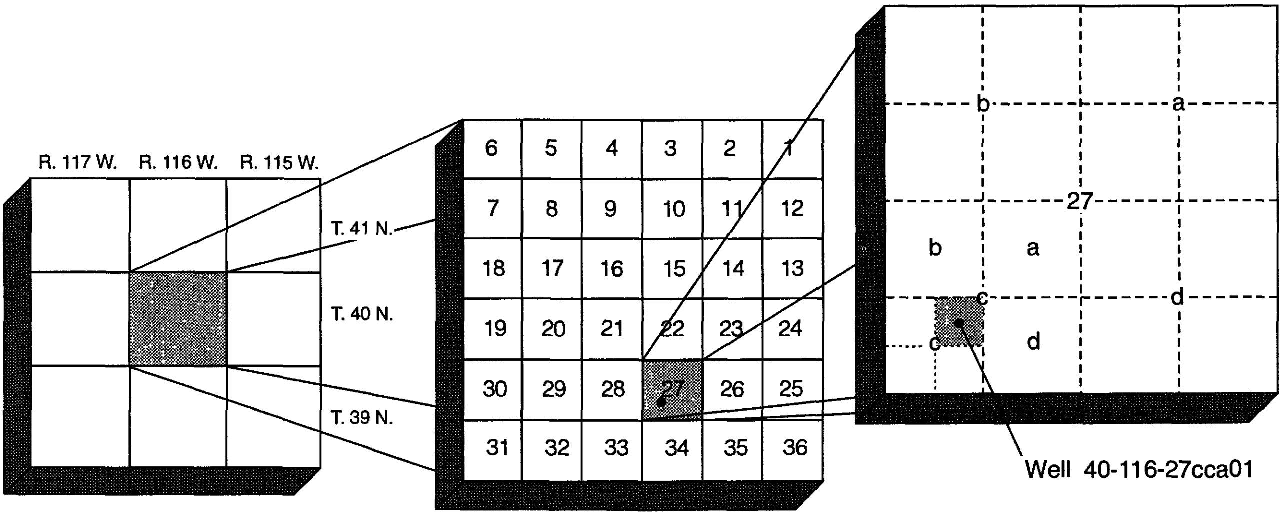
[2]Water-level measurement made in recently pumped well.

[3]Water-level measurement discrepancy is less than precision of method ($\pm$ 20 ft) used to determine water altitude.

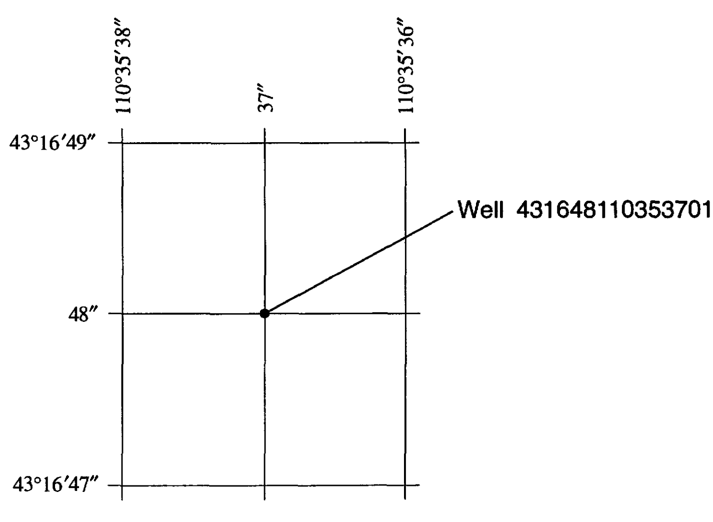
[4]Hillside site likely with perched ground water not representative of Snake River alluvium, colluvium, or gravel, pediment, and fan deposits.

[5]Water-level measurement made in pumping well, so not used to prepare water-level map.

[6]Site in isolated rock outcrop within boundary describing Quaternary alluvium and gravel, pediment, and fan deposits on water-level map. Site left on water-level map because small, isolated rock outcrops within Jackson aquifer are not delineated on map; or site is in topographically similar Qg deposit, so Qg deposit is incorporated into the Jackson aquifer boundary.



A. System for numbering wells and springs in surveyed townships.



B. System for numbering wells and springs using latitude and longitude.

Figure 6. Systems for numbering wells and springs.

Thickness

The thickness of Quaternary unconsolidated deposits in Jackson Hole was previously unknown. Wells completed in these deposits generally are less than 200 ft in depth. Thin clay and other fine-grained strata observed in these shallow wells likely are discontinuous and of small lateral extent, so they cannot be used to infer the bottom of the unconsolidated deposits. No oil and gas exploration wells, which might have indicated the thickness of the unconsolidated deposits, were found in Jackson Hole. Behrendt and others (1968) estimated that Holocene deposits are about 400 ft thick.

Other estimates of the thickness of Quaternary unconsolidated deposits in the study area were based on extrapolation of the strike and dip of less permeable underlying units. Based on projection of the Huckleberry Ridge Tuff westward to the Teton Fault, Pierce and Good (1992) estimated that "as much as 4,000 to 7,000 ft of fault-basin fill accumulated in the last 2 Ma years (essentially Quaternary time) in central-western Jackson Hole."

Because the thickness of Quaternary unconsolidated deposits was unknown, a time-domain electromagnetic (TDEM) survey was performed in Jackson Hole in September 1993. TDEM is a magnetic induction method for determining subsurface electrical resistivity (Hoekstra and Cline, 1986, p. 241-251). TDEM equipment consists of a transmitter loop and receiver positioned on the land surface. Exploration depth is proportional to the length of the transmitter loop. An electric current is used to generate a primary magnetic field that causes eddy currents in the subsurface. The intensity of the currents mainly is a function of subsurface electrical resistivity. Resistivity, expressed in ohm-meters (ohm-m), indicates the resistance of a material to flow of an electric current. The more resistant a material is to an electric current, the higher its resistivity. In general, high resistivities (about 50 ohm-m and greater) correspond to saturated, coarse-grained materials (sand, gravel, and other unconsolidated deposits such as volcanic rocks), and low resistivities (less than 50 ohm-m) correspond to less permeable, fine-grained materials such as clay, silt, claystone, shale, siltstone, or fine-grained sandstone (David Campbell, USGS, unpub. data, 1995). Additionally, Peterson and others (1989) state that "water-bearing formations are the coarser grained, relatively well-sorted" portions of unconsolidated deposits "identified in TDEM sounding inversions as higher resistivity units compared to adjacent clay-rich units." Finally, the presence of clay in poorly-sorted glacial deposits could decrease the resistivity of an unconsolidated deposit. In the Teton County study, it was assumed that the depth of significant contrast between high and low resistivity layers represented the bottom of the Quaternary unconsolidated deposits.

TDEM was used in this study because it is less susceptible to near-surface "geologic noise" than are more common geophysical techniques such as the direct-current method. "Geologic noise" is defined as an interference (for example, a highly conductive near-surface layer) that obscures the exploration objective. TDEM, a deep exploration method, has an on-cycle (electrical current is generated) and off-cycle (electrical current is turned off). After the current is turned off, eddy currents at a particular time and depth are a function of subsurface electrical resistivity. At early times, eddy currents are concentrated near the ground surface and measurement of the electromagnetic signal is sensitive to the resistivity of near-surface layers. At later times, however, current intensity in the near-surface layers is small and has a negligible effect on the measured electromagnetic signal. Thus, "geologic noise" is reduced at later times and geologic interfaces below conductive near-surface layers can be detected with TDEM. Interested readers are referred to Hoekstra and Cline (1986) and Nabighian and Macnae (1991) for detailed discussion of the method.

TDEM data collected in the field were interpreted by combining layers with similar resistivity to typically produce two or three composite layers. A composite layer generally has an "average" resistivity based on the individual lithologic units composing the layer. Lithologic units with thickness less than about 10 percent of the exploration depth usually cannot be detected with TDEM and are combined with other units by the modeling step (David Campbell, USGS, unpub. data, 1995). Additionally, a unit's resistivity must differ by a factor of about two from adjacent units to be distinguished as a separate layer. Because TDEM accuracy is limited to about 15 percent, modeled resistivities and associated depths reported in this study are considered "best-fit" estimates.

The results of nine TDEM measurements made in Jackson Hole are listed in table 6. Eight measurements were made in Grand Teton National Park to avoid potential interference from wire fences and buried electrical cables commonly found in developed areas (pl. 2). The ninth measurement was made in the southern part of Jackson Hole in a large hay field. Large transmitter loops (typically 1,000 ft on a side) were used to maximize exploration depth.

Table 6. *Results of a time-domain electromagnetic survey in Jackson Hole, Wyoming*

[TDEM, time-domain electromagnetic; ohm-m, ohm-meters; ft, feet; --, no data]

TDEM measurement site location (pl. 2)	Local number	Layer 1		Layer 2		Layer 3 resistivity (ohm-m)	Total exploration depth (ft)
		Resistivity (ohm-m)	Thickness (ft)	Resistivity (ohm-m)	Thickness (ft)		
Northeast of Jenny Lake	44-116-12ddc01	380	1,000	110	800	30	1,800
South Antelope Flats	43-115-21cbb01	160	820	10	620	2	1,400
Baseline Flats	43-116-13aba01	340	1,000	100	710	70	1,700
Spread Creek near Moosehead Ranch	44-114-08dba01	40	30	60	1,500	7	1,500
North Antelope Flats near Lost Creek Ranch	44-115-26dca01	180	380	20	780	170	1,200
Potholes area southeast of Jackson Lake	44-115-02cba01	210	2,400	10	--	--	2,400
East of Jackson Airport	42-116-12cac01	180	450	30	--	--	450
South of Gros Ventre River, near junction	41-116-03aab01	100	460	10	520	310	980
Oliver Ranch, west of South Park Loop road	40-117-12adb01	60	910	20	--	--	910

Modeling results of the TDEM data indicate that Quaternary unconsolidated deposits, generally corresponding to layer 1 in the model, had moderate to high resistivities (ranging from 40 to 380 ohm-m) and ranged in estimated thickness from about 380 ft in the northern part of Antelope Flats (site 44-115-26dca01) to about 2,400 ft near the Potholes area (site 44-115-02cba01) in Grand Teton National Park (table 6). The indicated resistivity range generally corresponds to the 95-percent resistivity range (58-170 ohm-m) reported in the literature for Rocky Mountain Quaternary alluvium (Keller and Frischknecht, 1966, p. 44).

The Spread Creek site (44-114-08dba01) is anomalous because of a lack of significant resistivity contrast between layers 1 (40 ohm-m) and 2 (60 ohm-m). Additionally, the Spread Creek site is on an alluvial deposit that would be expected to have a resistivity greater than 58 ohm-m, based on the 58-174 ohm-m range reported by Keller and Frischknecht (1966). This range, however, encompasses only 95 percent of the reported values for Rocky Mountain Quaternary alluvium. It was assumed that the 40 ohm-m value for Spread Creek was an outlying value still representative of Quaternary alluvium, especially because of the lack of significant resistivity contrast with layer 2. Thus, the depth of unconsolidated deposits is assumed to be about 1,500 ft for the Spread Creek site, the combined depth of layers 1 and 2.

TDEM layers 2 and 3, representing rocks other than Quaternary sands and gravels, generally had resistivities less than 50 ohm-m. Layer 2 thickness ranged from 520 to 1,500 ft. Resistivities of 15-50 ohm-m generally correspond to sedimentary rocks of Quaternary and Tertiary age (Keller and Frischknecht, 1966, p. 40). Fine-grained units commonly associated with resistivities less than 50 ohm-m and that are exposed near Jackson Hole include the Tertiary Shooting Iron and Teewinot Formations and the Cretaceous Harebell Formation (pl. 1). The Shooting Iron Formation includes lacustrine and fluviatile claystone and siltstone. The upper part of the Teewinot Formation contains claystone, marlstone, and tuff. The Harebell Formation, a marine conglomerate, is primarily sandstone and claystone. Resistivity values less than 20 ohm-m likely are associated with marine shales. A resistivity range of 5-20 ohm-m was reported by Keller and Frischknecht (1966, p. 40) for marine sedimentary rocks of Mesozoic age.

Ground-Water Use and Yield

Water from Quaternary unconsolidated deposits is used for domestic, public supply, commercial, livestock, and irrigation purposes. In this study, 36 measured, reported, or estimated discharges from 28 wells completed in and 3 springs issuing from these deposits ranged from 1.3 gal/min (42-114-03bbc01) to 3,000 gal/min (41-116-33cab01) (table 5) with a median yield of 25 gal/min.

Depth to water in 127 wells and test holes completed in Quaternary unconsolidated deposits ranged from 0.82 (41-117-02dab01) to 233.91 ft (44-116-13abd01) below land surface (table 5); median depth to water was 10.78 ft below land surface. All but 12 of the 127 wells and test holes were completed in alluvium and colluvium, which includes terrace deposits and gravel, pediment, and fan deposits. Water-level data from wells completed in alluvial, colluvial, glacial, and landslide deposits were grouped when determining median depth to water.

Quaternary and Tertiary Volcanic Rocks

The major outcrops of Quaternary and Tertiary volcanic rocks occur as laterally extensive extrusive strata in the northern part of the study area. These strata consist primarily of Quaternary basalt and rhyolite flows, tuffs, and the Tertiary Huckleberry Ridge rhyolitic tuff. Lesser outcrops of Quaternary and Tertiary intrusive rocks also occur in the study area.

In this study, estimated discharges from two springs issuing from Huckleberry Ridge Tuff were 3 gal/min (47-118-34abc01) and 5 gal/min (46-118-34caa01) (table 5). Measured discharge from one well (41-117-25baa01) completed in Tertiary extrusive igneous rock was 50 gal/min. Igneous rocks can yield from a few tens of gal/min to as much as 200 gal/min from fractured zones to individual springs (Cox, 1976, sheet 2).

Depth to water in well 41-117-25baa01 ranged from 5.33 ft on July 15, 1993, to 7.04 ft on July 22, 1992 (table 5). No other wells completed in volcanic rocks were found during this study.

Tertiary Rocks

Tertiary rocks include the Teewinot, Camp Davis, Colter, Tepee Trail, and Hoback Formations and the Pinyon Conglomerate. The Teewinot Formation, exposed in small areas east of Jackson Hole (pl. 1), consists of porous limestone, claystone, and pumicite. The unit thickness can be greater than 6,000 ft in the study area. The lower two-thirds consists of porous limestone beds about 100-200 ft thick interbedded with pumicite beds 20-75 ft thick (Love and others, 1992). Although Teewinot outcrops are not extensive, the unit can be a substantial, local source of water because of fractures and solution channels in the limestone. The Camp Davis Formation consists of calcareous conglomerate, interbedded silty and sandy mudstone, and calcareous, sandy conglomerate. The Colter Formation consists of conglomerate and poorly cemented sandstone. The Tepee Trail Formation consists of hard andesitic conglomerate, sandstone, and claystone. Although the Tepee Trail Formation is not extensive enough to be included in plate 1, it was verified in the field. The Hoback Formation consists of interbedded sandstone and claystone with thick red and gray conglomerate. The Pinyon Conglomerate contains quartzite roundstones in a matrix of coarse-grained sandstone, and sporadic boulders of older conglomerate and quartzite.

Discharge ranges from a few tens of gal/min from Tertiary conglomerates to 120 gal/min from limestone fractures and solution channels in the Teewinot Formation (Cox, 1976, sheet 2). In this study, measured discharge from one well (44-114-31bbc01) completed in the Teewinot Formation was 17.4 gal/min, and estimated discharge from a spring (43-115-12cbd01) issuing from the formation was 5 gal/min (table 5). Estimated discharge from a spring (46-114-20ada01) issuing from the Colter Formation was 1 gal/min and estimated discharge from a spring (lat-long 434709110062401) issuing from the Tepee Trail Formation was 50 gal/min. Median discharge from one well completed in and three springs issuing from Tertiary rocks (table 5) was 11.2 gal/min. Data from the Teewinot, Colter, and Tepee Trail Formations were grouped when determining median discharge.

Depth to water in three wells completed in Tertiary rocks ranged from 14.08 (39-115-18bcd01) to 101.56 ft (44-114-31bbc01) below land surface (table 5); median depth to water was 32.70 ft below land surface. Water-level data from wells completed in the Teewinot and Camp Davis Formations were grouped when determining median depth to water. No other wells completed in Tertiary rocks were inventoried during this study.

Mesozoic Rocks

Mesozoic rocks primarily are exposed in the eastern part of the study area and include the Harebell Formation, Bacon Ridge Sandstone, Frontier Formation, Aspen Shale, Bear River Formation, and Preuss Sandstone (pl. 1). The Harebell Formation is a conglomerate consisting of quartzite roundstones, gold-bearing and tuffaceous sandstones, and tuffaceous claystone. The Bacon Ridge Sandstone is a thick-bedded, fine-grained sandstone interbedded with marine shale, siltstone, and thick coal beds. The Frontier Formation is a coarse-grained sandstone interbedded with shale and thin coal beds. The Aspen Shale contains tuffaceous shale and claystone interbedded with sandstone, claystone, and bentonite. The Bear River Formation contains calcareous sandstone interbedded with dark-gray to black shale. The Preuss Sandstone consists of sandy siltstone and claystone. Although the Twin Creek Limestone and Preuss Sandstone are not extensive enough to be included in plate 1, they were verified in the field.

In this study, discharges from wells completed in and springs issuing from Mesozoic rocks ranged from 1 gal/min (44-113-25cda01) to 800 gal/min (42-112-28dac01) (table 5); median discharge was 20 gal/min. The low value represents a well completed in undifferentiated Mesozoic rocks, and the high value represents a spring issuing from the Bacon Ridge Sandstone north of the Gros Ventre River. Although the undifferentiated Mesozoic rocks could include the Bacon Ridge Sandstone and other formations, it was not possible to identify the specific formation supplying water to well 44-113-25cda01. Data from undifferentiated Mesozoic rocks, the Harebell Formation, Bacon Ridge Sandstone, Frontier Formation, Bear River Formation, and Preuss Sandstone were grouped when computing median discharge.

Depth to water in six wells completed in Mesozoic rocks ranged from 4.72 ft (42-113-17abb01) to 91.35 ft (lat-long 432108110495101) below land surface (table 5); median depth to water was 37.25 ft below land surface. Water-level data from wells completed in undifferentiated Mesozoic rocks, the Aspen Shale, and Bear River Formation were grouped when determining median depth to water.

Paleozoic Rocks

Paleozoic rocks in the study area include the Tensleep Sandstone, Darwin Sandstone Member of the Amsden Formation, Madison Limestone, Darby Formation, Bighorn Dolomite, and Gallatin Limestone. The Tensleep Sandstone, exposed primarily on the flanks of the Teton and Gros Ventre Ranges (pl. 1), consists of fine-grained sandstone interbedded with dolomite in the middle and lower parts of the unit. The unit is as much as 450 ft thick in the study area. Paleozoic rocks also are exposed on the western flank of the Teton Range and in the Gros Ventre Range, and smaller outcrops occur in the Washakie, Hoback, Wyoming, and Snake River Ranges (pl. 1). The Darwin Sandstone Member of the Amsden Formation consists of fine to medium-grained, porous sandstone. The Madison Limestone is as much as 1,500 ft thick and consists of massive limestone, thin-bedded dolomitic limestone, and dolomite. The Darby Formation is as much as 450 ft thick and contains thin-bedded dolomitic siltstone, shale, and siliceous dolomite. The Bighorn Dolomite is as much as 500 ft thick and contains siliceous dolomite. The Gallatin Limestone, as much as 250 ft thick, consists of limestone, green shale, and glauconitic conglomerate beds.

Fractures and solution channels in Paleozoic rocks can yield large quantities of water. Discharges of a few tens to several hundred gal/min have been reported for wells completed in these rocks (Cox, 1976, sheet 2). Additionally, Cox (1976) reported discharges of 100 gal/min for springs issuing from the Bighorn Dolomite and Gallatin Limestone.

Water discharge in Paleozoic carbonate rocks depends on the extent of secondary permeability. Fractures and bedding planes enlarged by calcite or dolomite dissolution can result in large secondary permeability (Freeze and Cherry, 1979). Cox (1976) reported that discharges from wells completed in Paleozoic rocks ranged from 6 to 720 gal/min. In this study, estimated discharges for two springs issuing from the Madison Limestone were 500 gal/min (lat-long 434029110593001) and 800 gal/min (lat-long 433957110572001) (table 5). Estimated spring discharge from the Darby Formation (lat-long 434103110572601) was 35 gal/min, and from the Bighorn Dolomite (lat-long 434646110583201) was 30 gal/min.

Estimated discharges from all springs issuing from Paleozoic rocks ranged from 2 gal/min (41-115-01bba01 and 46-111-33add01) to 800 gal/min (lat-long 433957110572001) (table 5). The low value represents discharge from springs issuing from the Tensleep Sandstone and undifferentiated Cambrian rocks. Although the latter could include the Gallatin Limestone, Gros Ventre Formation, and Flathead Sandstone, identifying the specific Cambrian formation supplying water to spring 46-111-33add01 was not possible. Measured discharge from one well completed in the Darwin Sandstone Member of the Amsden Formation was 40 gal/min (41-116-18bcb01). The median discharge from all springs issuing from and one well completed in Paleozoic rocks was 25 gal/min. Data from the Tensleep Sandstone, Darwin Sandstone Member, Madison Limestone, Darby Formation, Bighorn Dolomite, and undifferentiated Cambrian rocks were grouped when computing median discharge.

Depth to water in two wells completed in Paleozoic rocks ranged from 21.83 ft (41-116-32add01) to 67.51 ft (41-116-18bcb01) (table 5); median depth to water in all wells completed in Paleozoic rocks was 23.55 ft. Well 41-116-32add01 was completed in the Bighorn Dolomite, and well 41-116-18bcb01 was completed in the Darwin Sandstone Member.

Precambrian Metamorphic Rocks

Precambrian metamorphic rocks, in the core of the Teton Range, are exposed mainly in the western part of the study area (pl. 1). Smaller outcrops occur in the Washakie and Gros Ventre Ranges.

Discharge of water from Precambrian metamorphic rocks is variable and depends on the extent of local fracture zones. Cox (1976) reported discharges of a few tens to 200 gal/min for springs issuing from Precambrian metamorphic rocks in the Teton Range. Precambrian metamorphic rocks lack substantial primary porosity or permeability. Substantial secondary permeability can result, however, from fracturing caused by tectonic activity. The extent of secondary permeability is greatest near major fault zones. Discharge of water from wells completed in fractured zones in Precambrian metamorphic rocks is generally adequate for domestic supplies.

In this study, estimated discharges from two springs issuing from Precambrian metamorphic rocks were 5 gal/min (lat-long 435358110561401) and 12 gal/min (lat-long 434537110545701) (table 5). No wells completed in Precambrian rocks were inventoried during this study.

Recharge, Movement, and Discharge

Aquifers in unconsolidated deposits and consolidated rocks can be recharged by precipitation, streamflow leakage, irrigation, and subsurface inflow from other aquifers. Unconsolidated alluvium in Teton County generally is recharged by infiltration of precipitation, streamflow leakage, irrigation water, and migration of deep ground water along fault zones. The presence of a warm spring near the Jackson Thrust Fault is an example of the latter mechanism (Love and Albee, 1972). The Jackson Thrust Fault is located at the southern edge of the East and West Gros Ventre Buttes.

Ground-water movement is affected by the location of recharge and discharge areas and by the thickness and permeability of the geologic unit. Grain size, sorting, and cementation between grains affect the primary permeability. Secondary permeability created by fracturing and dissolution also is important to ground-water movement. Fractures along anticlines can create conduits for vertical and horizontal ground-water flow. Vertical or near-vertical fractures at the crests of anticlines in areas of high precipitation can result in increased dissolution and large recharge rates. Anticlines in the study area are located northeast of Jackson Lake in T. 46 N., R. 115 W.; southeast of Emma Matilda Lake in T. 45 N., R. 115 W. and in T. 44 N., R. 115 W.; and east of Antelope Flats in T. 43 N., R.115 W. and in T. 42 N., R. 115 W. (Love and others, 1992). Aquifer-transmissivity values of 9,900 ft^2/d in the Jackson area (Nelson Engineering, 1985, p. 33) and 120,000 ft^2/d in the Westbank area (Nelson Engineering, 1992, p. 20) have been reported for exploration wells completed in sand and gravel deposits in Jackson Hole.

Water in alluvium generally moves by force of gravity toward local streams. A water-level-contour map can be used to determine the general direction of ground-water flow (Lenfest, 1986, p. 20). Ground water is assumed to flow in a direction perpendicular to the water-level contours, from areas of high hydraulic head to areas of low hydraulic head.

A water-level contour map (pl. 3) was developed for Jackson Hole using water-level data measured in July 1993. Water-level contours were drawn for an area comprising alluvium and colluvium and gravel, pediment, and fan deposits in Jackson Hole. The bulk of these deposits, designated in this report as the "Jackson aquifer," extend southward from Jackson Lake to just north of Hoback Junction. The objective of the water-level map was to determine the general direction of ground-water movement in the Jackson aquifer.

Water-level contours were drawn for the valley fill using universal kriging, a geostatistical method of interpolation. Universal kriging can be used to predict ground-water levels at specified points on the basis of measured water levels. The technique is especially useful for areas where few data exist. Readers can consult Skrivan and Karlinger (1980) and Karlinger and Skrivan (1981) for a detailed discussion of the theory and application of kriging.

A grid was superimposed on a map of the valley fill and nodes were established at 1,300-ft intervals. Kriged predictions of ground-water altitudes were calculated for each grid node. A preliminary water-level contour map with 50-ft contour intervals was prepared from the kriged ground-water altitudes, 137 ground-water altitudes determined from measured water levels, and 118 altitudes along perennial streams obtained from USGS topographic maps (1:24,000 scale). Ground-water levels were measured in Jackson Hole from July 12 through July 21, 1993.

The final map was prepared by modifying the preliminary map in areas where computer-generated contours differed from observed water-level altitudes and by limiting the water-level contours to the Jackson aquifer. In addition to measured water levels in wells, altitudes of perennial streams, selected intermittent streams, and selected lakes were used to refine water-level contours. Intermittent streams were used as controls for water-level contours if they were known to be flowing in July 1993 when water-levels were measured. Intermittent streams used as controls include Ditch Creek and Cottonwood Creek. Lakes within the Jackson aquifer boundary, including Jackson, Leigh, Jenny, and Phelps Lakes, also were used as controls for water-level contours.

Geology and topography were used to determine the boundary of the Jackson aquifer. First, Quaternary alluvium and colluvium (Qa) and Quaternary gravel, pediment, and fan deposits (Qt) units were combined when drawing water-level contours because these geologic units are lithologically and hydrologically similar. Qa deposits consist of unconsolidated clay, silt, sand, and gravel, and Qt deposits consist of locally derived, unconsolidated sand and gravel. Although Qt deposits are somewhat coarser than Qa deposits, the hydraulic conductivity of fine sand in relation to coarse sand varies by about three orders of magnitude, from about 1 to less than 10^3 ft/d (Heath, 1989). Topographically isolated glacial deposits (Qg) and landslide deposits (Qls) were excluded from the Jackson aquifer boundary. Qg deposits consist of generally unstratified and poorly sorted till and outwash of clay, silt, sand, gravel, and boulders, and Qls deposits consist of unconsolidated poorly sorted material ranging from clay to boulders. In contrast to Qa and Qt, the hydraulic conductivity of Qg varies over six orders of magnitude, from less than 10^{-6} to about 1 ft/d, and is significantly less than that of sand and gravel (Heath, 1989, p. 13).

Second, some Qg units within and adjacent to Qa/Qt units likely are hydraulically connected to the Jackson aquifer because of similar position on the landscape. Plate 1 and USGS topographic maps (1:100,000 scale) were used as a basis for inclusion of topographically similar Qg units within the Jackson aquifer boundary. Quaternary glacial units adjacent to or within Qa/Qt units were identified on plate 1. The elevation of the Qg units then was checked using USGS maps (1:100,000 scale) and compared with that of Qa/Qt units. Elevated or topographically distinct Qg units were assumed not to be hydraulically connected to the Jackson aquifer. Quaternary glacial units with terrain and elevation similar to that of the Jackson aquifer, however, likely are hydraulically connected to the aquifer and were incorporated into the aquifer boundary.

Third, other topographically distinct geologic units within the Jackson aquifer boundary were identified using USGS maps (1:100,000 scale) and excluded from water-level contouring. For example, the East and West Gros Ventre Buttes in T. 41 N., R. 117 W. comprise Quaternary or Tertiary conglomerate and Paleozoic Madison Limestone and Darby Formation rocks (pl. 1). These rocks are topographically isolated and likely not connected to the Jackson aquifer, according to the USGS map (1:100,000 scale). The East and West Gros Ventre Buttes were delineated on the water-level map and water levels were not drawn in these areas.

Various sources show different types of rocks in the East and West Gros Ventre Buttes. Plate 1 (based on Love and Christiansen, 1985) shows Quaternary or Tertiary conglomerate for the northern part of the East and West Gros Ventre Buttes. More recent work by Love and others (1992), however, shows Tertiary andesite and possibly basalt for the same area. This disparity might have resulted from scale differences. The geology map by Love and others (1992) is 1:62,500 scale and focuses on Grand Teton National Park. The state geology map (Love and Christiansen, 1985), however, is 1:500,000 scale and comprises the entire state of Wyoming.

Finally, the Jackson aquifer includes small, isolated pockets of the following units: Quaternary landslide deposits, Pleistocene/Pliocene conglomerate, Tertiary Shooting Iron Formation, Tertiary extrusive rock, Tertiary Teewinot Formation, and Ordovician Bighorn Dolomite. These units are of small areal extent compared with the Qa, Qt, and Qg units, so they are not shown on the water-level map.

Qa and Qt deposits can include perched ground water in terrace deposits that can result in a local water table that is distinct from the Jackson aquifer. Water *levels* (rather than the water *table*), however, were contoured in this study. If the water table had been contoured instead, then separate sets of contours would have been developed for the terrace deposits.

Not all wells where water levels were measured in July 1993 are shown on the water-level map (pl. 3), and some of the sites shown on the map are not in the Jackson aquifer. Of the 137 ground-water levels measured in July 1993, 10 were not used as controls for water-level contours because they are located outside the Jackson aquifer boundary. Of the 10, six were in Quaternary glacial deposits and one each was in Quaternary landslide deposits, the Tertiary Teewinot and Camp Davis Formations, and the Cretaceous Aspen Shale. Additionally, four Jackson aquifer sites listed in table 5 and visited in July 1993 were within Qa/Qt units depicted on plate 1, but were not used as water-level controls because they are well outside the contoured area (footnote 1 in table 5). Seven sites used as controls for the water-level map are in non-Jackson aquifer parts of table 5 (footnote 6 in table 5). Of the seven sites, two are in outcrops that were not delineated on the map because they are small and isolated; one site is in Ordivician Bighorn Dolomite and the other is in the Cretaceous Aspen Shale. The five remaining sites are in Quaternary glacial deposits topographically similar to the adjacent or surrounding Jackson aquifer. These five sites were assumed to be hydraulically connected to the Jackson aquifer. Two wells were pumping at the time of measurement and were not used as controls for water-level contours. Finally, ten water levels measured in July 1993 were considered anomalous and were not used as controls for water-level contours.

The 10 anomalous water-levels might have been caused by the following. Four of the anomalous measurements were made in recently pumped wells (footnote 2 in table 5). Three of the anomalous measurements were made on steep hillsides and likely represent perched ground water in units not hydraulically connected with the Jackson aquifer (footnote 4 in table 5). Finally, three of the anomalous measurements differed from nearby contours by values less than the precision of the method used to determine water altitude (footnote 3 in table 5). Water altitude was calculated by subtracting the measured depth to water from a land-surface altitude determined from contours on USGS topographic maps (1:24,000 scale). The precision of land-surface contours was assumed to be half the contour interval, or ± 20 ft at most sites. Because the water-level measurement discrepancies associated with the two sites were substantially less than 20 ft, the discrepancies can be attributed to the limited precision of the method used to determine water-level altitude.

Water-level contours ranged from 7,000 ft at Pilgrim and Pacific Creeks to 5,950 ft just north of Hoback Junction (pl. 3). Ground water in the study area generally moves from topographically high areas toward the Snake River and southwest through the valley in the direction of the Snake River. The shape of the water-level contours indicates that the Snake River was gaining in most of the valley at the time the water-level data were collected (July 1993), but was neither gaining nor losing in the Westbank and South Park areas. Flat Creek was gaining north of Jackson, neither gaining nor losing near Jackson, then gaining in the lower reach near the confluence with the Snake River. The Gros Ventre River appeared to be neither gaining nor losing along most of its length. Cottonwood Creek appeared to be losing south of Jenny Lake, and prior data collected in September 1971 indicate that it is a losing stream (Cox, 1976, sheet 3). Fish Creek appeared to be gaining northeast of Wilson.

Water in the study area also occurs in consolidated units within the Tertiary System, Mesozoic and Paleozoic Erathems, and the Precambrian system. The direction of water flow in these rocks, however, cannot be inferred because of insufficient data.

Ground water is discharged by pumped wells and is naturally discharged by springs and seeps, by evapotranspiration, and by discharge to streams and other geologic units. Springs and seeps occur where the water table intersects the land surface as a result of faults and fractures, changes in topography, or changes in lithology within a geologic unit or between geologic units. Ground-water discharge by evapotranspiration can occur where the water table is near the land surface, such as in alluvium near streams.

A streamflow gain-and-loss study was conducted in Jackson Hole from October 20 through October 22, 1992, to estimate the amount of ground-water discharge to the Snake River. Streamflows from October through March mainly result from ground-water discharge to streams (Glover, 1990, p. 14). The gain-and-loss study was performed in October because potential errors were minimized and the weather was favorable. Potential errors in estimating stream-aquifer relations include storage of streamflow as ice in January and February, unmeasured streamflow in small tributaries, snowmelt runoff during March - June, and unmeasured irrigation-return flow during July - October. Most diversions and laterals in the study area were dry during the gain-and-loss study.

Streamflow was measured at selected points on the Snake River and its major tributaries. Tributary flows were subtracted from the overall gain in each reach to estimate the quantity of ground-water discharge to the Snake River. Precipitation in the valley was negligible from October 20-22, 1992, and evapotranspiration was assumed to be negligible.

Results of the streamflow gain-and-loss study indicated that the total ground-water discharge to the Snake River was 395 ft^3/s between streamflow-gaging stations west of Moran (site 2) and below the confluence with Flat Creek (site 10) (table 7). Spring Creek discharge (11.8 ft^3/s) was not subtracted from the overall gain in the reach when estimating ground-water discharge to the Snake River. Because Spring Creek is fed by springs originating within the valley, flow of Spring Creek was considered ground-water discharge to the Snake River.

Changes in Water Levels

The July 1993 measurements indicated that some water levels in the Westbank and South Park areas were near the land surface. To help evaluate seasonal effects on the water table, water levels in 27 wells were remeasured in October 1993 in areas where the water table was within a few feet of the land surface. Static water levels were deeper in October than in July in 26 of the wells measured. The one exception was well 44-114-08dda01 at the Moosehead Ranch in Grand Teton National Park; the change in static water level was +1.66 ft in this well (table 8). The maximum decrease in static water level was -9.31 ft in well 42-117-25abb01 and the median water-level change was -1.76 ft.

Well 42-117-25abb01 is part of the monitoring network for the Teton Village wastewater-treatment plant. The observed change in static water level could have been caused by seasonal changes in the amount of infiltrating precipitation, irrigation diversions, seasonal changes in plant operating practices, or a combination of these factors. The plant, which injects treated wastewater into the alluvial aquifer, experiences high loadings during the summer. Irrigation water is diverted in the southwestern part of the county from May until October.

Table 7. *Estimated ground-water discharge to the Snake River in Teton County study area, Wyoming*

[Site number: simplified site number used in this report to identify location of streamflow-gaging stations. Station number: assigned by U.S. Geological Survey to locations where streams are regularly measured or sampled. The first two digits identify the major basin in which the station is located. The remaining six digits identify the relative location. Miscellaneous streamflow site number: assigned by the U.S. Geological Survey to locations where only one or a few measurements or samples have been obtained. The first six digits designate the latitude of the site, the next seven digits designate longitude, and the last two digits are sequence numbers to distinguish several sites that might be in close proximity to one another. ft^3/s, cubic feet per second; NA, not applicable; mi, mile]

Site number (pl. 2)	Station or miscellaneous streamflow site number	Streamflow measurement site	Measured discharge (ft^3/s)	Ground-water discharge in reach (ft^3/s)
2	13011000	Snake River near Moran	288	NA
3	13011500	Pacific Creek at Moran	46	NA
11	435017110304201	Buffalo Fork at Moran, east of Highway 191/89	163	NA
12	434730110322101	Spread Creek at Highway 191/89	11	NA
13	434050110425001	Cottonwood Creek 1.75 mi. north of Moose, east of Teton Park Road	1	NA
14	433931110424001	Snake River 0.25 mi. north of Moose at historic ferry crossing	790	281
15	433555110414201	Gros Ventre River 2.5 mi. east of Gros Ventre Junction	110	NA
17	432813110522701	Fish Creek 2 mi. south of Wilson, east of Wilson-Fall Creek Road at wooden bridge	77	NA
19	432628110515001	Mosquito Creek at Wilson-Fall Creek Road	4	NA
9	13018500	Flat Creek near Cheney	65	NA
10	13018750	Snake River below Flat Creek, near Jackson	1,160	114
		Total, Snake River, between stations 13011000 and 13018750:	NA	395

Table 8. *Changes in static water level in selected wells completed in Quaternary unconsolidated deposits in Teton County study area, Wyoming*

[Local number: See text describing well-numbering system in the section titled Ground Water. Geologic unit: Qa, alluvium and colluvium; Qt, gravel, pediment, and fan deposits; Qg, glacial deposits. (-), net decrease; (+), net increase]

Local number	Static water level (feet below land surface) July 1993	October 1993	Net water-level change (feet)
	Quaternary alluvium and gravel, pediment, and fan deposits		
40-117-01aba01	6.91	14.61	-7.70
40-117-01aba02	7.25	14.73	-7.48
40-117-01bba01	2.98	6.40	-3.42
41-116-09cac01	4.62	12.51	-7.89
41-117-02dab01	.82	1.63	-.81
41-117-11adc01	2.57	4.17	-1.60
41-117-11dab01	3.38	5.14	-1.76
41-117-11dab02	3.53	5.23	-1.70
41-117-14bdc01	2.27	5.49	-3.22
41-117-14bdc02	2.41	5.84	-3.43
41-117-14bdd01	4.07	7.01	-2.94
41-117-14bdd02	2.59	5.78	-3.19
41-117-22dcb01	1.14	1.98	-.84
41-117-26cbb01	4.65	6.49	-1.84
41-117-35dac01	3.29	5.35	-2.06
42-116-32bcc01	5.61	7.5	-1.9
42-117-25abb01	4.3	13.61	-9.3
42-117-25abb02	.95	9.44	-8.49
44-114-08dda01	13.86	12.20	+1.66
44-114-08dda02	2.63	2.71	-.08
44-114-08dda03	5.27	5.55	-.28
44-114-08dda04	5.08	5.43	-.35
44-114-08dda05	9.15	10.78	-1.63
45-113-27bca01	4.62	6.06	-1.44
45-113-27bca02	2.30	3.66	-1.36
45-113-27dac01	3.31	4.98	-1.67
	Quaternary glacial deposits		
41-117-25dca01	6.17	6.51	-.34

WATER USE

Water-use estimates for Wyoming for 1990 were compiled by the USGS in cooperation with State and local agencies. Estimates of total offstream water use for Teton County are shown in table 9. Six categories of offstream use are listed and each category is divided into surface- and ground-water sources. Most of the water use in the county was surface water (table 9).

Table 9. *Estimated total offstream water use in Teton County, Wyoming, in 1990*

	Units, in million gallons per day			
Offstream use	**Surface water**	**Ground water**	**Total**	**Consumptive use**
Public supply	0	2.40	2.40	0
Commercial	.05	1.14	1.19	.18
Domestic	.02	1.16	1.18	.47
Industrial	.06	.09	.15	.02
Livestock	.12	.03	.15	.15
Irrigation	89.29	.89	90.18	26.79
Totals	89.54	5.71	95.25	27.61

Surface water supplied about 94 percent of the total offstream use in the county. Irrigation accounted for nearly 100 percent of the offstream use of surface water. Only 6 percent of the total offstream use in the county was supplied by ground water. The largest use of ground water was for public supply (42 percent), followed by domestic (20 percent), commercial (20 percent), and irrigation (16 percent) uses. The smallest uses of ground water were for industrial and livestock (2 percent). These statistics indicate that ground water is a primary source of drinking water in rural areas where surface-water public supplies are not available.

Ground water for public supply is withdrawn by public and private suppliers and delivered to users. The commercial category includes water used for motels, hotels, restaurants, office buildings, other commercial facilities, and institutions. The industrial category includes water used by various industries for fabrication, processing, washing, and cooling.

WATER QUALITY

Water quality refers to organic and inorganic materials dissolved and suspended in water and also to the physical properties of water. The presence of a foreign substance in water generally is considered to reduce water quality, but not all materials in water are detrimental to water quality. Water quality is divided into biological, chemical, and physical categories. Biological water quality includes plant and animal organisms living primarily in surface water. Biological water quality is not described here because few biological data have been collected from streams in Teton County. General chemical characteristics and physical properties of ground and surface water are discussed in the following paragraphs. The reader is referred to Hem (1985) and Freeze and Cherry (1979) for a more thorough discussion of water quality.

Water can be classified into type by the dominant dissolved cation (positive ion) and anion (negative ion) in a water sample (Hem, 1985, p. 166). The dominant ions are the anion and cation with the largest concentration in milliequivalents per liter (me/L). For example, in a sodium sulfate type water, sodium is the cation with the largest concentration in me/L, and sulfate is the anion with the largest concentration in me/L. If a water sample does not contain a cation and anion that constitute as much as 50 percent of the totals, the water is classified as a mixture of the cations and anions having the largest concentrations.

Inorganic materials in water are classified by particle size. Dissolved materials, the smallest particles, usually are ionized and affect chemical water quality. Larger particles of insoluble suspended material are classified as sediment. Sediment can be filtered from water, but dissolved substances require more sophisticated removal techniques. Substances that pass through a 0.45-micrometer (μm) membrane filter are classified as dissolved, and those that cannot pass through are classified as particulate material (Hem, 1985, p. 60).

Physical properties of water commonly measured onsite during water-quality studies include water temperature, specific conductance, and pH. Temperature is an important controlling factor in many chemical processes. Ion solubility and the saturation levels of gases are controlled by water temperature. Local climatic and physical factors affect surface-water temperature. Common climatic factors include solar radiation, wind, air temperature, and vapor pressure. Physical factors include shading, stream width, depth, velocity, ground-water inflow, and proximity to reservoirs. Ground-water temperatures generally depend on the depth of the geologic unit below the surface of the earth. Water in deep geologic units generally has a higher temperature than water in shallow units.

Specific conductance, a measure of the ability of water to conduct electrical current, is expressed in microsiemens per centimeter (μS/cm) at 25 degrees Celsius (^{o}C) and is a function of the type and concentration of dissolved solids in the water. The concentration of dissolved solids, in milligrams per liter (mg/L), typically ranges from 55 to 75 percent of the specific conductance in μS/cm (Hem, 1985, p. 67). This relation varies with the composition and concentration of dissolved ions.

The hydrogen-ion activity of water is described by its pH, and the pH is defined as the negative logarithm of the hydrogen-ion activity expressed in moles per liter (Hem, 1985, p. 61). This parameter ranges from 0 to 14 standard units. At 25^{o}C, a pH greater than 7 indicates that the water is alkaline, whereas a pH less than 7 indicates that the water is acidic.

Chemical quality of water is related to the chemical composition of rocks and sediment in contact with the water and to materials introduced into the hydrologic environment by human activities. Surface-water quality depends on the water source and the exposure of the water to soluble material between the source and the sampling site. Ground-water quality depends on the chemical composition of rocks comprising the geologic units and on materials introduced by human activities at the land surface. Water temperature, the duration of water contact with the rocks, and the rate of movement of the water also affect the chemical quality of ground water. The source or cause and significance of common dissolved-mineral constituents and physical properties of surface and ground water are summarized in table 10.

The chemical characteristics and physical properties of water aid in evaluating its suitability for various uses. Water-quality standards for chemical constituents or properties adopted by the State of Wyoming and used for evaluating ground-water quality for domestic, agricultural, and livestock use are listed in table 11. Because of variation in water quality at different sampling points and the limited number of samples analyzed, samples of surface water or ground water reported here are not classified as suitable for specific uses. Individual samples listed in tables in this report can, however, be compared with the water-quality standards in table 11.

Table 10. *Source or cause and significance of common dissolved-mineral constituents and physical properties of water*

(modified from Popkin, 1973)

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter]

Constituent or property	Source or cause	Significance
Specific conductance (*m*S/cm)	Mineral content of the water.	Indicates degree of mineralization. Specific conductance is a measure of the capacity of the water to conduct an electric current. Varies with concentration and degree of ionization of the constituents.
pH	Acids, acid-generating salts, and free carbon dioxide lower the pH. Carbonates, bicarbonates, hydroxides, and phosphates, silicates, and borates raise the pH.	A pH of 7 indicates neutrality of a solution. Values higher than 7 denote increasing alkalinity; values lower than 7 indicate increasing acidity. The hydrogen-ion activity of water is described by its pH. Corrosiveness of water generally increases with decreasing pH. However, excessively alkaline water also might attack metals.
Hardness as calcium carbonate ($CaCO_3$)	In most water, nearly all the hardness is due to calcium and magnesium. All the metallic cations other than the alkali metals also cause hardness.	Consumes soap before a lather will form and deposits soap curd on bathtubs. Hard water forms scale in boilers, water heaters, and pipes. Hardness equivalent to the bicarbonate and carbonate is called carbonate hardness. Any hardness in excess of this is called noncarbonate hardness. Water of hardness of 60 mg/L or less are considered soft; 61 to 120 mg/L, moderately hard; 121 to 180 mg/L, hard; more than 180 mg/L, very hard.
Calcium (Ca) and magnesium (Mg)	Dissolved from practically all soil and rocks, but especially from limestone, dolomite, and gypsum. Calcium and magnesium are detected in large quantities in some brines. Magnesium is present in large quantities in seawater.	Cause most of the hardness and scale-forming properties of water; soap consuming (see hardness). Water low in calcium and magnesium is desired in electroplating, tanning, dyeing, and textile manufacturing.
Sodium (Na) and potassium (K)	Dissolved from practically all rocks and soil; also found in ancient brines, seawater, industrial brines, and sewage.	Large concentrations, in combination with chloride, give a salty taste. Moderate concentrations have little effect on the usefulness of water for most purposes. Sodium salts may cause foaming in steam boilers. Large sodium concentration may limit the use of water for irrigation.
Bicarbonate (HCO_3) and carbonate (CO_3)	Action of carbon dioxide in water on carbonate rocks such as limestone and dolomite.	Bicarbonate and carbonate produce alkalinity. Bicarbonates of calcium and magnesium decompose in steam boilers and hot-water facilities to form scale and release corrosive carbon dioxide gas. In combination with calcium and magnesium, cause carbonate hardness.

Table 10. *Source or cause and significance of common dissolved-mineral constituents and physical properties of water--Continued*

Constituent or property	Source or cause	Significance
Sulfate (SO_4)	Dissolved from rocks and soil containing gypsum, iron sulfides, and other sulfur compounds. Commonly present in mine water and in some industrial wastes.	Sulfate in water containing calcium forms hard scale in steam boilers. In large concentrations, sulfate in combination with other ions gives bitter taste to water. Some calcium sulfate is considered beneficial in the brewing process.
Chloride (Cl)	Dissolved from rocks and soil. Present in sewage and found in large concentrations in ancient brines, seawater, and industrial brines.	In large concentrations, in combination with sodium, gives salty taste to drinking water. In large concentrations, increases the corrosiveness of water.
Fluoride (F)	Dissolved in minute to small concentrations from most rocks and soil. Added to many water by fluoridation of municipal supplies.	Fluoride in drinking water reduces the incidence of tooth decay when the water is consumed during the period of enamel calcification. However, it may cause mottling of the teeth, depending on the concentration of fluoride, the age of the child, quantity of drinking water consumed, and susceptibility of the individual.
Silica (SiO_2)	Dissolved from practically all rocks and soil, commonly less than 30 mg/L. Large concentrations, as much as 100 mg/L, generally occur in alkaline water.	Forms hard scale in pipes and boilers. Transported in steam of high-pressure boilers to form deposits on blades of turbines. Inhibits deterioration of zeolite-type water softeners.
Iron (Fe)	Dissolved from practically all rocks and soil. Also may be derived from iron pipes, pumps, and other equipment. More than 1 or 2 mg/L of iron in surface water generally indicates acid wastes from mine drainage or other sources.	On exposure to air, iron in ground water oxidizes to reddish-brown precipitate. More than about 0.3 mg/L stains laundry and utensils reddish-brown. Objectionable for food processing, textile processing, beverages, ice manufacture, brewing, and other processes. Larger quantities cause unpleasant taste and favor growth of iron bacteria.
Dissolved solids	Chiefly mineral constituents dissolved from rocks and soil. Includes some water of crystallization.	Water containing more than 1,000 mg/L dissolved solids is unsuitable for many purposes.
Nitrate (NO_3)	Decaying organic matter, sewage, fertilizers, animal waste, and nitrates in soil.	Concentration much greater than the local average may indicate contamination. Water with large nitrate concentrations has been reported to be the cause of methemoglobinemia (an often fatal disease in infants) and therefore should not be used in infant feeding. Nitrate has been shown to be helpful in reducing intercrystalline cracking of boiler steel. It encourages growth of algae and other organisms that produce undesirable tastes and odors.

Table 11. *Wyoming ground-water quality standards for domestic, agricultural, and livestock use*

(Modified from Wyoming Department of Environmental Quality, 1990a, p. 9)

[All constituent concentrations are in milligrams per liter unless noted otherwise. µg/L, micrograms per liter; mg/L, milligrams per liter; °C, degrees Celsius; --, no data]

Constituent or property	Domestic use	Agricultural use	Livestock use
Aluminum (µg/L)	--	5,000	5,000
Arsenic (µg/L)	50	100	200
Barium (µg/L)	1,000	--	--
Boron (µg/L)	750	750	5,000
Cadmium (µg/L)	10	10	50
Chloride	250	100	2,000
Chromium (µg/L)	50	100	50
Copper (µg/L)	1,000	200	500
Fluoride	[1](1.4-2.4)	--	--
Iron (µg/L)	300	5,000	--
Lead (µg/L)	50	5,000	100
Manganese (µg/L)	50	200	--
Mercury (µg/L)	2	--	.05
Nitrate, as nitrogen	10	--	--
Nitrite, nitrate + nitrite, as nitrogen	--	--	100
Selenium (µg/L)	10	20	50
Silver (µg/L)	50	--	--
Sulfate	250	200	3,000
Dissolved solids	500	2,000	5,000
pH, standard units	(6.5-9.0)	(4.5-9.0)	(6.5-8.5)
Sodium-adsorption ratio	--	8	--

[1]Dependent on the annual average of the maximum daily air temperature: 1.4 mg/L corresponds with a temperature range of 26.3 to 32.5°C and 2.4 mg/L corresponds with a temperature of 12.0°C and below.

The U.S. Environmental Protection Agency (USEPA) has established primary and secondary drinking-water regulations and health advisories pertinent to public drinking-water supplies (table 12) (U.S. Environmental Protection Agency, 1991 a, b, c). The USEPA regulations specify maximum contaminant levels and secondary maximum contaminant levels. The maximum contaminant levels are health related and legally enforceable. Although maximum contaminant levels apply only to public drinking-water supplies, they are useful indicators of the suitability of water for human consumption. The secondary maximum contaminant levels are for constituents that primarily affect the esthetic qualities of drinking water. An example is chloride, which, at concentrations exceeding 250 mg/L, might impart a bitter taste to drinking water. Secondary maximum contaminant levels have no legally enforceable requirements. Health advisories are guidance levels that would not cause adverse health effects over specified short periods for most people.

Table 12. *Selected maximum and secondary maximum contaminant levels for public drinking-water supplies*

[All constituent concentrations are in milligrams per liter unless noted otherwise. µg/L, micrograms per liter; --, no established level]

Constituent or property	Maximum contaminant level	Secondary maximum contaminant level
Inorganic:		
Arsenic (µg/L)	[1]50	--
Barium (µg/L)	[1]1,000	--
Cadmium (µg/L)	[2]5	--
Chloride	--	[3]250
Chromium (µg/L)	[2]100	--
Copper (µg/L)	--	[3]1,000
Fluoride	[2]4.0	[3]2.0
Iron (µg/L)	--	[3]300
Lead (µg/L)	[1]50	--
Manganese (µg/L)	--	[3]50
Mercury (µg/L)	[2]2	--
Nitrite plus nitrate, as nitrogen	[1]10	--
Selenium (µg/L)	[2]50	--
Silver (µg/L)	--	[3]100
Sulfate	--	[3]250
Zinc (µg/L)	--	[3]5,000
Dissolved solids	--	[3]500
pH, standard units	--	[3]6.5-8.5
Selected organic:		
2,4-D	[2].07	--
Silvex	[2].05	--
Endrin	[1].0002	--
Lindane	[2].0002	--
Methoxychlor	[2].04	--
Toxaphene	[2].003	--

[1]U.S. Environmental Protection Agency, 1991a
[2]U.S. Environmental Protection Agency, 1991b
[3]U.S. Environmental Protection Agency, 1991c

Surface-Water Quality

The water quality of a stream is determined by collecting water samples on a systematic basis. Water quality in streams varies seasonally and with streamflow magnitude. A single sample defines the type and concentration of material in the stream only for the time and conditions of the sampling. Because ground water was the primary emphasis in this study, only two surface-water samples were collected, both for pesticides analysis. The surface-water pesticides data are discussed in the section titled Agricultural Chemicals in Surface and Ground Water. Other surface-water-quality data have been collected for selected sites in the county by the USGS. These data are compiled and published annually in USGS data reports for Wyoming.

The specific conductance of water samples collected from streams in the county ranged from 117 μS/cm (site 1) to 345 μS/cm (site 7) in water year 1992 (Druse and others, 1993, p. 448). Specific conductance generally increases downstream in a drainage basin, reflecting an increase in dissolved-solids concentration. The concentration of dissolved solids in a stream typically increases as the distance from the headwaters increases. Although specific-conductance data at several sites on one stream in the county are not available, data collected in other Wyoming basins (Plafcan and Ogle, 1994) support the general trend.

Fluctuations in discharge cause much of the variability in the chemical quality of surface water. Specific conductance typically varies inversely with stream discharge. A comparison of monthly values of specific conductance and daily mean discharge for the Snake River above Jackson Lake, at Flagg Ranch (site 1) is shown in figure 7 for water year 1992. The specific-conductance values are higher during low flows and smaller during high flows.

The principal dissolved constituents in county streams for which current water-quality data are available are calcium, magnesium, sodium, bicarbonate, and sulfate. Although chemical water-quality samples have been collected at selected streams in Teton County since 1965, most records are of short duration (1 to 6 years). Current data are available only for the Snake River above Jackson Lake, at Flagg Ranch (site 1) and Cache Creek near Jackson (site 7). Data for water year 1992 indicate that water in the Snake River above Jackson Lake, at Flagg Ranch is a sodium bicarbonate type and that water in Cache Creek near Jackson is a calcium bicarbonate type.

The chemical quality of surface water also can be affected by human activity. Dissolved-solids concentration in streams can be increased by either reduction in flow by upstream diversion of water containing smaller concentrations or by discharge of irrigation or other used water containing larger concentrations, or both. Dissolved trace elements, herbicides, nutrients, and other contaminants can enter surface water as a result of municipal, agricultural, domestic, industrial, or recreational uses of water. Substantial contamination problems have not been documented in Teton County. Two surface-water samples were collected in July 1993 in the Westbank area for analysis of herbicides, however, because of concern about effects that agricultural chemicals might have on stream quality. The results are discussed in the agricultural chemicals section of this report.

Ground-Water Quality

Data on the quality of water in geologic units are obtained by collecting water samples from wells completed in a specific geologic unit or from springs that issue from a geologic unit. Water-quality data in this report consist of analyses of water-quality samples collected as part of the current study. Analyses of water-quality samples from wells completed in and springs issuing from Quaternary unconsolidated deposits, Quaternary and Tertiary volcanic rocks, Tertiary rocks, Mesozoic rocks, Paleozoic rocks, and Precambrian metamorphic rocks are discussed in this report. Because of water-quality variability, individual geologic units are discussed in each section.

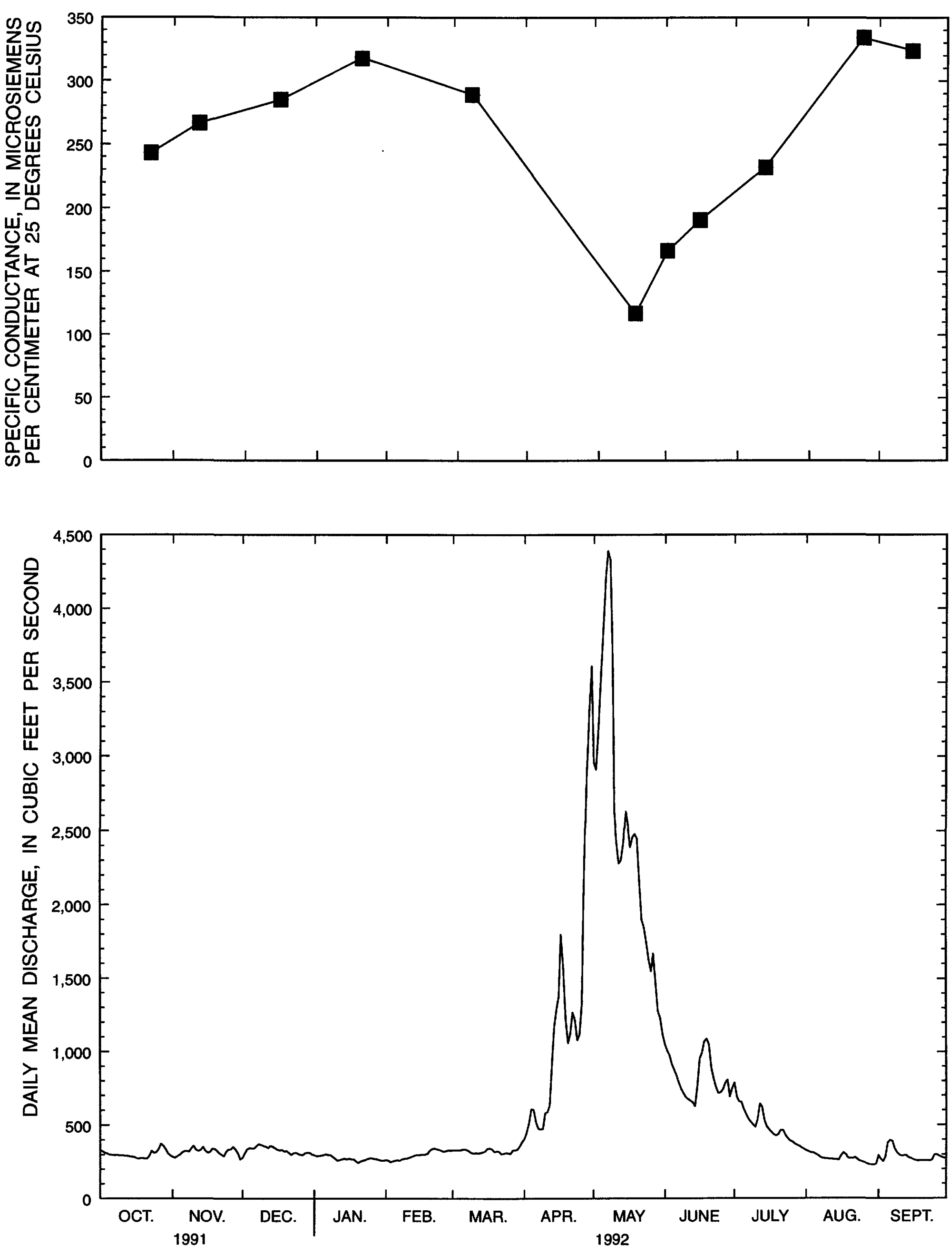


Figure 7. Comparison of specific conductance and daily mean discharge in the Snake River above Jackson Lake, at Flagg Ranch (site 1) in Teton County study area, Wyoming, water year 1992.

Quaternary Unconsolidated Deposits

Thirty-four water-quality samples, including one duplicate sample, were collected from wells completed in and springs issuing from Quaternary unconsolidated deposits. Of those, 28 water samples were collected from alluvium, colluvium, and gravel, pediment, and fan deposits, 5 samples from glacial deposits, and 1 sample from landslide deposits.

Dissolved-solids concentration of water samples from Quaternary unconsolidated deposits ranged from 91 to 707 mg/L (table 13). Nitrite-plus-nitrate concentration ranged from less than 0.050 to 7.50 mg/L as nitrogen. Stacked bar charts, which by the height of the bars show the concentrations of principal constituents, indicate that water type varied by lithology for samples collected from alluvium, glacial, and landslide deposits (fig. 8). The bar charts also indicate the dominant cations and anions and, therefore, water type. In the water sample from the landslide deposits, sodium was the dominant cation, and bicarbonate (measured as alkalinity multiplied by 1.22) was the dominant anion; sodium and potassium were combined for convenience, but sodium generally was more common. Thus, this water sample was classified as a sodium bicarbonate type. In the water samples from alluvium and glacial deposits, calcium was the dominant cation and bicarbonate was the dominant anion. Twenty water samples were collected from Quaternary unconsolidated deposits for analysis of trace elements; dissolved concentrations of these constituents are shown in table 14.

Quaternary and Tertiary Volcanic Rocks

Three water samples were collected from springs issuing from Quaternary and Tertiary volcanic rocks. One water sample (48-117-16ccc01) was from a Quaternary rhyolite flow, and the other two samples were from Tertiary extrusive rock. All three samples were collected north and west of the Teton Range, in the extreme northwestern part of the study area.

The dissolved-solids concentration of the water sample from the Quaternary rhyolite flow was 22 mg/L (table 13), which was the lowest dissolved-solids concentration in the study area. Nitrite-plus-nitrate concentration of water samples from Quaternary and Tertiary volcanic rocks ranged from less than 0.050 to 0.130 mg/L. Stacked bar charts indicate that water type and concentrations of principal constituents varied by lithology for samples collected from a rhyolite flow and from extrusive rock (fig. 9). In the water sample from the rhyolite flow, cations were mixed (predominantly calcium and sodium) and the dominant anion was bicarbonate. In the water sample from the extrusive rock, calcium was the dominant cation and bicarbonate was the dominant anion. Thus, water in this sample was classified as a calcium bicarbonate type.

Tertiary Rocks

Nine water samples were collected from wells completed in and springs issuing from Tertiary rocks. Three samples were collected from the Teewinot Formation, three from the Camp Davis Formation, and one each from the Colter, Tepee Trail, and Hoback Formations.

Dissolved solids concentration of water samples from Tertiary rocks ranged from 80 to 306 mg/L (table 13). Nitrite-plus-nitrate concentration ranged from less than 0.050 to 0.580 mg/L. Stacked bar charts indicate that, although the concentrations of principal constituents varied by lithology, water type was the same for samples collected from the Teewinot, Camp Davis, Colter, Tepee Trail, and Hoback Formations (fig. 10). In water samples from these formations, calcium was the dominant cation and bicarbonate was the dominant anion. Water in these samples was classified as a calcium bicarbonate type. Four water samples were collected from Tertiary rocks for analysis of trace elements; dissolved concentrations of these constituents are shown in table 14.

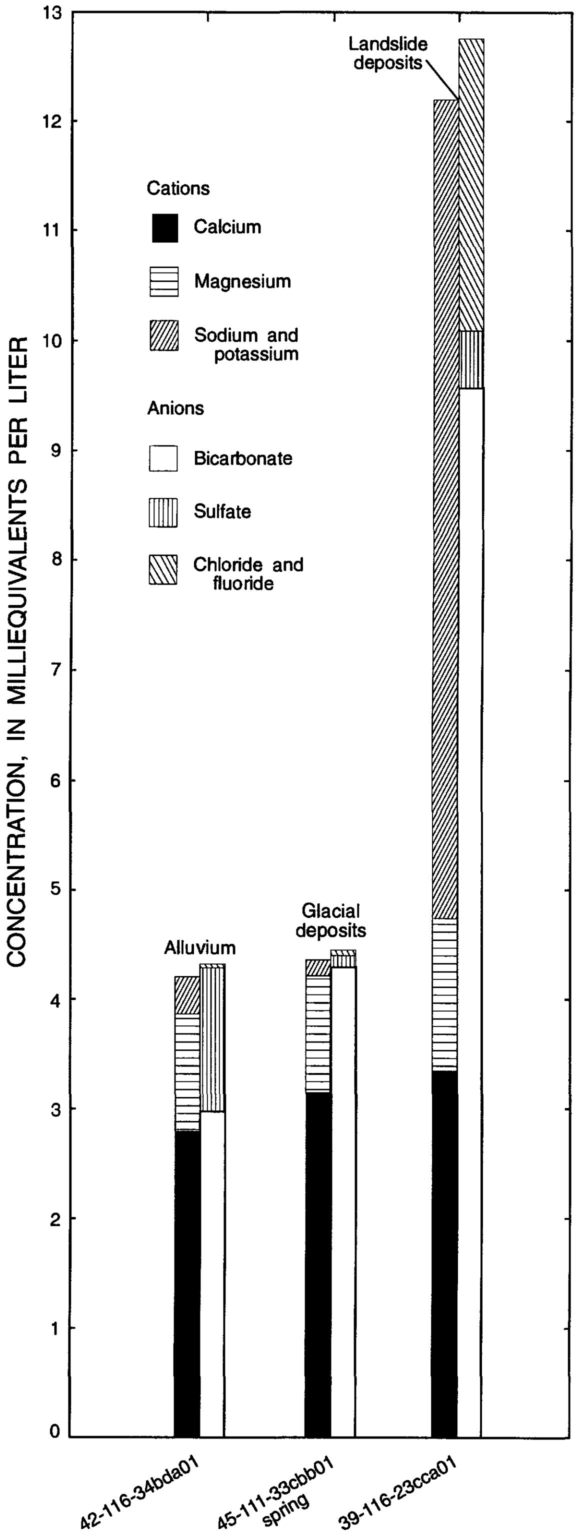


Figure 8. Principal chemical constituents in ground-water samples collected from representative wells completed in and springs issuing from Quaternary unconsolidated deposits in Teton County study area, Wyoming.

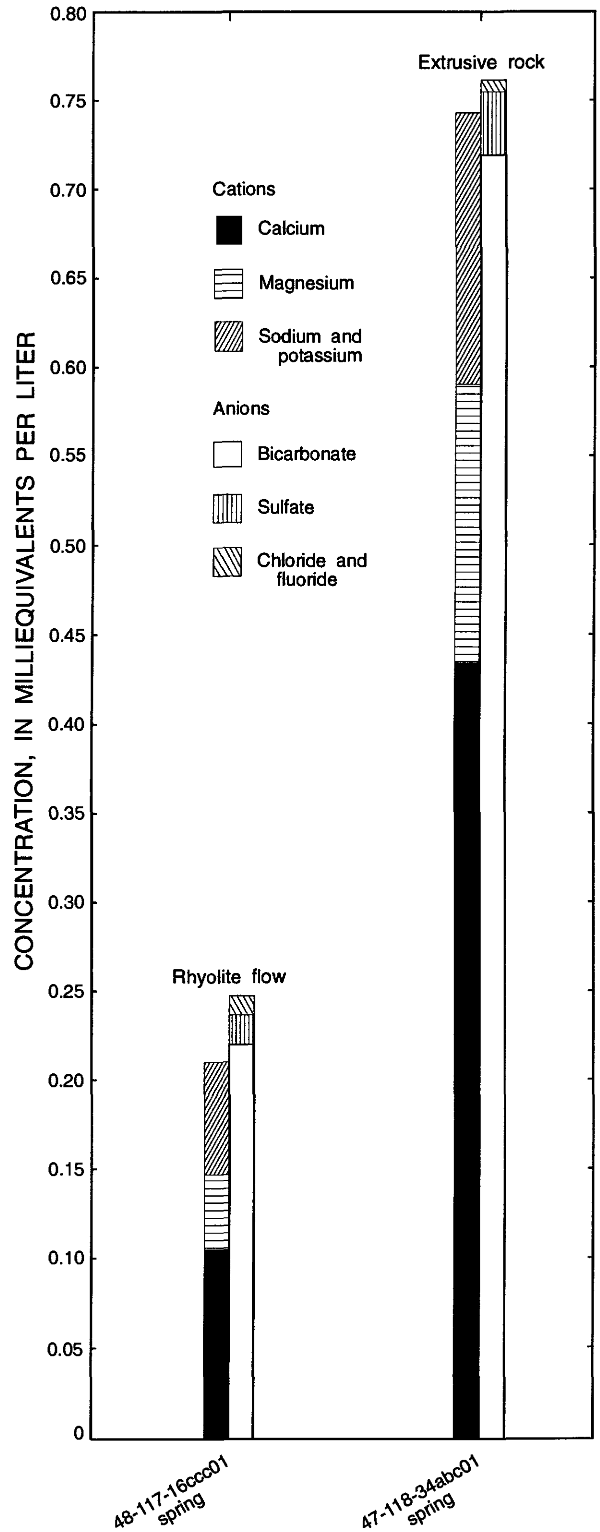


Figure 9. Principal chemical constituents in ground-water samples collected from springs issuing from Quaternary and Tertiary volcanic rocks in Teton County study area, Wyoming.

Table 13. *Chemical analyses and physical properties of water samples*

[Local number: See text describing well-numbering system in the section titled Ground-Water Data. Analytical results in milligrams

Local number	Date sampled	Well depth (feet)	Specific conductance (µS/cm)	pH	Water temperature (°C)	Hardness ($CaCO_3$)	Calcium, dissolved (Ca)	Magnesium, dissolved (Mg)	Sodium, dissolved (Na)	Sodium adsorption ratio
							Quaternary alluvium, colluvium, and			
40-116-06adb01	07-12-91	42	495	7.9	10.5	270	76	19	4.9	0.1
40-116-17cdd01	07-24-92	50	610	7.6	8.0	320	81	28	4.1	.1
40-116-19cbc01	07-11-91	30	395	7.4	10.5	170	32	23	29	1
40-116-20aaa01	07-27-92	180	660	7.7	10.0	350	82	35	6.4	.1
40-116-27cca01	07-23-92	53	863	7.3	9.0	460	100	51	13	.3
	07-23-92	53	863	7.3	9.0	460	100	50	11	.2
40-117-01bba01	07-17-93	80	--	--	8.5	--	--	--	--	--
41-111-30adb01	08-09-91	Spring	770	7.3	7.0	340	100	23	27	.6
41-115-03baa01	07-29-92	Spring	225	8.0	5.5	120	32	10	.90	0
41-115-18dcc01	07-22-92	86	--	--	8.0	270	71	22	2.3	.1
41-116-09acd01	07-23-92	50	430	7.7	9.0	210	62	14	7.4	.2
41-116-11abb01	07-25-92	90	275	8.0	8.0	140	37	12	2.4	.1
41-116-22bab01	07-25-92	--	268	8.1	8.5	140	35	12	2.4	.1
41-116-33cab01	07-20-92	148	517	7.6	9.0	260	69	22	5.7	.2
41-116-33cba01	07-29-92	--	435	7.7	10.0	230	60	19	4.3	.1
41-117-13bbb01	07-28-92	--	270	7.8	9.0	120	37	7.5	7.4	.3
41-117-14acb01	07-21-92	--	265	7.9	9.5	130	38	7.9	6.0	.2
41-117-15adc01	07-21-92	60	268	8.0	8.5	130	37	8.8	3.0	.1
41-117-35dac01	07-17-93	--	--	--	6.0	--	--	--	--	--
42-115-11aad01	08-10-91	76	455	7.6	20.0	220	57	19	6.0	.2
42-116-21abd01	08-10-91	48	290	7.6	7.5	140	42	8.1	7.2	.3
42-116-34bda01	07-22-92	101	370	7.9	9.0	190	56	13	7.2	.2
42-117-24dac01	07-20-92	--	283	7.8	10.0	150	42	9.9	1.9	.1
44-112-13dad01	06-25-92	Spring	295	7.8	5.0	140	43	7.6	6.9	.3
44-118-19adc01	08-07-91	220	325	7.6	9.0	180	48	14	1.8	.1
45-112-23aab01	06-26-92	--	420	8.6	8.0	15	4.7	.69	94	11
45-112-31bca01	06-22-92	75	335	7.9	12.0	140	40	9.8	19	.7
45-113-07dbd01	06-24-92	45	260	8.0	6.5	120	36	7.0	6.3	.3
45-113-27dac01	07-26-92	--	330	7.5	9.0	170	48	11	7.4	.3
LAT-LONG-434528110570101	08-07-91	70	320	7.5	5.5	170	47	13	1.4	0
										Quaternary
41-117-25dca01	07-24-92	143	--	--	9.5	260	66	23	29	.8
41-117-27cba01	07-21-92	48	365	7.6	8.5	180	52	13	4.0	.1
41-117-34cca01	07-27-92	--	350	7.6	6.5	170	35	19	5.5	.2
45-111-33cbb01	06-25-92	Spring	415	7.8	4.0	210	63	13	1.9	.1
47-118-04dbd01	06-27-92	--	112	7.8	7.0	48	13	3.7	4.0	.3
										Quaternary
39-116-23cca01	07-27-92	147	1,160	7.7	12.5	240	67	17	170	5
										Quaternary
48-117-16ccc01	06-27-92	Spring	22	6.1	9.0	7	2.1	.51	1.1	.2

collected from selected wells and springs in Teton County study area, Wyoming

per liter except as indicated; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; --, no data; <, less than]

Potassium, dissolved (K)	Alkalinity, total (as $CaCO_3$)	Sulfate, dissolved (SO_4)	Chloride, dissolved (Cl)	Fluoride, dissolved (F)	Silica, dissolved (SiO_2)	Dissolved solids, sum of constituents	Nitrogen, NO_2, dissolved	Nitrogen, NO_2+NO_3, dissolved	Nitrogen, NH_3, dissolved	Phosphorus, total (P)
gravel, pediment, and fan deposits										
1.6	232	30	8.1	0.20	11	292	<0.010	0.530	<0.010	0.010
2.1	221	110	4.7	.60	19	383	<.010	.290	.020	<.010
4.2	196	38	5.4	.20	17	267	<.010	.090	<.010	.030
6.6	199	170	6.3	.90	42	469	<.010	<.050	.150	.020
4.7	427	62	16	.30	31	538	<.010	.790	.030	.020
4.8	426	62	17	.30	31	535	<.010	.790	.020	.020
--	--	--	--	--	--	--	--	--	--	--
2.0	279	130	4.7	.20	15	470	<.010	.078	<.010	<.010
.40	122	3.6	2.3	.10	4.5	127	<.010	.110	.040	<.010
1.6	174	100	2.8	.10	8.2	316	<.010	.790	.010	.010
1.5	175	56	1.9	.20	9.7	258	<.010	.130	.020	.010
1.0	145	7.4	2.8	.10	10	160	<.010	.130	.020	<.010
2.5	145	4.2	2.8	.20	21	168	<.010	.140	.020	.010
2.1	228	48	13	.20	14	314	<.010	.800	.020	.030
2.0	216	25	4.9	.20	14	261	<.010	.540	.030	<.010
1.9	126	10	5.9	.40	15	161	<.010	.160	.020	<.010
1.6	131	8.5	5.3	.30	12	159	<.010	.200	.030	.010
1.4	134	4.7	3.5	.20	12	152	<.010	.200	.020	<.010
--	--	--	--	--	--	--	--	--	--	--
2.0	150	75	3.3	.60	14	267	<.010	.096	<.010	<.010
1.8	141	11	3.9	.40	16	176	<.010	.270	<.010	<.010
1.1	149	63	.90	.20	7.2	238	<.010	.092	.020	<.010
1.0	151	2.9	3.0	.10	9.3	162	<.010	.240	.020	<.010
1.3	150	5.0	.40	<.10	18	173	<.010	.160	.020	.020
.80	174	3.1	<.10	.20	15	--	<.010	1.10	.020	<.010
.60	218	8.9	3.1	.50	13	261	<.010	.990	.080	<.010
1.6	174	11	.40	.20	15	202	<.010	.120	.020	.020
2.2	124	12	.40	<.10	25	163	<.010	<.050	.030	.020
3.3	180	5.4	1.8	.20	24	209	<.010	<.050	.040	.030
.90	159	3.4	<.10	<.10	5.9	--	<.010	.061	<.010	<.010
glacial deposits										
6.2	286	1.0	38	.40	40	378	<.010	<.050	1.40	.190
1.2	191	4.7	4.8	.20	12	208	<.010	.320	.030	<.010
5.3	180	9.1	2.1	.40	48	233	<.010	<.050	.180	.140
2.5	215	5.0	1.8	<.10	25	242	<.010	.250	.020	.020
.90	55	1.4	.40	.20	32	91	<.010	.390	.010	.020
landslide deposits										
2.4	479	25	91	1.9	12	707	0.270	7.50	0.120	0.010
rhyolite flow										
.60	11	.80	.20	.10	10	22	<.010	<.050	.020	<.010

Table 13. *Chemical analysis and physical properties of water samples collected*

Local number	Date sampled	Well depth (feet)	Specific conductance (μS/cm)	pH	Water temperature (°C)	Hardness ($CaCO_3$)	Calcium, dissolved (Ca)	Magnesium, dissolved (Mg)	Sodium, dissolved (Na)	Sodium adsorption ratio
										Tertiary extrusive
46-118-34caa01	08-08-91	Spring	22	6.6	5.5	6	1.8	0.42	1.1	0.2
47-118-34abc01	08-08-91	Spring	77	6.6	6.0	30	8.7	1.9	2.8	.2
										Teewinot
43-115-12cbd01	06-25-92	Spring	380	7.8	5.0	190	57	12	2.3	.1
44-114-31bbc01	07-26-92	160	245	8.0	8.0	120	34	8.6	2.7	.1
LAT-LONG-440601110355201	06-23-92	Spring	112	7.7	--	47	15	2.3	3.9	.2
										Camp Davis
38-115-05dcd01	07-24-92	Spring	380	7.0	6.5	200	67	8.5	4.9	.1
39-115-18bcd01	07-12-91	140	460	7.5	8.5	280	96	9.7	4.8	.1
LAT-LONG-432031110260701	07-10-91	135	330	7.3	6.0	200	50	18	5.6	.2
										Colter
46-114-20ada01	06-24-92	Spring	170	8.1	7.0	87	27	4.8	2.1	.1
										Tepee Trail
LAT-LONG-434709110062401	06-28-92	Spring	94	7.7	3.0	40	13	1.9	2.0	.1
										Hoback
LAT-LONG-431925110260601	07-10-91	Spring	370	7.7	6.0	270	80	17	2.8	.1
										Undifferentiated
42-112-23bac01	08-09-91	Spring	315	7.4	5.0	170	48	12	2.3	.1
44-113-25cda01	06-22-92	--	940	9.2	6.0	5	1.3	.32	220	45
45-113-22cbb01	06-24-92	154	530	7.4	7.5	240	68	16	22	.6
										Harebell
46-113-20aac01	06-23-92	130	475	9.4	9.5	3	1.1	.02	110	28
	06-23-92	130	--	--	--	3	1.2	.01	110	27
										Bacon Ridge
42-112-28dac01	08-09-91	Spring	380	7.5	5.0	200	55	14	6.3	.2
										Aspen
40-117-20cba01	07-28-92	Spring	325	7.5	8.0	160	52	7.8	7.6	.3
LAT-LONG-432324110505501	07-11-91	127	590	7.4	6.5	270	76	19	11	.3
										Bear River
39-116-14cad01	07-23-92	--	1,630	8.9	12.0	5	1.1	.51	410	81
39-116-26bac01	07-11-91	80	1,080	7.5	6.5	450	140	23	42	.9
LAT-LONG-432108110495101	07-09-91	97	330	7.4	14.0	160	52	7.6	7.9	.3
										Preuss
LAT-LONG-433200111011801	08-05-91	Spring	460	7.1	13.0	230	71	14	3.2	.1

from selected wells and springs in Teton County study area, Wyoming--Continued

Potassium, dissolved (K)	Alkalinity, total (as $CaCO_3$)	Sulfate, dissolved (SO_4)	Chloride, dissolved (Cl)	Fluoride, dissolved (F)	Silica, dissolved (SiO_2)	Dissolved solids, sum of constitutents	Nitrogen, NO_2, dissolved	Nitrogen, NO_2+NO_3, dissolved	Nitrogen, NH_3, dissolved	Phosphorus, total (P)
igneous rocks										
0.70	9.0	1.1	<0.10	<0.10	11	--	<0.010	0.130	<0.010	<0.010
1.2	36	1.7	<.10	.10	23	--	<.010	.071	<.010	.010
Formation										
3.9	197	6.2	.90	.40	43	244	<.010	.110	.010	.020
3.4	125	2.6	1.2	.30	37	166	<.010	.160	.040	.040
.40	46	12	.50	.20	17	80	<.010	.310	.040	.020
Formation										
1.4	194	22	4.1	.10	9.4	234	<.010	.110	.050	.030
1.9	250	17	9.8	.20	14	306	<.010	.580	<.010	.010
1.2	190	15	3.3	.20	8.2	215	<.010	<.050	<.010	<.010
Formation										
1.2	91	2.2	.80	.20	21	114	<.010	.065	.030	.030
Formation										
1.7	46	1.1	.50	.20	35	84	<.010	.120	.010	.120
Formation										
.60	267	4.4	3.9	.10	5.9	275	<.010	<.050	<.010	<.010
Mesozoic rocks										
1.2	153	14	2.1	<.10	7.5	179	<.010	.110	<.010	<.010
1.2	502	9.7	2.4	1.6	9.4	548	<.010	<.050	.310	.060
3.2	271	15	4.1	.20	20	314	<.010	.530	.030	.060
Formation										
.20	230	2.4	6.1	8.2	13	280	<.010	<.050	.010	<.010
.20	230	2.5	6.4	8.3	13	280	<.010	<.050	.010	<.010
Sandstone										
1.3	188	18	<.10	.10	7.9	--	<.010	.180	<.010	<.010
Shale										
1.0	178	3.1	.90	.20	9.3	191	<.010	.550	.030	<.010
.70	271	9.4	6.6	.20	19	308	<.010	.790	<.010	.030
Formation										
.70	699	210	12	3.3	7.2	1,060	<.010	<.050	.170	.040
3.0	319	24	110	.30	13	591	<.010	9.70	<.010	.040
1.4	175	4.1	3.9	.20	14	197	--	--	--	--
Sandstone										
.70	243	7.1	2.1	<.10	12	256	<.010	.150	<.010	<.010

Table 13. *Chemical analysis and physical properties of water samples collected*

Local number	Date sampled	Well depth (feet)	Specific conductance (μS/cm)	pH	Water temperature (°C)	Hardness ($CaCO_3$)	Calcium, dissolved (Ca)	Magnesium, dissolved (Mg)	Sodium, dissolved (Na)	Sodium adsorption ratio
										Tensleep
41-115-01bba01	06-22-92	Spring	530	8.0	6.0	280	64	28	5.9	0.2
LAT-LONG-433317111014201	08-05-91	Spring	490	7.4	7.0	250	66	21	3.0	.1
LAT-LONG-433401111020801	08-05-91	Spring	470	7.5	6.5	240	69	17	1.2	0
LAT-LONG-434018111020201	08-05-91	Spring	245	7.3	7.0	110	27	10	1.6	.1
								Darwin Sandstone Member		
41-116-18bcb01	07-29-92	180	540	7.6	10.0	230	56	21	26	.8
										Madison
LAT-LONG-433957110572001	08-06-91	Spring	150	7.5	2.0	81	22	6.4	.60	0
LAT-LONG-434029110593001	08-06-91	Spring	200	7.3	5.0	100	28	8.4	.50	0
										Darby
LAT-LONG-434103110572601	08-06-91	Spring	265	7.3	4.5	140	36	11	.60	0
LAT-LONG-434721110572701	08-07-91	--	325	7.3	9.5	180	51	12	.80	0
										Bighorn
41-116-32add01	07-28-92	--	530	7.5	10.5	260	70	21	9.8	.3
LAT-LONG-432219110263501	07-10-91	Spring	155	8.2	5.0	100	26	8.5	.60	0
LAT-LONG-434646110583201	08-07-91	Spring	455	7.3	6.0	240	72	15	1.0	0
									Undifferentiated	
41-115-16cca01	07-22-92	Spring	183	8.1	12.0	89	24	7.0	2.0	.1
46-111-33add01	06-26-92	Spring	1,400	6.5	8.5	500	160	24	91	2
										Precambrian
LAT-LONG-434537110545701	08-06-91	Spring	205	7.0	6.5	110	30	8.6	2.4	.1
LAT-LONG-435358110561401	08-08-91	Spring	16	6.4	3.0	5	1.5	.25	1.4	.3

from selected wells and springs in Teton County study area, Wyoming--Continued

Potassium, dissolved (K)	Alkalinity, total (as $CaCO_3$)	Sulfate, dissolved (SO_4)	Chloride, dissolved (Cl)	Fluoride, dissolved (F)	Silica, dissolved (SiO_2)	Dissolved solids, sum of constitutents	Nitrogen, NO_2, dissolved	Nitrogen, NO_2+NO_3, dissolved	Nitrogen, NH_3, dissolved	Phosphorus, total (P)
Sandstone										
1.7	284	10	4.7	0.20	26	312	<0.010	0.290	0.020	0.020
.60	253	4.3	2.1	.10	13	262	<.010	.083	<.010	.050
1.4	227	2.2	.20	.10	8.0	236	<.010	.220	<.010	.010
.80	116	1.5	<.10	.20	11	--	<.010	.053	<.010	.170
of the Amsden Formation										
2.6	200	62	23	.50	17	331	<.010	.680	.020	<.010
Limestone										
.20	82	1.3	<.10	.20	2.3	--	<.010	.190	<.010	<.010
.30	107	1.1	<.10	.30	3.9	--	<.010	.160	<.010	<.010
Formation										
.30	139	3.5	2.1	.10	2.8	140	<.010	.150	<.010	.010
.40	178	2.1	2.0	<.10	6.5	183	<.010	.220	.020	<.010
Dolomite										
2.4	236	41	13	.20	16	319	<.010	.810	.020	.020
.40	92	2.4	<.10	.20	2.8	--	--	--	--	--
.40	241	2.4	2.0	<.10	6.6	245	<.010	.210	<.010	<.010
Cambrian rocks										
.70	94	2.1	1.1	<.10	7.8	102	<.010	.120	.020	<.010
25	622	17	100	.20	39	829	<.010	<.050	.080	<.010
metamorphic rocks										
.80	113	1.9	<.10	.10	14	--	<.010	.130	<.010	<.010
.30	8.0	.80	<.10	<.10	9.5	--	<.010	<.050	<.010	<.010

Table 14. *Concentrations of selected trace elements for water samples*

[Local number: See text describing well-numbering system in the section titled

Local number	Date sampled	Aluminum, dissolved (Al)	Arsenic, dissolved (As)	Boron, dissolved (Ba)	Cadmium, dissolved (Cd)
			Quaternary alluvium, colluvium, and		
40-116-06adb01	07-12-91	<10	2	30	--
40-116-17cdd01	07-24-92	10	1	30	<10
40-116-19cbc01	07-11-91	<10	4	40	<1.0
40-116-27cca01	07-23-92	<10	4	40	<10
	07-23-92	<10	4	40	<10
41-116-11abb01	07-25-92	<10	<1	10	<10
41-116-22bab01	07-25-92	10	2	<10	<10
41-116-33cab01	07-20-92	<10	3	20	<10
41-117-14acb01	07-21-92	10	2	40	<10
41-117-15adc01	07-21-92	<10	1	20	<10
42-115-11aad01	08-10-91	<10	3	30	--
42-116-21abd01	08-10-91	<10	3	50	--
42-116-34bda01	07-22-92	20	<1	20	<10
42-117-24dac01	07-20-92	<10	<1	10	<10
44-112-13dad01	06-25-92	<10	<1	10	<10
44-118-19adc01	08-07-91	<10	<1	10	--
45-112-31bca01	06-22-92	10	<1	30	<10
					Quaternary
41-117-25dca01	07-24-92	<10	2	130	<10
41-117-27cba01	07-21-92	<10	1	20	<10
47-118-04dbd01	06-27-92	10	<1	<10	<10
					Camp Davis
39-115-18bcd01	07-12-91	10	<1	20	--
LAT-LONG-432031110260701	07-10-91	<10	<1	10	--
					Colter
46-114-20ada01	06-24-92	20	4	<10	<10
					Hoback
LAT-LONG-431925110260601	07-10-91	<10	<1	10	--
					Harebell
46-113-20aac01	06-23-92	<10	<1	620	<10
	06-23-92	<10	<1	610	<10
					Aspen
LAT-LONG-432324110505501	07-11-91	10	1	20	--
					Bear River
39-116-14cad01	07-23-92	10	<1	410	<10
39-116-26bac01	07-11-91	<10	<1	60	<1.0
LAT-LONG-432108110495101	07-09-91	<10	<1	10	<1.0
					Tensleep
41-115-01bba01	06-22-92	20	4	20	<10
					Bighorn
LAT-LONG-432219110263501	07-10-91	<10	<1	<10	--
					Precambrian
LAT-LONG-434537110545701	08-06-91	<10	<1	10	--

collected from selected wells and springs in Teton County study area, Wyoming

Ground-Water Data. Analytical results in micrograms per liter; --, no data; <, less than]

Chromium, dissolved (Cr)	Copper, dissolved (Cu)	Iron, dissolved (Fe)	Lead, dissolved (Pb)	Manganese, dissolved (Mn)	Mercury, dissolved (Hg)	Selenium, dissolved (Se)	Zinc, dissolved (Zn)
gravel, pediment, and fan deposits							
<1	1	--	<1	--	<0.1	<1	--
<1	3	85	<1	2	<.1	1	15
<1	20	130	<1	1	<.1	<1	46
<1	1	5	<1	<1	<.1	2	13
<1	<1	<3	<1	<1	<.1	2	6
<1	<1	<3	<1	<1	<.1	<1	<3
<1	<1	63	<1	<1	<.1	<1	14
<1	2	6	<1	<1	<.1	<1	6
<1	<1	<3	<1	<1	<.1	<1	4
<1	3	<3	<1	<1	<.1	<1	26
<1	<1	--	<1	--	<.1	<1	--
<1	<1	--	<1	--	<.1	<1	--
<1	<1	<3	<1	<1	<.1	<1	4
<1	2	<3	<1	<1	<.1	<1	11
<1	<1	<3	<1	<1	<.1	<1	<3
<1	3	--	<1	--	<.1	<1	--
<1	3	<3	<1	<1	<.1	<1	37
glacial deposits							
<1	<1	220	<1	520	<.1	<1	7
<1	<1	<3	<1	<1	<.1	<1	9
<1	1	30	3	16	<.1	<1	980
Formation							
<1	2	--	<1	--	<.1	<1	--
<1	<1	--	<1	--	<.1	<1	--
Formation							
<1	1	7	<1	6	<.1	<1	<3
Formation							
<1	<1	--	<1	--	.1	<1	--
Formation							
<1	1	53	<1	1	<.1	<1	<3
4	<1	5	<1	<1	<.1	<1	<3
Shale							
1	2	--	1	--	<.1	<1	--
Formation							
<1	<1	28	<1	4	<.1	<1	5
<1	7	54	<1	2	<.1	2	26
<1	9	16	<1	1	<.1	<1	260
Sandstone							
<1	2	<3	<1	<1	<.1	<1	<3
Dolomite							
<1	2	--	<1	--	<.1	<1	--
metamorphic rocks							
<1	<1	--	<1	--	<.1	<1	--

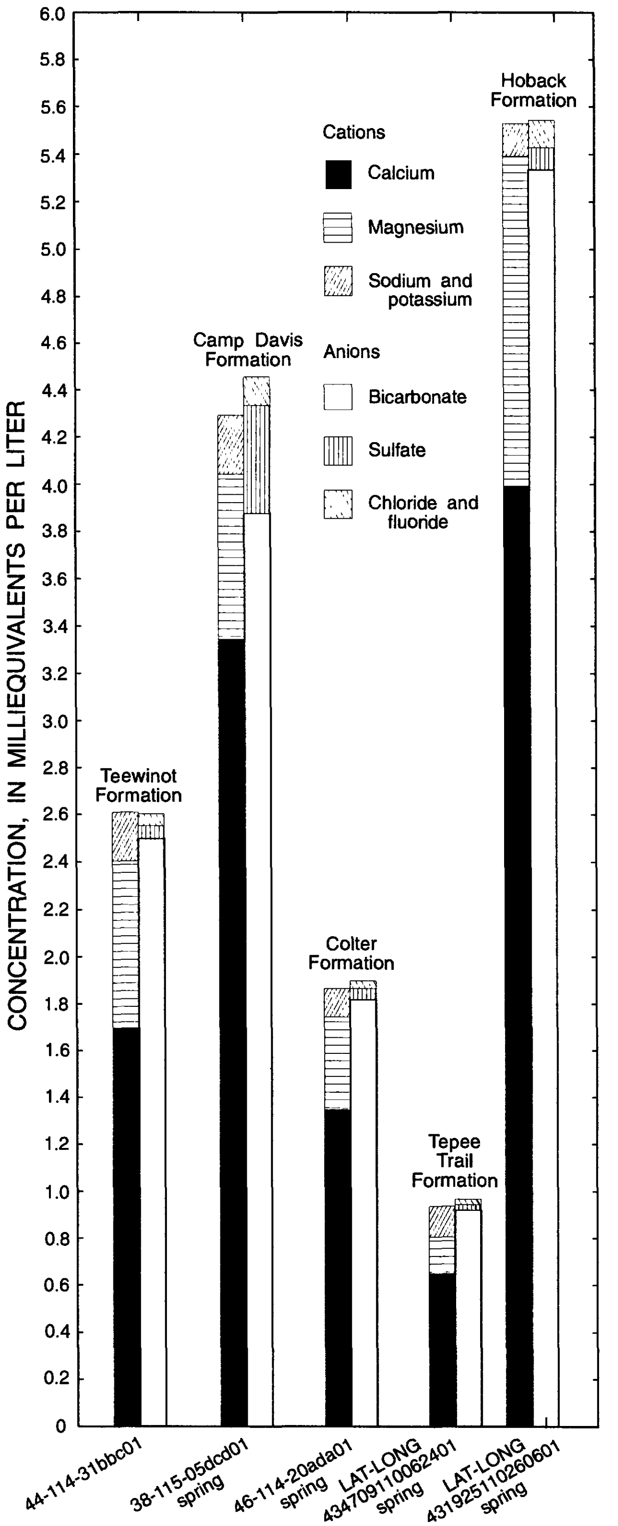


Figure 10. Principal chemical constituents in ground-water samples collected from representative wells completed in and springs issuing from Tertiary rocks in Teton County study area, Wyoming.

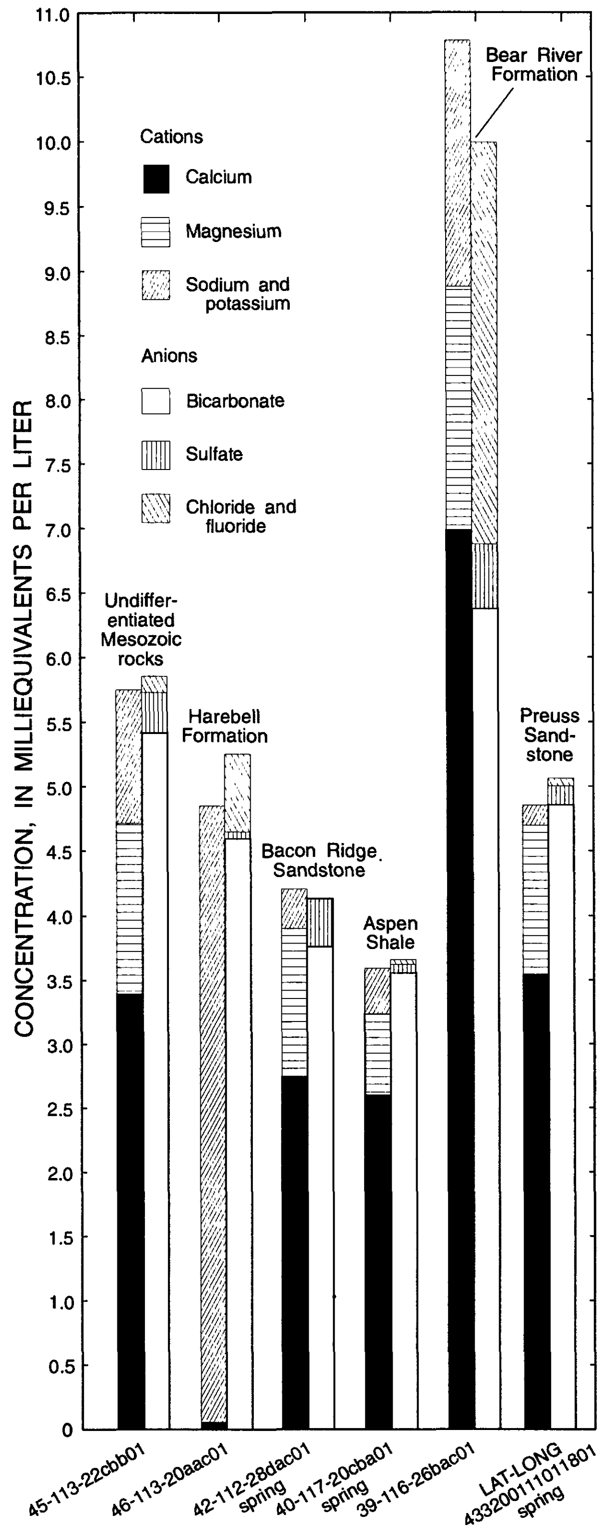


Figure 11. Principal chemical constituents in ground-water samples collected from representative wells completed in and springs issuing from Mesozoic rocks in Teton County study area, Wyoming.

Mesozoic Rocks

Twelve water-quality samples, including one duplicate sample, were collected from wells completed in and springs issuing from Mesozoic rocks. Three of the water samples were collected from undifferentiated Mesozoic rocks, two were from the Harebell Formation, one was from the Bacon Ridge Sandstone, two were from the Aspen Shale, three were from the Bear River Formation, and one was from the Preuss Sandstone. Although undifferentiated Mesozoic rocks include the Harebell, Bacon Ridge, Aspen, and Bear River Formations, the specific formations supplying water to wells and springs completed in and issuing from these rocks could not be identified.

Dissolved-solids concentration of water samples from Mesozoic rocks ranged from 179 to 1,060 mg/L (table 13). The largest value corresponds to a water sample from the Bear River Formation. Nitrite-plus-nitrate concentration ranged from less than 0.050 to 9.70 mg/L. Stacked bar charts indicate that water type and concentrations of principal constituents varied by lithology for samples collected from the undifferentiated Mesozoic rocks, Harebell Formation, Bacon Ridge Sandstone, Aspen and Bear River Formations, and Preuss Sandstone. In water samples collected from undifferentiated Mesozoic rocks, the Bacon Ridge Sandstone, the Aspen and Bear River Formations, and the Preuss Sandstone, calcium was the dominant cation and bicarbonate was the dominant anion (fig. 11). Water in these samples was classified as a calcium bicarbonate type. In the water sample from the Harebell Formation, sodium was the dominant cation and bicarbonate was the dominant anion. Water in this sample was classified as a sodium bicarbonate type. Six water samples were collected from Mesozoic rocks for analysis of trace elements; dissolved concentrations of these constituents are shown in table 14.

Paleozoic Rocks

Fourteen water-quality samples were collected from wells completed in and springs issuing from Paleozoic rocks. Four water samples were collected from the Tensleep Sandstone, one from the Darwin Sandstone Member of the Amsden Formation, two from the Madison Limestone, two from the Darby Formation, three from the Bighorn Dolomite, and two from undifferentiated Cambrian rocks.

Dissolved-solids concentration of water samples from Paleozoic rocks ranged from 102 to 829 mg/L (table 13). Nitrite-plus-nitrate concentration ranged from less than 0.050 to 0.810 mg/L. Stacked bar charts indicate that water type and concentrations of principal constituents varied by lithology for samples collected from the Tensleep Sandstone and Darwin Sandstone Member of the the Amsden Formation, Madison Limestone, Darby Formation, Bighorn Dolomite, and undifferentiated Cambrian rocks. In water samples from the Tensleep Sandstone, Madison Limestone, Darby Formation, Bighorn Dolomite, and undifferentiated Cambrian rocks, calcium was the dominant cation and bicarbonate was the dominant anion (fig. 12). Water in these samples was classified as a calcium bicarbonate type. Cations (calcium, magnesium, and sodium) were mixed and bicarbonate was the dominant anion in the water sample from the Darwin Sandstone Member. Two water samples were collected from Paleozoic rocks for analysis of trace elements; dissolved concentrations of these constituents are shown in table 14.

Precambrian Metamorphic Rocks

Two water samples were collected from springs issuing from Precambrian metamorphic rocks. Nitrite-plus-nitrate concentration of the two water samples ranged from less than 0.050 to 0.130 mg/L (table 13). A stacked bar chart associated with one of the samples (lat-long 434537110545701) indicates that calcium was the dominant cation and bicarbonate was the dominant anion (fig. 13). Thus, water in this sample was classified as a calcium bicarbonate type. The same water sample was analyzed for trace elements; dissolved concentrations of these constituents are shown in table 14.

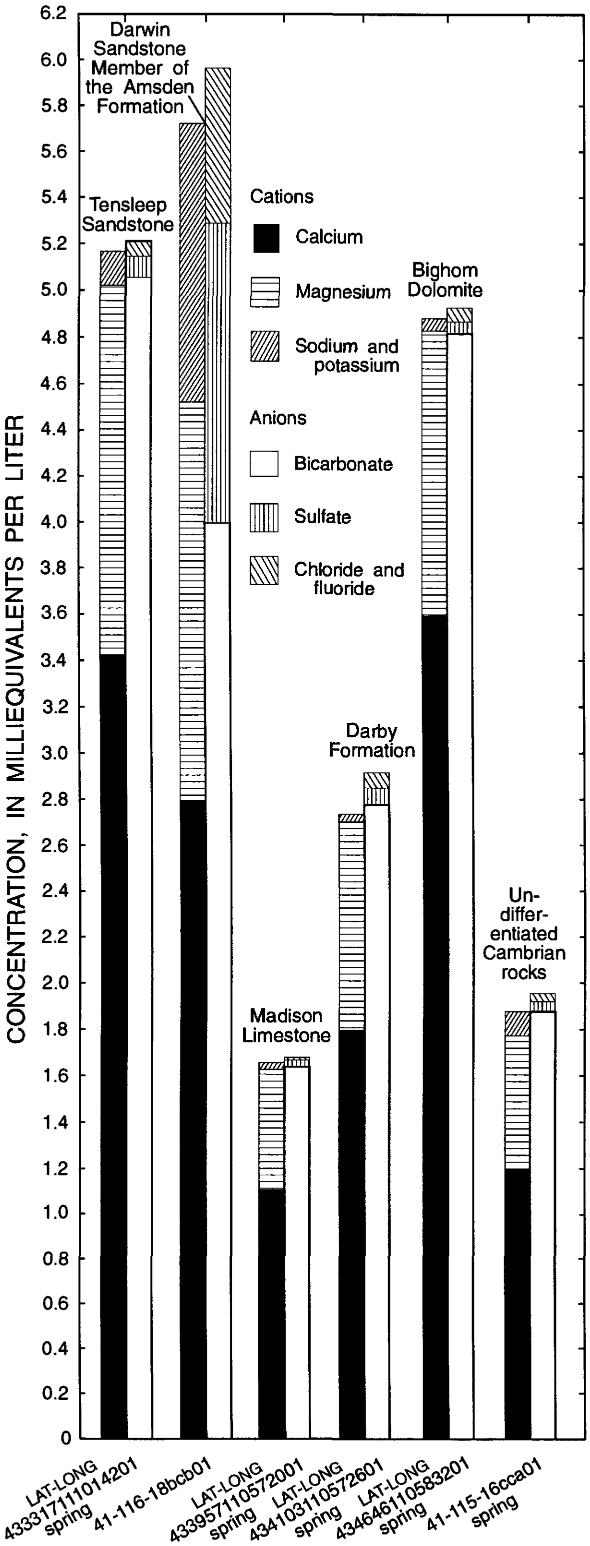


Figure 12. Principal chemical constituents in ground-water samples collected from representative wells completed in and springs issuing from Paleozoic rocks in Teton County study area, Wyoming.

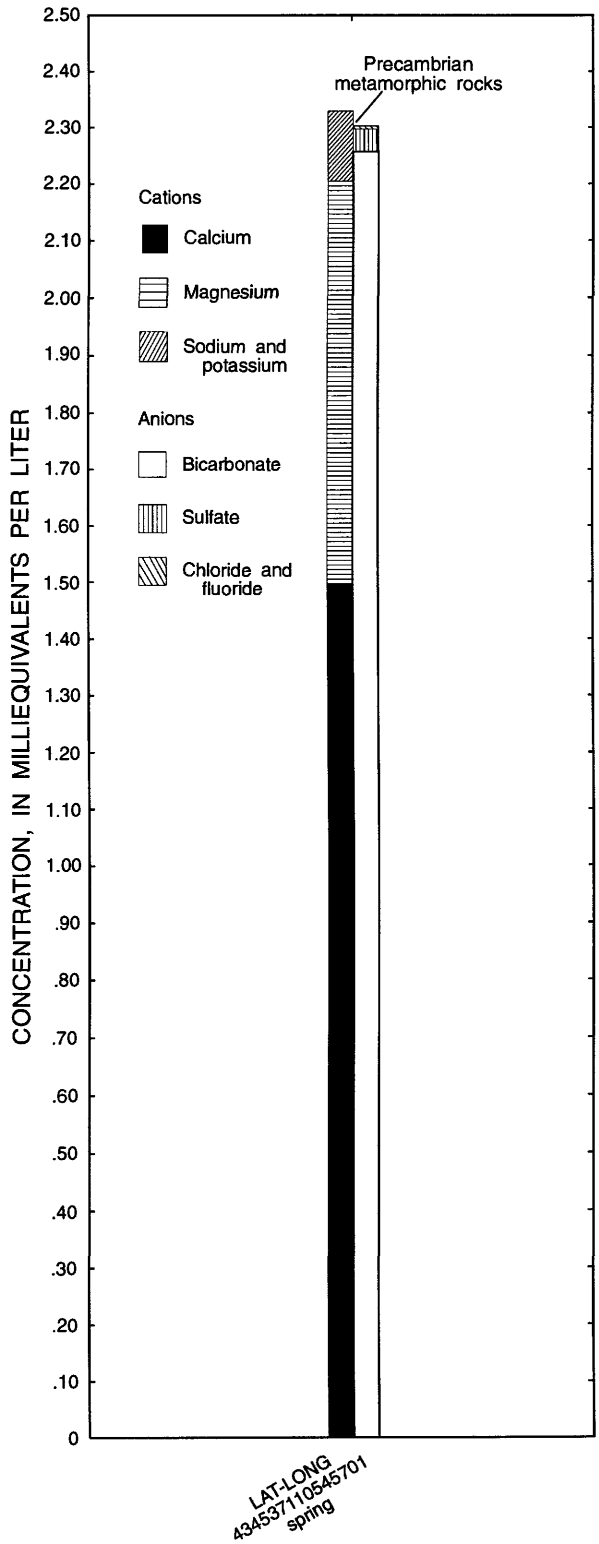


Figure 13. Principal chemical constituents in ground-water samples collected from a spring issuing from Precambrian metamorphic rocks in Teton County study area, Wyoming.

Agricultural Chemicals in Surface and Ground Water

The potential contamination of surface water and ground water by agricultural chemicals is an increasing State and national concern. Surface- and ground-water contamination by pesticides depends on the mobility and persistence of chemicals in the environment. Important factors affecting the degradation rate of pesticides include precipitation, amount and composition of applied irrigation water, soil temperature, microbial populations, topography, and the structure and nature of the chemicals themselves.

Pesticides are used in limited quantities in populated areas in Teton County. Because of concerns that limited pesticide use could potentially affect surface- and ground-water quality in these areas, three ground-water and two surface-water samples were collected for analysis for herbicides and insecticides. No ground-water samples had detectable concentrations of the pesticides analyzed for. Both surface-water samples, however, had detectable concentrations of malathion, an insecticide commonly used to control mosquitoes during the summer in the Wilson and Jackson areas. The water sample from Fish Creek at Wilson (site 16) had a malathion concentration of 2.6 μg/L, and Fish Creek south of Wilson (site 18) had a malathion concentration of 0.02 μg/L (table 15). These concentrations are well below the draft USEPA lifetime health advisory of 200 μg/L for malathion (U.S. Environmental Protection Agency, 1993, p. 5). Maximum contaminant levels for malathion have not been promulgated. USEPA lifetime health-advisory levels are considered acceptable for ingesting everyday over the course of a person's lifetime.

Malathion concentration in the water sample from Fish Creek at Wilson (site 16) exceeds the Wyoming Department of Environmental Quality surface-water aquatic-life chronic value of 0.1 μg/L (Wyoming Department of Environmental Quality, 1990b). The USEPA has determined that a chronic value should not adversely affect freshwater aquatic organisms if the value is not exceeded more than once every 3 years. Chronic values correspond to 4-day averages and represent a response to a continuous, long-term stimulus. Because the sample from Fish Creek at Wilson represents only a single point in time, the sample cannot be used to classify water as suitable for a specific use. The water sample can be used, however, as a general indicator of water quality in the stream at the time and location of sampling.

Table 15. *Chemical analysis of surface and ground water for pesticides in Teton County study area, Wyoming*

[Miscellaneous streamflow site number: assigned by U.S. Geological Survey to locations where only one or a few measurements or samples have been obtained. The first six digits designate the latitude of the site, the next seven digits designate longitude, and the last two digits are sequence numbers to distinguish between several sites that might be in close proximity to one another. Local number: see text describing well-numbering system in the section titled Ground-Water Data. Analytical results in micrograms per liter. Site type: SW, surface water; GW, ground water; <, less than; --, no data]

Miscellaneous streamflow site or local number	Water-yielding unit	Site type	Sampling date	Diazinon, total	Ethion, total	Malathion, total	Methyl parathion, total	Parathion, total	Trithion, total	2,4-D, total
Fish Creek at Wilson, where Wilson-North Road crosses Fish Creek (site 16) (433005110521301)	--	SW	07-17-93	<0.01	<0.01	2.6	<0.01	<0.01	<0.01	<0.01
Fish Creek 2.5 mi. south of Wilson east of Wilson-Fall Creek Road (site 18) (432752110515801)	--	SW	07-20-93	<.01	<.01	.02	<.01	<.01	<.01	<.01
40-117-01bba01	Alluvium	GW	07-17-93	<.01	<.01	<.01	<.01	<.01	<.01	<.01
41-117-35dac01	Alluvium	GW	07-17-93	<.01	<.01	<.01	<.01	<.01	<.01	<.01
42-116-34bda01	Alluvium	GW	07-22-93	--	--	--	--	--	--	<.01

Miscellaneous streamflow site or local number	2,4,5-T, total	Silvex, total	2,4-DP, total	Picloram, total	Dicamba, total	Disyston, total	Phorate, total	Chlor-pyrifos, total	DEF, total	Fonofos, total
Fish Creek at Wilson, where Wilson-North Road crosses Fish Creek (site 16) (433005110521301)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fish Creek 2.5 mi. south of Wilson east of Wilson-Fall Creek Road (site 18) (432752110515801)	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
40-117-01bba01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
41-117-35dac01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
42-116-34bda01	<.01	<.01	<.01	<.01	<.01	--	--	--	--	--

SUMMARY

Surface- and ground-water data were compiled and analyzed to summarize the water resources of the Teton County study area. Streamflow in the study area is both perennial and intermittent. Most streams in the study area originate in the mountains, are perennial, and have sustained streamflow resulting from precipitation, low evapotranspiration, ground-water storage, and water released from melting snowpack. Some streams are intermittent along a particular reach in some years. The Gros Ventre River at Zenith flowed intermittently at various time in 1988 and 1992.

Geologic units were grouped by their areal extent, hydrologic properties, and recharge-discharge characteristics. Groupings include geologic units in unconsolidated deposits of Quaternary age, volcanic rocks of Quaternary and Tertiary age, rocks of Tertiary, Mesozoic, and Paleozoic age, and metamorphic rocks of Precambrian age. Wells and springs inventoried during the study most commonly were completed in or issued from Quaternary unconsolidated deposits and Tertiary, Mesozoic, and Paleozoic rocks. The largest measured or reported discharges from wells and springs were from Quaternary unconsolidated deposits (3,000 gal/min), the Bacon Ridge Sandstone of Cretaceous age (800 gal/min), and the Madison Limestone of Mississippian age (800 gal/min). Discharges from all other geologic units differed, but most wells and springs yielded 25 gallons per minute or less.

A geophysical survey was performed in Jackson Hole to determine the depth of Quaternary unconsolidated deposits. The study was necessary because no wells are known to fully penetrate the saturated thickness of the deposits. A time-domain electromagnetic survey of nine sites in Jackson Hole indicated that the depth of the sediments ranged from about 380 ft in the northern part of Antelope Flats to about 2,400 ft near the Potholes area in Grand Teton National Park. Electrical resistivity, which ranged from 2 to 380 ohm-meters, was used to infer rock type in the subsurface. The low values are assumed to represent fine-grained, less permeable materials such as claystones, shales, siltstones, or fine-grained sandstones, and the higher values are assumed to represent coarse-grained materials such as sand and gravel.

Ground water is recharged by infiltration of precipitation, streamflow leakage, irrigation water, and inflow from other aquifers. Ground water is discharged through pumped wells and is naturally discharged by springs and seeps, by evapotranspiration, and by discharge to streams and other geologic units.

A gain-and-loss study along the Snake River indicated that ground-water discharge to the reach between streamflow-gaging stations near Moran and south of the Flat Creek confluence was 395 ft^3/s. The gain-and-loss study was performed in October 1992 during base-flow conditions when most irrigation diversions were dry. Inflows from tributaries were subtracted from measured streamflow gain to yield the estimated ground-water discharge to the reach.

Water-level contours were generated from 137 water-level measurements in wells completed in Quaternary alluvium, colluvium, and gravel, fan, and pediment deposits and from 118 stream altitudes. The water-level contours indicate that ground water flows from topographically high areas toward the Snake River and southwest through the valley in the general direction of the Snake River. The water-level contours decreased from 7,000 ft at Pilgrim and Pacific Creeks to 5,950 ft just north of Hoback Junction.

Static water levels in 27 wells completed in Quaternary unconsolidated deposits were measured in July and October of 1993 to identify any seasonal change. Water levels were deeper in October than in July in 26 of the wells measured, the maximum decrease in water level was 9.31 ft and the median change was -1.76 ft.

Surface water supplied about 94 percent of the total offstream water use in Teton County in 1990. Almost all offstream surface-water use was for irrigation. Six percent of the total offstream water use in the county is supplied by ground water. The largest use of ground water is for public supply.

A water sample collected from a rhyolite flow of Quaternary age had the lowest dissolved-solids concentration (22 mg/L) in the study area. Dissolved-solids concentration in water samples from Quaternary unconsolidated deposits, and Tertiary, Mesozoic, and Paleozoic rocks ranged from 80 to 1,060 mg/L. The latter value corresponded to a water sample from the Bear River Formation of Cretaceous age. Water type varied between lithologic groupings. The largest nitrite-plus-nitrate concentrations were found in water samples collected from Quaternary landslide deposits (7.50 mg/L) and the Bear River Formation (9.70 mg/L).

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GLOSSARY

Alluvium is clay, silt, sand, gravel, or similar unconsolidated material deposited by a stream or other body of running water.

Anticline is an arched fold in which the rock layers dip away from the axis of the fold.

Aquifer is a body of rock that contains sufficient saturated, permeable material to yield substantial quantities of water to wells and springs.

Average discharge is the arithmetic average of all complete water years of record of discharge whether consecutive or not.

Bedrock is a general term for the consolidated (solid) rock that underlies soils or other unconsolidated surficial material.

Clastic rocks are composed principally of broken rock fragments that are derived from pre-existing rocks or minerals and have been transported from their place of origin. The most common clastic rocks are sandstone and shale.

Colluvial deposit is heterogeneous incoherent soil or rock material that slowly moves (creeps) downslope. Although creep is too slow to be observed, the cumulative results become obvious over a period of years.

Commercial water use is water for motels, hotels, restaurants, office buildings, other commercial facilities, and institutions. The water may be obtained from a public supply or may be self-supplied.

Cubic foot per second is the rate of discharge representing a volume of 1 cubic foot passing a given point during 1 second and is equivalent to about 7.48 gallons per second, 448.8 gallons per minute, or 0.02832 cubic meter per second.

Discharge is the volume of water (or generally, the volume of liquid plus suspended material) that passes a given point within a given period.

Dissolved refers to a substance present in true chemical solution. In practice, however, the term includes all forms of substances that will pass through a 0.45-micrometer membrane filter, and thus may include some colloidal particles.

Domestic water use is water for household purposes, such as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, and watering lawns and gardens. Also called residential water use. The water may be obtained from a public supply or may be self-supplied.

Drainage basin is the total area drained by a stream and its tributaries. Drainage area, determined planimetrically from topographic maps, is expressed in square miles.

Evapotranspiration is the withdrawal of water from surface water and soil by evaporation and plant transpiration. This water is transmitted to the atmosphere as vapor.

Fault is a fracture in bedrock along which movement of the bedrock has occurred.

Formation is a body of rock identified by unique physical characteristics and relative position.

Industrial water use is water used for industrial purposes such as fabrication, processing, washing, and cooling, and includes such industries as steel, chemical and allied products, paper and allied products, mining, and petroleum refining. The water may be obtained from a public supply or may be self-supplied.

Infiltration is the flow of water into soil at land surface, as contrasted with percolation, which is movement of water through soil layers or other surficial material.

Intermittent stream is a stream that ceases to flow occasionally or seasonally because evaporation and leakage to ground water exceed the available water supply.

Irrigation water use is artificial application of water on lands to assist in the growing of crops and pastures or to maintain vegetative growth in recreational lands, such as parks and golf courses.

Limestone is dense rock formed by chemical precipitation of calcium carbonate from solution in water.

Livestock water use is water for livestock watering, feed lots, dairy operations, fish farming, and other on-farm needs. Livestock as used here includes cattle, sheep, goats, hogs, and poultry. Also included are animal specialties.

Micrograms per liter is a unit expressing the concentration of chemical constituents in solution as mass (micrograms) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to 1 milligram per liter.

Milligrams per liter is a unit for expressing the concentration of chemical constituents in solution as mass (milligrams) of solute per unit volume (liter) of water. Concentration of suspended sediment also is expressed in milligrams per liter and is based on the mass (dry weight) of sediment per liter of water-sediment mixture.

Peak discharge (peak flow, flood peak) is the maximum instantaneous discharge during a specified time interval. The series of annual peak discharges at a gaging station is used to determine the recurrence interval (frequency) and exceedance probability of floods.

Pediment is a broad, gently sloping erosion surface developed at the base of a mountain range in a dry region and is usually covered with a thin layer of gravel.

Perennial stream is a stream that flows continuously.

Permeability is a measure of the relative ease with which a porous or fractured medium can transmit a liquid under a potential gradient (the capacity of a rock to transmit a fluid such as water or petroleum).

Potentiometric Surface is a surface that is defined by the levels to which water will rise in tightly cased wells.

Public supply water use is water withdrawn by public and private water suppliers and delivered to users. Public suppliers provide water for a variety of uses, such as domestic, commercial, thermoelectric power, industrial, and public water use.

Recharge is the process by which water is absorbed and added to the saturated zone (aquifer), either directly into a body of rock or indirectly by way of an adjacent body of rock. Also, it is the quantity of water that is added to the saturated zone.

Sandstone is the consolidated equivalent of sand. (See particle-size classification.)

Saturated zone is the subsurface zone in which all openings are full of water and are under hydrostatic pressure equal to or greater than atmospheric pressure.

Sediment is unconsolidated solid material that originates mostly from disintegrated rocks and is transported by water or air. Also, it may include chemical and biochemical precipitates or decomposed organic material, such as humus.

Shale is the consolidated equivalent of clay. (See particle-size classification.)

Siltstone is the consolidated equivalent of silt.

Specific conductance is a measure of the ability of the water to conduct an electrical current. It is expressed in microsiemens per centimeter at 25 degrees Celsius. Specific conductance is related to the type and concentration of ions in solution and can be used for approximating the dissolved-solids concentration of the water.

Stage is the height of a water surface above an established datum plane.

Streamflow is the discharge in a natural channel. Although the term "discharge" can be applied to a flow of a canal, the word "streamflow" is used only to describe the discharge in a surface-stream course. The term "streamflow" is more general than "runoff," since streamflow may be applied to discharge whether or not it is affected by diversion or regulation.

Streamflow-gaging station is a particular site on a stream, canal, lake, or reservoir where systematic observations of hydrologic data are obtained.

Terrace is a step-like landform above a stream and its floodplain, representing a former, abandoned floodplain of a stream.

Unconsolidated refers to sediment grains that are loose, separate, or unattached to one another.

Volcaniclastic refers to a clastic rock containing volcanic material.

Water table refers to the upper surface of the saturated zone; the water pressure is equal to atmospheric pressure.

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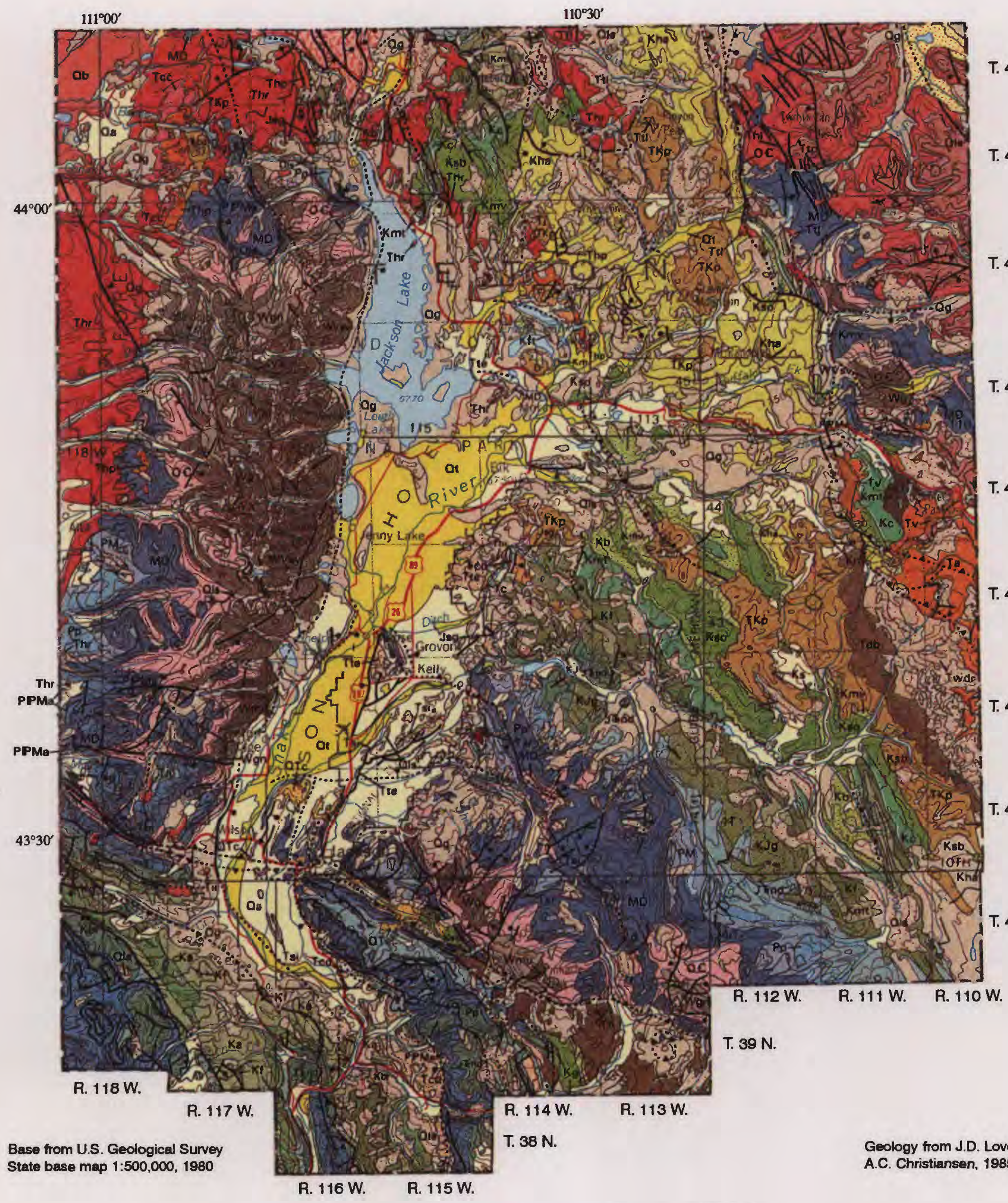
PREPARED IN COOPERATION WITH THE
WYOMING STATE ENGINEER

WATER-RESOURCES INVESTIGATIONS REPORT 95-4204
Geologic map - PLATE 1
Nolan, B.T., and Miller, K.A., 1995, Water resources of Teton County, Wyoming



EXPLANATION

CONTACT

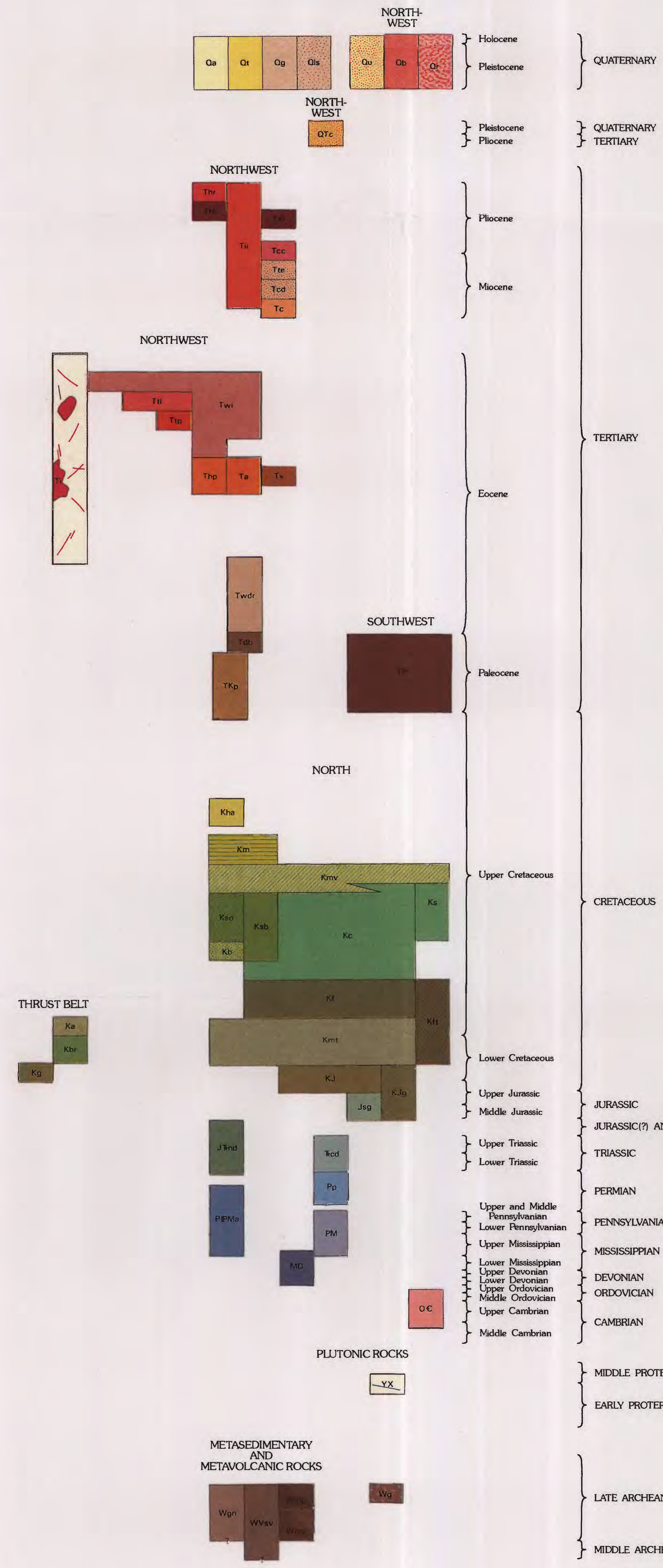
FAULT--Dotted where concealed. Bar and ball on downthrown side. Includes shear zones as well as faults in Precambrian rocks in the Wind River Range, Medicine Bow Mountains and Sierra Madre

THRUST FAULT--Dotted where concealed. In some places the dotted line indicates where the fault intersects an unconformity between faulted strata below and unfaulted strata above; in other places it indicates where the shallower part of the fault disappears into bedding planes. Sawteeth on upper plate. Some thrust faults are deeply buried and are approximately located on the basis of seismic data and drilling

SHEAR ZONE

Correlation and list of map units modified by Joel Galloway from Love and Christiansen (1985, sheet 2) and Love, Christiansen, and Ver Ploeg (1987)

CORRELATION OF MAP UNITS



LIST OF MAP UNITS

QUATERNARY DEPOSITS

- Qa — ALLUVIUM AND COLLUVIUM
- Qt — GRAVEL, PEDIMENT, AND FAN DEPOSITS
- Qg — GLACIAL DEPOSITS
- Qls — LANDSLIDE DEPOSITS
- Qu — UNDIFFERENTIATED SURFICIAL DEPOSITS
- Qb — BASALT FLOWS AND INTRUSIVE IGNEOUS ROCKS
- Qr — RHYOLITE FLOWS, TUFFS, AND INTRUSIVE IGNEOUS ROCKS
- QTc — CONGLOMERATE

TERTIARY SEDIMENTARY AND IGNEOUS ROCKS

- Thr — HUCKLEBERRY RIDGE TUFF OF YELLOWSTONE GROUP
- Ti — INTRUSIVE AND EXTRUSIVE IGNEOUS ROCKS
- Thl — HEART LAKE CONGLOMERATE
- Tsi — SHOOTING IRON FORMATION
- Tcc — CONANT CREEK TUFF
- Tte — TEEWINOT FORMATION
- Tcd — CAMP DAVIS FORMATION
- Tc — COLTER FORMATION
- INTRUSIVE IGNEOUS ROCKS
- ABSAROKA VOLCANIC SUPERGROUP
  - THOROFARE CREEK GROUP
    - Twi — Wiggins Formation
    - Tt — Two Ocean and Langford Formations - In places may include Trout Peak Trachyandesite of Sunlight Group
    - Ta — Aycross Formation
  - SUNLIGHT GROUP
    - Ttp — Trout Peak Trachyandesite
    - Thp — HOMINY PEAK FORMATION
- Tv — VOLCANIC CONGLOMERATE
- Twdr — WIND RIVER FORMATION
- Th — HOBACK FORMATION
- Tdb — DEVILS BASIN FORMATION
- TKp — PINYON CONGLOMERATE

MESOZOIC AND PALEOZOIC SEDIMENTARY ROCKS

- Kha — HAREBELL FORMATION
- Km — MEETEETSE FORMATION
- Kmv — MESAVERDE FORMATION
- Kso — SOHARE FORMATION
- Ksb — SOHARE FORMATION AND BACON RIDGE SANDSTONE
- Kb — BACON RIDGE SANDSTONE
- Kc — CODY SHALE
- Ks — STEELE SHALE
- Kf — FRONTIER FORMATION
- Kft — FRONTIER FORMATION AND MOWRY AND THERMOPOLIS SHALES
- Kmt — MOWRY AND THERMOPOLIS SHALES
- Ka — ASPEN SHALE
- Kbr — BEAR RIVER FORMATION
- Kg — GANNET GROUP
- KJ — CLOVERLY AND MORRISON FORMATIONS
- KJg — CLOVERLY, MORRISON, SUNDANCE, AND GYPSUM SPRING FORMATIONS
- Jsg — SUNDANCE AND GYPSUM SPRING FORMATIONS
- J̄Tend — NUGGET SANDSTONE AND CHUGWATER AND DINWOODY FORMATIONS
- Tcd — CHUGWATER AND DINWOODY FORMATIONS
- Pp — PHOSPHORIA FORMATION AND RELATED ROCKS
- P̄PMa — PHOSPHORIA FORMATION AND RELATED ROCKS, TENSLEEP SANDSTONE, AND AMSDEN FORMATION
- PM — TENSLEEP SANDSTONE AND AMSDEN FORMATION
- MD — MADISON LIMESTONE AND DARBY FORMATION
- O€ — BIGHORN DOLOMITE, GALLATIN LIMESTONE, GROS VENTRE FORMATION, AND FLATHEAD SANDSTONE

PRECAMBRIAN ROCKS

- Wgn — GRANITE GNEISS
- Wvsv — METASEDIMENTARY AND METAVOLCANIC ROCKS
  - Wmu — Metamorphosed mafic and ultramafic rocks

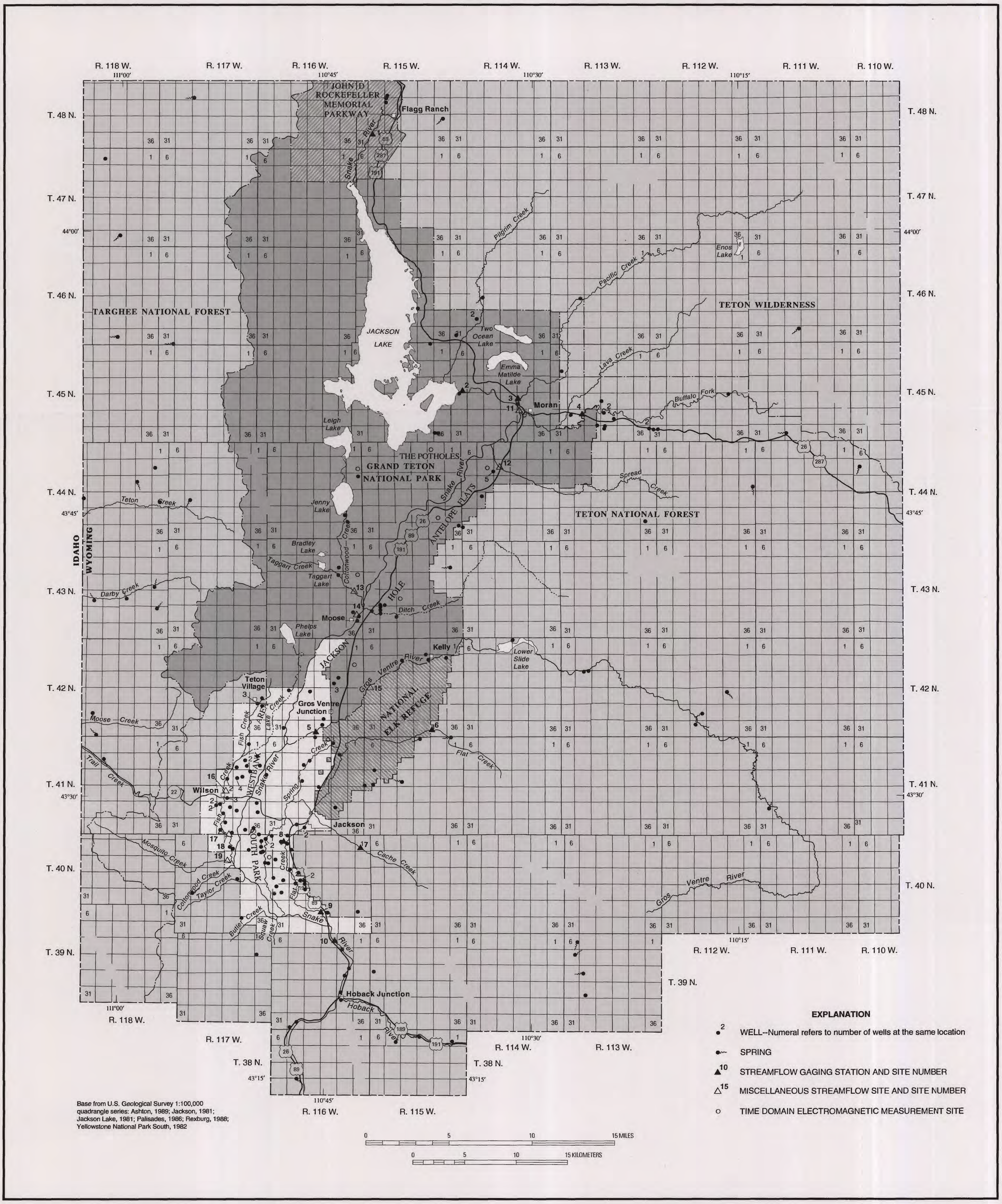
PLUTONIC ROCKS

- YX — MAFIC INTRUSIVE ROCKS
- Wg — GRANITIC ROCKS OF 2,600-Ma AGE GROUP

GEOLOGIC MAP OF TETON COUNTY STUDY AREA, WYOMING

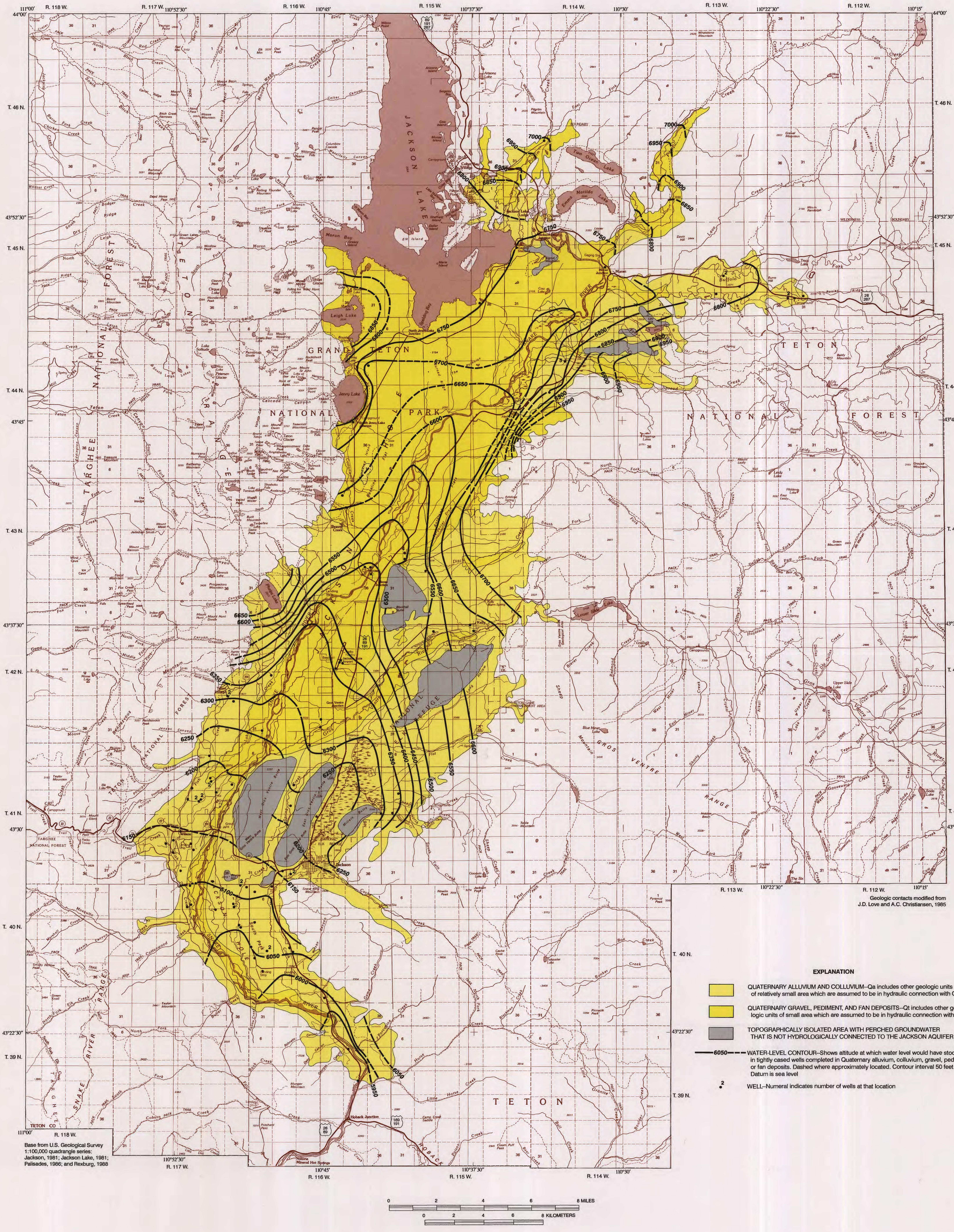
PREPARED IN COOPERATION WITH THE
WYOMING STATE ENGINEER

WATER-RESOURCES INVESTIGATIONS REPORT 95-4204
Surface-water, ground-water, and geophysical-data networks - PLATE 2
Nolan, B.T., and Miller, K.A., 1995 Water resources of Teton County, Wyoming, exclusive of Yellowstone National Park



MAP SHOWING SURFACE-WATER, GROUND-WATER, AND GEOPHYSICAL-DATA NETWORKS, TETON COUNTY STUDY AREA, WYOMING

by
Bernard T. Nolan and Kirk A. Miller
1995



MAP SHOWING WATER-LEVEL CONTOURS FOR ALLUVIUM, COLLUVIUM, GRAVEL, PEDIMENT, AND FAN DEPOSITS IN JACKSON HOLE, WYOMING, JULY 12-21, 1993

by
Pamela M. Hann