HYDROLOGY AND WATER CHEMISTRY OF SHALLOW AQUIFERS ALONG THE UPPER CLARK FORK, WESTERN MONTANA

By David A. Nimick

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CONVERSION FACTORS, VERTICAL DATUM, ABBREVIATED WATER-QUALITY UNITS, AND ACRONYMS

Multiply	By	To obtain
acre	4,047	square meter
cubic foot per second (ft^3/s)	0.028317	cubic meter per second
foot (ft)	0.3048	meter
foot squared per day (ft^2/d)	0.0929	meter squared per day
gallon per minute (gal/min)	0.06309	liter per second
gallon per minute per foot [(gal/min)/ft]	0.207	liter per second per meter
inch (in.)	25.4	millimeter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.59	square kilometer

Temperature can be converted to degrees Celsius (°C) or degrees Fahrenheit (°F) by the equations:

$$°C = 5/9\ (°F - 32)$$
$$°F = 9/5\ (°C) + 32$$

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

Abbreviated water-quality units used in this report:

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

Acronyms used in this report:

MCL Maximum Contaminant Level
SMCL Secondary Maximum Contaminant Level

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ABSTRACT

Shallow ground-water resources along the upper Clark Fork have been developed primarily in Quaternary alluvium and unconsolidated Tertiary deposits, although bedrock supplies water to wells locally. Well yields and transmissivity values varied considerably and tended to be largest (medians of 40 gallons per minute and 970 feet squared per day, respectively) for alluvium and smallest (medians of 15 gallons per minute and 130 feet squared per day, respectively) for bedrock. Ground-water levels generally responded to seasonal events, such as spring runoff and irrigation. Ground water generally flows from upland areas toward the Clark Fork.

The chemical composition of ground water was dominated primarily by calcium, magnesium, and bicarbonate derived from the dissolution of carbonate minerals. Other ground-water types also were present locally. Increased sodium concentrations probably result from ion-exchange reactions, and increased sulfate concentrations result from mixing of geothermal water or leachate from mine wastes. Nitrate (as nitrogen) concentrations were elevated in some agricultural areas, but only one ground-water sample had a nitrate concentration (11 milligrams per liter) that exceeded Primary Drinking-Water Regulations established by the U.S. Environmental Protection Agency for public supplies. Concentrations of trace elements in ground water were generally very small and below minimum reporting levels; however, some contaminants associated with mine wastes were detected. Although concentrations of arsenic were relatively small (maximum of 20 micrograms per liter) in all ground-water samples, concentrations were largest in water from alluvium located within 300 feet of the Clark Fork. Elevated cadmium concentrations (maximum of 6 micrograms per liter) were measured in water from one well downgradient from several tailings ponds. One water sample from this well exceeded the Primary Drinking-Water Regulation. In general, the water-quality data collected during this study indicate that, although mining has occurred in the basin for more than 125 years, ground water contains elevated concentrations of trace elements only in localized areas.

Streamflow data indicate that ground-water inflow to the Clark Fork is significant primarily in two reaches. Between Racetrack and Garrison, irrigation-return flow probably is the main source of this water. Between Jens and Cramer Creek, geothermal water from bedrock flows upward through alluvium to the river. Water-quality data and computations of major-ion loading in the river also support this conclusion. The only trace elements associated with mining that occurred in the Clark Fork in concentrations significantly greater than minimum reporting levels were arsenic, copper, and manganese. Arsenic concentrations (maximum of 8.1 micrograms per liter) showed no downstream trend. Copper and manganese concentrations were largest at Warm Springs (maximums of 14 and 350 micrograms per liter, respectively) and decreased downstream.

INTRODUCTION

Large areas of land along the upper Clark Fork have been contaminated by trace elements derived from mining, milling, and smelting activities between Butte and Anaconda during the past 125 years (Moore and Luoma, 1990; Shovers and others, 1991). Trace elements of concern are arsenic, cadmium, copper, iron, lead, manganese, and zinc. Chromium, mercury, nickel, and silver also were associated with the ores that were mined but they have not been found in large concentrations in water associated with mine wastes. Although no large-scale mining has occurred along the Clark Fork, arsenic and metals have been transported from upstream areas to the Clark Fork valley by water and wind. As examples, floods have carried mine wastes (tailings) down tributary streams and deposited them along channels and on low terraces of the Clark Fork. Contaminated sediments also have accumulated in Milltown Reservoir. Diversion of river water containing sediment mixed with mine tailings has affected irrigated land. In addition, air fall from smelter emissions has increased the arsenic and metal content of surface soils.

In response to these conditions and the continuing threat to the water resources of the upper Clark Fork, the U.S. Environmental Protection Agency designated the affected areas as hazardous waste sites that are eligible for study and remedial cleanup provided by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA, commonly known as the Superfund Act) and the Superfund Amendments and Reauthorization Act of 1986 (SARA). These areas are contiguous from Butte to Milltown Reservoir.

Trace elements from the contaminated areas that are present throughout the valley can be mobilized into water that supports the Clark Fork fishery or that is used for water supply or irrigation. Although some instances of ground water contaminated with arsenic and metals have been documented (Montana Department of Health and Environmental Sciences, 1989; TetraTech, Inc., 1987; Woessner and others, 1984), particularly within Superfund sites near Anaconda, Warm Springs, and Milltown, the extent of any such contamination in shallow aquifers throughout the upper Clark Fork valley is not well known. Furthermore, water-resources information that could be used to characterize aquifers or determine pathways for transport of metals in ground water has not been compiled or is unavailable for parts of the valley. Consequently, the U.S. Geological Survey (USGS), in cooperation with the Montana Bureau of Mines and Geology, began a study of hydrologic conditions along the upper Clark Fork.

Purpose and Scope

This report describes the hydrology of shallow aquifers along the upper Clark Fork between Warm Springs and Milltown (fig. 1). Information is provided on aquifer characteristics and water chemistry for aquifers in Quaternary deposits, unconsolidated Tertiary deposits, and bedrock. Additional gaging and chemical data from streams provide a basis for describing the relation of streamflow to shallow aquifers.

Existing data and data collected specifically for this study were used to analyze the hydrology. Existing data include drillers' logs on file at the Montana Bureau of Mines and Geology, USGS well-inventory data, and limited water-quality data. Eleven shallow wells were installed in Quaternary alluvium near the Clark Fork for water-quality sampling and observation of water levels. Holes were drilled with a hollow-stem auger, and wells were completed with 2-in.-diameter polyvinyl-chloride (PVC) pipe. Data collected during 1985-89 for this study were from the following sources:

1. Inventory of 780 existing wells from site visits, utilizing drillers' logs where available;
2. Periodic or continuous measurement of water levels in 14 wells;
3. Simultaneous measurement of streamflow at 16 sites on the Clark Fork, on 24 tributaries, and in 2 diversion canals in October 1986; and
4. Collection of 79 water samples (excluding duplicates) for analysis of dissolved chemical constituents from 51 wells, 1 spring, and 12 stream sites.

Previous Investigations

Several investigators have previously studied the geology and water resources of the area. Alt and Hyndman (1980) compiled a regional geologic map of the study

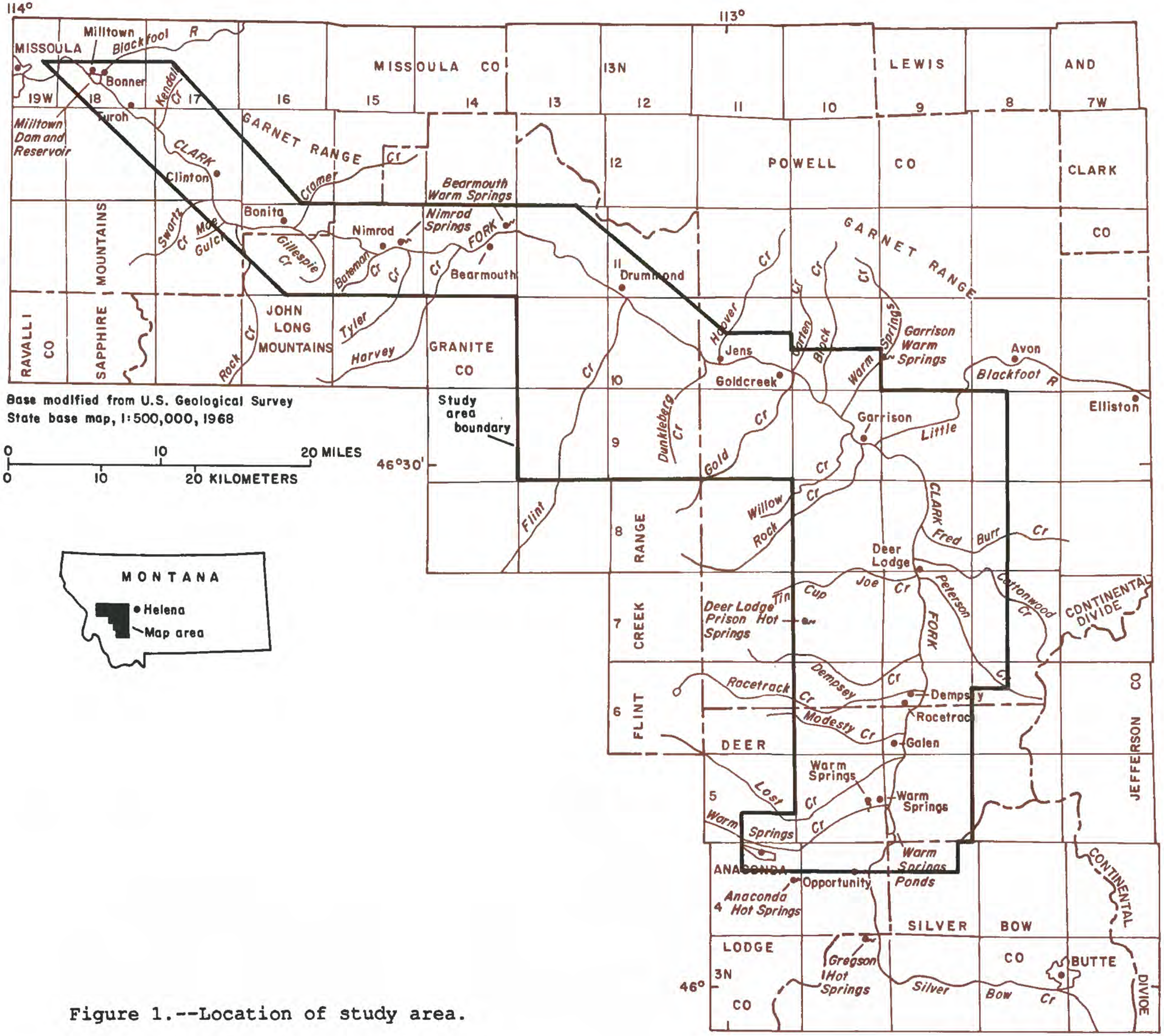

Figure 1.--Location of study area.

area. Mutch (1961), Ruppel (1961), and Wanek and Barclay (1966) studied in detail the geology of an area south and west of Garrison. Gwinn (1961), Kauffman (1963), Konizeski (1965), Fields and Shepard (1965), Montgomery (1958), Nelson and Dobell (1959), Rasmussen (1969), Wallace and Klepper (1976), and Wheeler (1974) described the geology of the area between Garrison and Milltown. Alden (1953) described the glacial geology of the entire study area.

Konizeski and others (1968) described the geology and water resources of the Deer Lodge Valley, which includes the study area south of Garrison. Woessner and others (1984) studied the hydrology of coarse-grained alluvium near Milltown and documented the movement of dissolved arsenic from reservoir sediments contaminated with mine wastes to wells in Milltown. Boettcher and Gosling (1977) presented an overview of the water resources of the upper Clark Fork basin.

Various authors have examined the fate of arsenic and metals in mine wastes of flood-plain deposits and bed sediment of the Clark Fork. Brooks and Moore (1989) studied the movement of arsenic and metals from flood-plain soils to shallow ground water near Racetrack. The distribution of trace elements in bank and bed sediment of the Clark Fork from Warm Springs to Milltown was examined by Moore and others (1989), Brook and Moore (1988), Axtmann and Luoma (1987), and Andrews (1987). Nimick (1990) and Nimick and Moore (1991, in press) mapped the extent of contaminated flood-plain deposits between Warm Springs and Racetrack. Results of USGS collection of water samples for chemical analysis between 1968 and 1990 in the basin have been summarized by Brosten and Jacobson (1985) and Lambing (1987, 1988, 1989, 1990, and 1991).

Quality Assurance

All water-quality samples were collected and preserved by methods described by Knapton (1985), Claassen (1982), and Wood (1976). The water samples were analyzed by the Montana Bureau of Mines and Geology. The precision of chemical analysis was evaluated by analyzing duplicate samples from five sampling sites. The relative standard deviation (RSD) of the concentrations of a constituent measured in a set of duplicate samples provides an estimate of the variation that can be expected in analyses for that constituent. RSD's were computed from the equation:

$$\mathrm{RSD} = \frac{\text{standard deviation of values}}{\text{mean of values}} \times 100 \qquad (1)$$

In this study, for instance, an RSD of 10 percent for analysis of a constituent from one set of duplicate samples indicates that the standard deviation of the two analyses is 10 percent of the mean of the two analyses. Consistent values of RSD's for a constituent from multiple sets of duplicates would indicate that other water analyses probably have a similar level of precision.

As many as five RSD's were computed for each constituent in this study. No RSD's were computed for constituents that had one or both concentrations less than the minimum reporting level in all duplicate samples. Constituents in that category were aluminum, cadmium, chromium, copper, lead, lithium, molybdenum, nickel, silver, and zirconium. RSD's were computed for the remaining constituents. For analyses having concentrations greater than three times the minimum reporting level, most constituents had RSD's of less than 10 percent. Boron, carbonate, iron, nitrate, and titanium had RSD's of less than 20 percent. Vanadium had a maximum RSD of 52 percent. Precision of analyses of constituents with concentrations near the minimum reporting level was not as good. RSD's for these analyses were as large as 60 percent. No data were available to estimate precision for selenium or for onsite analyses. Although calibration standards were used in laboratory and onsite analyses, no reference samples were analyzed to determine accuracy of the analyses.

Systems for Specifying Geographic Locations

In this report, wells and springs are numbered according to geographic position within the rectangular grid system used in Montana by the U.S. Bureau of Land Management (fig. 2). The number consists of as many as 14 characters. The first three characters specify the township and its position north (N) of the Montana Base Line. The next three characters specify the range and its position west (W) of the Montana Principal Meridian. The next two characters are the section number. The next one to four characters designate the quarter section (160-acre tract), quarter-quarter section (40-acre tract), quarter-quarter-quarter section (10-acre tract), and quarter-quarter-quarter-quarter section (2.5-acre tract), respectively, in which the well or spring is located. The subdivisions of the section are designated A, B, C, and D in a counterclockwise direction, beginning in the northeast quadrant. The last two characters form a sequence number indicating the order of inventory. For example, as shown in figure 2, well 04N10W05AACC01 is the first well inventoried in the SW1/4 SW1/4 NE1/4 NE1/4 sec. 5, T. 4 N., R. 10 W.

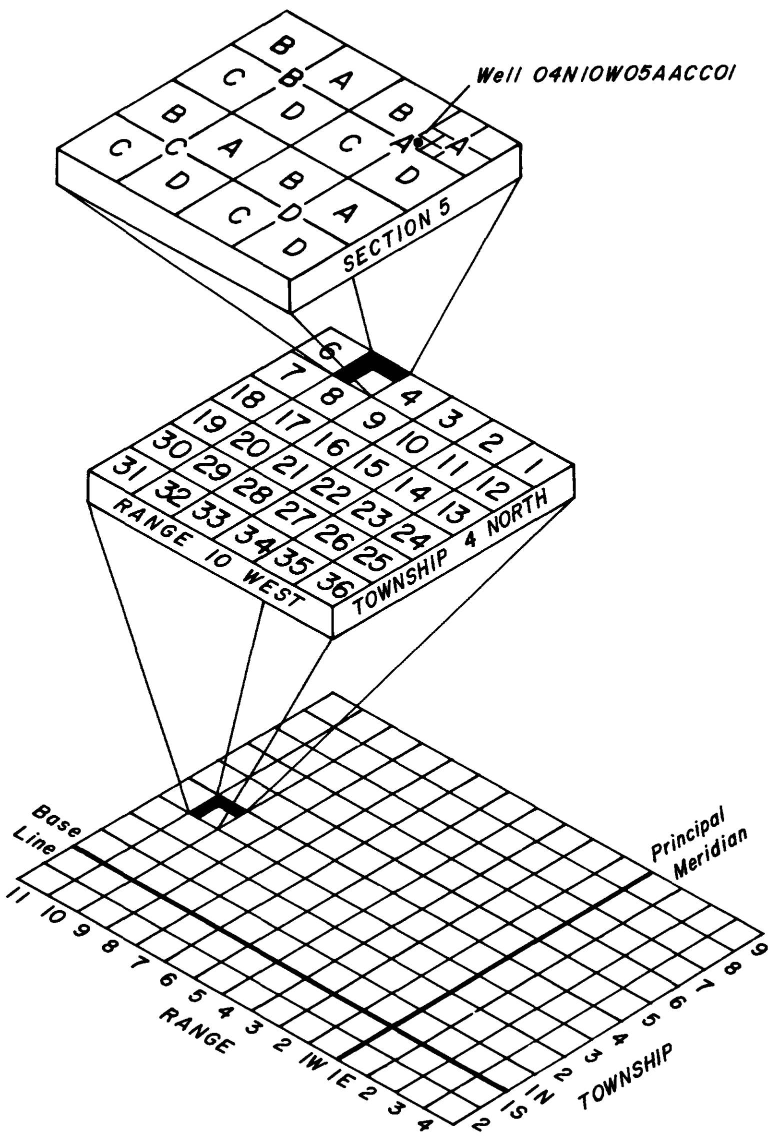

Figure 2.--Well and spring numbering system.

Streamflow-measurement sites are identified by a site number that consists of as many as three characters. The first one or two characters are numbers that specify downstream order. The next character is a letter that designates a site on the mainstem Clark Fork (M) or a tributary of the Clark Fork (T). Irrigation diversions also are designated with a T. Streamflow-measurement sites are also identified by a station number. For USGS streamflow-gaging stations, the station number consists of eight digits: the first two digits, which identify the drainage basin, and the remaining six digits, which identify position in downstream order. For miscellaneous streamflow-measurement sites, the station number consists of 15 digits that represent the latitude and longitude of the site (first 13 digits) plus a sequence number (last two digits).

Acknowledgments

Many landowners and residents provided information about their wells, permitted water-level measurements, and allowed water-quality sampling. The author appreciates and acknowledges their assistance.

DESCRIPTION OF STUDY AREA

The study area (fig. 1) encompasses the valley of the Clark Fork from near the town of Warm Springs downstream to Milltown Reservoir. The area includes about 910 mi^2.

Drainage and Physiography

The Clark Fork begins at the confluence of Silver Bow and Warm Springs Creeks. Within the study area, major tributaries to the river are the Little Blackfoot River, Flint Creek, and Rock Creek (near Clinton). Most other tributaries that contribute substantial flow to the Clark Fork drain the Flint Creek Range. The study area contains two Rock Creeks (near Garrison and near Clinton) and two Warm Springs Creeks (near Warm Springs and near Garrison).

The upper Clark Fork valley lies in west-central Montana within the Northern Rocky Mountains Physiographic Province, an area characterized by rugged mountains and intermontane valleys. The valley is broad south of Garrison, less broad from Garrison to Drummond, and narrow from Drummond to Milltown. The broad portion of the Flint Creek valley south of Drummond also is in the study area. The Clark Fork ranges in altitude from about 4,800 ft near Warm Springs to 3,260 ft near Milltown over the 90-mi length studied.

South of Garrison, broad and high dissected terraces flank a narrow strip of low terraces that border the river. The high terraces typically range from 200 to 400 ft above the river, but can be as much as 1,000 ft. West of the valley, the Flint Creek Range has rugged peaks at altitudes of as much as 10,170 ft. East of the valley, mountains along the Continental Divide have altitudes of as much as 8,600 ft. From Garrison to Drummond, the valley is less distinct because small hills create an undulating valley floor. This part of the valley is bordered on the south by the Flint Creek Range and on the north by the low mountains of the Garnet Range. From Drummond to Milltown, the valley is less than 1 mi wide and is bordered on both sides by mountains generally having altitudes less than 7,500 ft. The John Long and Sapphire Mountains are south of this reach and the Garnet Range is north.

Climate

The study area is semiarid and receives about half its precipitation during May, June, and July. Winter typically is the driest season. Average annual precipitation in the valley ranges from about 12 to 14 in. (U.S. Department of Agriculture, 1981, sheet 8). Average valley temperatures range from 20 °F in January to 63 °F in July (National Oceanic and Atmospheric Administration, 1988).

General Geology

The general geology of the study area can be characterized as mountains composed of various types of bedrock adjacent to valleys that are underlain by Tertiary and Quaternary sedimentary deposits (fig. 3). Most highland areas consist of folded and faulted complexes of Precambrian metasedimentary rocks and Paleozoic and Mesozoic sedimentary rocks. Carbonate rocks are common in the Paleozoic sequence. A few areas, such as along the Continental Divide east of the study area, are underlain by Cretaceous granitic and Tertiary volcanic rocks.

In this report, Tertiary deposits are the unconsolidated valley fill that underlies areas of the Clark Fork valley south of Garrison and near Drummond. Tertiary volcanic rocks and other consolidated deposits of Tertiary age are grouped with the rocks of Precambrian through Mesozoic age and are referred to as bedrock.

Quaternary deposits are unconsolidated and consist mostly of alluvium along the mainstem Clark Fork and glacial outwash on the west side of the Clark Fork valley south of Garrison and along the Gold Creek and Flint Creek valleys. Glacial till is present locally.

South and east of Drummond, the study area encompasses two north-northeast trending intermontane valleys. The valleys, Flint Creek and Clark Fork south of Garrison, are structural basins bounded by normal faults and are filled with as much as 8,000 ft of Upper Cretaceous(?) rocks and Tertiary deposits. The Upper Cretaceous(?) rocks, deposited as basin fill, consist of 2,500 to 4,000 ft of conglomerate interlayered with lenses of siltstone, sandstone, tuff, and carbonaceous shale. The lithology of Tertiary deposits is known from outcrops along the valley margins and from lithologic logs of oil-exploration wells in the Clark Fork valley south of Garrison. Deposits of Oligocene and Miocene age include clay, silt, sand, and gravel as well as sandstone, limestone, and shale. Pliocene beds as much as several hundred feet thick are composed of thin-bedded silt, extensive intercalated lenses of cross-bedded sand and gravel, and sparse lenses of volcanic ash. The high terraces in the Flint Creek valley and Clark Fork valley south of Garrison are formed on Tertiary deposits and are remnants of a late Pliocene or early Pleistocene erosional surface. During the Quaternary Period, much of the west side of the Clark Fork valley south of Garrison received a veneer of glacial deposits from the melting of ice caps that had formed on the Flint Creek Range. Outwash is the most extensive glacial deposit, particularly near Anaconda, where the valleys of Lost and Warm Springs Creeks converge, and along the other major tributaries draining the east side of the Flint Creek Range. Outwash also underlies the Gold Creek and Flint Creek valleys. Glacial till occurs in moraines at the mouths of Rock (near Garrison), Tin Cup Joe, Dempsey, and Racetrack Creeks. Quaternary alluvium, which occurs near all streams, commonly is less than 100 ft thick and fine to coarse grained.

West of Drummond, the valley of the Clark Fork forms part of the Montana Lineament, a series of faults, straight valleys, and folds extending from northern Idaho to a point east of Helena (Vice, 1984). The valley is considerably shallower than the upstream intermontane valleys and is an erosional feature formed by downcutting of the river. No Tertiary deposits have been found in this part of the Clark Fork valley. The valley floor is underlain by Quaternary alluvium, which consists of interbedded gravel, sand, and sandy gravel with lenses of silt and clay.

Where both Tertiary and Quaternary sediments are present, they are difficult to distinguish. In this report, the top of the uppermost fine-grained unit is considered to be the boundary between Tertiary and Quaternary deposits. Deposits recorded as sand or gravel in the upper part of lithologic logs generally are assumed to be Quaternary in age. Konizeski and others (1968) estimated that the thickness of Quaternary alluvium in the Clark Fork valley south of Garrison averages less than 25 ft. Debra Hanneman (Montana College of Mineral Science and Technology, oral commun., 1987) indicates that, on the basis of research of Tertiary deposits in western Montana valleys, Quaternary deposits may be as thick as 200 ft but are more typically less than 100 ft. Using geophysical methods, Wheeler (1974) estimated the maximum thickness of alluvium in the Clark Fork valley between Cramer Creek and Milltown to be 300 ft.

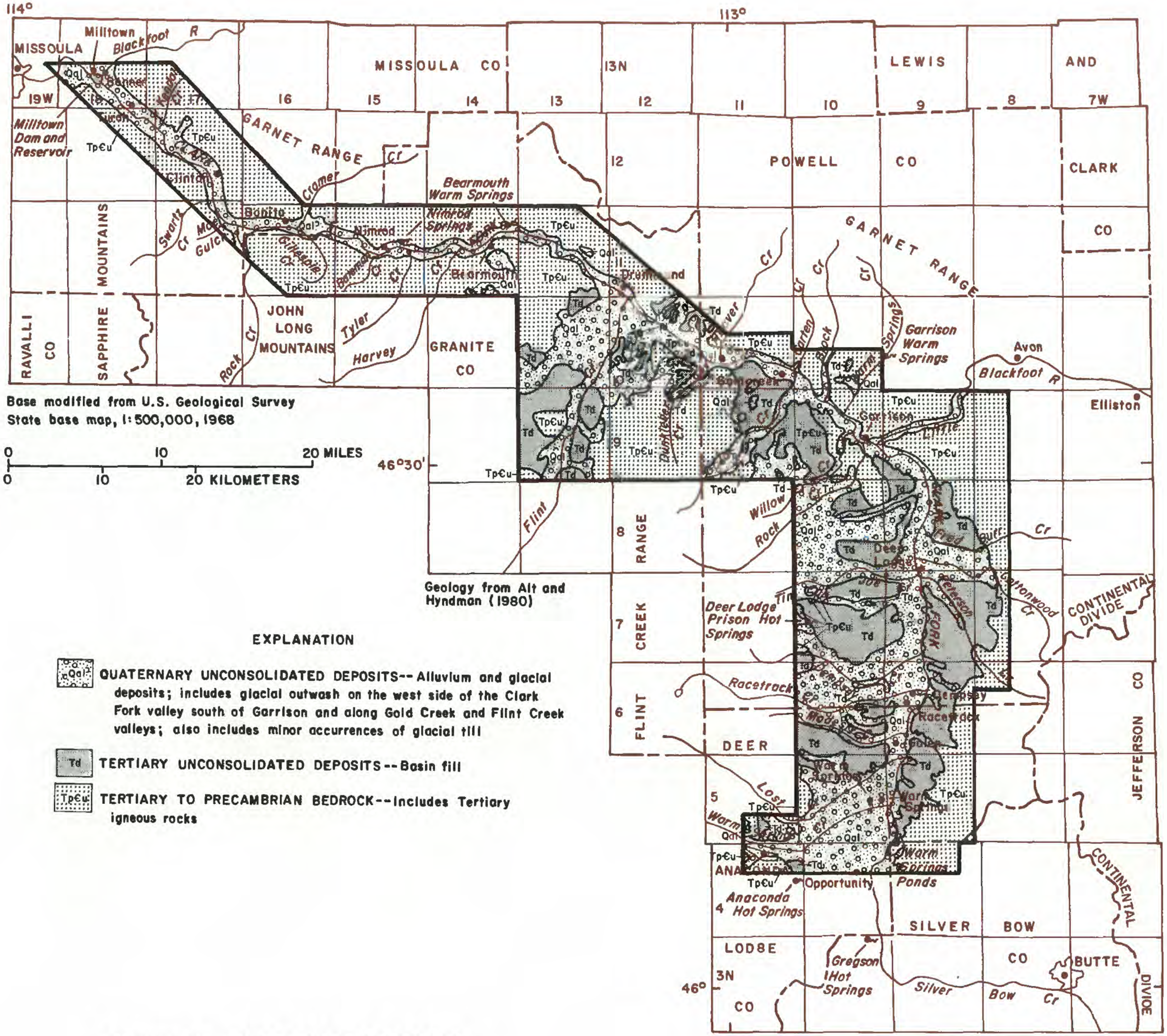

Figure 3.--Generalized geology.

The primary sources of ground water in the study area are shallow, unconsolidated deposits of Quaternary and Tertiary age. Wells have been drilled into bedrock only where the unconsolidated deposits are thin or absent. The relation of well depth and specific capacity of wells completed in these aquifers is shown in figure 4.

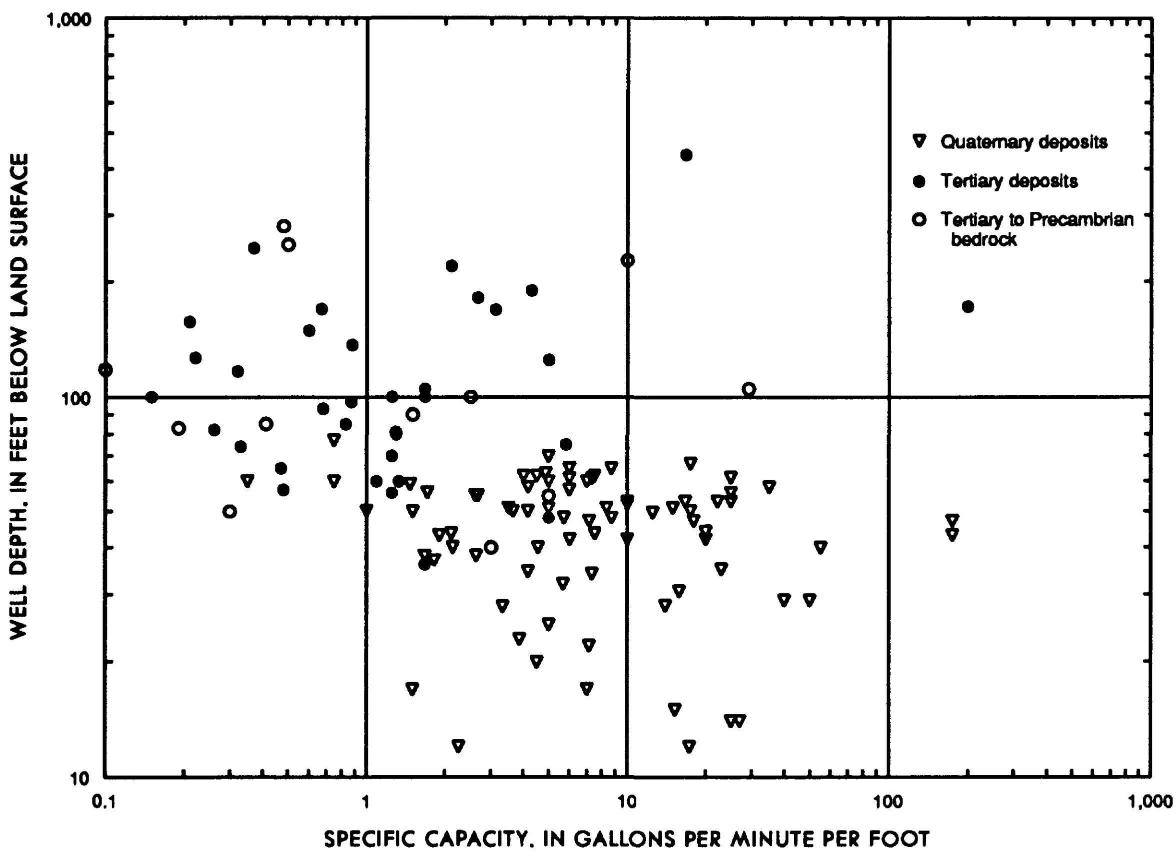

Figure 4.--Range of depths and specific capacities for wells completed in various aquifers in the upper Clark Fork valley, Montana.

Transmissivity, which is a measure of the rate at which water is transmitted through an aquifer under a unit hydraulic gradient, is the only aquifer hydraulic characteristic that was studied in detail. Some transmissivity values were obtained from previous studies. Other values were computed as part of this study from specific-capacity data obtained from drillers' logs using a method described by Walton (1962, p. 12). Assumptions made in using Walton's method were a well diameter of 6 in., a pumping time of 1 hour, and a storage coefficient of 0.01. Transmissivities computed from the specific-capacity data are only estimates, because the reliability of data reported by drillers could not be determined and because well-construction specifications were not always sufficiently detailed or consistent with Walton's assumptions. Obtaining transmissivity from streamflow-recession hydrographs was considered but not done because irrigation diversions strongly affect streamflow of the Clark Fork.

Quaternary Deposits

Quaternary alluvium along the Clark Fork and many of its tributaries is a common source of water for domestic use throughout the study area. Outwash plains are extensive in the Flint Creek valley and the Clark Fork valley south of Garrison. In these areas, water from the alluvium is used for irrigation. In the narrow Clark Fork valley west of Drummond, alluvium is the sole developed source of ground water.

Aquifer Characteristics

Quaternary alluvium is the principal aquifer that yields water to 496 inventoried wells (table 1 at back of report). These wells have a median depth of 37 ft and few are deeper than 70 ft. Alluvium yields more water to wells than do Tertiary deposits or bedrock. For the 96 wells completed in alluvium that had measured discharge, the minimum discharge was 3 gal/min, the maximum was 580 gal/min, and the median was 40 gal/min.

Where not affected by irrigation, ground-water levels typically were highest during spring runoff and then gradually declined until the following spring. Ground-water levels had short-term rises in response to snowmelt or rainfall. These conditions are typified by the hydrographs for wells 04N10W05AACC02 and 04N10W06BADD01 (fig. 5) in a nonirrigated area of the Warm Springs Creek valley near Anaconda. The water-level rise in spring 1987 was small because the quantity of snowmelt runoff was small that year. However, in many wells near the Clark Fork, water levels generally were lowest in mid-summer (fig. 6) in response to streamflow depletion caused by irrigation diversions. Continuous hydrographs for well 10N11W25CBAC01 and the nearby Clark Fork at Goldcreek show the similarity between water level in alluvium and river stage (fig. 7).

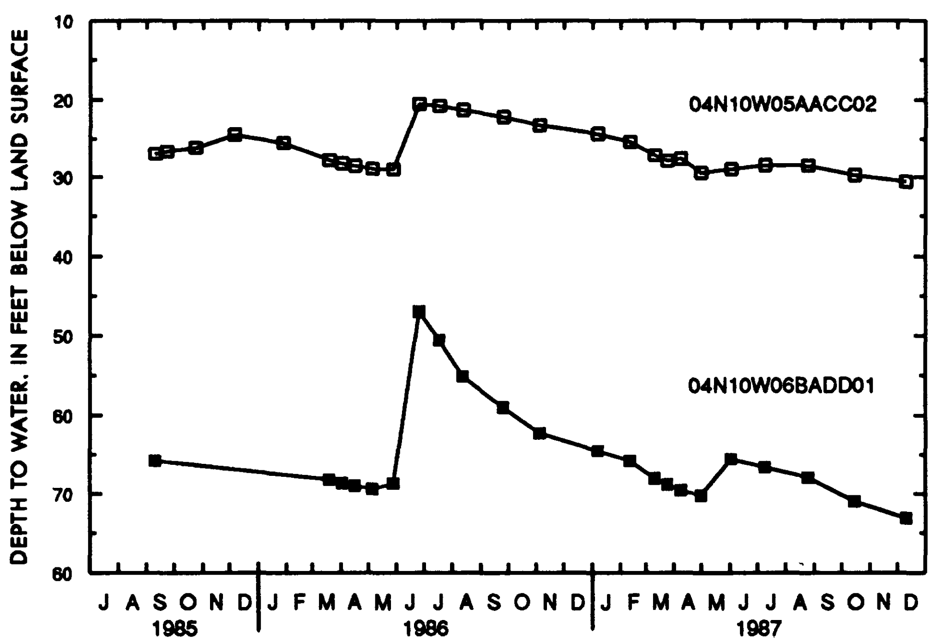

Figure 5.--Water levels measured intermittently in observation wells completed in Quaternary alluvium along Warm Springs Creek near Anaconda.

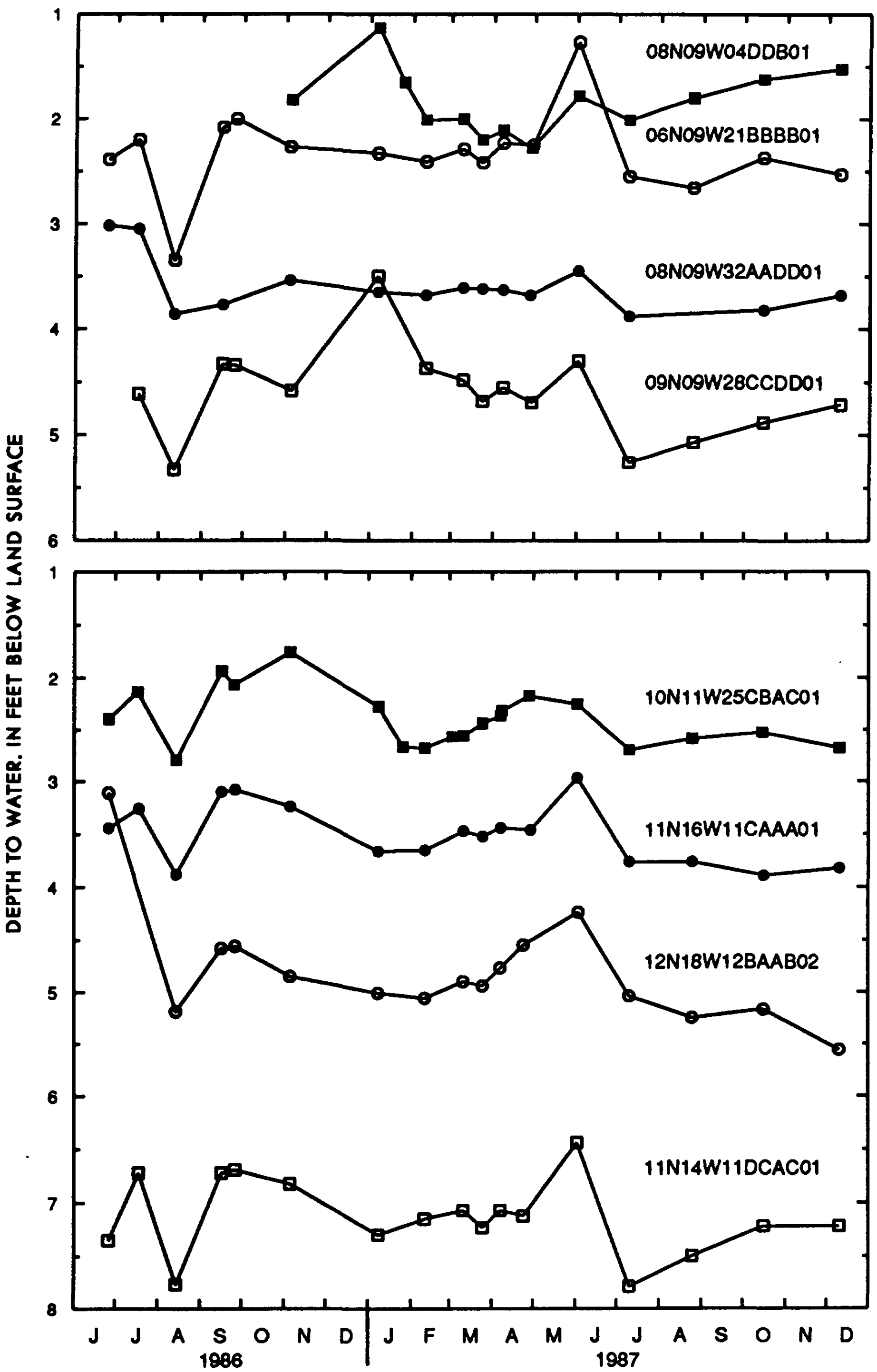

Figure 6.--Water levels measured intermittently in observation wells completed in Quaternary alluvium and located within 300 feet of the Clark Fork.

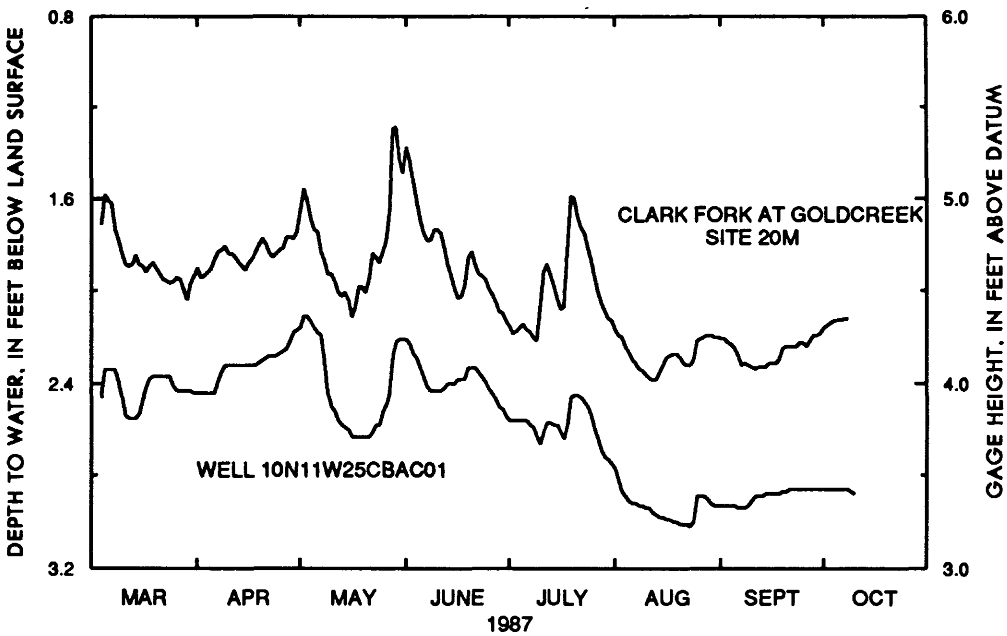

Figure 7.--Relation of water levels in Quaternary alluvium to water stage (gage height) in the Clark Fork near Goldcreek.

The altitude and configuration of the potentiometric surface in Quaternary and Tertiary deposits are shown on plate 1. Water-level data shown on the map were measured between 1985 and 1987; therefore, the location of the contours is approximate. In preparing the map, tributary streams were assumed to be gaining flow from ground water. However, no data were collected that substantiate this assumption. Further, the Quaternary and Tertiary deposits were treated as one aquifer in preparing the contours, because Quaternary and Tertiary deposits probably are hydraulically connected to some degree. Horizontal ground-water flow normally is perpendicular to the contours and in the direction of decreasing water-level altitude. In this area, ground-water flow generally follows surface topography. Potentiometric gradients generally are largest where topography is steep or aquifers less transmissive. Thus, water in Quaternary and Tertiary deposits flows primarily toward the nearest stream.

Recharge to alluvium is by infiltration of precipitation, irrigation water, and stream water during periods of high flow, and by inflow from underlying aquifers. Discharge from alluvium generally is by outflow directly to streams or by evapotranspiration where the water table is very shallow. Water in alluvium also is discharged by vertical flow to underlying Tertiary deposits, particularly where extensive irrigation causes water levels in alluvium to rise.

Transmissivity of alluvium was determined from aquifer tests in two areas and from specific-capacity data collected throughout the study area. In the Clark Fork valley south of Garrison, Konizeski and others (1968) conducted aquifer tests of 15 wells completed in alluvium and computed transmissivity values ranging from 2,670 to 23,400 ft^2/d with a median of 6,680 ft^2/d. In the Milltown area, Woessner and others (1984) conducted aquifer tests of eight wells completed in alluvium and computed transmissivity values ranging from 18,200 to 4,370,000 ft^2/d with a median of about 385,000 ft^2/d. Alluvium near Milltown likely is the most transmissive aquifer in the study area, because the aquifer is thick and consists of very coarse gravels and boulders. Specific-capacity data from 81 wells inventoried during this study and completed in alluvium had a minimum of 0.35 (gal/min)/ft, a maximum of 175 (gal/min)/ft, and a median of 6.0 (gal/min)/ft. Corresponding transmissivity values ranged from 40 to 38,000 ft^2/d and had a median of 970 ft^2/d.

Water Chemistry

Forty-four water samples collected from 28 wells completed in Quaternary alluvium were analyzed for water chemistry (table 2 at back of report). Domestic wells were sampled once. Wells installed for this study were sampled two to four times.

Major ions

The percentages of major ions in these samples are shown in trilinear diagrams in figures 8 and 9. For project wells sampled more than once, data plotted in the trilinear diagrams are for 1989. Water samples from almost all these wells had a calcium bicarbonate or calcium-magnesium bicarbonate composition, most likely caused by dissolution of carbonate rocks that are common in the area and by fragments of these rocks that have been incorporated into alluvium.

Although sulfate was less abundant than bicarbonate in most samples, the percentage of sulfate relative to other anions varied throughout the area. The percentages of sulfate were used to help distinguish possible sources of water in alluvium.

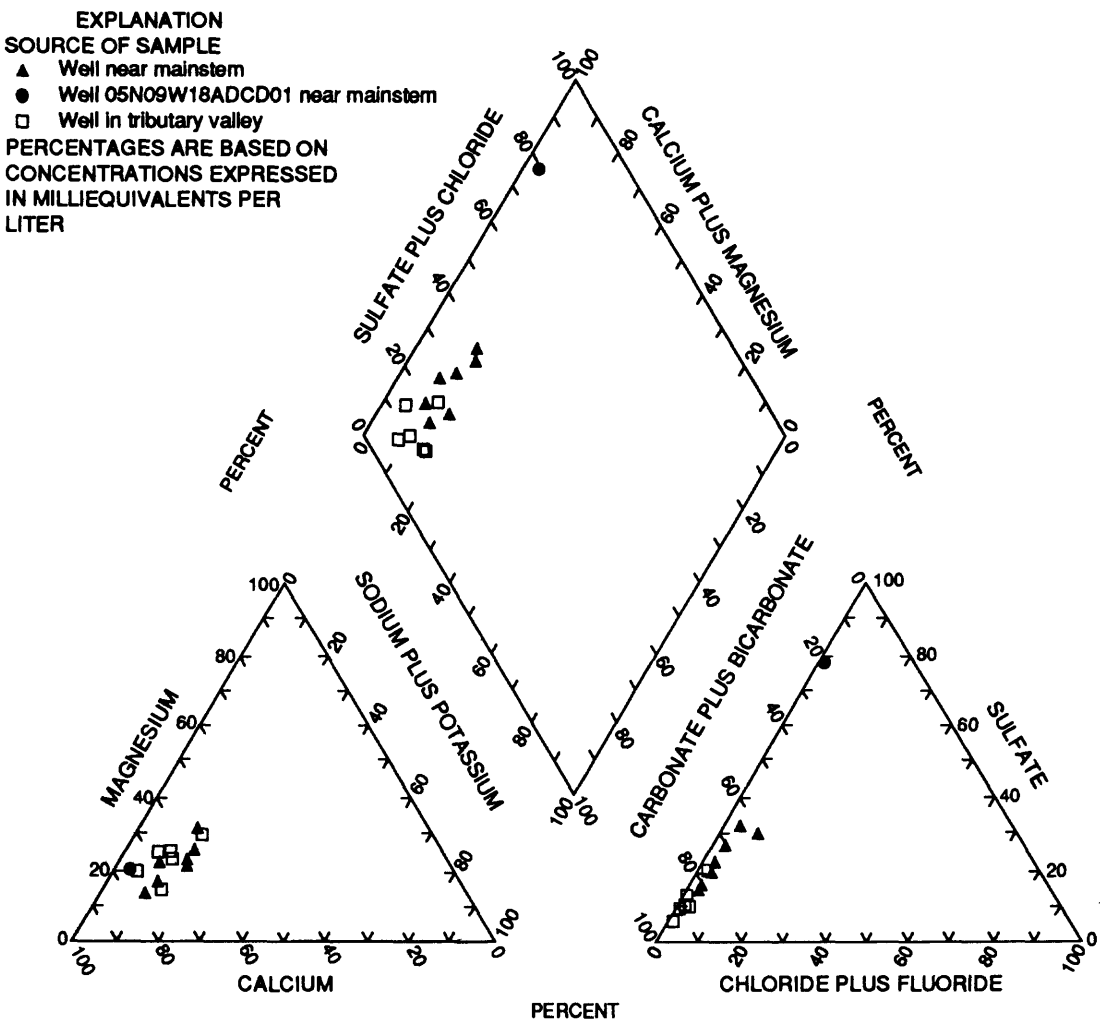

Figure 8.--Percentages of major ions in water from wells completed in Quaternary alluvium in tributary valleys and in the mainstem Clark Fork valley upstream from Jens.

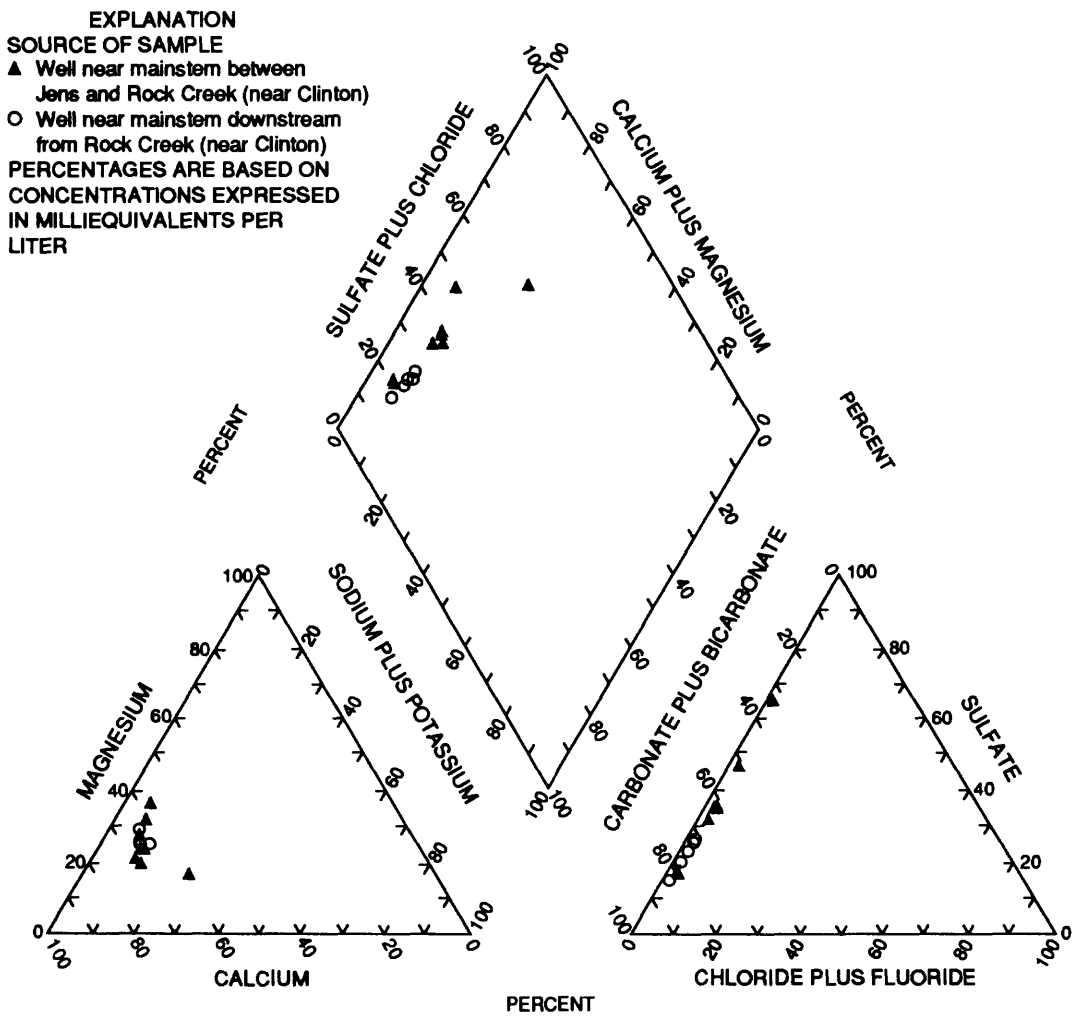

Figure 9.--Percentages of major ions in water from wells completed in Quaternary alluvium in the mainstem Clark Fork valley downstream from Jens.

Percentages of sulfate were smallest in water samples from alluvium in tributary valleys such as Gold Creek and Flint Creek, and in tributary valleys on the west side of the Clark Fork south of Garrison (fig. 8). Sulfate generally was less than 15 percent of the total anions in milliequivalents per liter. No significant sources of sulfate have been identified in these tributary valleys.

The percentage of sulfate in water samples from alluvium generally was larger along the Clark Fork than along tributaries (fig. 8). In the southern Clark Fork upstream from Jens, several sulfate concentrations were greater than 25 percent of the total anions. Sulfate in such large quantities could be derived from oxidation of mine wastes, which can affect the quality of both ground water and surface water (see section "Relation of Streamflow to Shallow Aquifers"). The mine wastes are now located in waste piles and tailings ponds in headwater valleys of the Clark Fork (Moore and Luoma, 1990) and in flood-plain deposits along the Clark Fork (Brooks and Moore, 1989; Nimick and Moore, 1991; in press). Sulfide minerals in these mine wastes can oxidize and release sulfate to shallow ground water and to Silver Bow Creek, the Clark Fork, and possibly other headwater streams.

Sulfate concentrations in water samples from alluvium of the southern Clark Fork valley generally were largest in the reach downgradient from Warm Springs Ponds. The ponds, which are located about 0.5 mi upstream from the beginning of the Clark Fork, were built to treat contaminated water in Silver Bow Creek. Pond water recharges the alluvium and creates a contaminant plume containing arsenic, cadmium, iron, manganese, and sulfate in ground water downgradient from the ponds (Montana Department of Health and Environmental Sciences, 1989). Well 05N09W18ADCD01 produced calcium sulfate water from this plume (fig. 8). Other sources of sulfate that may affect water quality in alluvium of the southern Clark Fork valley include leachate from tailings in ponds located northeast of Anaconda (TetraTech, Inc., 1987) and flow from Warm Springs, which discharges ground water containing naturally occurring sulfate. Warm Springs is reported to locally recharge alluvium (Sonderegger, 1984; Sonderegger and Bergantino, 1981); however, the extent of any resulting sulfate plume in alluvium is not known.

Between Jens and Rock Creek (near Clinton), geothermal water discharges to the Clark Fork, probably from faults along the Montana Lineament (Vice, 1984). Six of the eight wells completed in alluvium in this reach produced water in which sulfate constituted more than 30 percent of the anions (fig. 9). Five of these wells produced calcium bicarbonate-sulfate or calcium sulfate water that represents undiluted geothermal water or a mixture of geothermal water and the calcium bicarbonate water that is typical of most water in the alluvium. The sixth well (11N13W23CDBA01) produced a calcium sulfate water that is similar in composition to the water discharging at Bearmouth Warm Springs (Sonderegger and Bergantino, 1981) that may be relatively undiluted geothermal water. The small concentration of dissolved oxygen (0.1 mg/L, table 2) in water from this well infers that the water has not mixed with the normally oxygenated water in alluvium but comes from a source having little dissolved oxygen. The large strontium concentration of 6,300 μg/L (compared to concentrations of less than 800 μg/L in most samples from alluvium) also indicates a geothermal source of ground water in this well. Downstream from the mouth of Rock Creek (near Clinton), the Clark Fork has no significant sources of sulfate other than river water; consequently, percentages of sulfate in Clark Fork alluvium generally were smaller (15 to 30 percent of total anions) than elsewhere in the valley (fig. 9).

Concentrations of dissolved solids in water samples from alluvium ranged from 112 to 1,240 mg/L, with most values between 200 and 400 mg/L. Concentrations less than 200 mg/L generally were from areas south of Deer Lodge where crops are irrigated with water from tributaries and where applied surface water apparently dilutes the local ground water. Concentrations greater than 400 mg/L were mainly from areas along the mainstem valley where concentrations of sulfate and other constituents were large.

Nitrate (as nitrogen) concentrations in water samples from alluvium commonly were less than 1 mg/L. However, some of the wells in the extensively irrigated southern Clark Fork valley yielded water having larger concentrations. In that area, nitrate concentrations in wells 05N10W29BABC01, 06N09W21BBBB01, and 06N10W23DCDD01 ranged from 1.5 to 1.9 mg/L. The relatively large concentration of nitrate (2.5 mg/L) in well 11N12W31AACB01 in Drummond may have been caused by contamination from septic tanks, animal waste, or fertilizer. The nitrate in water from this well probably is derived from fertilizer, because nitrate concentrations resulting from septic-tank effluent or animal manure commonly is accompanied by elevated concentrations of chloride. The source of nitrate (2.7 to 4.5 mg/L) in well 09N09W28CCDD01 is not known.

Primary[1] and Secondary[2] Drinking-Water Regulations have been established by the U.S. Environmental Protection Agency for public drinking-water supplies (table 3 at back of report). Of the water samples collected from wells completed in alluvium during this study (table 2), none had concentrations of major ions that exceeded Primary Drinking-Water Regulations. However, concentrations of sulfate and dissolved solids in samples from several wells exceeded the Secondary Drinking-Water Regulations. Sulfate concentrations exceeded the SMCL of 250 mg/L in samples collected at two wells. Dissolved-solids concentrations exceeded the SMCL of 500 mg/L in samples collected at three wells.

Trace elements

Analyses of trace-element concentrations in water samples from alluvium were a particularly important part of this study because of the proximity between the mine wastes in pond and flood-plain sediments and the shallow ground water along the entire length of the Clark Fork. Oxidation of sulfide minerals in the mine wastes and subsequent leaching of trace elements has the potential to contaminate ground water. Arsenic, cadmium, copper, iron, lead, manganese, and zinc are the trace elements found in large concentrations in the mine wastes (Moore and Luoma, 1990; Brooks and Moore, 1989; Nimick and Moore, in press). With the exception of iron and manganese, these are the trace elements of concern in the Clark Fork valley owing to their toxicity. Arsenic, cadmium, and lead are toxic to humans and cadmium, copper, and zinc are toxic to aquatic organisms. Concentrations of these trace elements in ground water could be particularly important where ground-water discharge contributes a substantial quantity of flow to surface water. However, data are insufficient to evaluate how ground-water discharge might be affecting trace-element concentrations in the Clark Fork.

The solubility of some trace elements depends on whether the water is oxygenated or reduced. The existence of reduced or oxygenated (redox) conditions in ground water can be inferred from several water-quality constituents. However, chemical constituents may not be in thermodynamic equilibrium and may provide conflicting evidence about oxidation-reduction (redox) conditions. Constituents analyzed in this study that are redox indicators include dissolved oxygen, As^{+3} (the reduced species of arsenic), iron, and manganese. Oxygenated conditions are indicated by dissolved-oxygen concentrations greater than 1.0 mg/L and by the absence of detectable As^{+3}, iron, or manganese. Dissolved As^{+3}, iron, and manganese are stable in large concentrations under reduced conditions but are not likely to exist under oxygenated conditions. Under oxygenated conditions, As^{+3} oxidizes to As^{+5}, which can remain dissolved in water although it can be partly removed by sorption reactions. The As^{+5} concentration can be computed by subtracting the As^{+3} concentration from the As^{+3} plus As^{+5} concentration. Dissolved iron and manganese concentrations can be large under reduced conditions because the reduced species of these elements (Fe^{+2} and Mn^{+2}) are stable. Under oxygenated conditions, these species can oxidize and be removed from solution by precipitation of oxide and hydroxide minerals.

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[1] National Primary Drinking-Water Regulations are established for contaminants which, if present in drinking water, may cause adverse human health effects. Either a Maximum Contaminant Level (MCL) or a treatment technique is specified by these regulations for regulated contaminants. MCL's are health-based and enforceable (U.S. Environmental Protection Agency, 1991a).

[2] Secondary Drinking-Water Regulations are established for contaminants that can adversely affect the odor or appearance of water and result in discontinuation of use of the water. These regulations specify Secondary Maximum Contaminant Levels (SMCL), which are esthetically based and nonenforceable (U.S. Environmental Protection Agency, 1991b).

On the basis of concentrations of redox-sensitive constituents, water in alluvium generally is oxygenated. Conditions may be reduced at a few wells, such as wells 10N11W25CBAC01, 10N10W31BABA02, and 05N09W18ADCD01. Conditions are likely to be reduced in alluvium where organic matter accumulates. Such sites include the sediments of the Warm Springs Ponds or other water bodies and lenses of organic-rich material in flood-plain sediments that were deposited in oxbows or other low-energy depositional environments.

Arsenic (As^{+3} plus As^{+5}) concentrations in water samples from alluvium generally ranged from 0.2 to 11 µg/L. The concentrations were largest (3.5 to 20 µg/L) in samples from wells located within 300 ft of the Clark Fork. Even though the values are less than the MCL of 50 µg/L, they indicate that arsenic could be of concern in water from mainstem alluvium. Two sources of the arsenic are plausible. First, arsenic may be leached from oxidized sulfide minerals in mine wastes that are intermixed with flood-plain deposits along the Clark Fork. Brooks and Moore (1989) documented the downward movement of arsenic from these fluvially deposited mine wastes to shallow ground water at a study site near Racetrack. The same process could occur elsewhere in the southern Clark Fork valley. Arsenic concentrations larger than the maximum value (20 µg/L) measured might be found if wells were installed in areas with large volumes of flood-deposited tailings. Additional wells completed in alluvium directly overlain by tailings deposits more than 1 ft thick could be installed to verify any occurrence and to monitor the movement of arsenic leached from flood-deposited tailings. No wells sampled during this study were located in such areas. Second, Clark Fork water, which had dissolved-arsenic concentrations in the same range as in ground water near the river, may flow through alluvium near the river channel. Arsenic concentrations in water from alluvium were smallest (0.2 to 1.1 µg/L) along Clark Fork tributaries, excluding Flint Creek where concentrations were larger (2.6 to 6.6 µg/L). Because Flint Creek drains an important mining area, arsenic-rich sediments derived either from natural sources or from deposition of mine wastes are the probable sources of arsenic in alluvium of this valley.

Although iron and manganese are abundant in rocks and sediments associated with ores, their concentrations in ground water normally are controlled by the redox potential of water in the aquifer. As would be expected in oxygenated water, concentrations of iron and manganese in most samples were small or less than the minimum reporting level. Iron and manganese concentrations were large in samples from some wells, primarily where small concentrations of dissolved oxygen (less than 1.0 mg/L) indicate the presence of suboxygenated or reduced conditions. Concentrations of iron and manganese in samples from these wells were as much as 2,500 and 1,300 µg/L, respectively. Water from well 05N09W18ADCD01 had large concentrations of iron (540 µg/L) and manganese (63 µg/L), because the well is located within the contaminant plume being recharged with reduced leachate from the Warm Springs Ponds (Montana Department of Health and Environmental Sciences, 1989).

Concentrations of cadmium larger than the minimum reporting level (2 µg/L) were measured only in samples from well 05N09W18ADCD01, which is located in the contaminant plume just described. Concentrations of cadmium in four samples from this well ranged from less than the minimum reporting level to 6 µg/L.

Copper, lead, and zinc are the other trace elements associated with mine wastes. The concentrations in water generally were small, showed little relation to possible sources, and were within the same ranges as in water from Tertiary deposits and bedrock. Copper concentrations were commonly near or less than the minimum reporting level. The largest concentrations of copper in water from alluvium (11 µg/L) were in samples from two wells--near the Clark Fork near Drummond (well 10N12W09CADA01) and near Flint Creek (well 09N13W03DAAD01). Concentrations of lead were less than the minimum reporting level in all water samples. Zinc occurred in measurable quantities in most water samples; the largest concentration in alluvium was 126 µg/L (well 10N11W25CBAC01).

Trace-element concentrations measured in water samples from domestic wells may have been affected by the metallic materials commonly used in well casings and plumbing. Samples from these wells were collected after thorough flushing of the well and water-distribution pipes and from a point as close to the well as possible to decrease the potential for alteration of trace-element concentrations. Copper, lead, nickel, and zinc probably are the inorganic trace elements most likely to be leached from domestic plumbing. Systematic differences generally were not discernible in the range of trace-element concentrations found in water samples from PVC-cased wells versus steel-cased wells. Exceptions include the PVC-cased wells in which larger arsenic and cadmium concentrations have been attributed to specific sources.

Of the water samples from alluvium analyzed during this study, one constituent concentration in one sample exceeded the applicable MCL. A cadmium concentration of 6 µg/L (table 2) in a water sample from well 05N09W18ADCD01 located downgradient of the Warm Springs Ponds exceeded the MCL of 5 µg/L (table 3). Concentrations of two trace elements in samples from several wells exceeded the Secondary Drinking-Water Regulations. Manganese concentrations exceeded the SMCL of 50 µg/L in samples collected at eight wells; four of these wells also produced water that exceeded the SMCL of 300 µg/L for iron. Wells 05N09W18ADCD01 and 11N13W23CDBA01 produced water that exceeded the SMCL's for four constituents--the trace elements of iron and manganese and the major ions of sulfate and dissolved solids. For the constituents examined in this study, water-quality criteria established by the State of Montana for public-water supplies (table 3) are identical to, or in the case of cadmium and fluoride less stringent than, contaminant levels designated in Primary and Secondary Drinking-Water Regulations.

Tertiary Deposits

Tertiary deposits crop out in low hills near Garrison and occur beneath extensive terraces in the Clark Fork valley south of Garrison and in the Flint Creek valley. Sequences of Tertiary deposits as much as 5,000 feet thick also underlie both valleys. Coarse-grained beds and lenses of sand and gravel yield water to wells. Fine-grained deposits, such as lacustrine silt and clay, commonly do not yield water to wells.

Aquifer Characteristics

The 117 wells completed in Tertiary deposits and inventoried for this study are all located between Anaconda and Drummond (table 1). These wells have a median depth of 109 ft and few are deeper than 200 ft. Discharges of wells completed in Tertiary deposits tend to be less than for Quaternary alluvium and more than for bedrock. However, large-capacity wells have been developed in Tertiary deposits where local water-bearing zones are thick. The minimum discharge for 35 wells completed in this aquifer was 10 gal/min, the maximum was 2,400 gal/min, and the median was 20 gal/min.

Water levels in Tertiary deposits in many areas respond to ground-water recharge as a result of the extensive application of surface water for irrigation. Irrigation water is distributed in unlined ditches starting in April or May and is applied to fields by flooding or sprinklers. Excess water commonly is applied. In the southern Clark Fork valley, water levels were measured in wells 05N10W10CCBC01 and 07N09W31CCAD01, which are 115 and 182 ft deep, respectively, and completed in Tertiary sand and gravel. Water levels in these wells rose during the summer and peaked at the end of the irrigation season, which occurs in late summer or early fall (fig. 10). Water levels declined through the winter and spring. These seasonal patterns may be delayed in deeper wells, owing to the time needed for deep percolation. In contrast, water levels in well 10N11W36BCAD01 along the Clark Fork near Goldcreek peaked in July, probably in response to a shorter irrigation period. A continuous hydrograph for well 08N09W27BDDD01, located northeast of Deer Lodge near Fred Burr Creek, indicates that water levels peaked in June (fig. 11) in response to natural recharge from spring runoff and perhaps limited irrigation from the small tributary streams east of the Clark Fork.

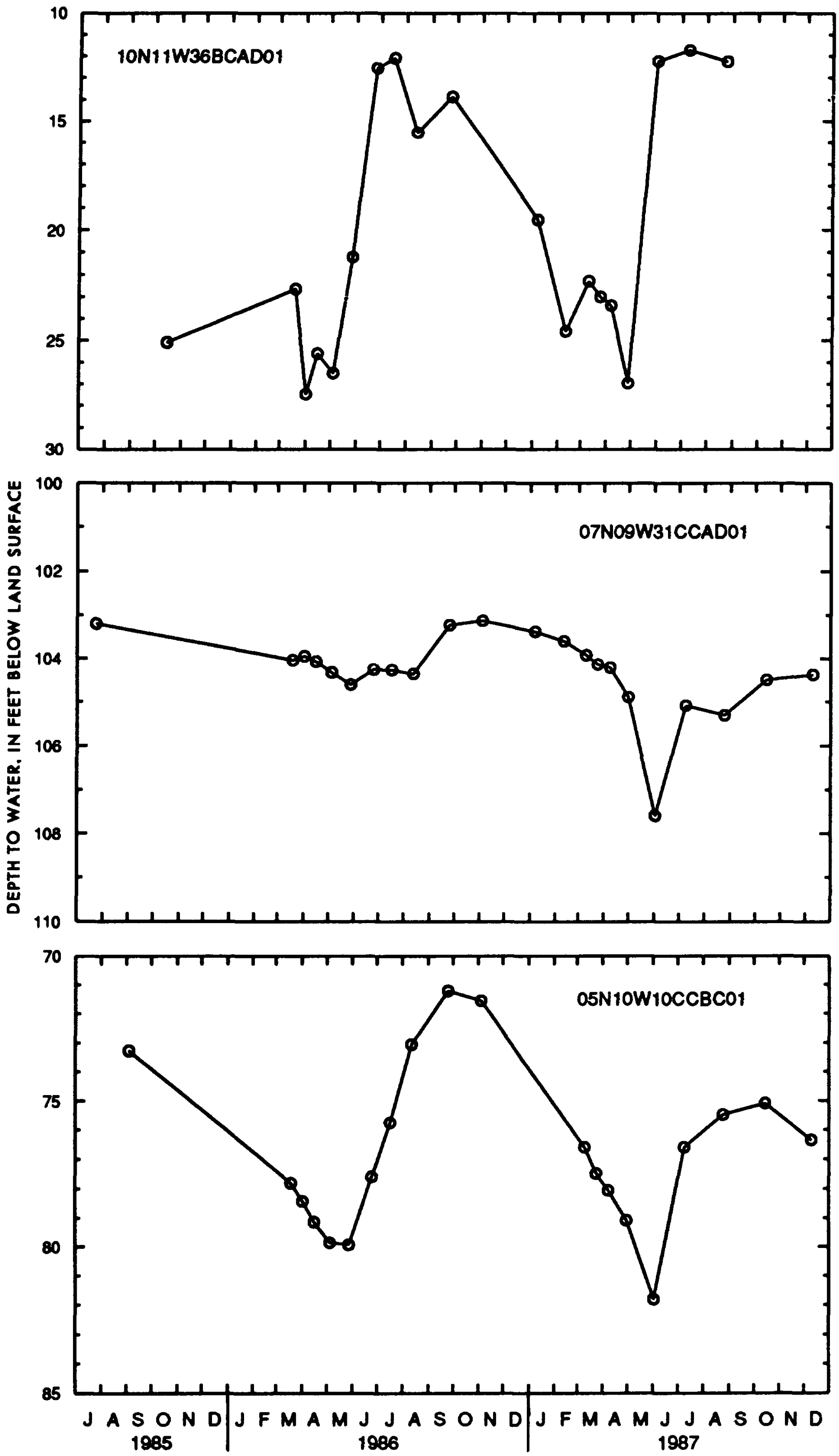

Figure 10.--Water levels measured intermittently in observation wells completed in Tertiary deposits in the Clark Fork valley upstream from Drummond.

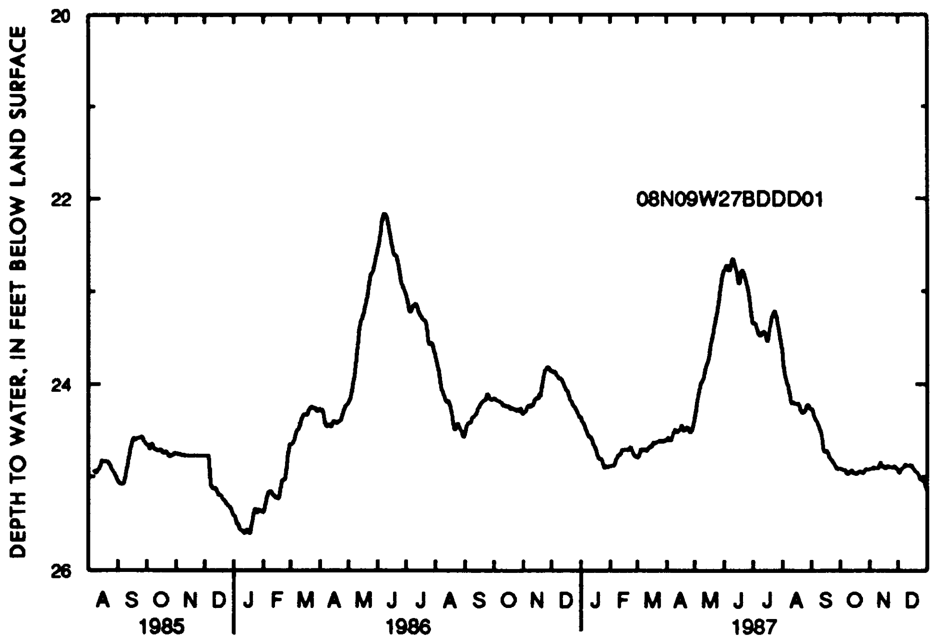

Figure 11.--Water levels measured by continuous recorder in an observation well completed in Tertiary deposits in the upper Clark Fork valley south of Garrison.

Quaternary and Tertiary deposits probably are hydraulically connected. Therefore, water-level data from wells completed in Tertiary deposits were used in combination with data from alluvium to construct potentiometric contours for water levels in shallow unconsolidated deposits in the Clark Fork valley south of Garrison and the Flint Creek valley (pl. 1).

Recharge to Tertiary deposits is by infiltration of precipitation and irrigation water, and by inflow from overlying Quaternary alluvium (where present) and deeper or laterally adjacent aquifers in some areas. Water in Tertiary deposits probably moves from high-terrace areas toward stream valleys. There, it discharges to alluvium.

The heterogeneity of Tertiary deposits in the study area is demonstrated by a wide range of transmissivity values. In the Clark Fork valley south of Garrison (Deer Lodge Valley), Konizeski and others (1968) estimated the transmissivity of Tertiary deposits from aquifer tests and specific-capacity data. Transmissivity values determined from aquifer tests of five wells during that study ranged from 80 to 5,080 ft^2/d and had a median of 130 ft^2/d. Transmissivity values converted from specific-capacity data for eight wells pumped during that study ranged from 110 to 9,360 ft^2/d and had a median of 470 ft^2/d. Specific-capacity data from 34 wells inventoried for this study and completed in Tertiary deposits ranged from 0.15 to 200 (gal/min)/ft and had a median of 1.2 (gal/min)/ft. Transmissivity estimates based on these values ranged from 15 to 44,000 ft^2/d and had a median of 160 ft^2/d. These values have a range of about three orders of magnitude. Possible causes of this variability are differing lengths of well screen or perforations, thickness of gravel zones penetrated, and well efficiency, but the causes are likely a reflection of the heterogeneous nature of the aquifer material. Inaccuracies in reported data could also increase the variability of transmissivity values converted from specific-capacity data.

Nineteen water samples collected from 17 wells completed in Tertiary deposits were analyzed for water chemistry (table 2). The percentages of major ions in one sample from each of these wells are shown in figure 12.

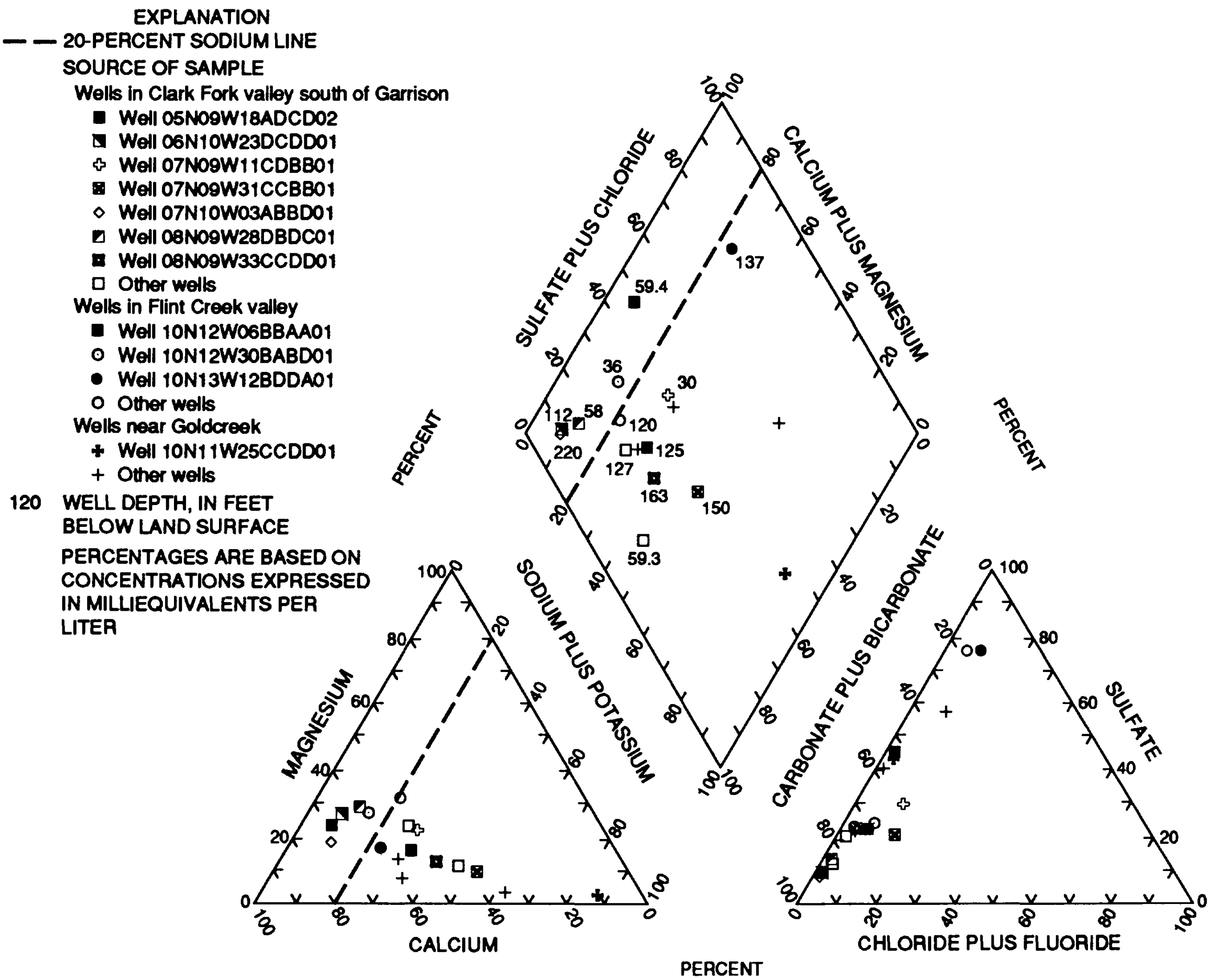

Figure 12.--Percentages of major ions in water from wells completed in Tertiary deposits. Dashed line separates samples in which sodium is more or less than 20 percent of total cations. In the upper diagram, well depths are identified for sites in the Clark Fork valley south of Garrison and in the Flint Creek valley.

Water samples from Tertiary deposits had variable percentages of sodium, which commonly is exchanged from aquifer materials and replaced by calcium and magnesium ions from ground water. This process increases the percentage of sodium dissolved in ground water and decreases percentages of dissolved calcium and magnesium. The abundance of exchangeable sodium affects the extent to which this exchange reaction occurs.

Some water samples from one group of wells, which are completed in Tertiary deposits at depths generally shallower than 60 ft, had relatively little sodium. These samples were from wells in the Clark Fork valley south of Garrison and in Flint Creek valley. Sodium was less than about 20 percent of the total cations in milliequivalents per liter. The water was either a calcium bicarbonate or a calcium-magnesium bicarbonate type and was similar to that in Quaternary alluvium and streamflow of Clark Fork tributaries. The small percentages of sodium probably were due to exchangeable sodium in the shallow parts of the aquifer having already been leached. The similarity in composition of water samples from shallow Tertiary deposits and tributary streamflow indicates that irrigation water diverted from tributary streams might be the primary source of recharge to shallow Tertiary deposits in many areas. This conclusion is supported by hydrographs showing the effects of irrigation on water levels in wells (figs. 10 and 11). Examples of shallow wells completed in Tertiary deposits include well 08N09W28DBDC01 (58 ft deep) in the southern Clark Fork valley and well 10N12W30BABD01 (36 ft deep) in the Flint Creek valley. Several deep wells also produced calcium bicarbonate water. For example, well 07N10W03ABBD01 (220 ft deep) produced calcium bicarbonate water, which presumably had migrated downward from overlying Quaternary glacial outwash. The driller's log indicates that the 12-in.-diameter casing is surrounded by a 38-in.-diameter annulus that was backfilled with 1/4-in. gravel. This type of well completion could enhance the vertical hydraulic connection between the Quaternary alluvium and Tertiary deposits. Similar leakage may occur around well 06N10W23DCDD01, which is 112 ft deep.

Water samples from a second group of wells, which are completed in Tertiary deposits at depths generally greater than about 60 ft, had mixed water compositions that varied considerably throughout the study area. Sodium was more than 20 percent of the total cations in these samples. This percentage of sodium distinguishes this water from that in alluvium, shallow Tertiary deposits, bedrock, and streams. The most commom water types were calcium-sodium bicarbonate or sodium-calcium bicarbonate, as found in wells 07N09W31CCBB01 (150 ft deep) and 08N09W33CCDD01 (163 ft deep) in the Clark Fork valley south of Garrison and in well 10N12W06BBAA01 (125 ft deep) in the Flint Creek valley. Wells in the Goldcreek area produced water having the largest sodium concentrations. Sodium could be introduced by sodium exchange from aquifer materials or by recharge of sodium-rich water from deeper Tertiary deposits and bedrock. Variability in the chemistry of deposits with different lithologies could cause variations in the rate and quantity of sodium exchanged.

Three wells yielded water with anomalous compositions. Well 05N09W18ADCD02 is located on the Clark Fork flood plain. Water samples from the well had substantial concentrations of sulfate, which probably was derived from the contaminant plume emanating from the Warm Springs Ponds. Well 07N09W11CDBB01 is very shallow (30 ft) but yielded a mixed water with relatively large concentrations of sodium and dissolved solids that were similar to concentrations in water from deeper Tertiary deposits. This was the only well sampled on the east side of the Clark Fork valley south of Garrison where tributaries of the Clark Fork drain Cretaceous volcanic rocks and granite. The water may be typical of shallow ground water in drainages having little, if any, carbonate bedrock. Water in well 10N13W12BDDA01, located in the Flint Creek valley, had a calcium sulfate composition similar to the water from several warm springs; this condition infers that water from deeper bedrock is recharging the Tertiary deposits. The large strontium concentration (4,100 μg/L) also infers a deeper source.

Dissolved-solids concentrations in water samples from Tertiary deposits in the Clark Fork valley south of Garrison were generally less than 400 mg/L. Exceptions were samples from wells 07N09W11CDBB01 (659 mg/L) and 05N09W18ADCD02 (432 and 449 mg/L). The median dissolved-solids concentration for all wells in this part of the valley was 286 mg/L. Dissolved-solids concentrations were larger in Flint Creek valley and the Gold Creek area, where median concentrations were 454 and 443 mg/L, respectively.

Nitrate concentrations in some water samples from Tertiary deposits were greater than 1 mg/L. Concentrations greater than 1 mg/L probably indicate a nitrate source that is related to human activites such as fertilizer, septic-tank effluent, or animal manure. The area affected was not widespread, as concentrations in two nearby wells could differ considerably. On the east side of the Clark Fork valley near Deer Lodge, well 07N09W11CDBB01 produced water having a nitrate concentration of 6.2 mg/L. Near Goldcreek, water from well 10N11W35BBBC01 had a concentration of 10 mg/L. Water from these wells had large chloride concentrations, which indicates that the nitrate source probably was animal waste or septic effluent. Upgradient sewage lagoons may have been the source of nitrate (4.5 mg/L) in water from well 05N09W18ADCD02, which is near the town of Warm Springs. Large concentrations of nitrate appear to be more widespread in the Flint Creek valley than in the Clark Fork valley. Three of four sampled wells there had nitrate concentrations greater than 1 mg/L. The maximum concentration was 3.0 mg/L. Water samples from all three wells had large chloride concentrations, indicating a probable animal or septic source of the nitrate.

Trace-element concentrations in water from Tertiary deposits were mostly within the same ranges as in alluvium. Arsenic concentrations between 12 and 14 µg/L in water from wells 10N13W12BDDA01 and 10N12W06BBAA01 in the Flint Creek valley and well 09N11W01BCAC01 in the Gold Creek valley may have been caused by mining activities in these drainages, but more likely were caused by the naturally occurring arsenic found in volcanic rocks within the Tertiary deposits. Some copper and zinc concentrations in Tertiary deposits, however, were slightly larger than those in alluvium, with maximum values of 30 µg/L for copper and 300 µg/L for zinc. These large values may have been caused by leaching of metals from domestic-well plumbing and may not represent actual concentrations in Tertiary deposits. Large trace-element concentrations generally were not observed; therefore, water in Tertiary deposits probably has not been affected by mining and related activities. Tertiary deposits downgradient from the Warm Springs Ponds have been affected by mine wastes (Montana Department of Health and Environmental Sciences, 1989), but large sulfate concentrations (150 and 160 mg/L) in water from well 05N09W18ADCD02 were the only evidence of a plume found during this study.

No Primary Drinking-Water Regulations were exceeded by water samples from wells completed in Tertiary deposits; however, the sample from well 10N11W35BBBC01 equaled the MCL of 10 mg/L for nitrate. Secondary Drinking-Water Regulations were exceeded for four variables: pH of 8.5 was exceeded in one sample, sulfate concentration of 250 mg/L was exceeded in two samples, dissolved-solids concentration of 500 mg/L was exceeded in five samples, and manganese concentration of 50 µg/L was exceeded in two samples.

Bedrock

Bedrock near valley margins is used as a source of water in the study area. With the exception of well 05N11W26AAAA01 in the Lost Creek valley near Anaconda, all inventoried wells completed in bedrock are located between Garrison and Nimrod. These wells are completed primarily in sedimentary formations of Cretaceous age.

Aquifer Characteristics

This report contains data for 26 wells completed in bedrock (table 1). These wells have a median depth of 88 ft and few are deeper than 200 ft. Wells completed in bedrock are near outcrops and produce sufficient water for domestic use. Bedrock in the area typically yields less water to wells than Quaternary alluvium or Tertiary deposits. The minimum discharge for 13 wells completed in bedrock was 3 gal/min, the maximum was 350 gal/min, and the median was 15 gal/min.

Few data are available to describe water-level fluctuations in bedrock aquifers. The hydrograph for well 10N12W17BABB01, which is 227 ft deep and is located about 3 mi south of Drummond, is shown in figure 13. Water-level rises in late spring and summer probably were caused by annual spring recharge and possibly irrigation.

Recharge to bedrock is by infiltration of precipitation on rock outcrops in highland areas and possibly inflow from other aquifers. Ground water generally flows toward the Clark Fork. Discharge from bedrock is by outflow to other aqui-

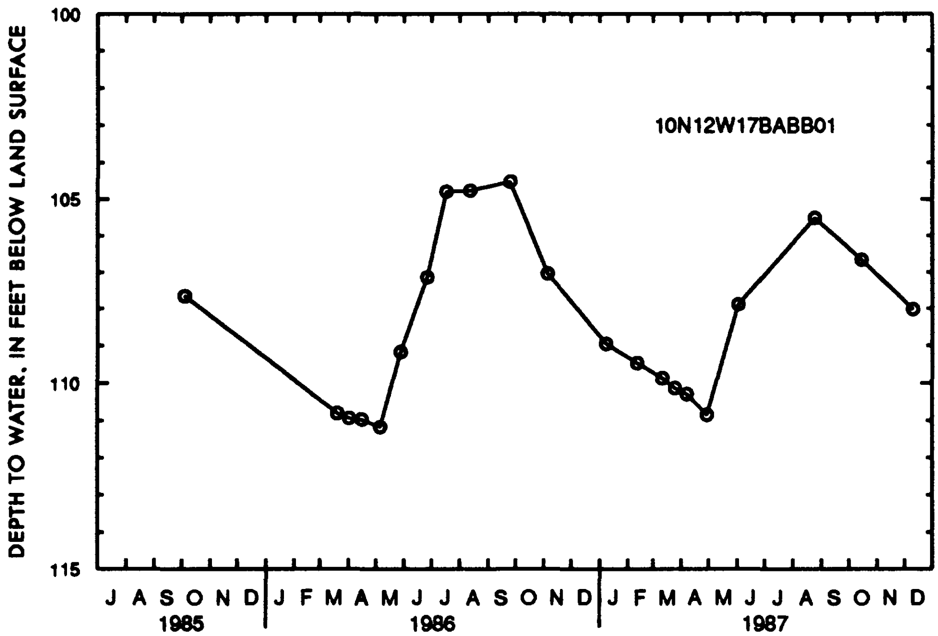

Figure 13.--Water levels measured intermittently in an observation well completed in bedrock in the upper Clark Fork valley near Drummond.

fers and to streams, either indirectly through Quaternary alluvium or Tertiary deposits or directly through springs. Springs located in the Clark Fork valley between Garrison and Rock Creek (near Clinton) are the best evidence of discharge from bedrock in the study area. These springs issue from folded and faulted Paleozoic sedimentary rocks, which lie along the Montana Lineament. Two small cold-water springs (10N11W22BDCD01 and 11N12W29BDAB01) were inventoried in this area. An additional three large springs, all with warm-water discharges, were investigated during previous geothermal studies (Sonderegger and Bergantino, 1981; Leonard and others, 1978; Williams, 1975). One of the large springs, Garrison Warm Springs (10N09W19ACB01), is located near Warm Springs Creek north of Garrison and about 0.5 mi outside the study area. The other two, Nimrod Springs (11N15W14CBDD01) and Bearmouth Warm Springs (11N14W11DCCD01), are located along the Clark Fork near Nimrod and Bearmouth, respectively (fig. 1). Water temperatures of these warm springs range from 20 to 25 °C. Williams (1975) postulated that recharge water moves downward to depths of less than 0.6 mi before flowing upward to the Clark Fork valley along faults. For Nimrod Springs, a nearby thrust fault likely functions as a dam, diverting southward-moving ground water upward to the spring (Kauffman, 1963).

In the Clark Fork valley south of Garrison, water from bedrock discharges primarily to the thick sequence of Tertiary valley-fill deposits in the basin. Some water also discharges to springs. For instance, Anaconda and Deer Lodge Hot Springs discharge water from bedrock on the western edge of the valley (Sonderegger and Bergantino, 1981). Warm Springs is located in the middle of the valley where bedrock is buried deeply beneath Tertiary deposits. This spring is thought to receive geothermal water rising rapidly from bedrock along faults in the Tertiary deposits (Sonderegger, 1984).

Transmissivity of bedrock was estimated from specific-capacity data for 12 wells. The minimum specific-capacity value was 0.1 (gal/min)/ft, the maximum was 29 (gal/min)/ft, and the median was 1.0 (gal/min)/ft. Transmissivity values estimated from the specific-capacity data ranged from 9 to 5,400 ft^2/d and had a median of 130 ft^2/d. These values are considered to represent bedrock at depths of less than a few hundred feet, where secondary porosity due to fracturing probably is more significant than at greater depths.

Water Chemistry

Seven water samples collected from six wells completed in bedrock and from Nimrod Springs (the only spring sampled during this study) were analyzed for water chemistry (table 2). Major-ion chemistry of water samples from the wells (fig. 14) is similar to that of water from Tertiary deposits (fig. 12).

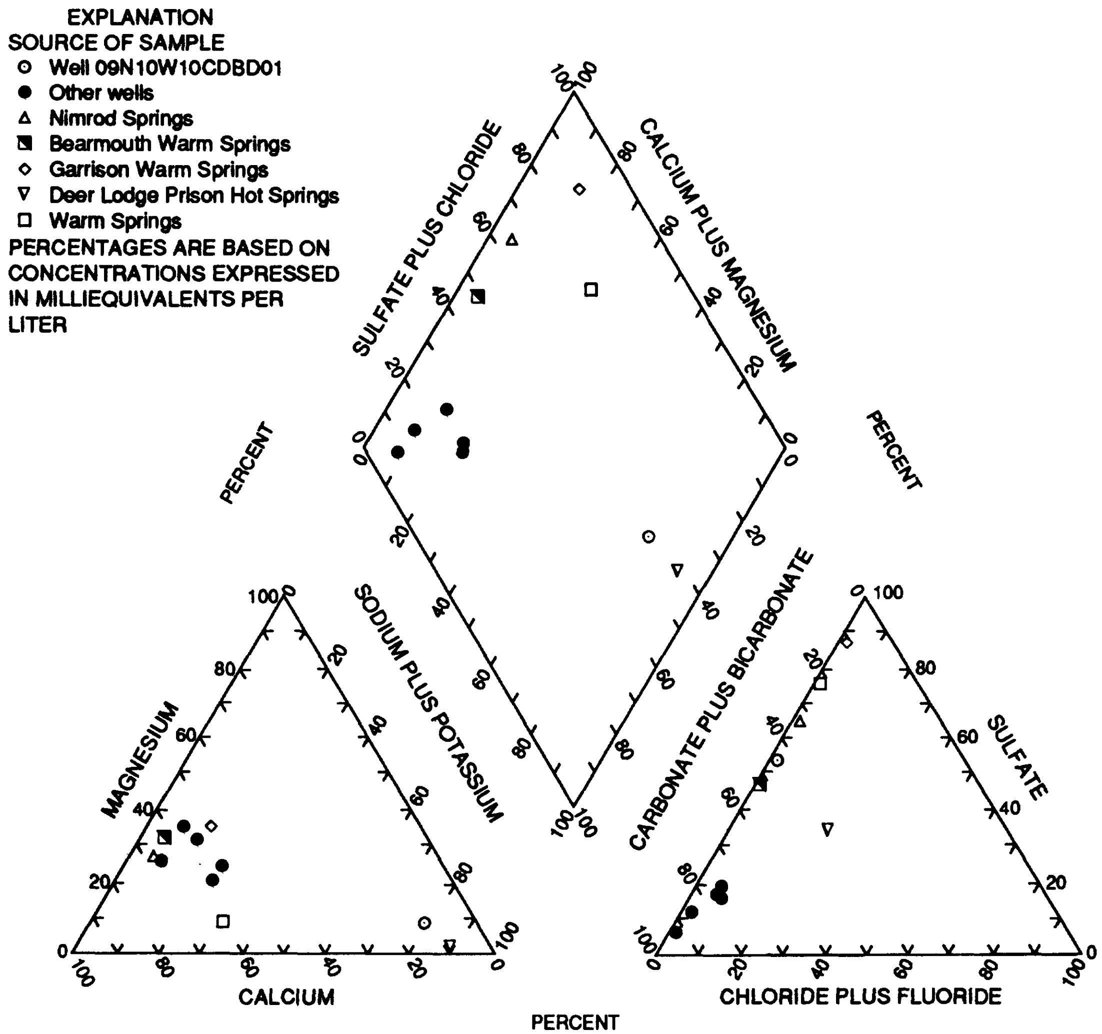

Figure 14.--Percentages of major ions in water from wells and springs completed in bedrock in and near the study area. Water-chemistry data for all springs except Nimrod Springs is from Sonderegger and Bergantino (1981).

Water samples from some wells had a calcium bicarbonate or calcium-magnesium bicarbonate composition, whereas others had larger percentages of sodium and sulfate. Well 09N10W10CDBD01 in the Warm Springs Creek valley near Garrison produced an unusual sodium sulfate water that was similar in composition to water from the Deer Lodge Prison Hot Springs and from well 10N11W25CCDD01 completed in Tertiary deposits near Goldcreek. The wells withdraw relatively shallow ground water, whereas water discharging from springs probably comes from deeper parts of the aquifer. Consequently, geothermal water discharging from springs sampled during this study and by Sonderegger and Bergantino (1981) in and near the study area had a character that was distinctly different from that of ground water from sampled wells. Water from geothermal springs had large proportions of sulfate and, in some instances, sodium.

Dissolved-solids concentrations ranged from 292 to 651 mg/L and had a median of 407 mg/L. Concentrations of arsenic and metals were small or less than the minimum reporting level and were in the same range as samples from alluvium and Tertiary deposits.

The Primary Drinking-Water Regulations were exceeded only by the sample from well 10N10W19DCCC01. The nitrate (as nitrogen) concentration of 11 mg/L slightly exceeded the MCL of 10 mg/L. The chloride concentration of 16 mg/L in this sample indicates that the nitrate source probably was animal waste or septic effluent. SMCL's for sulfate (250 mg/L) and dissolved solids (500 mg/L) were exceeded in water samples from two wells.

RELATION OF STREAMFLOW TO SHALLOW AQUIFERS

Surface-water data were collected to investigate the relations between streamflow and shallow aquifers. Discharge measurements were made during a period of low flow to determine gaining and losing reaches of the river. Water-quality data were collected to aid in interpreting the source(s) of ground-water discharge to the river.

Flow Characteristics

Streamflow was measured near the end of the 1986 irrigation season and after 2 weeks without measurable precipitation (less than 0.01 in.). Most sites were measured on October 21; four tributaries and one irrigation diversion, however, were measured on October 23 or 24. The location of each measurement site is shown in figure 15 and the data are given in table 4 at back of report.

Flow in the Clark Fork increased primarily in response to tributary inflow. Of the 983 ft^3/s determined at Turah Bridge (site 42M), 111 ft^3/s (11 percent) entered the study area as mainstem flow, 706 ft^3/s (72 percent) was contributed by tributaries, and 14 ft^3/s (-1 percent) was diverted for irrigation. The remaining 180 ft^3/s (18 percent) is assumed to be inflow of water from shallow aquifers.

Most ground-water inflow to the Clark Fork was measured in two reaches. The first significant gaining reach of the river was between Racetrack (site 5M) and Garrison (site 12M). Total inflow in this reach was about 88 ft^3/s, or half the total ground-water inflow to the river in the study area. Most of the inflow (55 ft^3/s) was between Racetrack and Deer Lodge (site 8M). Potentiometric contours (pl. 1) also indicate that ground water flows toward the river in this part of the valley. Tributaries draining the Flint Creek Range are heavily used for irrigation, and return flow from irrigated areas may be the source of recharge for much of the ground water that eventually discharges to the river in this reach.

The second significant gaining reach of the river was between Jens (site 22M) and a point downstream from the mouth of Cramer Creek (site 35M). Ground-water contributions to this reach included 68.3 ft^3/s of unaccounted gain in streamflow and 7.6 ft^3/s measured at Nimrod Springs (site 31T). Part of the 68.3 ft^3/s of ground-water inflow enters the Clark Fork from Bearmouth Warm Springs, which has a reported discharge of 1.8 ft^3/s (Sonderegger and Bergantino, 1981). Total ground-water inflow was 75.9 ft^3/s, or about 11 percent of flow at site 35M. On the basis of water-quality data presented later in this report, bedrock aquifers underlying the valley are the probable source of the measured ground-water inflow to the river. Flow from Nimrod Springs and Bearmouth Warm Springs is visible evidence of water discharge directly from bedrock, but most discharge from bedrock probably reaches the river through Quaternary alluvium.

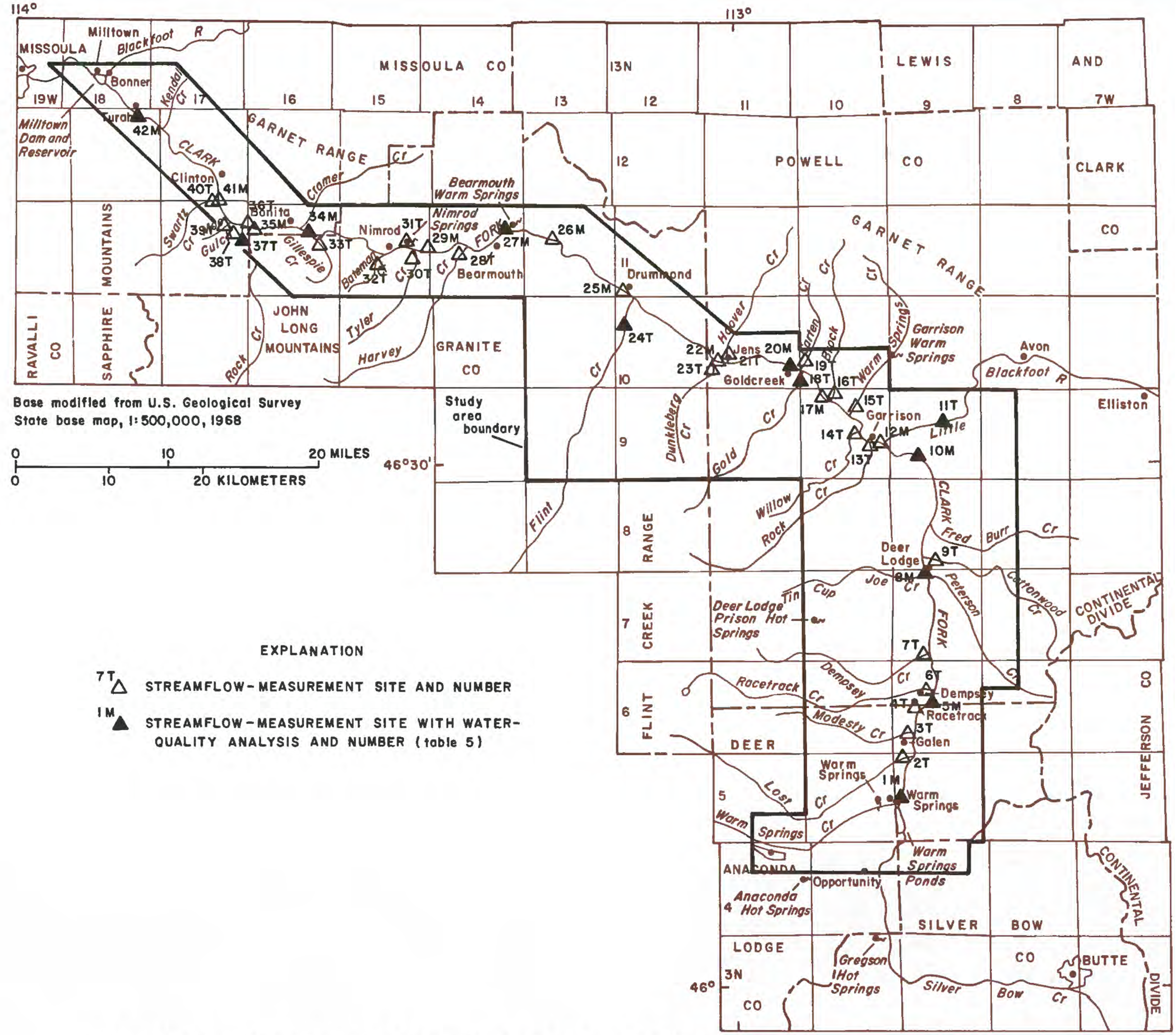

Figure 15.--Location of streamflow-measurement sites.

Water Chemistry

Stream-water-chemistry data obtained during this study represent virtually simultaneous conditions at many mainstem and tributary sites in the upper Clark Fork valley. Thus, the data are useful for assessing water chemistry at the time of data collection rather than over a period of time.

Water samples were collected for chemical analysis using the depth-integration method (Guy and Norman, 1970). Water-chemistry data for samples collected on October 20 and 21, 1986, at eight Clark Fork and four tributary sites are given in figure 16 and in table 5 at back of report. Data for specific conductance and pH measured on October 21, 23, and 24, 1986, at an additional 8 mainstem sites, 18 tributaries, and 1 spring are given in table 4.

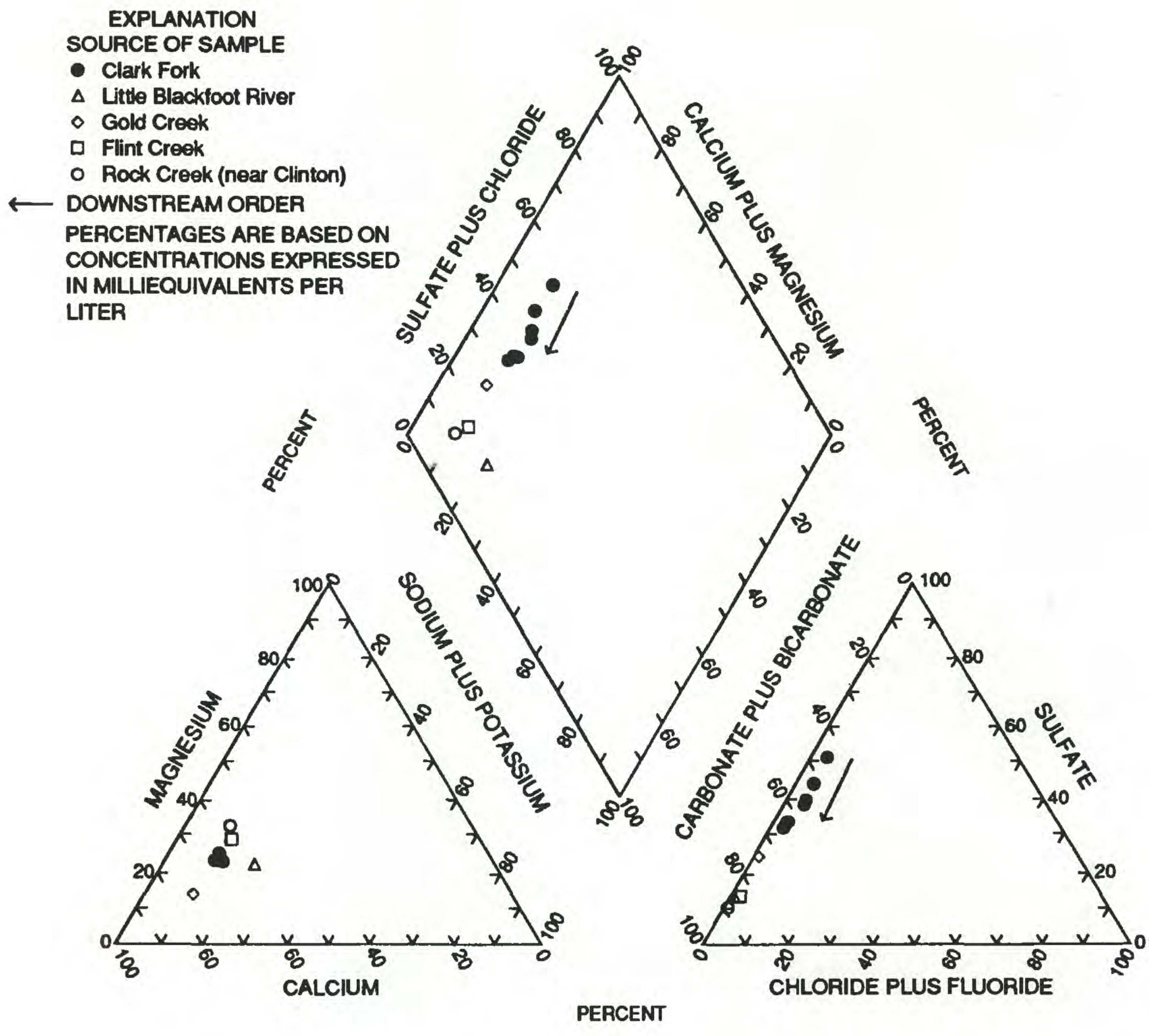

Figure 16.--Percentages of major ions in water from the Clark Fork and tributaries. The downstream order is shown for four sampling sites on the Clark Fork between Warm Springs and Garrison.

In the upstream reach between Warm Springs (site 1M) and Garrison (site 10M), water composition changed progressively downstream from a calcium sulfate-bicarbonate type to a calcium bicarbonate type as tributary inflow diluted the sulfate provided by headwater streams (fig. 16). Downstream from the mouth of the

Little Blackfoot River (site 11T), water type in the Clark Fork was calcium bicarbonate, and the proportions of major ions were virtually the same at each sampling site.

The numerous measurements of specific conductance made during October 1986 provide additional data to further analyze the changes in general water chemistry that occur along the Clark Fork in response to tributary and ground-water inflow. Specific-conductance values generally decreased downstream, from more than 500 µS/cm upstream from Garrison (sites 1M to 10M) to 394 µS/cm at Turah Bridge, near Bonner (site 42M). The primary cause of the downstream decrease was dilution by tributary inflow. Most large tributaries had water with small values of specific conductance (less than about 400 µS/cm).

Local increases in specific conductance in two areas interrupted the general downstream decrease. The first reach in which specific-conductance values increased was between Warm Springs (site 1M) and Racetrack (site 5M), where specific-conductance values increased from 510 to 563 µS/cm. Lost Creek (site 2T) and Modesty Creek (site 3T) contributed substantial flow (74.2 ft^3/s) having relatively large specific conductance (flow-weighted average of 630 µS/cm) to the Clark Fork in this reach. However, inflow from these tributaries did not account for the entire increase in the Clark Fork. Discharge of ground water having large specific conductance also may have increased specific-conductance values in this reach. Possible sources of ground water having large dissolved-solids concentrations include the Warm Springs Ponds, Warm Springs, and tailings ponds located northeast of Anaconda. Ground-water data are insufficient to determine what contribution any of these sources might make to the increase in specific conductance in the Clark Fork between Warm Springs and Racetrack.

Loading computations can be used to estimate the contribution of ground-water discharge to streamflows in the reach between Warm Springs and Racetrack. Dissolved-solids concentrations, which must be used in loading computations instead of specific-conductance values, are available for only a limited number of sites. Specific-conductance values (table 4), however, can be used to estimate dissolved-solids concentrations. Linear regression (fig. 17) of specific-conductance and dissolved-solids data for all surface-water samples (table 5) shows a strong correlation between the two variables ($R^2 = 0.99$). Therefore, dissolved-solids concentrations can be estimated reasonably well from specific-conductance values using the equation:

$$DS = 0.62 \times SC \qquad (2)$$

where:

DS = dissolved-solids concentration in mg/L, and
SC = specific conductance in µS/cm.

Loading of dissolved solids in the mainstem from tributary and ground-water sources can be represented by the following equation:

$$Q_{M_U} DS_{M_U} + Q_{T_1} DS_{T_1} + \ldots + Q_{T_n} DS_{T_n} + Q_{GW} DS_{GW} = Q_{M_D} DS_{M_D} \qquad (3)$$

where:

Q = discharge in ft^3/s; negative if discharge is out of mainstem,
DS = dissolved-solids concentration in mg/L,
M_U = value measured in mainstem at upstream end of reach,
M_D = value measured in mainstem at downstream end of reach,
T = value measured in tributary,
1, ... n = subscripts indicating individual tributaries, and
GW = value estimated for ground-water inflow (or outflow if negative).

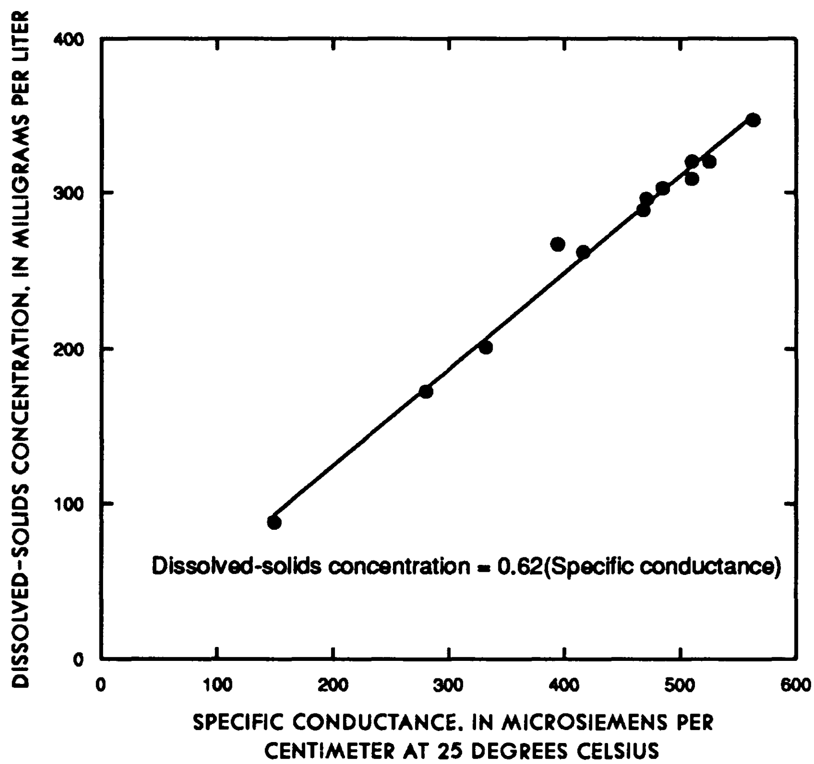

Figure 17.--Relation between specific-conductance values and dissolved-solids concentrations for stream-water samples from the upper Clark Fork valley.

Discharges listed in table 4 and dissolved-solids concentrations converted from specific-conductance values or listed in table 4 can be substituted into the equation. Because no specific-conductance or dissolved-solids data are available for the irrigation diversion above Racetrack bridge (site 4T), and because the site is less than 0.5 mi upstream from site 5M, the dissolved-solids concentration for site 5M is substituted for site 4T. The equation can be solved for either the discharge or the dissolved-solids concentration of ground water. Assuming that the dissolved-solids concentration in ground-water inflow (DS_{GW}) was equal to the average concentration (980 mg/L) of water samples from well 05N09W18ADCD01, ground-water discharge to the Clark Fork would have had to be only 2.2 ft^3/s to account for the observed increase in specific conductance between Warm Springs and Racetrack. This computed rate of ground-water inflow compares well to the 3.3 ft^3/s computed from streamflow measurements.

The second reach in which specific-conductance values increased was between Drummond (site 25M) and Clinton (site 34M), where specific-conductance values in the mainstem increased from 440 to 485 µS/cm. Without the dilution caused by Flint Creek (site 24T), specific conductance probably also would have increased in the Clark Fork between Jens (site 22M) and Drummond. The large net increase in dissolved-solids load in the reach between Jens and Clinton probably can be attributed to ground-water inflow to the river. From table 4, 54.3 ft^3/s of unaccounted flow is assumed to be ground-water inflow to this reach. Using loading computations similar to those described above, the computed dissolved-solids concentration of this ground-water inflow would have been 729 mg/L. Additional loading computations using the concentrations of major ions available for a few sites along the Clark Fork indicate that the ground-water inflow between Goldcreek (site 20M) and Clinton (site 34M) was a calcium sulfate-bicarbonate water type with a composition similar to that at Bearmouth Warm Springs and Nimrod Springs (site

31T). The similarity between estimated and actual composition of spring water discharging from bedrock supports the conclusion of ground-water inflow to the Clark Fork.

The only trace elements associated with mining that occurred in the Clark Fork in concentrations significantly greater than minimum reporting levels were arsenic, copper, and manganese. Arsenic concentrations ranged from 5.1 to 8.1 µg/L in samples from the Clark Fork and showed no downstream trend. In contrast, copper and manganese concentrations were relatively large at upstream stations. Lambing (1990) found similar trends in the median values of dissolved concentrations of these trace elements from long-term sampling at two sites: Deer Lodge (site 8M) and Turah Bridge, near Bonner (site 42M). The largest copper concentration (14 µg/L) was measured at Warm Springs (site 1M). By comparison, the U.S. Environmental Protection Agency (1986) freshwater aquatic criterion for copper in water having the hardness measured in this sample (230 mg/L) is 24 µg/L. Manganese concentrations of 350 and 95 µg/L measured in samples from the Clark Fork at Warm Springs (site 1M) and near Racetrack (site 5M), respectively, exceeded the SMCL of 50 µg/L. Concentrations of copper and manganese in the Clark Fork decreased downstream. Concentrations of arsenic, copper, and manganese in the Little Blackfoot River, Gold Creek, and Rock Creek (near Clinton) generally were less than concentrations in the Clark Fork. Concentrations of these trace elements in Flint Creek were roughly equal to mainstem concentrations, presumably as a result of mining activity in the Flint Creek drainage.

SUMMARY AND CONCLUSIONS

Ground water occurs at shallow depths in three geologic units in the Clark Fork valley between Warm Springs and Milltown. The principal aquifers consist of Quaternary alluvium and Tertiary deposits. Bedrock is used as a source of water where alluvium and Tertiary deposits are not present. Yields normally were largest in wells completed in alluvium (range of 3-580 gal/min, median of 40 gal/min) and smallest in wells completed in bedrock (range of 3-350 gal/min, median of 15 gal/min). Ground-water levels generally responded to seasonal events. In some areas, highest water levels coincided with spring runoff. In irrigated areas, water levels peaked in summer or fall; however, water levels tended to be at a minimum in mid-summer in wells completed in alluvium close to streams that were depleted by diversions. Data to describe aquifer characteristics are limited. However, well specific-capacity data and reported results of aquifer tests indicate that transmissivity values of all the aquifers are extremely variable. Values for alluvium (range of 40-38,000 ft^2/d, median of 970 ft^2/d) commonly were much larger than values for Tertiary deposits (range of 15-44,000 ft^2/d, median of 160 ft^2/d) and bedrock (range of 9-5,400 ft^2/d, median of 130 ft^2/d).

Calcium, magnesium, and bicarbonate were the dominant ions in many ground-water samples. Sulfate generally was a dominant anion only in areas affected by mine wastes or geothermal discharge. Substantial amounts of sodium were found in some samples from unconsolidated Tertiary deposits.

Nitrate was detected in some water samples from all aquifers in concentrations large enough to indicate probable local contamination from fertilizers, septic-tank effluent, and possibly animal wastes. The National Primary Drinking-Water Regulation for nitrate was exceeded in a water sample from one well completed in bedrock.

Trace elements present in the Clark Fork valley have resulted from natural deposition, mining and smelting activity, and transport of mine wastes in many parts of the area. Arsenic, cadmium, copper, iron, lead, manganese, and zinc are the elements generally associated with sulfide ores in the area and that have affected water resources, at least near mining and smelting areas. Of these, only arsenic and cadmium had elevated concentrations in ground water. Arsenic concentrations in Quaternary alluvium were largest (maximum measured value was 20 µg/L) within 300 ft of the river. The source of arsenic could be river water percolating through the alluvium or the oxidation of sulfide minerals, which occurs in mine wastes mixed into flood-plain deposits. The cadmium concentration was greater than the minimum reporting level in samples from one well completed in Quaternary alluvium, and exceeded the National Primary Drinking-Water Regulation in one sample (6 µg/L), from a well downgradient from the Warm Springs Ponds, which were built to treat contaminated water in Silver Bow Creek. Trace-element concentrations in water from Tertiary deposits and bedrock were mostly within the same ranges as in water from alluvium, and no elevated concentrations attributable to mine wastes were detected.

Streamflow data collected over a 4-day period in 1986 indicate that most flow in the Clark Fork was derived from tributaries. Potentiometric contours on the water level in Quaternary alluvium and Tertiary deposits indicate that ground water flows toward the mainstem, particularly in the valley south of Garrison. Ground-water inflow to the river, probably augmented by irrigation-return flow, was substantial (88 ft^3/s) between Racetrack and Garrison. Discharge from bedrock also augments flow in the Clark Fork between Jens and Cramer Creek. Loading computations using chemistry data for streamflow samples indicate that the dissolved-solids concentration and major-ion composition of water discharging to the river from bedrock were similar to those found in Nimrod Springs, Bearmouth Warm Springs, and in samples from a few wells completed in Quaternary alluvium where recharge is assumed to be from bedrock. Streamflow and specific-conductance data indicate that the small quantity of ground water discharging to the Clark Fork between Warm Springs and Racetrack comes from a source having a large dissolved-solids concentration.

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SUPPLEMENTAL DATA

Table 1.--Ground-water data for the upper Clark Fork valley, Montana

[Principal aquifer: Qal, Quaternary alluvium; Td, Tertiary deposits; Czu, undivided Quaternary alluvium and Tertiary deposits; TpЄu , undivided Tertiary to Precambrian bedrock. Water-level measurement: DW, dry well; FW, flowing well. Water-level source: A, other government agency; D, driller; O, owner; R, reported by owner; S, U.S. Geological Survey. Abbreviations: gal/min, gallons per minute; (gal/min)/ft, gallons per minute per foot. Symbol: --, no data]

				Water level					
Well or spring number	Principal aquifer	Altitude of land surface (feet above sea level)	Depth of well (feet below land surface)	Date of measurement	Feet below or above (+) land surface	Source	Altitude (feet above sea level)	Discharge[1] (gal/min)	Specific capacity[1] [(gal/min)/ft]
13N18W22CDCC01	Qal	3,290	70	04-30-87	31.36	S	3,259	--	--
13N18W22CDCC02	Qal	3,290	42	04-30-87	34.57	S	3,255	--	--
13N18W22CDCC03	Qal	3,290	60	--	45	O	3,245	--	--
13N18W22CDCD01	Qal	3,290	--	04-23-87	38.77	S	3,251	--	--
13N18W22CDCD02	Qal	3,290	--	05-06-87	34.02	S	3,256	--	--
13N18W27BAAB01	Qal	3,290	--	04-23-87	33.18	S	3,257	--	--
13N18W27BAAB02	Qal	3,290	56	04-28-87	42.06	S	3,248	--	--
13N18W27BAAB03	Qal	3,300	60	--	--	--	--	--	--
13N18W27BAAC01	Qal	3,290	56	06- -62	32	R	3,258	--	--
13N18W27BAAC02	Qal	3,290	67	06-04-59	31	D	3,259	35	18
13N18W27BAAC03	Qal	3,290	70	08-05-64	34	D	3,256	15	5.0
13N18W27BAAC04	Qal	3,300	68	04-28-87	37.96	S	3,262	--	--
13N18W27BAAC05	Qal	3,310	136	--	--	--	--	--	--
13N18W27BAAC06	Qal	3,290	--	--	--	--	--	--	--
13N18W27BAAD01	Qal	3,310	60	--	--	--	--	--	--
13N18W27BABA01	Qal	3,290	55.5	04-23-87	33.28	S	3,257	20	--
13N18W27BABA02	Qal	3,300	--	--	--	--	--	--	--
13N18W27BABB01	Qal	3,290	65	10-12-66	31.5	D	3,259	100	8.7
13N18W27BABB02	Qal	3,290	60	--	--	--	--	--	--
13N18W27BABB03	Qal	3,290	74	04-22-87	32.60	S	3,257	100	--
13N18W27BABB04	Qal	3,290	51	04-20-27	26	R	3,264	20	--
13N18W27BABD01	Qal	3,290	62	08-30-50	30.9	D	3,259	--	--
13N18W27BADA01	Qal	3,290	68	04-29-87	33.05	S	3,257	--	--
13N18W27BADB01	Qal	3,290	81	04-29-87	32.20	S	3,258	--	--
13N18W27BADB02	Qal	3,290	--	--	--	--	--	--	--
13N18W27BADB03	Qal	3,390	55.5	04-02-64	32	D	3,358	20	--
13N18W27BADB04	Qal	3,290	68	04-30-87	30.70	S	3,259	--	--
13N18W27BDBD01	Qal	3,280	61.5	05-07-87	14.55	S	3,265	100	25
13N18W27BDCA01	Qal	3,280	53	05-07-87	15.62	S	3,264	100	22
13N18W27BDCD01	Qal	3,280	50.8	08-14-62	15	D	3,265	25	5.0
13N18W27BDDC01	Qal	3,280	--	--	--	--	--	--	--
13N18W27CAAB01	Qal	3,280	57	09-19-62	19	D	3,261	50	--
13N18W27DBCA01	Qal	3,280	--	05-07-87	13.60	S	3,266	--	--
13N18W27DCAA01	Qal	3,285	77	07-03-59	30	D	3,255	15	.75
13N18W27DCAB01	Qal	3,280	51	03-09-70	17.5	D	3,263	75	15
13N18W27DDBC01	Qal	3,285	58	05-07-87	17.41	S	3,268	--	--
13N18W27DDCA01	Qal	3,285	60	03-12-87	15	D	3,270	50	5.0
13N18W27DDCA02	Qal	3,285	40	05-07-87	18.59	S	3,266	--	--
13N18W27DDCB01	Qal	3,285	--	--	--	--	--	--	--
13N18W27DDCD01	Qal	3,280	32	- -85	15	O	3,265	--	--
13N18W27DDCD02	Qal	3,280	27	05-12-87	15.57	S	3,264	--	--
13N18W34AAAB01	Qal	3,280	50	07-28-78	9	D	3,271	80	--
13N18W34AAAB02	Qal	3,280	--	--	--	--	--	--	--
13N18W34AABA01	Qal	3,270	27	05-12-87	6.32	S	3,264	--	--
13N18W34AABC01	Qal	3,260	40	05-12-87	6.40	S	3,254	30	2.1
13N18W34AABC02	Qal	3,260	--	05-12-87	5.73	S	3,254	--	--
13N18W34AADA01	Qal	3,270	58	09-15-76	17	D	3,253	75	4.2
13N18W35BBCB01	Qal	3,280	--	05-13-87	7.88	S	3,272	--	--
13N18W35BDCA01	Qal	3,300	82	05-07-87	25.12	S	3,275	--	--
13N18W35CAAA01	Qal	3,300	40	08-03-60	30	D	3,270	20	--

Table 1.--Ground-water data for the upper Clark Fork valley, Montana--Continued

Well or spring number	Principal aquifer	Altitude of land surface (feet above sea level)	Depth of well (feet below land surface)	Water level: Date of measurement	Water level: Feet below or above (+) land surface	Water level: Source	Water level: Altitude (feet above sea level)	Discharge[1] (gal/min)	Specific capacity[1] [(gal/min)/ft]
13N18W35CCDC01	Qal	3,325	--	06-09-87	10.38	S	3,315	--	--
13N18W35DDDD01	Qal	3,310	39	05-15-87	11.06	S	3,299	--	--
13N18W35DDDD02	Qal	3,310	37	05-15-87	9.68	S	3,300	--	--
12N18W01CCBD01	Qal	3,315	--	06-10-87	6.37	S	3,309	--	--
12N18W01CCCD01	Qal	3,320	--	--	--	--	--	--	--
12N18W01CCDB01	Qal	3,320	27	06-10-87	9.26	S	3,311	--	--
12N18W01CCDC01	Qal	3,320	--	--	--	--	--	--	--
12N18W01CDCD01	Qal	3,340	50	03-04-70	9	D	3,331	100	--
12N18W02CBBC01	Qal	3,320	--	--	--	--	--	--	--
12N18W02CBDA01	Qal	3,315	--	--	--	--	--	--	--
12N18W02DABA01	Qal	3,320	53	05-15-87	11.56	S	3,308	50	10
12N18W02DCAC01	Qal	3,320	--	--	--	--	--	--	--
12N18W02DCBB01	Qal	3,320	60	06-09-87	24.82	S	3,295	--	--
12N18W11AADA01	Qal	3,320	--	--	--	--	--	--	--
12N18W11AADA02	Qal	3,310	--	--	--	--	--	--	--
12N18W12ACBA01	Qal	3,330	--	05-28-87	7.03	S	3,323	--	--
12N18W12ACBB01	Qal	3,350	59	05-28-87	20.60	S	3,329	50	1.5
12N18W12ACBC01	Qal	3,350	--	05-28-87	21.12	S	3,329	--	--
12N18W12ACCB01	Qal	3,350	--	--	--	--	--	--	--
12N18W12ACCC01	Qal	3,350	--	--	--	--	--	--	--
12N18W12ACCC02	Qal	3,360	43.5	04-20-67	21	D	3,339	40	2.1
12N18W12ACDC01	Qal	3,350	--	--	--	--	--	--	--
12N18W12BAAB01[2]	Qal	3,330	8	06-26-86	3.11	S	3,327	--	--
12N18W12BAAB02[2]	Qal	3,330	19.2	08-14-86	5.35	S	3,325	--	--
12N18W12BAAC01	Qal	3,330	58	05-20-87	5.95	S	3,324	--	--
12N18W12BABB01	Qal	3,320	49	05-20-87	7.33	S	3,313	--	--
12N18W12BABD01	Qal	3,320	49	05-20-87	7.76	S	3,312	--	--
12N18W12BADA01	Qal	3,340	17	05-20-87	13.00	S	3,327	--	--
12N18W12BADA02	Qal	3,340	--	--	--	--	--	--	--
12N18W12BADA03	Qal	3,335	30	08-26-65	7.5	D	3,328	--	--
12N18W12BADD01	Qal	3,345	61	05-20-87	13.45	S	3,332	100	7.3
12N18W12BCAA01	Qal	3,340	--	--	--	--	--	--	--
12N18W12BCBA01	Qal	3,355	--	--	--	--	--	--	--
12N18W12BCBD01	Qal	3,360	--	06-09-87	15.51	S	3,344	--	--
12N18W12BCDA01	Qal	3,355	50	06-09-87	19.10	S	3,336	--	--
12N18W12BCDA02	Qal	3,350	50	06-10-87	20.11	S	3,330	--	--
12N18W12BCDB01	Qal	3,365	--	--	--	--	--	--	--
12N18W12BDBB01	Qal	3,340	53	05-28-87	20.28	S	3,320	100	17
12N18W12BDDA01	Qal	3,350	38	09-26-62	22	D	3,328	21	2.6
12N18W12BDDD01	Qal	3,355	50	05-30-79	18	D	3,337	50	4.2
12N18W12DAAB01	Qal	3,355	--	06-04-87	7.36	S	3,348	40	5.0
12N18W12DAAC01	Qal	3,355	--	--	--	--	--	--	--
12N18W12DABA01	Qal	3,355	--	06-04-87	7.63	S	3,347	--	--
12N18W12DABB01	Qal	3,362	44	06-03-87	19.69	S	3,342	100	20
12N18W12DACC01	Qal	3,360	49.5	09-21-77	24	D	3,336	75	12
12N18W12DADA01	Qal	3,355	--	--	--	--	--	--	--
12N18W12DADB01	Qal	3,355	42	07-16-71	15	D	3,340	100	10
12N18W12DADD01	Qal	3,355	35	--	--	--	--	--	--
12N18W12DADD02	Qal	3,362	43	03-05-71	12	D	3,350	75	7.5
12N18W12DBAA01	Qal	3,363	--	06-03-87	19.32	S	3,344	--	--
12N18W12DBBA01	Qal	3,362	--	--	--	--	--	--	--
12N18W12DBBA02	Qal	3,363	37	06-03-87	20.96	S	3,342	20	1.8
12N18W12DBBB01	Qal	3,360	43.5	05-29-87	20.78	S	3,339	40	1.9
12N18W12DBDB01	Qal	3,360	50	06-09-87	21.85	S	3,338	--	--
12N18W12DDAB01	Qal	3,365	42	06-04-87	12.74	S	3,352	40	20

Table 1.--Ground-water data for the upper Clark Fork valley, Montana--Continued

Well or spring number	Principal aquifer	Altitude of land surface (feet above sea level)	Depth of well (feet below land surface)	Water level: Date of measurement	Water level: Feet below or above (+) land surface	Water level: Source	Water level: Altitude (feet above sea level)	Discharge[1] (gal/min)	Specific capacity[1] [(gal/min)/ft]
12N18W12DDBA01	Qal	3,365	47	09-16-73	16	D	3,349	90	18
12N18W12DDBA02	Qal	3,360	50	06-04-87	12.99	S	3,347	50	4.2
12N18W12DDDD01	Qal	3,370	25	05-28-87	12.29	S	3,358	--	--
12N18W12DDDB01	Qal	3,370	25	--	--	--	--	--	--
12N17W07CCAA01	Qal	3,370	28	05-28-87	10.41	S	3,360	--	--
12N17W07CCAD01	Qal	3,370	46	--	--	--	--	--	--
12N17W07CDCD01	Qal	3,365	--	05-29-87	9.25	S	3,356	--	--
12N17W07DCCB01	Qal	3,360	--	05-29-87	7.66	S	3,352	--	--
12N17W07DDAC01	Qal	3,375	62	05-29-87	8.53	S	3,366	--	--
12N17W07DDDB01	Qal	3,375	63	05-29-87	10.10	S	3,365	--	--
12N17W16CBCB01	Qal	3,430	65	06-05-87	41.2	S	3,389	--	--
12N17W16CBDC01	Qal	3,430	37	--	17	O	3,413	--	--
12N17W16CCDD01	Qal	3,430	56	06-03-87	33.9	S	3,396	12	1.7
12N17W16CDDD01	Qal	3,440	53	06-03-87	34.6	S	3,405	30	10
12N17W17BBCC01	Qal	3,380	34	--	--	--	--	--	--
12N17W17BCCC01	Qal	3,390	44	05-27-87	2.72	S	3,387	--	--
12N17W17BDAC01	Qal	3,420	--	--	--	--	--	--	--
12N17W17CAAC01	Qal	3,400	--	06-17-87	19.39	S	3,381	--	--
12N17W17DAAC01	Qal	3,440	61	06-02-87	30.62	S	3,409	30	6.0
12N17W17DAAC02	Qal	3,440	65	06-02-87	30.93	S	3,409	--	--
12N17W17DADA01	Qal	3,440	88	--	--	--	--	--	--
12N17W17DADA02	Qal	3,440	60	06-02-87	37.21	S	3,403	--	--
12N17W17DADA03	Qal	3,440	60	--	--	--	--	--	--
12N17W17DADB01	Qal	3,440	65	06-11-87	33.79	S	3,406	30	6.0
12N17W17DBAB01	Qal	3,420	--	06-02-87	35.12	S	3,385	--	--
12N17W17DDCB01	Qal	3,440	--	--	--	--	--	--	--
12N17W18AADD01	Qal	3,380	51	05-27-87	17.06	S	3,363	28	3.5
12N17W18ABAD01	Qal	3,370	40	05-29-87	6.94	S	3,363	--	--
12N17W18ADAA01	Qal	3,370	--	--	--	--	--	--	--
12N17W18ADCA01	Qal	3,380	30	05-27-87	6.83	S	3,373	--	--
12N17W18ADDB01	Qal	3,380	50	05-27-87	8.91	S	3,371	40	3.6
12N17W18ADDD01	Qal	3,385	55	--	--	--	--	--	--
12N17W20AAAC01	Qal	3,400	60	06-03-87	15.4	S	3,385	--	--
12N17W21AACB01	Qal	3,430	60	08-30-77	30	D	3,400	35	7.0
12N17W21ABBB01	Qal	3,440	--	06-03-87	28.7	S	3,411	--	--
12N17W22ACDB01	Qal	3,450	60	06-05-87	20.7	S	3,429	--	--
12N17W22ADDC01	Qal	3,460	--	06-05-87	20.6	S	3,439	--	--
12N17W22BBCC01	Qal	3,440	52	06-03-87	21.5	S	3,419	20	10
12N17W22BBDA01	Qal	3,430	--	06-05-87	18.3	S	3,412	--	--
12N17W22BCAD01	Qal	3,440	51	06-03-87	21.1	S	3,419	25	8.3
12N17W22BDCA01	Qal	3,440	58	02-14-77	8	D	3,432	35	35
12N17W22CADD01	Qal	3,420	34.5	06-03-87	5.4	S	3,415	100	4.2
12N17W22DAAB01	Qal	3,460	70	--	--	--	--	--	--
12N17W22DAAD01	Qal	3,460	38	--	--	S	--	--	--
12N17W22DACA01	Qal	3,460	--	06-05-87	24.6	S	3,435	--	--
12N17W22DBCB01	Qal	3,440	40	07- -68	15	D	3,425	50	4.6
12N17W22DBCC01	Qal	3,440	40	07-12-67	15	D	3,425	50	4.6
12N17W23CCDB01	Qal	3,490	100	06-05-87	55.00	S	3,435	--	--
12N17W27AABB01	Qal	3,460	55	06-04-87	22.2	S	3,438	60	2.6
12N17W27AABC01	Qal	3,460	--	--	--	--	--	--	--
12N17W27AABC02	Qal	3,460	40	--	--	--	--	--	--
12N17W27AABD01	Qal	3,460	--	--	--	--	--	--	--
12N17W27AACA01	Qal	3,460	40	--	--	--	--	--	--
12N17W27AACA02	Qal	3,460	--	--	--	--	--	--	--
12N17W27AACB01	Qal	3,460	62	09-11-73	25	D	3,435	15	7.5

Table 1.--Ground-water data for the upper Clark Fork valley, Montana--Continued

Well or spring number	Principal aquifer	Altitude of land surface (feet above sea level)	Depth of well (feet below land surface)	Water level: Date of measurement	Water level: Feet below or above (+) land surface	Water level: Source	Water level: Altitude (feet above sea level)	Discharge[1] (gal/min)	Specific capacity[1] [(gal/min)/ft]
12N17W27AACD01	Qal	3,460	--	--	--	--	--	--	--
12N17W27ABAC01	Qal	3,440	62	06-04-87	7.9	S	3,432	9	4.5
12N17W27ADBA01	Qal	3,460	--	--	--	--	--	--	--
12N17W27ADCA01	Qal	3,465	--	06-09-87	29.10	S	3,436	--	--
12N17W27ADCD01	Qal	3,465	--	--	--	--	--	--	--
12N17W27ADDC01	Qal	3,465	--	06-10-87	28.70	S	3,436	--	--
12N17W27DAAB01	Qal	3,470	--	--	--	--	--	--	--
12N17W27DABA01	Qal	3,470	--	--	--	--	--	--	--
12N17W27DABA02	Qal	3,470	--	--	--	--	--	--	--
12N17W27DACA01	Qal	3,470	--	--	--	--	--	--	--
12N17W27DACA02	Qal	3,470	--	06-09-87	4.44	S	3,466	--	--
12N17W27DACD01	Qal	3,465	--	--	--	--	--	--	--
12N17W27DADB01	Qal	3,470	56	07-29-66	26	D	3,444	50	25
12N17W27DADC01	Qal	3,465	--	--	--	--	--	--	--
12N17W27DADD01	Qal	3,465	--	--	--	--	--	--	--
12N17W27DDAB01	Qal	3,465	--	--	--	--	--	--	--
12N17W27DDAB02	Qal	3,460	--	06-10-87	6.98	S	3,453	--	--
12N17W27DDAC01	Qal	3,460	--	06-10-87	4.88	S	3,455	--	--
12N17W27DDAC02	Qal	3,460	--	--	--	--	--	--	--
12N17W27DDAD01	Qal	3,460	--	--	--	--	--	--	--
12N17W27DDDA01	Qal	3,465	--	--	--	--	--	--	--
12N17W27DDDA02	Qal	3,465	40	06-11-87	15.12	S	3,450	--	--
12N17W27DDDA03	Qal	3,460	--	06-12-87	5.25	S	3,455	--	--
12N17W27DDDD01	Qal	3,460	60	06-11-87	15	O	3,445	--	--
12N17W34AAAD01	Qal	3,465	40	06-11-87	14	O	3,451	--	--
12N17W34AADC01	Qal	3,465	--	--	--	--	--	--	--
12N17W34CACD01	Qal	3,515	65.7	06-16-87	51.3	S	3,464	--	--
12N17W34DBCD01	Qal	3,455	--	--	--	--	--	--	--
12N17W34DBDD01	Qal	3,455	--	06-12-87	7.20	S	3,448	--	--
12N17W34DCAA01	Qal	3,470	--	06-16-87	8.4	S	3,462	--	--
12N17W34DCAD01	Qal	3,470	41.2	06-16-87	10.3	S	3,460	--	--
12N17W34DDAC01	Qal	3,470	--	06-15-87	11.1	S	3,459	--	--
12N17W34DDBA01	Qal	3,470	55	06-15-87	9.9	S	3,460	--	--
12N17W34DDBD01	Qal	3,470	--	06-16-87	10.5	S	3,460	--	--
12N17W34DDCB01	Qal	3,470	--	06-16-87	11.3	S	3,459	--	--
12N17W35BCCC01	Qal	3,460	--	06-11-87	9.78	S	3,450	--	--
12N17W35CBBB01	Qal	3,460	--	--	--	--	--	--	--
12N17W35CBBB02	Qal	3,460	27	06-11-87	11.07	S	3,449	--	--
12N17W35CBBC01	Qal	3,460	--	--	--	--	--	--	--
12N17W35CBCB01	Qal	3,460	--	06-12-87	8.93	S	3,451	--	--
12N17W35CBCC01	Qal	3,460	60	06-12-87	8.96	S	3,451	--	--
11N17W02ABB 01	Qal	3,510	60	--	--	--	--	--	--
11N17W02ABCB01	Qal	3,510	50	06-03-87	7.13	S	3,503	--	--
11N17W02ACBA01	Qal	3,510	--	06-12-87	8.4	S	3,502	--	--
11N17W02ACBD01	Qal	3,510	--	06-12-87	8.93	S	3,501	--	--
11N17W02ACDC01	Qal	3,510	--	--	--	--	--	--	--
11N17W02CADA01	Qal	3,505	--	06-03-87	6.59	S	3,498	--	--
11N17W12ADDD01	Qal	3,545	80	06-03-87	10.69	S	3,534	--	--
11N17W12ADDD02	Qal	3,545	--	--	--	--	--	--	--
11N16W06CCDD01	Qal	3,560	54	--	--	--	--	--	--
11N16W06CCDD02	Qal	3,560	--	06-04-87	6.94	S	3,553	--	--
11N16W06CDCD01	Qal	3,560	--	--	--	--	--	--	--
11N16W06CDCD02	Qal	3,560	--	--	--	--	--	--	--
11N16W07AAAA01	Qal	3,550	29	07-23-62	8	D	3,542	200	40
11N16W07AAAA02	Qal	3,550	--	06-19-87	8.45	S	3,542	--	--

Well or spring number	Principal aquifer	Altitude of land surface (feet above sea level)	Depth of well (feet below land surface)	Water level: Date of measurement	Water level: Feet below or above (+) land surface	Water level: Source	Water level: Altitude (feet above sea level)	Discharge[1] (gal/min)	Specific capacity[1] [(gal/min)/ft]
11N16W08ABBA01	Qal	3,565	40	--	--	--	--	--	--
11N16W08ABBA02	Qal	3,565	60	06-04-87	20	O	3,545	--	--
11N16W08ADAB01	Qal	3,580	40	06-04-87	19.53	S	3,560	--	--
11N16W08BAD 01	Qal	3,559	51.5	10-09-86	12.06	S	3,547	87	--
11N16W08BDA 01	Qal	3,556	42	10-10-86	11.97	S	3,544	87	--
11N16W09DABB01	Qal	3,570	--	--	--	--	--	--	--
11N16W10CBBB01	Qal	3,570	18	06-04-87	4.18	S	3,566	--	--
11N16W11AADC01	Qal	3,670	84	--	--	--	--	--	--
11N16W11AADC02	Qal	3,660	48	11-04-75	20	D	3,640	40	5.7
11N16W11ACAC01	Qal	3,650	--	--	--	--	--	--	--
11N16W11CAAA01[2]	Qal	3,610	23.7	06-26-86	3.44	S	3,607	--	--
11N16W11CACC01	Qal	3,620	22	--	--	S	--	--	--
11N16W11CDBA01	Qal	3,610	--	--	--	--	--	--	--
11N16W15AAAB01	Qal	3,580	--	--	--	--	--	--	--
11N16W15AACD01	Qal	3,590	--	06-05-87	6.22	S	3,584	--	--
11N16W15AADB01	Qal	3,580	--	06-05-87	3.42	S	3,577	--	--
11N15W07DBCA01	Qal	3,680	30	--	--	S	--	--	--
11N15W07DCDA01	Qal	3,670	60	06-10-87	8.41	S	3,662	--	--
11N15W14CBDD01[3]	Tp€u	3,790	--	--	--	S	--	--	--
11N15W24ADAA01	Qal	3,780	62	--	--	--	--	--	--
11N15W24ADDB01	Qal	3,740	--	05-22-87	4.36	S	3,736	--	--
11N15W24ADDB02	Qal	3,740	8.4	05-22-87	5.58	S	3,734	--	--
11N14W11DCAC01[2]	Qal	3,790	25.3	06-26-86	7.25	S	3,783	--	--
11N14W11DCCD01[3]	Tp€u	3,820	--	--	--	S	--	--	--
11N14W14BBCC01	Qal	3,850	--	--	--	--	--	--	--
11N14W14BBCD01	Qal	3,850	--	--	--	--	--	--	--
11N14W14CBDB01	Qal	3,800	--	06-11-87	13.06	S	3,787	--	--
11N14W15DDA 01	Qal	3,780	47	10-10-86	7.20	S	3,773	50	7.1
11N14W15DDB 01	Qal	3,780	53	10-09-86	8.46	S	3,772	50	25
11N14W16CCCD01	Qal	3,780	--	06-11-87	9.06	S	3,771	--	--
11N14W16CCDC01	Qal	3,775	20	06-11-87	+.3	S	3,775	--	--
11N14W16CDCB01	Qal	3,780	--	--	--	--	--	--	--
11N14W17CDCB01	Qal	3,720	42	--	--	--	--	--	--
11N14W17CDDB01	Qal	3,770	47	06-11-87	6.08	S	3,764	350	175
11N14W17CDDD01	Qal	3,760	43	06-12-87	3.75	S	3,756	350	175
11N14W18DDCC01	Tp€u	3,795	105	12-16-77	16	D	3,779	350	29
11N14W18DDDD01	Qal	3,750	18	06-11-87	6.25	S	3,744	--	--
11N13W07CBCD01	Qal	3,835	15	--	--	--	--	--	--
11N13W07DDCD01	Qal	3,850	37	--	--	--	--	--	--
11N13W07DDCD02	Qal	3,850	--	06-17-87	20.79	S	3,829	--	--
11N13W07DDDA01	Qal	3,835	18	--	--	--	--	--	--
11N13W07DDDB01	Qal	3,850	35	06-17-87	7.72	S	3,842	--	--
11N13W08CC 01	Qal	3,840	30	06-17-87	6.70	S	3,833	--	--
11N13W08CDCB01	--	3,850	--	06-16-87	15.05	S	3,835	--	--
11N13W08CDCD01	Qal	3,850	--	06-16-87	16.79	S	3,833	--	--
11N13W16ABCC01	Tp€u	3,880	140	06-16-87	62.58	S	3,817	--	--
11N13W17ADA 01	Qal	3,870	20	06-16-87	13.76	S	3,856	--	--
11N13W17BABA01	Qal	3,850	--	06-17-87	21.74	S	3,828	--	--
11N13W17BABB01	Qal	3,840	22	06-16-87	6.83	S	3,833	--	--
11N13W17BDAA01	Qal	3,840	60	--	--	--	--	--	--
11N13W22AAAC01	Qal	3,910	87	--	--	--	--	--	--
11N13W23CDBA01	Qal	3,900	25	06-19-87	11.84	S	3,888	--	--
11N13W23CDDA01	Qal	3,900	29	06-16-87	6.04	S	3,894	--	--
11N13W26AACC01	--	3,960	190	06-16-87	42.88	S	3,917	20	.16
11N13W36DDBA01	Td	3,970	80	--	--	--	--	--	--

Table 1.--Ground-water data for the upper Clark Fork valley, Montana--Continued

Well or spring number	Principal aquifer	Altitude of land surface (feet above sea level)	Depth of well (feet below land surface)	Water level: Date of measurement	Water level: Feet below or above (+) land surface	Water level: Source	Water level: Altitude (feet above sea level)	Discharge[1] (gal/min)	Specific capacity[1] [(gal/min)/ft]
11N13W36DDBA02	Td	3,980	120	06-15-87	45.50	S	3,935	--	--
11N12W29BDAA01	TpЄu	4,260	160	10-04-85	12.85	S	4,247	--	--
11N12W29BDAB01[3]	TpЄu	4,280	--	--	--	--	--	--	--
11N12W29CCCC01	TpЄu	4,050	55	10-02-85	47.45	D	4,003	15	5.0
11N12W30CDDD01	--	3,980	--	--	--	--	--	--	--
11N12W31AAAA01	--	4,000	--	--	--	--	--	--	--
11N12W31AAAD01	--	4,000	--	--	--	--	--	--	--
11N12W31AACA01	TpЄu	3,960	155	10-23-69	25	D	3,935	--	--
11N12W31AACB01	Qal	3,960	55	10-02-85	37.73	S	3,922	40	2.7
11N12W31AACB02	Qal	3,960	--	06-09-87	31.6	S	3,928	--	--
11N12W31AACC01	--	3,950	--	--	--	--	--	--	--
11N12W31AACC02	--	3,955	--	06-09-87	24.6	S	3,930	--	--
11N12W31AACD01	Qal	3,965	39.1	06-09-87	35.4	S	3,930	--	--
11N12W31AACD02	--	3,965	57	06-09-87	33.8	S	3,931	--	--
11N12W31AACD03	--	3,980	--	06-10-87	30.0	S	3,950	--	--
11N12W31AACD04	--	3,965	--	--	--	--	--	--	--
11N12W31AACD05	TpЄu	3,960	80	10-02-85	28.71	S	3,931	--	--
11N12W31AADD01	--	3,955	80	--	--	--	--	--	--
11N12W31ABAC01	Qal	3,955	--	06-09-87	7.9	S	3,947	--	--
11N12W31ABAD01	--	3,960	50	06-09-87	17.3	S	3,943	20	1.0
11N12W31ABCD01	--	3,965	113	06-08-87	7.7	S	3,957	--	--
11N12W31ABDA01	Qal	3,950	23.3	06-10-87	19.9	S	3,930	--	--
11N12W31ABDA02	Qal	3,950	45.2	06-11-87	23.4	S	3,927	--	--
11N12W31ABDA03	--	3,955	--	--	--	--	--	--	--
11N12W31ADAA01	--	3,955	--	--	--	--	--	--	--
11N12W31ADAA02	Qal	3,955	50	06-11-87	30.9	S	3,924	35	18
11N12W31ADAB01	--	3,950	--	06-10-87	21.4	S	3,929	--	--
11N12W31ADAB02	Qal	3,990	50	--	--	--	--	--	--
11N12W31ADAD01	Qal	3,955	39.6	06-11-87	17.4	S	3,938	--	--
11N12W31ADAD02	Qal	3,960	32.3	06-11-87	19.1	S	3,941	--	--
11N12W31ADAD03	Qal	3,960	40.9	06-12-87	21.4	S	3,939	--	--
11N12W31ADBA01	--	3,960	83.8	06-09-87	22.1	S	3,938	--	--
11N12W31ADBB01	Qal	3,960	20.2	06-09-87	17.3	S	3,943	--	--
11N12W31ADBD01	--	3,955	--	06-12-87	11.0	S	3,944	--	--
11N12W31ADBD02	Qal	3,955	--	06-09-87	6.4	S	3,949	--	--
11N12W31ADDA01	--	3,955	--	06-08-87	15.2	S	3,940	--	--
11N12W31CCAC01	--	3,955	--	--	--	S	--	--	--
11N12W31CCAD01	Qal	3,965	35.1	06-10-87	16	S	3,949	--	--
11N12W31CCDA01	Qal	3,960	40	--	--	--	--	--	--
11N12W31CDAB01	--	4,000	--	--	--	--	--	--	--
11N12W31CDAD01	--	3,950	--	06-10-87	22.6	S	3,927	--	--
11N12W31CDBA01	Td	4,000	100	06-10-87	65.9	S	3,934	35	1.7
11N12W31CDBC01	Td	4,020	170	06-10-87	52.6	S	3,967	10	.67
11N12W31CDBC02	Td	4,020	76.7	06-10-87	56.2	S	3,964	--	--
11N12W31CDBC03	Td	4,010	105	06-12-87	71.5	S	3,939	15	1.7
11N12W31CDCB01	Td	4,000	63.2	06-10-87	35.6	S	3,964	--	--
11N12W31CDDA01	Qal	3,955	37.5	06-09-87	10.8	S	3,944	--	--
11N12W31DABA01	Qal	3,950	35.3	06-10-87	9.3	S	3,941	--	--
11N12W31DABA02	Qal	3,950	10	--	--	--	--	--	--
11N12W31DABC01	--	3,950	--	06-08-87	12.1	S	3,938	--	--
11N12W31DABC02	Qal	3,950	8	--	--	--	--	--	--
11N12W31DBDA01	Qal	3,950	12	--	--	--	--	--	--
11N12W31DCAD01	--	3,950	--	--	--	--	--	--	--
11N12W32BCBC01	--	3,960	--	06-11-87	14.0	S	3,946	--	--
11N12W32BCBC02	Qal	3,960	32	06-11-87	16.9	S	3,943	17	5.7

Well or spring number	Principal aquifer	Altitude of land surface (feet above sea level)	Depth of well (feet below land surface)	Water level: Date of measurement	Water level: Feet below or above (+) land surface	Water level: Source	Water level: Altitude (feet above sea level)	Discharge[1] (gal/min)	Specific capacity[1] [(gal/min)/ft]
11N12W32BCCD01	--	3,955	--	06-11-87	14.0	S	3,941	--	--
11N12W32CBAA01	--	3,970	--	--	--	--	--	--	--
11N12W34BBCD01	Tp€u	4,120	10.5	10-02-85	7.77	S	4,112	--	--
10N13W12BDDA01	Td	4,120	137	09-25-85	47.72	S	4,072	15	.88
10N13W22AAAA01	Td	4,253	60	09-25-85	9.48	S	4,244	--	--
10N13W22BDDA01	Td	4,240	85	09-25-85	45.92	S	4,194	20	.83
10N13W25CCCC01	Qal	4,162	18	12-27-63	10	O	4,152	--	--
10N13W26ABAA01	Td	4,200	100	08-18-77	18	D	4,182	15	1.2
10N13W26DCCB01	Qal	4,200	20	09-25-85	4.77	S	4,195	9	4.5
10N13W29ABDD01	Td	4,360	50	09-26-85	10.81	S	4,349	--	--
10N13W29DDAA01	Czu	4,360	45	09-26-85	5.32	S	4,355	--	--
10N13W33CCBC01	Td	4,390	70	04-12-79	18	D	4,372	--	--
10N13W34BBBB01	Td	4,308	180	12-30-63	170	R	4,138	--	--
10N13W34DAAC01	Czu	4,235	50	09-26-85	5.4	S	4,230	--	--
10N13W36BABA01	Czu	4,164	34	10-01-85	12.63	S	4,151	--	--
10N12W04AAAB01	Tp€u	4,120	30	10-02-85	13.77	S	4,106	--	--
10N12W04CACD01	Czu	4,000	28	10-02-85	24.64	S	3,975	15	--
10N12W06BAAA01	Td	3,955	400	--	--	--	--	--	--
10N12W06BBAA01	Td	4,000	125	09-24-85	35.50	S	3,965	25	5.0
10N12W06CBBC01	Td	4,030	120	09-25-85	46.17	S	3,984	--	--
10N12W09CADA01	Qal	4,000	80	09-24-85	7.12	S	3,993	15	--
10N12W09CCCD01	Td	4,008	157	09-24-85	29.96	S	3,978	15	.21
10N12W14BADC01	Qal	4,040	62	12-04-69	25	D	4,015	20	4.0
10N12W17BABB01	Tp€u	4,090	227	10-04-85	107.66	S	3,982	70	10
10N12W17BBDB01	Czu	4,020	45	10-01-85	24.75	S	3,995	--	--
10N12W30BABD01	Td	4,120	36	09-24-85	16.52	S	4,103	30	1.7
10N12W31ACDA01	Td	4,210	120	10-01-85	FW	S	--	--	--
10N12W32BBDC01[3]	Czu	4,275	--	--	--	--	--	--	--
10N11W19ACAC01	Qal	4,110	15	04-29-87	DW	S	--	--	--
10N11W19BBBA01	--	4,085	--	--	--	--	--	--	--
10N11W20CACA01	Qal	4,134	70	04-29-87	11.27	S	4,123	--	--
10N11W20CADA01	--	4,134	225	04-29-87	13.59	S	4,120	--	--
10N11W20DAAD01	Qal	4,120	28	06-12-65	16	D	4,104	20	3.3
10N11W21CDBC01	--	4,120	--	--	--	--	--	--	--
10N11W22BCDD01	Tp€u	4,160	50	10-18-85	40.91	S	4,119	--	--
10N11W22BDCD01[3]	Tp€u	4,160	--	--	--	--	--	--	--
10N11W23CADC01	Td	4,210	60	--	--	--	--	--	--
10N11W25CBAC01[2]	Qal	4,180	6.9	06-26-86	2.4	S	4,178	--	--
10N11W25CCDD01	Td	4,190	--	10-16-85	13.25	S	4,177	--	--
10N11W35BBBC01	Td	4,195	60	10-17-85	16.03	S	4,179	25	1.1
10N11W36ACDD01	Td	4,280	--	10-16-85	14.48	S	4,266	--	--
10N11W36BABB01	Qal	4,185	17.4	04-29-87	8.60	S	4,176	--	--
10N11W36BBAA01	Qal	4,185	24	04-29-87	4.49	S	4,181	--	--
10N11W36BCAD01	Td	4,220	100	10-16-85	25.09	S	4,195	12	.15
10N10W19DCCC01	Tp€u	4,380	40	10-16-85	24.97	S	4,355	--	--
10N10W31ADCA01	--	4,240	--	--	--	--	--	--	--
10N10W31BABA01	Qal	4,200	28.1	10-09-86	6.52	S	4,193	42	14
10N10W31BABA02	Qal	4,200	63	10-09-86	6.61	S	4,193	37	4.9
09N13W03DAAD01	Qal	4,250	35	10-04-85	13.9	S	4,236	15	--
09N13W10DCCC01	Qal	4,365	23	09-26-85	5.55	S	4,359	50	3.8
09N13W22BCDA01	Qal	4,440	38	09-26-85	12.54	S	4,427	25	1.7
09N13W27BCDD01	Qal	4,524	25	12-19-63	15	R	4,509	20	--
09N13W28CBAA01	Qal	4,523	--	09-26-85	10.57	S	4,512	--	--
09N12W04BABB01	Tp€u	4,440	83	10-01-85	18.32	S	4,422	10	.19
09N11W01BCAC01	Td	4,365	81	10-17-85	37.12	S	4,328	22	1.3

Table 1.--Ground-water data for the upper Clark Fork valley, Montana--Continued

Well or spring number	Principal aquifer	Altitude of land surface (feet above sea level)	Depth of well (feet below land surface)	Water level: Date of measurement	Water level: Feet below or above (+) land surface	Water level: Source	Water level: Altitude (feet above sea level)	Discharge[1] (gal/min)	Specific capacity[1] [(gal/min)/ft]
09N11W01CABB01	Qal	4,330	--	10-17-85	10.41	S	4,320	--	--
09N11W11DCDA01	Qal	4,460	--	10-16-85	17.98	S	4,442	--	--
09N11W13BAAC01	Td	4,460	30.5	10-16-85	18.17	S	4,442	--	--
09N11W15DAAC01	Td	4,645	36	--	16	O	4,629	--	--
09N11W16ADCC01	Td	4,760	48	10-18-85	20	O	4,740	--	--
09N11W16DDCD01	TpЄu	4,765	45	--	12	R	4,753	--	--
09N11W21ACCC01	Qal	4,878	--	--	--	--	--	--	--
09N10W04BDBC01	TpЄu	4,330	93	07-17-85	30.29	S	4,300	--	--
09N10W04BDBC02	TpЄu	4,320	90	07-17-85	31.79	S	4,288	12	1.5
09N10W04CACC01	--	4,270	--	--	--	--	--	--	--
09N10W04CDBB01	Czu	4,270	88	04-27-87	8.29	S	4,262	--	--
09N10W04CDBB02	Qal	4,270	16.7	04-27-87	8.02	S	4,262	--	--
09N10W05CBA 01	Qal	4,220	42	10-10-86	4.11	S	4,216	42	6.0
09N10W05DDDA01	Qal	4,260	40	--	--	--	--	--	--
09N10W05DDDA02	Qal	4,260	40	--	--	--	--	--	--
09N10W08AADA01	Qal	4,260	29	06-14-73	3	D	4,257	350	50
09N10W08ABDB01	Qal	4,260	21	--	--	--	--	--	--
09N10W08ABDB02	Qal	4,260	26	04-28-87	5.16	S	4,255	--	--
09N10W08ABDB03	Qal	4,260	32	04-28-87	7.23	S	4,253	--	--
09N10W10CCAD01	TpЄu	4,305	40	06-18-73	10	D	4,295	15	3.0
09N10W10CDBD01	TpЄu	4,290	118	07-17-85	21.75	S	4,268	10	.10
09N10W10CDCC01	TpЄu	4,275	50	07-17-85	5.81	S	4,269	10	.30
09N10W14DDCD01	--	4,620	--	05-28-87	48.5	S	4,572	--	--
09N10W15AABB01	TpЄu	4,560	280	01-28-77	217	D	4,343	30	.48
09N10W15BABC01	--	4,275	--	--	--	--	--	--	--
09N10W15BABD01	Qal	4,275	25	04-27-87	4.14	S	4,271	--	--
09N10W15BACA01	Qal	4,275	27	--	--	--	--	--	--
09N10W15BBAB01	Qal	4,275	53.7	04-29-87	4.38	S	4,271	--	--
09N10W16AADB01	--	4,360	--	05-07-87	9.98	S	4,350	--	--
09N10W22ABAB01	TpЄu	4,360	120	--	--	--	--	--	--
09N10W22DAAD01	Qal	4,360	25	05-07-87	11.48	S	4,348	--	--
09N10W23AADD01	Czu	4,360	52	--	--	--	--	--	--
09N10W23ACBD01	TpЄu	4,335	100	10-11-85	7.28	S	4,328	50	2.5
09N10W23ACDD01	--	4,340	--	--	--	--	--	--	--
09N10W23ADCC01	--	4,340	--	05-07-87	12	O	4,328	--	--
09N10W23BDAD01	TpЄu	4,355	47	07-17-85	4.53	S	4,350	--	--
09N10W23CAAD01	--	4,330	--	05-07-82	10.26	S	4,320	--	--
09N10W23CCAA01	TpЄu	4,380	140	09-30-74	44	D	4,336	3	--
09N10W24ABCA01	Qal	4,320	40	05-06-87	17.53	S	4,302	--	--
09N10W24ABCD01	Qal	4,320	--	--	--	--	--	--	--
09N10W24BABC01	TpЄu	4,400	250	07-17-85	34.85	S	4,365	5	.50
09N10W24BBBD01	--	4,390	111	--	--	--	--	--	--
09N10W24BBCA01	TpЄu	4,370	85	07-31-85	30.11	S	4,340	20	.41
09N10W24BBCA02	Czu	4,360	90	05-07-87	33.94	S	4,326	--	--
09N10W24BBDA01	Qal	4,350	30	05-07-87	26.50	S	4,324	--	--
09N10W24BBDB01	--	4,390	--	--	--	--	--	--	--
09N10W24BBDC01	--	4,350	--	--	--	--	--	--	--
09N09W01AABA01	Qal	4,560	30.6	09-10-85	7.10	S	4,553	30	16
09N09W28CABD01	--	4,570	220	05-06-87	55.90	S	4,514	--	--
09N09W28CCDD01[2]	Qal	4,380	17.1	06-25-86	1.7	S	4,378	--	--
09N09W28DCBB01	Td	4,520	80	07-01-80	10	D	4,510	20	1.3
09N09W28DCDA01	Td	4,560	150	10-11-85	98.81	S	4,461	--	--
09N09W29AADD01	Td	4,500	145	--	--	--	--	--	--
09N09W32BACA01	Td	4,419	57	09-05-85	9.07	S	4,410	20	.48
09N09W33AABB01	--	4,560	90	05-06-87	62.23	S	4,498	--	--

Well or spring number	Principal aquifer	Altitude of land surface (feet above sea level)	Depth of well (feet below land surface)	Water level: Date of measurement	Water level: Feet below or above (+) land surface	Water level: Source	Water level: Altitude (feet above sea level)	Discharge[1] (gal/min)	Specific capacity[1] [(gal/min)/ft]
09N09W33AABC01	Td	4,440	80	09-05-85	19.36	S	4,421	--	--
09N09W33ABCB01	Td	4,410	64	--	--	--	--	--	--
09N09W33CDBC01	Td	4,460	127	09-05-85	29.14	D	4,431	20	.22
09N09W34CC 01	Qal	4,438	17	08-01-57	12	S	4,426	3	1.5
08N10W23DBAD01	Td	5,080	113	10-11-78	26.78	S	5,053	--	--
08N09W03BD 01	Qal	4,472	29	08-08-57	19	S	4,453	--	--
08N09W03BDAD01	Qal	4,470	35	05-05-87	23.16	S	4,447	--	--
08N09W04DD 01	Qal	4,427	10	08-01-57	4	S	4,423	--	--
08N09W04DDB 01	Qal	4,420	20.3	11-05-86	1.82	S	4,418	--	--
08N09W09ADDD01	Qal	4,450	60	--	--	--	--	--	--
08N09W09BAAA01	Qal	4,475	--	09-05-85	12.87	S	4,462	--	--
08N09W11CADA01	Td	4,630	300	08-29-85	19.12	S	4,611	--	--
08N09W14CD 01	Td	4,634	385	09-05-57	119	S	4,515	--	--
08N09W14DADA01	Td	4,600	74	08-07-85	29.35	S	4,571	15	.33
08N09W15AA 01	Qal	4,476	19	07-21-59	11	S	4,465	--	--
08N09W15AB 01	Qal	4,467	12	07-21-59	9	S	4,458	9	2.2
08N09W15ABDB01	--	4,480	--	--	--	--	--	--	28
08N09W15BA 01	Qal	--	24	--	--	--	--	55	--
08N09W15CB 01	Qal	4,459	10	08-20-57	1	S	4,458	--	--
08N09W15CD 01	Qal	4,473	--	08-26-57	0	S	4,473	--	--
08N09W15CDDA01	Td	4,480	82	05-06-87	27.88	S	4,452	10	.26
08N09W16AD 01	Qal	4,462	9	08-01-57	4	S	4,458	--	--
08N09W16DADC01	--	4,440	--	--	--	--	--	--	--
08N09W20CAAB01	Td	4,562	117	09-05-85	45	S	4,517	20	.32
08N09W21AC 01	Qal	4,480	14	08-01-57	10	S	4,470	--	--
08N09W21DA 01	Qal	--	14	--	--	--	--	25	25
08N09W21DA 02	Qal	--	12	--	--	--	--	52	17
08N09W21DACC01	Qal	4,500	38	05-28-87	13.3	S	4,487	--	--
08N09W21DDAB01	Td	4,505	77	05-05-87	21.36	S	4,484	--	--
08N09W25BD 01	Qal	--	11	08-01-57	10	S	--	--	--
08N09W25CA 01	Qal	4,706	14	09-05-57	6	S	4,700	--	--
08N09W25DCBB01	Qal	4,742	29	07-31-85	5.18	S	4,737	--	--
08N09W27AC 01	--	--	11	--	--	--	--	5	--
08N09W27ACBC01	Td	4,570	75	07-31-85	7.79	S	4,562	35	5.8
08N09W27BDDD01	Td	4,565	94	07-31-85	25.06	S	4,540	--	--
08N09W28AAAB01	--	4,520	--	05-05-87	37.60	S	4,482	--	--
08N09W28AADB01	--	4,530	--	05-05-87	41.14	S	4,489	--	--
08N09W28ABAC01	Td	4,500	72	05-05-87	23.06	S	4,477	--	--
08N09W28AC 01	Qal	4,510	24.8	09-03-57	20.87	S	4,489	--	--
08N09W28AC 02	Qal	4,512	19	08-07-57	17	S	4,495	--	--
08N09W28ACDA01	--	4,520	--	--	--	--	--	--	--
08N09W28DA 01	Qal	4,543	28	09-05-57	6	S	4,537	--	--
08N09W28DBDC01	Td	4,520	58	07-31-85	24.13	S	4,496	20	--
08N09W28DCAA01	Td	4,530	60	12-23-69	35	D	4,495	20	1.3
08N09W28DCCC01	--	4,540	--	05-08-87	25.16	S	4,515	--	--
08N09W32AADD01[2]	Qal	4,490	9.4	06-25-86	3.02	S	4,487	--	--
08N09W32AADD02[2]	Td	4,490	59.3	07-14-87	3.93	S	4,486	--	--
08N09W32DCDA01	Td	4,550	50	05-08-87	31.15	S	4,519	--	--
08N09W32DD 01	Qal	4,527	25	08-01-57	11	S	4,516	--	--
08N09W32DDBD01	Td	4,560	97	05-03-72	37	D	4,523	20	.87
08N09W33AABA01	Td	4,550	56	05-08-87	34.28	S	4,516	25	1.2
08N09W33B 01	Qal	4,504	6	08-01-57	2	S	4,502	--	--
08N09W33BAC 01	Qal	4,500	5.8	10-09-86	2.95	S	4,497	--	--
08N09W33CBCC01	Td	4,540	65	07-30-58	11	D	4,529	16	.47
08N09W33CCDD01	Td	4,540	163	08-14-31	6	A	4,534	--	--

Table 1.--Ground-water data for the upper Clark Fork valley, Montana--Continued

Well or spring number	Principal aquifer	Altitude of land surface (feet above sea level)	Depth of well (feet below land surface)	Water level: Date of measurement	Water level: Feet below or above (+) land surface	Water level: Source	Water level: Altitude (feet above sea level)	Discharge[1] (gal/min)	Specific capacity[1] [(gal/min)/ft]
08N09W34CD 01	Qal	4,587	7	08-01-59	4	S	4,583	--	--
07N10W02CADD01	Td	4,930	200	10-08-56	12	D	4,918	--	--
07N10W03ABBD01	Td	5,018	220	- -66	30	D	4,988	200	2.1
07N10W03DD 01	Czu	5,019	65	08-05-57	14	S	5,005	--	--
07N10W15DBCB01	Td	5,055	75	08-15-85	12.80	S	5,042	--	--
07N09W03CABB01	Td	4,610	150	08-16-85	67.94	S	4,542	--	--
07N09W04BABD01	Td	4,540	150	10-24-46	10	D	4,530	--	--
07N09W04DBAB01	Czu	4,550	85	05-14-87	9.30	S	4,541	--	--
07N09W04DBAC01	Qal	4,530	39	04-30-87	15.99	S	4,514	--	--
07N09W04DBAD01	Qal	4,540	40	04-03-75	23	D	4,517	--	--
07N09W04DBCA01	Qal	4,530	32	04-30-87	12.42	S	4,518	--	--
07N09W04DBCA02	Qal	4,540	35	05-28-87	11.6	S	4,528	--	--
07N09W04DBCC01	Qal	4,510	50	04-30-87	6.55	S	4,503	45	1.5
07N09W04DBDA01	Qal	4,540	--	--	--	--	--	--	--
07N09W04DBDB01	--	4,530	--	--	--	--	--	--	--
07N09W04DBDD01	--	4,540	--	05-14-87	8.36	S	4,532	--	--
07N09W04DCAA01	Qal	4,520	67	04-30-87	5.78	S	4,514	--	--
07N09W04DCAD01	Qal	4,520	40	--	--	--	--	--	--
07N09W04DDCA01	Czu	4,535	115	04-29-87	22.83	S	4,512	--	--
07N09W04DDCD01	--	4,540	--	04-29-87	11.26	S	4,529	--	--
07N09W04DDCD02	--	4,550	--	04-29-87	19.87	S	4,530	--	--
07N09W05DDDA01	--	4,570	--	--	--	--	--	--	--
07N09W06DBBC01	Td	4,697	190	01-03-63	45	D	4,652	50	--
07N09W06DBCB01	Qal	4,697	25	08-15-85	4.59	S	4,692	10	5.0
07N09W08ADD 01	Qal	4,550	12.7	08-01-57	6.47	S	4,544	--	--
07N09W08ADDD01	--	4,550	--	--	--	--	--	--	--
07N09W08DAAB01	Qal	4,530	--	04-30-87	5.63	S	4,524	--	--
07N09W08DAAC01	Qal	4,540	51	04-30-87	6.58	S	4,533	--	--
07N09W08DAAC02	Qal	4,530	--	04-30-87	7.20	S	4,523	--	--
07N09W08DDAD01	Qal	4,540	--	--	--	--	--	--	--
07N09W08DDAD02	--	4,540	--	--	--	--	--	--	--
07N09W09AA 01	Qal	4,558	35	07-01-57	32	S	4,526	--	--
07N09W09AAAB01	Td	4,560	75	04-29-87	31.09	S	4,529	--	--
07N09W09AADA01	Td	4,560	93	04-29-87	45.19	S	4,515	15	.68
07N09W09AADB01	Czu	4,560	107	04-29-87	27.43	S	4,533	--	--
07N09W09AADD01	--	4,580	--	--	--	--	--	--	--
07N09W09ABDD01	--	4,540	--	--	--	--	--	--	--
07N09W09ACAB01	--	4,540	--	--	--	--	--	--	--
07N09W09ADAD01	Td	4,580	122	04-29-87	53.92	S	4,526	--	--
07N09W09ADAD02	--	4,580	--	--	--	--	--	--	--
07N09W09ADDD01	Td	4,570	137	--	--	--	--	--	--
07N09W09DADA01	Td	4,580	137	04-28-87	39.21	S	4,541	--	--
07N09W09DADA02	Td	4,580	118	04-28-87	49.72	S	4,530	--	--
07N09W09DADD01	Td	4,580	100	--	--	--	--	--	--
07N09W09DDDA01	Qal	4,560	37	05-01-87	6.26	S	4,554	--	--
07N09W09DDDA02	Qal	4,560	40	05-01-87	+.60	S	4,561	--	--
07N09W09DDDD01	--	4,596	--	04-28-87	25.45	S	4,571	--	--
07N09W10BBCD01	--	4,630	--	04-29-87	95.45	S	4,535	--	--
07N09W10BBCD02	--	4,600	--	04-29-87	64.12	S	4,536	--	--
07N09W10BBCD03	Td	4,630	93	04-29-87	63.90	S	4,566	--	--
07N09W10BC 02	Td	4,605	114	08-01-57	69	S	4,536	--	--
07N09W10BCBC01	Td	4,610	130	04-29-87	60	O	4,550	--	--
07N09W10BCCB01	Td	4,600	114	08-15-85	66.50	S	4,533	--	--
07N09W10BCCD01	Td	4,620	175	04-28-87	94.04	S	4,526	--	--
07N09W10BCDC01	--	4,680	--	04-28-87	105	S	4,575	--	--

Well or spring number	Princi-pal aquifer	Alti-tude of land surface (feet above sea level)	Depth of well (feet below land sur-face)	Water level: Date of measure-ment	Water level: Feet below or above (+) land surface	Water level: Source	Water level: Alti-tude (feet above sea level)	Dis-charge[1] (gal/min)	Spe-cific capa-city[1] [(gal/min)/ft]
07N09W10CCCD01	Td	4,600	117	04-24-76	50	D	4,550	--	--
07N09W11CDBB01	Td	4,740	30	08-16-85	10.70	S	4,729	--	--
07N09W14BA 01	Qal	4,796	32	09-06-57	26	S	4,770	--	--
07N09W14DCCD01	Td	4,960	439	10-10-85	328.57	S	4,631	--	--
07N09W16AADA01	Td	4,585	89	04-28-87	20.27	S	4,565	--	--
07N09W16AADB01	Td	4,580	105	04-27-87	14.82	S	4,565	--	--
07N09W16ADAA01	Qal	4,560	40	08-26-63	26	O	4,534	--	--
07N09W16BB 01	Qal	4,558	15	08-01-57	7	S	4,551	--	--
07N09W16BBCB01	Qal	4,560	32	05-01-87	12.82	S	4,547	--	--
07N09W16CBCC01	Qal	4,574	46	08-16-85	15.13	S	4,559	--	--
07N09W16CC 01	Qal	4,558	14	07-31-57	3	S	4,555	--	--
07N09W16DADD01	Td	4,620	108	--	--	--	--	--	--
07N09W17AA 01	Qal	4,578	8	08-01-57	7	S	4,571	--	--
07N09W17AD 01	--	--	--	--	--	--	--	135	--
07N09W20ABDB01	Td	4,590	110	05-01-87	20.92	S	4,569	--	--
07N09W20CADD01	Td	4,620	180	08-16-85	36.55	S	4,583	--	--
07N09W24BC 01	Qal	4,927	55	09-06-57	42	S	4,885	--	--
07N09W27CCDD01	Td	4,760	246	08-07-85	156.93	S	4,603	--	--
07N09W28ABAC01	--	4,600	--	--	--	--	--	--	--
07N09W28ABCD01	--	4,620	--	04-24-87	29.64	S	4,590	--	--
07N09W28ACAB01	--	4,630	--	--	--	--	--	--	--
07N09W28CC 01	Qal	4,599	8	07-31-57	6	S	4,593	--	--
07N09W29AB 01	Qal	4,587	8	08-01-57	5	S	4,582	--	--
07N09W29ABAA01	Td	4,580	70	04-27-71	14	D	4,566	20	1.2
07N09W29ABCA01	Qal	4,640	30	08-27-76	11	D	4,629	--	--
07N09W29DB 01	--	4,606	17	08-01-57	10	S	4,596	--	--
07N09W30DD 01	Td	4,705	85	08-02-57	40	S	4,665	--	--
07N09W31CCAD01	Td	4,747	182	07-24-85	103.20	S	4,644	80	2.7
07N09W31CCBB01	Td	4,760	150	07-24-85	106.18	S	4,654	--	--
07N09W31CD 01	Td	4,729	48	08-02-57	41	S	4,688	--	--
07N09W31CDD 01	Td	4,729	50	09-03-57	40.47	S	4,689	--	--
07N09W31DB 01	Td	4,715	82	08-02-57	41	S	4,674	--	--
07N09W32ADAB01	--	4,670	--	05-01-87	40.53	S	4,629	--	--
07N09W32ADAB02	--	4,670	--	05-01-87	39.05	S	4,631	--	--
07N09W32DA 01	Qal	4,643	34	09-15-57	15	S	4,628	22	7.3
07N09W32DACA01	--	4,650	--	04-22-87	22.21	S	4,628	--	--
07N09W32DDCA01	Qal	4,650	65	04-23-87	20.23	S	4,630	--	--
07N09W33ADDD01	Td	4,670	80	04-23-87	44.15	S	4,626	--	--
07N09W33CBDD01	--	4,620	--	--	--	--	--	--	--
07N09W33CCBB01	--	4,640	--	--	--	--	--	--	--
07N09W33DABB01	--	4,680	--	--	--	--	--	--	--
07N09W33DADB01	Td	4,590	110	04-28-87	35.59	S	4,554	--	--
07N09W33DBAA01	--	4,640	--	04-24-87	37.40	S	4,603	--	--
07N08W05BA 01	Qal	5,094	12	08-07-57	11	S	5,083	--	--
07N08W06BB 01	Qal	4,958	5	--	--	--	--	--	--
07N08W07DB 01	Qal	5,313	22	09-06-57	8	S	5,305	--	--
07N08W17DA 01	Qal	5,690	20	09-05-57	15	S	5,675	--	--
07N08W18AA 01	Qal	5,430	22	09-05-57	8	S	5,422	--	--
07N08W20CB 01	Qal	5,518	7	09-06-57	2	S	5,516	--	--
07N08W21BA 01	--	5,803	52	09-05-57	40	S	5,763	--	--
07N08W29CD 01	Qal	5,883	10	09-06-57	8	S	5,875	--	--
06N10W01AD 01	Qal	4,761	22	08-01-57	13	S	4,748	--	--
06N10W04BBBA01	Qal	5,125	60	06-23-71	24	D	5,101	9	.35
06N10W05AA 01	Qal	5,167	18	08-01-57	8	S	5,159	--	--
06N10W05AABA01	Czu	5,145	127	02-19-52	5	D	5,140	--	--

Well or spring number	Principal aquifer	Altitude of land surface (feet above sea level)	Depth of well (feet below land surface)	Water level: Date of measurement	Water level: Feet below or above (+) land surface	Water level: Source	Water level: Altitude (feet above sea level)	Discharge[1] (gal/min)	Specific capacity[1] [(gal/min)/ft]
06N10W08AC 01	Qal	5,076	17	08-01-57	8	S	5,068	--	--
06N10W12DA 01	Qal	4,768	16	08-01-57	6	S	4,762	--	--
06N10W13BCBB01	Td	4,820	127	08-15-85	--	S	--	--	--
06N10W14AC 01	Qal	4,854	8	08-01-57	7	S	4,847	--	--
06N10W14BCDB01	Qal	4,875	15.4	08-29-85	11.59	S	4,863	--	--
06N10W14CA 01	Czu	4,884	84	08-01-57	14	S	4,870	--	--
06N10W14CBBB01	Czu	4,886	126	10- -55	16	D	4,870	530	18
06N10W15AAD 01	Qal	4,884	12.6	08-02-57	7.23	S	4,877	--	--
06N10W20DC 01	Czu	5,280	113	09-01-60	16	S	5,264	--	--
06N10W22DD 01	Qal	4,929	5	06-20-60	1	S	4,928	--	--
06N10W23BB 01	Td	4,927	175	06-20-60	20.92	S	4,906	--	--
06N10W23BC 01	Qal	4,926	37	06-21-60	17.38	S	4,909	--	--
06N10W23DA 01	Td	4,890	97	06-21-60	68.52	S	4,821	--	--
06N10W23DCDD01	Td	4,900	112	09-04-85	89.45	S	4,811	--	--
06N10W26AB 01	Qal	4,894	20	06-20-60	8	S	4,886	--	--
06N10W26DC 01	Qal	4,881	6	06-20-60	1.98	S	4,879	--	--
06N10W27AA 01	Czu	4,929	12	06-22-60	.48	S	4,928	--	--
06N10W27CCCC01	Td	5,005	88.7	06-21-60	60.38	S	4,945	--	--
06N10W28BB 01	Czu	5,115	71	06-01-60	52.98	S	5,062	--	--
06N10W28BBBB01	Czu	5,105	80	09-04-85	47.27	S	5,058	--	--
06N10W31CCDA01	Td	5,590	120	10-11-85	25.89	S	5,564	--	--
06N10W34AD 01	Qal	4,915	27	06-22-60	11.81	S	4,903	--	--
06N10W35AB 01	Qal	4,869	3	06-22-60	.51	S	4,868	--	--
06N09W03CCBC01	Czu	4,650	85	--	--	--	--	--	--
06N09W04BA 01	Qal	4,630	17	07-01-57	5	S	4,625	28	7.0
06N09W04BB 01	Qal	4,644	14	07-01-57	8	S	4,636	27	27
06N09W04BBCD01	Qal	4,650	31	07-25-85	11.91	S	4,638	--	--
06N09W04CC 01	--	4,658	8	07-01-57	4	S	4,654	10	--
06N09W04CDDD01	Qal	4,645	22	07-25-85	6.72	S	4,638	50	7.1
06N09W04DDAC01	Czu	4,650	70	05-29-87	11.7	S	4,638	--	--
06N09W04DDAD01	--	4,650	--	--	--	--	--	--	--
06N09W05ACAA01	--	4,660	--	--	--	--	--	--	--
06N09W05DADD01	--	4,680	--	04-22-87	7.99	S	4,672	--	--
06N09W05DDAA01	Czu	4,665	80	04-22-87	14.39	S	4,651	--	--
06N09W06AC 01	Qal	4,710	16	08-01-57	8	S	4,702	--	--
06N09W06ADBB01	Qal	4,708	52	07-24-85	35.71	S	4,672	--	--
06N09W07AD 01	Qal	4,719	7	09-01-57	5	S	4,714	--	--
06N09W07AD 02	Qal	--	35	--	--	--	--	92	23
06N09W07BCCC01	Td	4,770	400	08-29-85	50.17	S	4,720	--	--
06N09W07BCCC02	Td	4,770	436	08-01-77	40	D	4,730	2,400	17
06N09W07CD 01	Qal	4,756	11	08-01-57	6	S	4,750	--	--
06N09W07DC 01	Qal	--	40	--	--	--	--	110	55
06N09W07DDDA01	Td	4,722	253	06-18-74	15	D	4,707	--	--
06N09W08AA 01	Qal	4,673	8	08-01-57	5	S	4,668	--	--
06N09W08AD 01	Qal	4,685	10	08-01-57	5	S	4,680	--	--
06N09W08DAAD01	--	4,680	--	--	--	--	--	--	--
06N09W08DADD01	--	4,680	--	04-22-87	3	O	4,677	--	--
06N09W09BAAC01	--	4,640	--	--	--	--	--	--	--
06N09W09BABC01	Qal	4,650	31	07-24-85	5.16	S	4,645	--	--
06N09W09CADA01	--	4,640	--	04-22-87	6.81	S	4,633	--	--
06N09W09CCDB01	--	4,670	--	--	--	--	--	--	--
06N09W09DA 01	Qal	4,654	--	12-01-57	8	S	4,646	--	--
06N09W09DADD01	Td	4,690	83	04-23-87	40.51	S	4,649	--	--
06N09W09DD 01	Qal	4,656	11	07-01-57	5	S	4,651	--	--
06N09W09DDCA01	--	4,680	--	04-23-87	27.73	S	4,652	--	--

Well or spring number	Principal aquifer	Altitude of land surface (feet above sea level)	Depth of well (feet below land surface)	Water level: Date of measurement	Water level: Feet below or above (+) land surface	Water level: Source	Water level: Altitude (feet above sea level)	Discharge[1] (gal/min)	Specific capacity[1] [(gal/min)/ft]
06N09W10BBDA01	Td	4,720	135	08-07-85	80.91	S	4,639	--	--
06N09W10BCDB01	--	4,700	--	05-14-87	77.57	S	4,622	--	--
06N09W10CBBD01	--	4,680	--	04-23-87	54.91	S	4,625	--	--
06N09W17AA 01	Qal	4,689	21	07-01-57	5	S	4,684	--	--
06N09W17AABD01	Czu	4,680	65	--	--	--	--	--	--
06N09W17AABD02	Qal	4,680	14	05-14-87	3.3	S	4,677	--	--
06N09W17AACC01	Czu	4,680	58	05-14-87	12.93	S	4,667	--	--
06N09W17ADBC01	Czu	4,680	58	--	--	--	--	--	--
06N09W17BCDD01	Qal	4,710	48	07-24-85	9.42	S	4,701	--	--
06N09W17BDCC01	Td	4,710	190	07-24-85	37.72	S	4,672	600	4.3
06N09W17CDAA01	--	4,700	--	05-14-87	3.63	S	4,696	--	--
06N09W17DA 01	Qal	4,688	6	07-01-57	3	S	4,685	--	--
06N09W17DADA01	Td	4,675	172	03-02-81	9.5	D	4,666	100	200
06N09W18AB 01	Qal	4,738	17	08-01-57	8	S	4,730	--	--
06N09W18BCAC01	Qal	4,762	28.3	08-29-85	5.05	S	4,757	--	--
06N09W18DD 01	Qal	4,731	62	08-01-57	15	S	4,716	--	--
06N09W19AC 02	Qal	4,729	8	08-16-60	5.35	S	4,724	--	--
06N09W19DB 01	Qal	4,737	21	08-10-60	8.69	S	4,728	--	--
06N09W20BD 01	Qal	4,690	25	08-10-60	3.32	S	4,687	--	--
06N09W21BA 01	Qal	4,680	10	07-01-57	7	S	4,673	--	--
06N09W21BAAA01	--	4,750	--	04-21-87	80	O	4,670	--	--
06N09W21BABA01	--	4,730	--	04-21-87	50.13	S	4,680	--	--
06N09W21BABA02	--	4,720	--	05-14-87	45.65	S	4,674	--	--
06N09W21BABB01	--	4,720	--	04-21-87	29.75	S	4,690	--	--
06N09W21BBBB01[2]	Qal	4,700	23.7	06-25-86	2.39	S	4,698	--	--
06N09W21CCBA01	--	4,720	--	04-21-87	10.33	S	4,710	--	--
06N09W21CCBC01	--	4,680	--	04-21-87	7	O	4,673	--	--
06N09W21CCDC01	Qal	4,730	65	04-21-87	51.16	S	4,679	--	--
06N09W21CDBC01	Td	4,785	150	09-12-60	91	S	4,694	--	--
06N09W21CD 02	Td	4,810	160	09-07-60	115	S	4,695	--	--
06N09W21CDAB01	Td	4,860	245	04-29-72	170	D	4,690	15	.37
06N09W21CDBA01	Td	4,820	170	--	--	--	--	--	--
06N09W21CDBC01	Td	4,785	150	09-12-60	90.75	S	4,694	--	--
06N09W21CDCB01	--	4,790	--	--	--	--	--	--	--
06N09W29AC 01	Qal	4,704	16	08-08-60	3	S	4,701	--	--
06N09W29BB 01	Qal	4,708	8	08-22-60	1.15	S	4,707	--	--
06N09W29DAAD01	Qal	4,725	60	02-13-87	25	D	4,700	15	.75
06N09W30AB 02	Qal	4,728	6	09-06-60	+.9	S	4,729	--	--
06N09W30CD 01	Qal	4,754	10	08-10-60	4.86	S	4,749	--	--
06N09W31BB 01	Czu	--	208	--	--	S	--	--	--
06N09W31CD 01	Czu	4,772	157	09-07-60	9.23	S	4,763	--	--
06N09W31CDAB01	--	4,790	--	04-23-87	20.87	S	4,769	--	--
06N09W31DD 01	Qal	4,745	8	08-10-60	2.89	S	4,742	--	--
06N09W32AA 01	Qal	4,732	19	08-08-60	13	S	4,719	--	--
06N09W32DDAB01	Td	4,800	97	03-11-77	77	D	4,723	--	--
05N11W26AAAA01	Tp€u	5,360	55	08-20-85	39.65	S	5,320	--	--
05N10W02AA 01	Qal	4,870	34	06-20-60	24.8	S	4,845	--	--
05N10W02AAAB01	Td	4,875	48	09-04-85	15.86	S	4,859	50	5.0
05N10W03AA 01	Czu	4,926	105	08-01-60	65	S	4,861	--	--
05N10W03BBBB01	Td	5,033	149	09-04-85	104.20	S	4,929	15	.60
05N10W03CB 01	Qal	5,030	152	09-13-60	86.37	S	4,944	--	--
05N10W03CBCC01	Td	5,010	--	09-04-85	80.26	S	4,930	--	--
05N10W03DD 01	Czu	4,924	80	06-22-60	52.45	S	4,871	--	--
05N10W04AA 01	Czu	5,085	245	06-22-60	145.96	S	4,939	--	--
05N10W10CB 01	Qal	4,964	75	09-07-60	60.91	S	4,903	--	--

				Water level					
Well or spring number	Princi-pal aquifer	Alti-tude of land surface (feet above sea level)	Depth of well (feet below land sur-face)	Date of measure-ment	Feet below or above (+) land surface	Source	Alti-tude (feet above sea level)	Dis-charge[1] (gal/min)	Spe-cific capa-city[1] [(gal/min)/ft]
05N10W10CCBC01	Td	4,965	115	09-04-85	73.27	S	4,892	--	--
05N10W13BC 01	Qal	4,832	10	08-16-60	7.65	S	4,824	--	--
05N10W13DA 01	Qal	4,809	9	08-16-60	6.28	S	4,803	--	--
05N10W14DC 01	Qal	4,858	8	09-22-60	6.85	S	4,851	--	--
05N10W15BA 01	Qal	4,880	56	06-22-60	14	S	4,865	--	--
05N10W16AC 01	Qal	4,966	98	07-04-60	37	S	4,929	--	--
05N10W16DC 01	Qal	4,933	15	07-04-60	11	S	4,922	--	--
05N10W17CA 01	Czu	5,036	59	07-05-60	42.24	S	4,994	--	--
05N10W17CB 01	Czu	5,060	89	07-05-60	65.63	S	4,994	--	--
05N10W17CB 02	Qal	--	15	--	--	--	--	580	15
05N10W17DC 01	Czu	--	71	--	--	--	--	270	--
05N10W20CD 01	Qal	5,031	59	07-05-60	37	S	4,994	--	--
05N10W22DD 01	Czu	4,904	141	08-09-60	3	S	4,901	--	--
05N10W23DC 01	Qal	4,882	48	07-05-60	5	S	4,877	--	--
05N10W23DD 01	Qal	4,874	51	07-05-60	11	S	4,863	--	--
05N10W23DDCD01	Qal	4,875	37	07-24-85	9.77	S	4,865	--	--
05N10W24AA 01	--	--	200	--	--	--	--	975	--
05N10W24ABAA01	--	4,820	304	01-27-82	13	S	4,807	--	--
05N10W24CB 01	Qal	4,858	8	08-16-60	5.94	S	4,852	--	--
05N10W24DA 01	Qal	4,841	9	08-16-60	6.47	S	4,834	--	--
05N10W25DA 01	Qal	4,856	4	08-23-60	.60	S	4,855	--	--
05N10W27DADA01	Qal	4,923	14.5	09-10-85	5.54	S	4,917	--	--
05N10W27DCBD01	Qal	4,948	20	09-10-85	6.40	S	4,942	--	--
05N10W29BABC01	Qal	5,035	50	10-11-85	19.97	S	5,015	--	--
05N10W33AB 01	Qal	5,000	8	08-16-60	4.91	S	4,995	--	--
05N10W33BCCC01	Qal	5,030	35	10-10-85	22.78	S	5,007	--	--
05N10W33BCDB01	Qal	5,030	65	10-10-85	20.64	S	5,009	--	--
05N10W33DA 01	Qal	4,999	52	09-21-60	2.73	S	4,996	--	--
05N09W05BA 01	Qal	4,769	31	08-08-60	27	S	4,742	--	--
05N09W05CDAD01	Td	4,800	105	04-20-87	83.4	S	4,717	--	--
05N09W05CDBB01	Qal	4,780	31	07-25-85	14.52	S	4,765	--	--
05N09W05CDDD01	Czu	4,845	115	07-25-85	73.58	S	4,771	--	--
05N09W07CAAC01	Qal	4,770	12.8	04-30-87	5.91	S	4,764	--	--
05N09W07CB 01	Qal	4,781	10	08-17-60	7	S	4,774	--	--
05N09W07DABC01	Qal	4,775	9.6	09-10-85	2.39	S	4,773	--	--
05N09W07DCCC01	Qal	4,780	14	09-10-85	5.52	S	4,774	--	--
05N09W07DCDC01	Qal	4,780	11.7	09-10-85	4.86	S	4,775	--	--
05N09W08BCAB01	--	4,800	--	--	--	--	--	--	--
05N09W17BC 01	Czu	4,827	131	08-09-60	43	S	4,784	--	--
05N09W17BCCA01	Czu	4,830	139	04-20-87	42.62	S	4,787	--	--
05N09W17BCDB01	--	4,780	--	--	--	--	--	--	--
05N09W17BCDC01	Czu	4,870	85	- -85	20	O	4,850	--	--
05N09W17CACA01	Td	4,870	115	08-20-85	93.91	S	4,776	--	--
05N09W18AB 01	Qal	4,784	8	08-10-60	5.06	S	4,779	--	--
05N09W18ADCD01[2]	Qal	4,790	22.1	06-25-86	5.67	S	4,784	--	--
05N09W18ADCD02[2]	Td	4,790	59.4	07-14-87	5.52	S	4,784	--	--
05N09W29BC 01	Qal	4,843	20	09-12-60	8.73	S	4,834	--	--
04N11W01ACDD01	Qal	5,147	38	09-10-85	27.88	S	5,119	--	--
04N11W01BB 01	Qal	5,193	83	07-26-60	23.13	S	5,170	--	--
04N11W01BCCD01	Qal	5,190	72	09-10-85	30.86	S	5,159	--	--
04N11W01CAAA01	Qal	5,167	115	09-10-85	35.88	S	5,131	--	--
04N10W05AACC01	Qal	5,047	34	09-10-85	28.61	S	5,018	--	--
04N10W05AACC02	Qal	5,045	98	09-10-85	27	S	5,018	--	--
04N10W05AB 01	Qal	5,050	160	--	--	--	--	61	--

Table 1.--Ground-water data for the upper Clark Fork valley, Montana--Continued

Well or spring number	Principal aquifer	Altitude of land surface (feet above sea level)	Depth of well (feet below land surface)	Water level: Date of measurement	Water level: Feet below or above (+) land surface	Water level: Source	Water level: Altitude (feet above sea level)	Discharge[1] (gal/min)	Specific capacity[1] [(gal/min)/ft]
04N10W06BADD01	Qal	5,105	77	09-10-85	65.79	S	5,039	--	--
04N10W06BCAA01	Qal	5,124	45	09-10-85	35.76	S	5,088	--	--
04N10W06BCAC01	Qal	5,128	50	09-10-85	36.31	S	5,092	--	--
04N10W06BCBD01	Qal	5,130	43	09-10-85	32.73	S	5,097	--	--
04N10W06BDBB01	Qal	5,122	50	09-10-85	39.13	S	5,083	--	--
04N10W08DC 01	Qal	5,130	45	07-28-60	28	S	5,102	--	--
04N10W09AB 01	Qal	5,005	6	09-07-60	4	S	5,001	--	--
04N10W09BD 01	Qal	5,037	29	07-06-60	18	S	5,019	--	--
04N10W09DA 01	Qal	5,003	13	07-27-60	11	S	4,992	--	--
04N10W10ACCA01	Qal	4,970	48	08-21-85	--	--	--	200	8.7
04N10W10AD 01	Qal	4,941	5	--	--	--	--	--	--
04N10W10CC 01	Qal	5,004	23	07-26-60	6	S	4,998	--	--
04N10W10DADA01	Qal	4,950	57	08-21-85	13.41	S	4,937	30	6.0
04N10W10DB 01	Qal	4,963	6	07-27-60	6	S	4,957	--	--
04N10W10DC 01	Qal	4,973	17	07-26-60	6	S	4,967	--	--
04N10W10DC 02	Qal	4,978	20	07-26-60	4.05	S	4,973	--	--
04N10W11CBAC01	Td	4,940	169	08-21-85	3.04	S	4,937	50	3.1
04N10W11DD 01	Qal	4,926	8	--	--	--	--	--	--
04N09W04DD 01	Qal	5,781	23	07-01-57	21	S	5,760	--	--
04N09W05CD 01	Qal	5,525	17	08-01-60	12	S	5,513	--	--
04N09W06DC 01	Qal	5,340	9	08-01-60	5	S	5,335	--	--

[1]Well-discharge and specific-capacity data were obtained or determined from drillers' logs and are approximate.
[2]Well drilled and cased as part of this study.
[3]Spring.

Table 2.--Ground-water-chemistry data for the upper Clark Fork valley, Montana

[Constituents are dissolved, except as indicated; laboratory analyses by Montana Bureau of Mines and Geology; onsite measurements by U.S. Geological Survey; analyses with same date for a site are duplicate analyses. Geologic Unit: Qal, Quaternary alluvium; Td, Tertiary deposits; TpЄu, undivided Tertiary to Precambrian bedrock. Abbreviations: µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; mg/L, milligrams per liter; IT, incremental titration; µg/L, micrograms per liter. Symbols: --, no data; <, less than the minimum reporting level for analytical method used]

Well or spring number	Principal aquifer	Date of collection	Onsite specific conductance (µS/cm)	Onsite pH (standard units)	Temperature (°C)	Onsite dissolved oxygen (mg/L)	Calcium (mg/L as Ca)	Magnesium (mg/L as Mg)	Sodium (mg/L as Na)	Potassium (mg/L as K)
13N18W27BABB03	Qal	07-28-87	353	7.7	9.5	3.6	46	12	6.2	1.2
13N18W34AABC01	Qal	07-28-87	388	7.6	9.0	2.2	53	11	8.1	1.9
12N18W12BAAB02[2]	Qal	09-17-86	441	8.0	13.5	--	55	13	12	4.2
		01-27-87	405	7.8	7.0	--	56	13	9.5	3.3
		08-30-89	390	7.1	12.0	2.8	58	13	9.6	2.3
12N18W12BADD01	Qal	07-28-87	387	7.6	9.5	4.5	55	13	8.9	1.9
12N17W18ADDB01	Qal	07-29-87	405	7.3	11.0	3.6	59	13	9.1	2.0
		07-29-87	--	--	--	--	58	13	9.0	1.9
11N17W02ABCB01	Qal	07-28-87	350	7.3	9.0	4.2	49	12	9.6	1.8
11N16W07AAAA01	Qal	07-29-87	411	7.6	10.0	2.8	56	18	7.3	1.5
11N16W08BDA 01	Qal	07-29-87	464	7.6	9.0	2.8	67	15	11	2.4
11N16W11CAAA01[2]	Qal	09-17-86	440	8.0	11.0	--	53	12	16	4.0
		08-30-89	550	7.2	8.5	.6	80	18	15	3.2
		08-30-89	--	--	--	--	79	19	15	3.1
11N15W14CBDD01[1]	TpЄu	07-30-87	893	8.1	20.0	--	140	35	12	3.3
11N14W11DCAC01[2]	Qal	09-17-86	581	7.6	11.5	--	73	17	20	3.9
		08-30-89	585	7.2	10.0	.9	88	23	12	2.9
11N14W15DDB 01	Qal	07-29-87	502	7.6	8.5	5.4	75	15	13	3.0
11N13W23CDBA01	Qal	07-29-87	1,010	7.2	11.0	.1	120	21	47	26
11N12W29BDAA01	TpЄu	10-29-85	510	7.4	8.5	3.6	75	18	10	1.0
11N12W31AACB01	Qal	10-29-85	740	7.2	10.0	7.4	98	38	12	2.4
10N13W12BDDA01	Td	10-30-85	1,800	7.4	8.5	1.0	260	45	110	23
10N13W26DCCB01	Qal	10-30-85	621	7.1	10.0	2.8	76	25	20	8.6
10N12W04AAAB01	TpЄu	10-29-85	603	7.4	8.5	3.6	77	29	13	2.5
10N12W06BBAA01	Td	10-29-85	721	7.7	10.5	6.7	81	16	53	12
10N12W09CADA01	Qal	10-30-85	611	7.3	9.5	3.2	90	16	18	3.7
10N12W30BABD01	Td	10-30-85	820	7.2	9.5	6.5	100	30	31	2.3
10N12W31ACDA01	Td	10-30-85	618	7.5	7.0	--	64	26	34	1.6
10N11W25CBAC01[2]	Qal	09-17-86	609	7.3	15.0	--	89	13	18	5.0
		01-27-87	550	7.5	2.0	--	83	13	16	3.4
		08-30-89	595	6.8	13.0	<.1	94	13	17	3.7
10N11W25CCDD01	Td	11-05-85	615	8.8	8.0	.2	14	.7	120	1.3
10N11W35BBBC01	Td	11-06-85	2,030	7.6	8.5	.5	150	12	330	8.4
10N11W36ACDD01	Td	11-06-85	612	7.4	9.0	5.4	76	10	44	4.0
10N10W19DCCC01	TpЄu	11-06-85	810	7.2	--	5.6	100	35	27	1.5
10N10W31BABA02	Qal	07-30-87	476	7.4	10.0	<.1	76	16	11	2.2
09N13W03DAAD01	Qal	10-31-85	409	7.5	10.5	6.0	61	13	7.0	2.5
09N13W28CBAA01	Qal	10-31-85	425	7.4	8.5	6.9	60	14	9.4	3.5
09N11W01BCAC01	Td	11-06-85	710	7.5	8.5	2.3	90	7.5	57	3.7
09N11W21ACCC01	Qal	11-06-85	251	7.5	7.0	8.1	42	6.6	2.7	1.3

Well or spring number	Onsite bicarbonate (IT), (mg/L as HCO_3)	Onsite carbonate (IT), (mg/L as CO_3)	Onsite alkalinity (IT), (mg/L as $CaCO_3$)	Sulfate (mg/L as SO_4)	Chloride (mg/L as Cl)	Fluoride (mg/L as F)	Bromide (mg/L as Br)	Silica (mg/L as SiO_2)	Dissolved solids, calculated (mg/L)	Nitrate (mg/L as N)	Phosphorus (mg/L as P)
13N18W27BABB03	200	0	160	30	3.0	0.2	<0.1	18	207	0.87	<0.1
13N18W34AABC01	180	0	150	38	2.5	.4	<.1	17	222	.27	<.1
12N18W12BAAB02	210	0	170	49	3.7	.8	<.1	14	250	.37	<.1
	200	0	160	49	3.1	.4	.1	17	250	.59	<.1
	200	0	160	53	3.8	.5	<.1	18	249	.64	--
12N18W12BADD01	200	0	160	47	3.2	.4	<.1	18	242	.44	.1
12N17W18ADDB01	210	0	170	45	3.1	.4	<.1	19	253	.29	<.1
	--	--	--	45	2.8	.4	<.1	19	252	.31	<.1
11N17W02ABCB01	180	0	150	48	3.1	.4	<.1	18	228	.42	<.1
11N16W07AAAA01	240	0	200	42	3.2	.3	<.1	19	261	.46	<.1
11N16W08BDA 01	210	0	170	79	4.1	.5	<.1	20	295	.24	<.1
11N16W11CAAA01	180	0	150	61	7.7	1.3	<.1	14	256	.25	<.1
	240	0	200	100	7.0	.7	<.1	21	362	.70	--
	--	--	--	100	6.4	.7	<.1	20	357	.59	--
11N15W14CBDD01	220	0	180	320	3.0	.8	<.1	21	640	.20	<.1
11N14W11DCAC01	240	0	190	98	8.7	1.4	<.1	23	355	.26	<.1
	210	0	170	150	4.6	.8	<.1	20	405	.41	--
11N14W15DDB 01	220	0	180	99	5.0	.6	<.1	21	335	.28	.1
11N13W23CDBA01	230	0	190	350	5.0	.1	.1	34	717	.08	<.1
11N12W29BDAA01	320	0	260	17	2.7	.1	<.1	14	292	.55	.1
11N12W31AACB01	420	0	350	64	8.4	.1	<.1	16	444	2.5	.3
10N13W12BDDA01	240	0	200	780	41	.3	.2	26	1,410	1.4	<.1
10N13W26DCCB01	370	0	300	31	8.5	.1	<.1	35	384	.94	.2
10N12W04AAAB01	360	0	300	38	5.8	.3	<.1	20	360	1.2	<.1
10N12W06BBAA01	330	0	270	85	19	.4	<.1	78	506	2.2	<.1
10N12W09CADA01	250	0	210	110	5.4	.3	--	34	402	.5	<.1
10N12W30BABD01	360	0	300	100	26	.3	<.1	35	685	3.0	.2
10N12W31ACDA01	310	0	250	79	6.8	.6	<.1	27	386	.72	.1
10N11W25CBAC01	280	0	220	83	7.4	1.4	<.1	23	380	.25	<.1
	250	0	200	81	5.6	.9	<.1	19	348	.17	<.1
	310	0	250	92	7.4	.9	<.1	25	384	.25	--
10N11W25CCDD01	190	8	160	140	5.2	.6	.1	21	394	.02	<.1
10N11W35BBBC01	460	0	380	640	65	.8	--	35	1,470	10	<.1
10N11W36ACDD01	300	0	250	75	6.2	.8	.1	37	400	.42	<.1
10N10W19DCCC01	390	0	320	82	16	.2	<.1	17	473	11	<.1
10N10W31BABA02	260	0	210	62	4.5	.3	<.1	20	319	.04	<.1
09N13W03DAAD01	260	0	210	12	2.4	.1	<.1	28	250	.83	<.1
09N13W28CBAA01	250	0	210	19	2.9	.2	.1	34	264	.43	<.1
09N11W01BCAC01	280	0	230	160	2.9	.4	<.1	42	485	.32	<.1
09N11W21ACCC01	150	0	120	18	.50	.1	<.1	15	155	.03	<.1

Well or spring number	Phos-phorus, ortho (µg/L as P)	Alu-mi-num (µg/L as Al)	Arse-nic, As^{+3} and As^{+5} (µg/L as As)	Arse-nic, As^{+3} (µg/L as As)	Boron (µg/L as B)	Cad-mium (µg/L as Cd)	Chro-mium (µg/L as Cr)	Cop-per- (µg/L as Cu)	Iron (µg/L as Fe)	Lead (µg/L as Pb)	Lith-ium (µg/L as Li)	Man-ga-nese (µg/L as Mn)
13N18W27BABB03	<0.1	<30	1.0	<0.5	30	<2	<2	<2	<2	<40	3	<1
13N18W34AABC01	<.1	<30	1.6	<.5	<20	<2	<2	<2	<2	<40	<2	<1
12N18W12BAAB02	<.1	<30	6.8	--	130	<2	<2	<2	--	<40	--	--
	<.1	<30	9.8	--	100	<2	<2	3	--	<40	--	--
	<.1	<40	4.8	<.5	<40	<5	--	<4	<2	<40	18	22
12N18W12BADD01	<.1	<30	.9	<.5	60	<2	<2	<2	<2	<40	5	<1
12N17W18ADDB01	<.1	<30	1.1	<.5	60	<2	<2	<2	<2	<40	5	<1
	<.1	<30	1.1	<.5	80	<2	<2	<2	<2	<40	<2	<1
11N17W02ABCB01	<.1	<30	1.0	.7	60	<2	<2	<2	<2	<40	7	<1
11N16W07AAAA01	<.1	<30	2.6	<.5	40	<2	<2	<2	3	<40	8	<1
11N16W08BDA 01	<.1	<30	3.9	<.5	40	<2	<2	6	<2	<40	6	<1
11N16W11CAAA01	<.1	<30	11	--	30	<2	<2	<2	--	<40	--	--
	<.1	<40	9.2	<.5	80	<5	--	<4	<2	<40	19	190
	<.1	<40	9.6	<.5	90	<5	<5	<4	<2	<40	16	185
11N15W14CBDD01	<.1	<30	8.0	2.0	140	<2	<2	<2	<2	<40	30	<1
11N14W11DCAC01	<.1	<30	6.7	--	420	<2	<2	<2	--	<40	--	--
	<.1	<40	5.7	<.5	60	<5	--	<4	<2	<40	20	52
11N14W15DDB 01	<.1	<30	3.9	<.5	50	<2	<2	<2	<2	<40	11	<1
11N13W23CDBA01	<.1	<30	6.0	1.6	210	<2	<2	<2	2,500	<40	120	480
11N12W29BDAA01	.1	<30	.5	--	80	<2	<2	6	9	--	9	1
11N12W31AACB01	<.1	<30	.4	--	120	<2	<2	9	<2	--	10	<1
10N13W12BDDA01	<.1	<30	12	--	90	<2	<2	30	150	--	98	220
10N13W26DCCB01	.1	<30	3.5	--	90	<2	<2	8	<2	--	<2	<1
10N12W04AAAB01	<.1	<30	.5	--	60	<2	<2	5	<2	--	10	<2
10N12W06BBAA01	<.1	<30	12	--	40	<2	<2	11	<2	--	59	<1
10N12W09CADA01	--	<30	2.7	--	100	<2	<2	11	<2	--	12	<1
10N12W30BABD01	<.1	<30	.7	--	130	<2	<2	20	9	--	6	<1
10N12W31ACDA01	<.1	<30	2.8	--	80	<2	<2	4	<2	--	22	<1
10N11W25CBAC01	.1	<30	20	--	360	2	<2	9	--	<40	--	--
	<.1	<30	17	--	70	<2	<2	6	--	<40	--	--
	<.1	<40	8.2	<.5	50	<5	--	7	390	<40	19	500
10N11W25CCDD01	<.1	<30	<.1	--	140	<2	<2	<2	19	--	36	25
10N11W35BBBC01	--	<30	3.6	--	250	<2	<2	30	18	--	340	630
10N11W36ACDD01	<.1	<30	6.3	--	50	<2	<2	8	6	--	28	1
10N10W19DCCC01	<.1	<30	1.2	--	30	<2	<2	<2	<2	--	9	<1
10N10W31BABA02	<.1	<30	2.5	<.5	80	<2	<2	<2	370	<40	7	1,300
09N13W03DAAD01	<.1	<30	2.6	--	40	<2	<2	11	<2	--	<2	<1
09N13W28CBAA01	<.1	<30	6.6	--	<20	<2	<2	8	<2	--	<2	<1
09N11W01BCAC01	<.1	<30	14	--	60	<2	<2	8	<2	--	46	2
09N11W21ACCC01	.1	<30	.3	--	30	<2	<2	<2	<2	--	<2	<1

Well or spring number	Mercury (µg/L as Hg)	Molybdenum (µg/L as Mo)	Nickel (µg/L as Ni)	Selenium (µg/L as Se)	Silver (µg/L as Ag)	Strontium (µg/L as Sr)	Titanium (µg/L as Ti)	Vanadium (µg/L as V)	Zinc (µg/L as Zn)	Zirconium (µg/L as Zr)
13N18W27BABB03	<0.04	<20	<10	--	<2	150	4	<1	23	<4
13N18W34AABC01	<.04	<20	<10	--	<2	190	3	<1	7	<4
12N18W12BAAB02	<.04	--	<10	--	<2	160	<1	<1	<3	<4
	<.04	--	<10	--	3	180	<1	16	<3	<4
	--	<40	<20	--	--	200	<4	9	<6	--
12N18W12BADD01	<.04	<20	<10	--	<2	160	6	<1	6	<4
12N17W18ADDB01	<.04	<20	<10	--	<2	170	9	<1	28	<4
	<.04	<20	<10	--	<2	170	7	<1	28	<4
11N17W02ABCB01	<.04	<20	<10	--	<2	180	4	<1	10	<4
11N16W07AAAA01	<.04	<20	<10	--	<2	180	8	<1	57	<4
11N16W08BDA 01	<.04	<20	<10	--	<2	270	3	<1	<3	<4
11N16W11CAAA01	.05	--	<10	--	<2	230	<1	<1	<3	<4
	--	<40	20	--	--	380	<4	13	9	<6
	--	<40	<20	--	<4	370	<4	6	6	<6
11N15W14CBDD01	<.04	<20	<10	--	<2	980	15	<1	13	<4
11N14W11DCAC01	.05	--	<10	--	<2	400	<1	<1	<3	<4
	--	<40	<20	--	--	630	<4	<4	<6	<6
11N14W15DDB 01	<.04	<20	<10	--	<2	370	5	<1	14	<4
11N13W23CDBA01	<.04	<20	<10	--	<2	6,300	10	<1	77	<4
11N12W29BDAA01	--	<20	10	2.0	<2	1,300	3	<1	15	<4
11N12W31AACB01	--	<20	<10	3.7	<2	820	8	<1	120	<4
10N13W12BDDA01	--	<20	<10	.3	<2	4,100	30	<1	11	<4
10N13W26DCCB01	--	<20	<10	.2	<2	380	10	<1	<3	<4
10N12W04AAAB01	--	<20	<10	2.8	<2	660	4	<1	9	<4
10N12W06BBAA01	--	<20	<10	1.6	<2	1,100	4	6	<3	<4
10N12W09CADA01	--	<20	<10	.5	<2	420	12	<1	13	<4
10N12W30BABD01	--	20	<10	1.4	<2	740	7	1	50	<4
10N12W31ACDA01	--	<20	<10	3.4	<2	860	7	<1	<3	<4
10N11W25CBAC01	.06	--	<10	--	<2	370	<1	17	58	<4
	.09	--	<10	--	2	360	<1	<1	47	<4
	--	<40	<20	--	--	440	<4	8	126	<6
10N11W25CCDD01	--	30	20	<.1	<2	18	<1	<1	4	<4
10N11W35BBBC01	--	40	<10	.6	<2	190	20	<1	30	<4
10N11W36ACDD01	--	20	<10	.8	<2	210	5	<1	11	<4
10N10W19DCCC01	--	<20	<10	1.9	<2	980	2	<1	11	<4
10N10W31BABA02	<.04	<20	<10	--	<2	450	5	<1	3	<4
09N13W03DAAD01	--	<20	<10	.3	<2	150	1	<1	9	<4
09N13W28CBAA01	--	<20	<10	.3	<2	120	<1	<1	5	<4
09N11W01BCAC01	--	<20	<10	.2	<2	180	9	<1	8	<4
09N11W21ACCC01	--	<20	<10	.1	<2	160	1	<1	15	<4

Table 2.--Ground-water-chemistry data for the upper Clark Fork valley, Montana--Continued

Well or spring number	Principal aquifer	Date of collection	Onsite specific conductance (µS/cm)	Onsite pH (standard units)	Temperature (°C)	Onsite dissolved oxygen (mg/L)	Calcium (mg/L as Ca)	Magnesium (mg/L as Mg)	Sodium (mg/L as Na)	Potassium (mg/L as K)
09N10W04BDBC01	TpꞒu	11-05-85	668	7.3	8.0	3.8	83	18	38	2.7
09N10W10CDBD01	TpꞒu	11-05-85	1,010	8.1	8.0	.4	24	11	190	.80
09N10W24BBCA01	TpꞒu	11-05-85	665	7.3	9.0	4.4	77	21	38	3.4
09N09W28CCDD01[2]	Qal	09-17-86	760	8.2	12.0	--	75	27	38	6.0
		01-27-87	910	7.5	8.5	--	100	39	37	5.5
		08-29-89	1,010	7.0	10.5	2.1	130	45	36	5.0
09N09W33CDBC01	Td	10-24-85	621	7.4	7.0	4.6	66	19	41	4.7
08N09W04DDB 01	Qal	01-28-87	573	7.3	6.0	--	74	18	19	4.9
		01-28-87	--	--	--	--	74	18	19	5.0
08N09W28DBDC01	Td	10-24-85	531	7.4	9.5	5.6	70	21	14	4.7
08N09W32AADD01[2]	Qal	09-18-86	513	7.5	--	--	71	15	20	3.6
		08-10-87	--	--	--	--	59	12	18	3.7
08N09W32AADD02[2]	Td	08-04-87	298	7.4	10.0	--	27	4.6	30	6.9
		08-29-89	290	6.9	13.0	--	27	4.4	30	6.4
08N09W33CCDD01	Td	09-23-85	380	7.2	13.0	4.6	36	5.9	32	7.3
07N10W03ABBD01	Td	10-23-85	421	7.6	7.5	5.4	62	10	7.8	3.7
07N09W11CDBB01	Td	10-23-85	1,050	7.1	9.0	5.4	100	31	77	5.4
07N09W31CCBB01	Td	10-23-85	354	7.8	10.0	8.6	27	4.0	42	2.8
06N10W23DCDD01	Td	10-25-85	480	7.6	9.0	--	67	18	10	1.3
06N09W09BABC01	Qal	10-24-85	302	7.1	7.0	4.9	47	5.7	9.4	1.1
06N09W21BBBB01[2]	Qal	09-17-86	405	7.6	11.0	--	66	8.5	7.3	3.1
		08-29-89	410	7.5	9.0	--	68	8.0	8.1	3.2
05N10W29BABC01	Qal	10-24-85	388	7.8	--	9.6	54	11	11	1.5
05N09W18ADCD01[2]	Qal	09-17-86	1,180	7.4	10.0	--	200	32	18	5.4
		01-27-87	1,580	7.2	7.0	--	300	42	20	5.5
		08-04-87	901	7.3	11.0	--	160	22	15	4.4
		08-29-89	1,390	6.8	9.5	.2	270	44	15	4.9
05N09W18ADCD02[2]	Td	08-04-87	676	7.5	11.0	--	97	20	12	4.9
		08-29-89	635	7.2	9.5	2.2	100	22	13	3.3
04N10W10DADA01	Qal	10-25-85	150	7.5	7.5	6.2	19	4.9	5.7	.90

[1] Site 11N15W14CBDD01 is Nimrod Springs.
[2] Well drilled and completed with PVC casing as part of this study.

Table 2.--Ground-water-chemistry data for the upper Clark Fork valley, Montana--Continued

Well or spring number	Onsite bicarbonate (IT), (mg/L as HCO_3)	Onsite carbonate (IT), (mg/L as CO_3)	Onsite alkalinity (IT), (mg/L as $CaCO_3$)	Sulfate (mg/L as SO_4)	Chloride (mg/L as Cl)	Fluoride (mg/L as F)	Bromide (mg/L as Br)	Silica (mg/L as SiO_2)	Dissolved solids, calculated (mg/L)	Nitrate (mg/L as N)	Phosphorus (mg/L as P)
09N10W04BDBC01	340	0	280	58	19	.4	.1	20	403	.80	<.1
09N10W10CDBD01	280	0	230	270	5.2	.6	<.1	8.9	651	.10	<.1
09N10W24BBCA01	340	0	290	61	14	.8	--	28	410	1.4	<.1
09N09W28CCDD01	180	0	140	180	32	2.0	.1	9.9	465	2.7	<.1
	330	0	270	180	33	.7	<.1	18	580	2.7	<.1
	430	0	360	170	36	.6	<.1	22	655	4.5	--
09N09W33CDBC01	310	0	250	65	6.1	.5	.1	32	384	.90	.2
08N09W04DDB 01	240	0	190	95	6.8	.5	<.1	45	380	.30	<.1
	--	--	--	95	6.8	.5	<.1	45	380	.30	<.1
08N09W28DBDC01	310	0	250	35	4.9	.3	<.1	44	341	.42	<.1
08N09W32AADD01	270	0	220	56	6.7	.5	.1	48	353	.10	<.1
	--	--	--	24	6.3	.7	<.1	60	312	1.6	<.1
08N09W32AADD02	170	0	140	17	3.2	.9	<.1	79	250	.13	.1
	181	0	150	17	3.0	1.0	<.1	68	239	.16	--
08N09W33CCDD01	170	0	140	42	4.7	.9	<.1	73	286	.32	<.1
07N10W03ABBD01	240	0	200	17	2.4	.3	<.1	53	271	.23	<.1
07N09W11CDBB01	380	0	310	160	47	.4	<.1	49	659	6.2	.2
07N09W31CCBB01	140	0	120	35	18	.9	.2	37	234	.50	<.1
06N10W23DCDD01	290	0	240	22	1.7	.9	<.1	24	286	1.5	<.1
06N09W09BABC01	160	0	140	22	2.0	.8	<.1	23	190	.79	<.1
06N09W21BBBB01	210	0	180	34	3.7	.4	<.1	38	266	1.5	<.1
	220	0	180	34	3.8	.4	<.1	34	273	.59	--
05N10W29BABC01	200	0	160	39	2.4	.5	<.1	14	228	1.9	<.1
05N09W18ADCD01	250	0	200	450	9.2	.8	<.1	27	871	.19	<.1
	232	0	190	710	10	.6	.1	23	1,240	.20	.2
	200	0	160	350	3.6	.8	<.1	22	667	.03	<.1
	230	0	190	660	8.8	.9	<.1	18	1,140	.07	--
05N09W18ADCD02	250	0	200	150	4.2	.7	.1	26	432	--	<.1
	240	0	200	160	4.5	.8	<.1	24	449	4.5	--
04N10W10DADA01	80	0	71	8.1	.60	.2	<.1	31	112	.23	.2

Table 2.--Ground-water-chemistry data for the upper Clark Fork valley, Montana--Continued

Well or spring number	Phosphorus, ortho (µg/L as P)	Aluminum (µg/L as Al)	Arsenic, As^{+3} and As^{+5} (µg/L as As)	Arsenic, As^{+3} (µg/L as As)	Boron (µg/L as B)	Cadmium (µg/L as Cd)	Chromium (µg/L as Cr)	Copper (µg/L as Cu)	Iron (µg/L as Fe)	Lead (µg/L as Pb)	Lithium (µg/L as Li)	Manganese (µg/L as Mn)
09N10W04BDBC01	<.1	<30	1.3	--	30	<2	<2	17	29	--	24	<1
09N10W10CDBD01	<.1	<30	1.4	--	170	<2	<2	<2	58	--	220	12
09N10W24BBCA01	--	<30	5.4	--	80	<2	<2	10	25	--	30	1
09N09W28CCDD01	<.1	<30	1.7	--	200	<2	<2	<2	--	<40	--	--
	<.1	<30	1.0	--	<20	<2	<2	<2	--	<40	--	--
	<.1	<40	.9	<.5	80	<5	--	5	<2	<40	38	270
09N09W33CDBC01	.2	<30	1.4	--	140	<2	<2	11	18	--	9	3
08N09W04DDB 01	<.1	<30	6.5	1.0	30	<2	<2	2	16	<40	19	1
	<.1	<30	6.5	1.2	30	<2	<2	2	16	<40	19	1
08N09W28DBDC01	<.1	<30	2.6	--	20	<2	<2	3	<2	--	2	<1
08N09W32AADD01	<.1	<30	7.2	--	280	<2	<2	<2	--	<40	--	--
	--	<30	6.4	--	40	<2	<2	5	--	--	--	--
08N09W32AADD02	.2	<30	4.9	--	40	<2	4	2	--	<40	--	--
	<.1	<40	6.1	<.5	90	<5	--	<4	293	<40	49	4
08N09W33CCDD01	<.1	<30	6.4	--	80	<2	<2	4	<2	<40	56	<1
07N10W03ABBD01	.1	<30	2.2	--	100	<2	<2	5	<2	--	6	<1
07N09W11CDBB01	<.1	<30	4.1	--	120	<2	<2	12	<2	--	24	<1
07N09W31CCBB01	<.1	<30	1.2	--	110	<2	<2	9	23	--	8	1
06N10W23DCDD01	<.1	<30	.8	--	90	<2	<2	6	<2	--	<2	<1
06N09W09BABC01	<.1	<30	.2	--	40	<2	<2	2	<2	--	2	<1
06N09W21BBBB01	<.1	<30	4.0	--	120	<2	<2	<2	--	<40	--	--
	<.1	<40	1.6	.5	50	<5	--	5	--	<40	8	70
05N10W29BABC01	.2	<30	1.1	--	90	<2	3	6	4	--	5	1
05N09W18ADCD01	<.1	<30	8.5	--	210	3	<2	<2	--	<40	--	--
	.1	30	6.7	--	60	6	<2	2	--	<40	--	--
	<.1	<30	8.1	--	<20	<2	<2	<2	--	<40	--	--
	<.1	<40	9.1	<.5	50	<5	--	<4	540	<40	17	63
05N09W18ADCD02	<.1	<30	.9	--	<20	<2	<2	<2	--	<40	--	--
	<.1	<40	1.4	<.5	50	<5	--	<4	<2	<40	16	12
04N10W10DADA01	.1	40	.7	--	90	<2	3	3	<2	--	5	<1

Well or spring number	Mercury (µg/L as Hg)	Molybdenum (µg/L as Mo)	Nickel (µg/L as Ni)	Selenium (µg/L as Se)	Silver (µg/L as Ag)	Strontium (µg/L as Sr)	Titanium (µg/L as Ti)	Vanadium (µg/L as V)	Zinc (µg/L as Zn)	Zirconium (µg/L as Zr)
09N10W04BDBC01	--	<20	<10	1.0	<2	64	6	<1	28	<4
09N10W10CDBD01	--	<20	<10	.1	<2	2,100	<1	<1	6	<4
09N10W24BBCA01	--	<20	<10	.5	<2	700	3	<1	34	<4
09N09W28CCDD01	<.04	--	<10	--	<2	1,200	<1	<1	<3	<4
	.06	--	10	--	<2	1,700	<1	<1	<3	<4
	--	<40	20	--	--	1,900	<4	11	8	<6
09N09W33CDBC01	--	<20	<10	.9	<2	480	6	<1	3	<4
08N09W04DDB 01	.13	<20	<10	--	<2	480	<1	8	<3	<4
	.06	<20	<10	--	<2	480	<1	8	<3	<4
08N09W28DBDC01	--	<20	<10	.1	<2	540	7	<1	9	<4
08N09W32AADD01	<.04	--	<10	--	<2	430	<1	<1	5	<4
	<.04	--	<10	--	<2	490	3	<1	120	<4
08N09W32AADD02	<.04	--	<10	--	<2	290	10	8	6	<4
	--	<40	<20	--	--	300	<4	12	37	<6
08N09W33CCDD01	<.04	<20	<10	.4	<2	360	<1	5	20	<4
07N10W03ABBD01	--	<20	10	<.1	<2	200	7	6	8	<4
07N09W11CDBB01	--	<20	<10	1.5	<2	780	10	5	<3	<4
07N09W31CCBB01	--	<20	<10	.6	<2	160	1	<1	300	<4
06N10W23DCDD01	--	<20	<10	.7	<2	340	3	<1	59	<4
06N09W09BABC01	--	<20	<10	.2	<2	230	2	<1	13	<4
06N09W21BBBB01	<.04	--	<10	--	<2	240	<1	<1	<3	<4
	--	<40	<20	--	--	280	<4	13	19	6
05N10W29BABC01	--	<20	<10	.4	<2	170	3	<1	55	<4
05N09W18ADCD01	.07	--	<10	--	<2	470	3	<1	<3	<4
	.08	--	20	--	<2	690	2	<1	<3	<4
	<.04	--	<10	--	<2	370	30	<1	<3	<4
	--	<40	26	--	--	650	<4	11	10	<6
05N09W18ADCD02	<.04	--	<10	--	<2	320	20	<1	<3	<4
	--	<40	<20	--	--	360	<4	8	<6	<6
04N10W10DADA01	--	<20	<10	.1	4	96	2	5	3	4

Table 3.--Drinking-water regulations for public water supply[1],[2]

[MCL, Maximum Contaminant Level; SMCL, Secondary Maximum Contaminant Level; mg/L, milligrams per liter; µg/L, micrograms per liter; --, no regulation available or not applicable]

Water-quality characteristic	National Primary Drinking-Water Regulation[3] (MCL)	National Secondary Drinking-Water Regulation[4] (SMCL)	Montana drinking-water regulation[5]	Equivalent trace-element concentration[6] for MCL or SMCL (µg/L)
	Maximum concentration or value for indicated regulation			
	Physical property (standard units)			
pH	--	6.5-8.5	--	--
	Common constituents (mg/L)			
Dissolved solids	--	500	500	--
Chloride	--	250	250	--
Fluoride	4.0	2.0	4.0	--
Nitrate (as N)	10	--	--	--
Sulfate	--	250	250	--
	Trace elements (mg/L)			
Aluminum	--	.05-.2	--	50-200
Arsenic	.05	--	.05	50
Cadmium	.005	--	.01	5
Chromium	.1	--	.05	100
Copper[7]	--	1.0	--	1,000
Iron	--	.3	.3	300
Lead[8]	.05	--	.05	50
Manganese	--	.05	.05	50
Mercury	.002	--	.002	2
Selenium	.05	--	.01	50
Silver	--	.1	.05	100
Zinc	--	5.0	--	5,000

[1] Regulations in effect as of July 30, 1992.
[2] Listed only for properties, common constituents, and trace elements analyzed in this report.
[3] U.S. Environmental Protection Agency (1991a).
[4] U.S. Environmental Protection Agency (1991b).
[5] Roy Wells (Water Quality Bureau, Montana Department of Health and Environmental Sciences, oral commun., 1992).
[6] The U.S. Geological Survey reports trace-element concentrations in micrograms per liter.
[7] Copper is covered by an "action level" of 1.3 mg/L (U.S. Environmental Protection Agency, 1991c).
[8] Lead is covered by an "action level" of 0.015 mg/L (U.S. Environmental Protection Agency, 1991c).

Table 4.--Streamflow data for the upper Clark Fork valley, Montana

[Negative sign (-) in front of discharge value indicates flow out of the Clark Fork. Abbreviations: ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius. Symbol: --, no data]

Site number (fig. 15)	Station name	Station number	Date measured	Measured discharge (ft^3/s)	Discharge subtotal[1] (ft^3/s)	Difference[2] (ft^3/s)	Percent difference[3]	Onsite specific conductance (µS/cm)	Onsite pH (standard units)
1M	Clark Fork at Warm Springs	461117112461201	10-21-86	111	--	--	--	510	8.1
2T	Lost Creek near Galen	461305112462301	10-21-86	59.9	--	--	--	625	8.5
3T	Modesty Creek at Galen	461435112454601	10-21-86	14.3	--	--	--	650	8.1
4T	Irrigation diversion above Racetrack bridge	461558112443701	10-21-86	-5.5	--	--	--	--	--
5M	Clark Fork near Racetrack	461559112443301	10-21-86	183	180	+3	+2	563	8.1
6T	Racetrack Creek at Dempsey	461700112445501	10-21-86	25.4	--	--	--	158	7.9
7T	Dempsey Creek near Dempsey	461835112445501	10-21-86	8.4	--	--	--	325	8.1
8M	Clark Fork at Deer Lodge	12324200	10-21-86	[4]272	217	+55	+20	525	8.2
9T	Cottonwood Creek at Deer Lodge	12324250	10-21-86	2.3	--	--	--	376	8.5
10M	Clark Fork near Garrison	12324300	10-21-86	297	274	+23	+8	510	8.4
11T	Little Blackfoot River near Garrison	12324590	10-21-86[5]	[4]81	--	--	--	280	8.0
12M	Clark Fork at Garrison	12324600	10-21-86	388	378	+10	+3	488	8.3
13T	Rock Creek at Garrison	463111112490901	10-21-86	16.9	--	--	--	170	8.2
14T	Willow Creek near Garrison	463202112492601	10-21-86	[6].8	--	--	--	--	--
15T	Warm Springs Creek near Garrison	463230112503501	10-21-86	9.1	--	--	--	912	8.4
16T	Brock Creek near Garrison	463330112515501	10-21-86	.7	--	--	--	544	8.3
17M	Clark Fork below Brock Creek	463319112521001	10-21-86	429	416	+13	+3	472	7.9
18T	Gold Creek at Goldcreek	12324660	10-21-86[5]	24.4	--	--	--	416	7.7
19T	Carten Creek near Goldcreek	463512112542701	10-21-86	[6].2	--	--	--	572	8.4
20M	Clark Fork at Goldcreek	12324680	10-21-86	[4]457	454	+3	+1	468	8.9
21T	Hoover Creek at Jens	463602113002501	10-21-86	.8	--	--	--	639	7.9
22M	Clark Fork at Jens	463542113004201	10-21-86	440	458	-18	-4	468	8.0
23T	Dunkleberg Creek near Goldcreek	463550113021001	10-21-86	2.1	--	--	--	409	8.5
24T	Flint Creek near Drummond	12331500	10-21-86[5]	183	--	--	--	332	7.9
25M	Clark Fork at Drummond	12331600	10-21-86	647	625	+22	+3	440	8.2
26M	Clark Fork below Flint Creek, near Drummond	464245113142201	10-21-86	659	647	+12	+2	448	8.3
27M	Clark Fork at Bearmouth	464242113194501	10-21-86	685	659	+26	+4	471	8.5
28T	Harvey Creek near Drummond	464212113222001	10-21-86	4.0	--	--	--	183	8.4
29M	Clark Fork below Harvey Creek	464202113255001	10-21-86	690	689	+1	0	475	8.1
30T	Tyler Creek near Drummond	464208113271001	10-23-86	6.4	--	--	--	395	8.3
31T	Nimrod Springs near Drummond	464216113272501	10-21-86	7.6	--	--	--	922	7.9
32T	Bateman Creek near Drummond	464150113292801	10-23-86	.3	--	--	--	260	8.1
33T	Gillespie Creek near Clinton	464248113342001	10-21-86	[6].3	--	--	--	414	8.4
34M	Clark Fork near Clinton	12331900	10-21-86	[4]698	705	-7	-1	485	8.6
35M	Clark Fork below Cramer Creek	464330113392001	10-21-86	712	698	+14	+2	478	7.9
36T	Bonita oxbow near Clinton	464330113404101	10-24-86	9.4	--	--	--	395	7.9
37T	Rock Creek near Clinton	12334510	10-21-86[5]	[4]245	--	--	--	149	7.6
38T	Irrigation diversion below Rock Creek	464335113413001	10-24-86	-8.6	--	--	--	--	--
39T	Moe Gulch near Clinton	464332113414001	10-24-86	.9	--	--	--	233	8.1
40T	Swartz Creek at mouth, near Clinton	464504113431201	10-21-86	2.4	--	--	--	314	8.4
41M	Clark Fork below Swartz Creek, at Clinton	464505113431001	10-21-86	--	--	--	--	395	8.3
42M	Clark Fork at Turah Bridge, near Bonner	12334550	10-21-86	[4]983	961	+22	+2	394	8.6

[1]Calculated as discharge at nearest upstream mainstem station plus tributary inflow.
[2]Calculated as the difference between measured discharge and discharge subtotal.
[3]Calculated as follows: (difference between measured discharge and discharge subtotal, divided by discharge) times 100.
[4]Determined from river stage and established rating curve.
[5]Chemical constituents measured 10-20-86.
[6]Estimated.

Table 5.--Stream-water-chemistry data for the upper Clark Fork valley, Montana

[Constituents are dissolved, except as indicated; laboratory analyses by Montana Bureau of Mines and Geology; onsite measurements by U.S. Geological Survey; analyses with same date for a site are duplicate samples. Abbreviations: µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; mg/L, milligrams per liter; IT, incremental titration; µg/L, micrograms per liter. Symbols: --, no data; <, less than the minimum reporting level for analytical method used]

Site number (fig. 15)	Station name	Date of collection	Onsite specific conductance (µS/cm)	Onsite pH (standard units)	Temperature (°C)	Onsite dissolved oxygen (mg/L)	Hardness (mg/L as $CaCO_3$)	Calcium (mg/L as Ca)	Magnesium (mg/L as Mg)	Sodium (mg/L as Na)
1M	Clark Fork at Warm Springs	10-21-86	510	8.1	5.5	9.6	230	67	15	13
5M	Clark Fork near Racetrack	10-21-86	563	8.1	5.0	9.4	260	76	17	15
8M	Clark Fork at Deer Lodge	10-21-86	525	8.2	5.0	10.0	230	68	15	16
10M	Clark Fork near Garrison	10-21-86	510	8.4	5.0	12.2	230	67	15	16
11T	Little Blackfoot River near Garrison	10-20-86	280	8.0	--	10.6	130	38	8.6	6.6
18T	Gold Creek at Goldcreek	10-20-86	416	7.7	5.5	10.0	190	65	7.6	9.0
		10-20-86	--	--	--	--	190	65	7.5	9.0
20M	Clark Fork at Goldcreek	10-21-86	468	8.9	8.0	11.5	210	62	13	14
		10-21-86	--	--	--	--	210	61	14	14
24T	Flint Creek near Drummond	10-20-86	332	7.9	7.0	11.3	150	41	12	8.9
27M	Clark Fork at Bearmouth	10-21-86	471	8.5	7.5	10.9	220	63	15	13
34M	Clark Fork near Clinton	10-21-86	485	8.6	8.0	12.1	220	64	15	14
37T	Rock Creek near Clinton	10-20-86	149	7.6	7.5	10.8	68	17	5.9	3.1
42M	Clark Fork at Turah Bridge, near Bonner	10-21-86	394	8.6	8.5	12.1	180	51	13	11

Site number (fig. 15)	Potassium (mg/L as K)	Onsite bicarbonate (IT), (mg/L as HCO_3)	Onsite carbonate (IT), (mg/L as CO_3)	Onsite alkalinity (IT), (mg/L as $CaCO_3$)	Sulfate (mg/L as SO_4)	Chloride (mg/L as Cl)	Fluoride (mg/L as F)	Bromide (mg/L as Br)	Silica (mg/L as SiO_2)	Dissolved solids, calculated (mg/L)	Nitrate (mg/L as N)
1M	3.0	140	0	110	130	5.1	0.7	<0.1	9.6	309	0.04
5M	2.8	180	0	150	130	5.6	.7	<.1	13	347	.14
8M	2.8	180	0	150	110	6.3	.7	<.1	16	320	.14
10M	2.9	180	6	160	100	6.5	.7	<.1	17	320	.05
11T	1.7	150	0	120	18	1.5	.2	<.1	24	172	.03
18T	2.8	200	0	160	52	1.5	.2	<.1	29	262	.02
	2.9	--	--	--	53	1.5	.2	<.1	30	263	.03
20M	2.7	150	16	150	85	5.1	.6	<.1	18	289	.03
	2.6	--	--	--	86	5.0	.6	<.1	18	289	.03
24T	2.4	180	0	150	22	3.3	.2	<.1	24	201	.02
27M	2.9	170	10	160	82	5.3	.5	<.1	21	296	.02
34M	2.8	180	10	160	86	5.2	.5	<.1	20	303	.04
37T	1.1	84	0	69	7.6	.7	.1	<.1	12	88	.03
42M	2.3	150	9	140	68	4.1	.4	<.1	18	267	.02

Table 5.--Stream-water-chemistry data for the upper Clark Fork valley, Montana--Continued

Site number (fig. 15)	Phosphorus (mg/L as P)	Phosphorus, ortho (mg/L as P)	Aluminum (µg/L as Al)	Arsenic, As^{+3} and As^{+5} (µg/L as As)	Arsenic, As^{+3} (µg/L as As)	Boron (µg/L as B)	Cadmium (µg/L as Cd)	Chromium (µg/L as Cr)	Copper (µg/L as Cu)	Iron (µg/L as Fe)	Lead (µg/L as Pb)
1M	0.1	<0.1	<30	5.1	<0.5	30	<2	<2	14	<2	<40
5M	<.1	<.1	<30	6.5	.5	40	<2	<2	8	<2	<40
8M	<.1	<.1	<30	7.5	<.5	100	<2	<2	4	<2	<40
10M	.1	<.1	<30	7.6	<.5	90	<2	<2	3	<2	<40
11T	<.1	<.1	<30	4.6	.6	30	<2	<2	<2	2	<40
18T	<.1	<.1	<30	2.6	<.5	40	<2	<2	<2	2	<40
	<.1	<.1	<30	2.4	<.5	<20	<2	<2	<2	3	<40
20M	<.1	<.1	<30	7.9	.5	60	<2	<2	4	<2	<40
	<.1	<.1	<30	7.2	<.5	<20	<2	<2	<2	<2	<40
24T	<.1	<.1	<30	7.4	<.5	20	<2	<2	<2	4	<40
27M	<.1	<.1	<30	6.8	<.5	140	<2	<2	<2	<2	<40
34M	<.1	<.1	<30	8.1	<.5	130	<2	<2	<2	<2	<40
37T	<.1	<.1	30	.6	<.5	<20	<2	<2	2	6	<40
42M	.1	<.1	<30	6.7	<.5	40	<2	<2	<2	<2	<40

Site number (fig. 15)	Lithium (µg/L as Li)	Manganese (µg/L as Mn)	Mercury (µg/L as Hg)	Molybdenum (µg/L as Mo)	Nickel (µg/L as Ni)	Silver (µg/L as Ag)	Strontium (µg/L as Sr)	Titanium (µg/L as Ti)	Vanadium (µg/L as V)	Zinc (µg/L as Zn)	Zirconium (µg/L as Zr)
1M	10	350	0.09	<20	<10	<2	180	<1	2	<3	<4
5M	10	95	<.04	<20	<10	<2	240	<1	<1	<3	<4
8M	9	28	<.04	<20	<10	<2	250	<1	<1	<3	<4
10M	11	25	<.04	<20	<10	<2	260	<1	<1	<3	<4
11T	9	3	<.04	<20	<10	<2	150	<1	<1	<3	<4
18T	8	14	.11	<20	<10	<2	230	<1	<1	<3	<4
	9	14	.10	<20	<10	<2	230	<1	<1	<3	<4
20M	11	13	.07	<20	<10	<2	250	<1	<1	<3	<4
	13	13	.16	<20	<10	<2	250	<1	<1	<3	<4
24T	3	19	.13	<20	<10	<2	110	<1	1	<3	<4
27M	12	8	.18	<20	<10	<2	280	<1	<1	<3	<4
34M	9	6	<.04	<20	<10	<2	290	<1	<1	<3	<4
37T	2	1	.10	<20	<10	<2	30	<1	2	<3	<4
42M	8	4	<.04	<20	<10	<2	210	<1	<1	<3	<4