Review and Analysis of Available Streamflow and Water-Quality Data for Park County, Colorado, 1962–98

By Robert A. Kimbrough

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CONVERSION FACTORS, DEFINITIONS, AND ABBREVIATIONS

Multiply	By	To obtain
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
foot (ft)	0.3048	meter (m)
inch	2.54	centimeter (cm)
mile (mi)	1.609	kilometer (km)
pound (lb)	0.4536	kilogram (kg)
square mile (mi^2)	2.590	square kilometer (km^2)

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

$$°F = 1.8\,(°C) + 32$$

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25°C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

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.

Altitude, as used in this report, refers to distance above or below sea level

Additional Abbreviations

cols/100 mL	colonies per 100 milliters
µm	micrometer
pCi/L	picocuries per liter

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Abstract

Information on streamflow and surface-water and ground-water quality in Park County, Colorado, was compiled from several Federal, State, and local agencies. The data were reviewed and analyzed to provide a perspective of recent (1962–98) water-resource conditions and to help identify current and future water-quantity and water-quality concerns.

Streamflow has been monitored at more than 40 sites in the county, and data for some sites date back to the early 1900's. Existing data indicate a need for increased archival of streamflow data for future use and analysis. In 1998, streamflow was continuously monitored at about 30 sites, but data were stored in a data base for only 10 sites.

Water-quality data were compiled for 125 surface-water sites, 398 wells, and 30 springs. The amount of data varied considerably among sites; however, the available information provided a general indication of where water-quality constituent concentrations met or exceeded water-quality standards.

Park County is primarily drained by streams in the South Platte River Basin and to a lesser extent by streams in the Arkansas River Basin. In the South Platte River Basin in Park County, more than one-half the annual streamflow occurs in May, June, and July in response to snowmelt in the mountainous headwaters. The annual snowpack is comparatively less in the Arkansas River Basin in Park County, and mean monthly streamflow is more consistent throughout the year. In some streams, the timing and magnitude of streamflow have been altered by main-stem reservoirs or by interbasin water transfers.

Most values of surface-water temperature, dissolved oxygen, and pH were within recommended limits set by the Colorado Department of Public Health and Environment. Specific conductance (an indirect measure of the dissolved-solids concentration) generally was lowest in streams of the upper South Platte River Basin and higher in the southern one-half of the county in the Arkansas River Basin and in the South Platte River downstream from Antero Reservoir.

Historical nitrogen concentrations in surface water were small. Nitrite was not detected, most un-ionized ammonia concentrations were less than 0.02 milligram per liter, and all nitrate concentrations were less than 1.2 milligrams per liter. Nitrate concentrations were higher in urban and built-up areas than in rangeland and forest areas. Most median concentrations of total phosphorus at individual sites were less than 0.05 milligram per liter, and concentrations were not significantly different among urban and built-up, rangeland, and forest areas. An upward trend in total phosphorus concentration was determined for flow from the East Portal of the Harold D. Roberts Tunnel, but the slope of the trend line was small and the concentrations were equal or nearly equal to the detection limit of 0.01 milligram per liter. Using median phosphorus loads for two South Platte River sites, the annual phosphorus load transported out of Park County in the South Platte River was calculated to be about 10,000 pounds.

Median iron and manganese concentrations for most areas of Park County were less than in-stream water-quality standards, even though several individual concentrations were one to two orders of magnitude larger than the standards. The largest concentrations of aluminum, cadmium, chromium, copper, iron, manganese, nickel, and zinc were from the upper North Fork South Platte River Basin or the Mosquito Creek Basin.

All ground-water concentrations of chloride and most ground-water concentrations of sulfate were less than the U.S. Environmental Protection Agency (USEPA) drinking-water standard of 250 milligrams per liter. Median dissolved-solids concentrations in ground water ranged from 160 milligrams per liter in the crystalline-rock aquifers to 257 milligrams per liter in the sedimentary-rock aquifers. Dissolved-solids concentrations greater than the USEPA drinking-water standard of 500 milligrams per liter were detected in about 10 percent of the wells and in all aquifer types sampled but were most common in samples from the sedimentary-rock aquifers between the towns of Jefferson and Hartsel.

Nitrate concentrations in ground water greater than the USEPA drinking-water standard of 10 milligrams per liter were measured primarily in samples collected during the 1990's in wells located in subdivisions northeast of Bailey. Nitrate concentrations in these subdivision wells were significantly larger than concentrations measured in wells in the same area in the 1970's, indicating a possible increase in ground-water contamination.

Most trace-element concentrations measured in Park County ground water were less than USEPA drinking-water standards; however, standards for iron, manganese, and zinc were exceeded in a small number of samples. Trace-element concentrations exceeding the standards occurred in each aquifer type, and median concentrations of iron, manganese, and zinc were similar among aquifer types.

The physical and chemical characteristics of springwater in Park County varied greatly and were dependent on the type of rock in which the water originated. Specific conductance was lowest in springs originating in the crystalline-rock aquifers of Precambrian age and highest in a spring that may originate in evaporite beds in a sedimentary-rock aquifer that is composed of the Maroon Formation of Paleozoic age.

INTRODUCTION

Located about 50 miles west of the Front Range urban centers of Denver and Colorado Springs (fig. 1), Park County was one of the fastest growing counties in Colorado in 1998, based on percentage of change in population. With increasing population and development comes an increased demand for water resources and the potential to affect the quality of the resource. Local entities in Park County are interested in obtaining current and objective information regarding water quantity and water quality in Park County. This information can be used to determine better land-use and water-management practices to protect existing resources and help identify current and future water-quantity and water-quality concerns.

Prior to an assessment of current hydrologic conditions, a review and analysis of available water-resources data are useful. A review of historical data helps to identify gaps in available data and allows for prioritizing and focusing future studies. In 1999, the U.S. Geological Survey (USGS), in cooperation with Park County and the Center of Colorado Water Conservancy District, compiled and analyzed available information on streamflow and surface-water and ground-water quality in Park County for 1962–98.

Purpose and Scope

This report presents available data for surface- and ground-water resources in Park County for 1962–98. Specific objectives of this report are (1) to summarize historical data on streamflow and on the quality of surface-water and ground-water resources, (2) to analyze historical data and assess the broad-scale spatial and temporal variability in streamflow and water quality, and (3) where possible, to identify, describe, and explain the primary natural and human factors that affect observed streamflow and water quality in Park County.

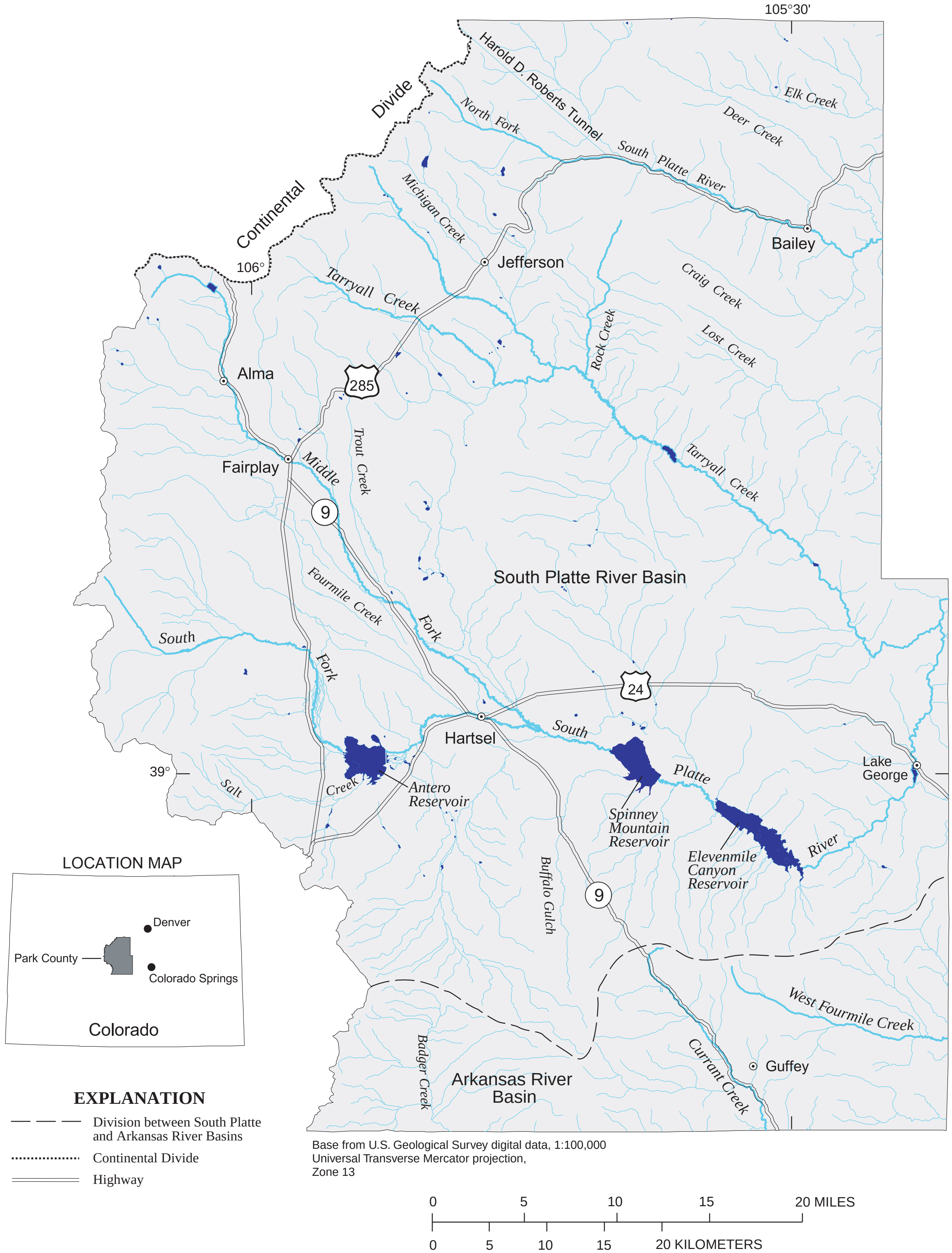

Figure 1. Location of Park County, Colorado.

Streamflow data were compiled for 43 streamflow-gaging stations, and water-quality data were summarized for 125 surface-water sites, 398 wells, and 30 springs. Water-quality analyses exist for various properties and constituents including water temperature, dissolved oxygen, pH, specific conductance, nutrients (nitrogen and phosphorus), major ions, trace elements, radon, radionuclides, and suspended sediment. In this report, the term “surface water” refers to rivers and streams and does not include lakes, reservoirs, wetlands, or ponds.

Acknowledgments

The author thanks the many individuals and agencies that provided water-quantity and water-quality data for Park County. Special thanks are extended to Lynda James, Bob Barford, and Tom Eisenman of Park County; Steve Bohman, Denver Water; Doug Darling, City of Aurora; Joni Nuttle, Colorado Department of Public Health and Environment; Anne Seiler, Rivers of Colorado Water Watch Network; and Robert Cooper, Office of the State Engineer, Colorado Division of Water Resources. The author also thanks USGS employees Sharon Qi and Jennifer Flynn for their assistance with data aggregation and management.

DESCRIPTION OF THE STUDY AREA

Located adjacent to the eastern side of the Continental Divide, Park County encompasses about 2,210 mi^2 in central Colorado (fig. 1). Park County is located in the Front Range Section of the Southern Rocky Mountains Physiographic Province (Dennehy and others, 1993). Most of Park County is situated in the headwaters area of the South Platte River Basin. The major tributaries to the South Platte River in the county are Tarryall Creek and the South, Middle, and North Forks of the South Platte River (hereinafter referred to as the South Fork, Middle Fork, and North Fork) (fig. 1). About 13 percent of the county lies within the Arkansas River Basin. Major tributaries in the Arkansas River Basin include Badger, Currant, and West Fourmile Creeks (located in southern Park County, fig. 1).

The terrain in Park County is varied. A large, grass-covered plateau referred to as South Park is situated in central Park County, and high mountain peaks border the county to the north and west. Land-surface altitude ranges from 14,000-ft mountain peaks along the Continental Divide in the northwestern part of the county to about 7,200 ft where the South Platte River exits the eastern side of the county. Average annual precipitation (1961–90) ranges from about 10 to 40 inches (Daly and Taylor, 1998) and varies with altitude (fig. 2). Precipitation amounts greater than 18 inches per year occur in the Mosquito Range and mountains along the Continental Divide in the western part of the county, in the unnamed mountain range in the northern part of the county, and in the Platte River, Kenosha, and Tarryall Mountains in the eastern part of the county. Much of the mountain precipitation is in the form of snow, which on average accumulates to more than 300 inches per year in the mountains north and west of Alma (fig. 2). Annual average precipitation is least in an area surrounding the town of Hartsel (fig. 2).

Land cover in Park County is 53 percent natural herbaceous plants, grasses, and sedges (herbaceous rangeland at lower altitudes, tundra at higher altitudes); 39 percent forest (deciduous and evergreen); 5 percent alpine (mixture of tundra, snow, ice, and barren rock); 2 percent pasture or hay; and 1 percent open water (fig. 3). Trees and shrubs also exist with the herbaceous land cover but generally account for less than 25 percent of the cover.

The population of Park County in 1998 was 13,330. Some of the major urban areas in Park County include the towns of Alma, Bailey, Fairplay, and Lake George (fig. 3). Built-up land use is a subcategory of urban land use. Built-up areas consist of low-density housing and other development and are located along stream valleys or in land parcels referred to as subdivisions. The extent of built-up areas in Park County may be inferred from a figure showing existing wells in the county in 1996 (fig. 4). Although the towns of Alma, Bailey, and Fairplay have public water-supply systems, most county residences receive their domestic water supply from individual wells. The largest clusters of wells are located in the northwestern part of the county near Alma and Fairplay, in areas to the west and south of Jefferson, and in the North Fork of the South Platte River Basin northeast of Bailey. Wells in the Arkansas River Basin are located primarily in the southeastern corner of the county from Guffey east to the county line.

The surficial geology of Park County (fig. 5) ranges from unconsolidated alluvial deposits of Quaternary age to crystalline rocks of Precambrian age (Tweto, 1979; Klein and others, 1978). The

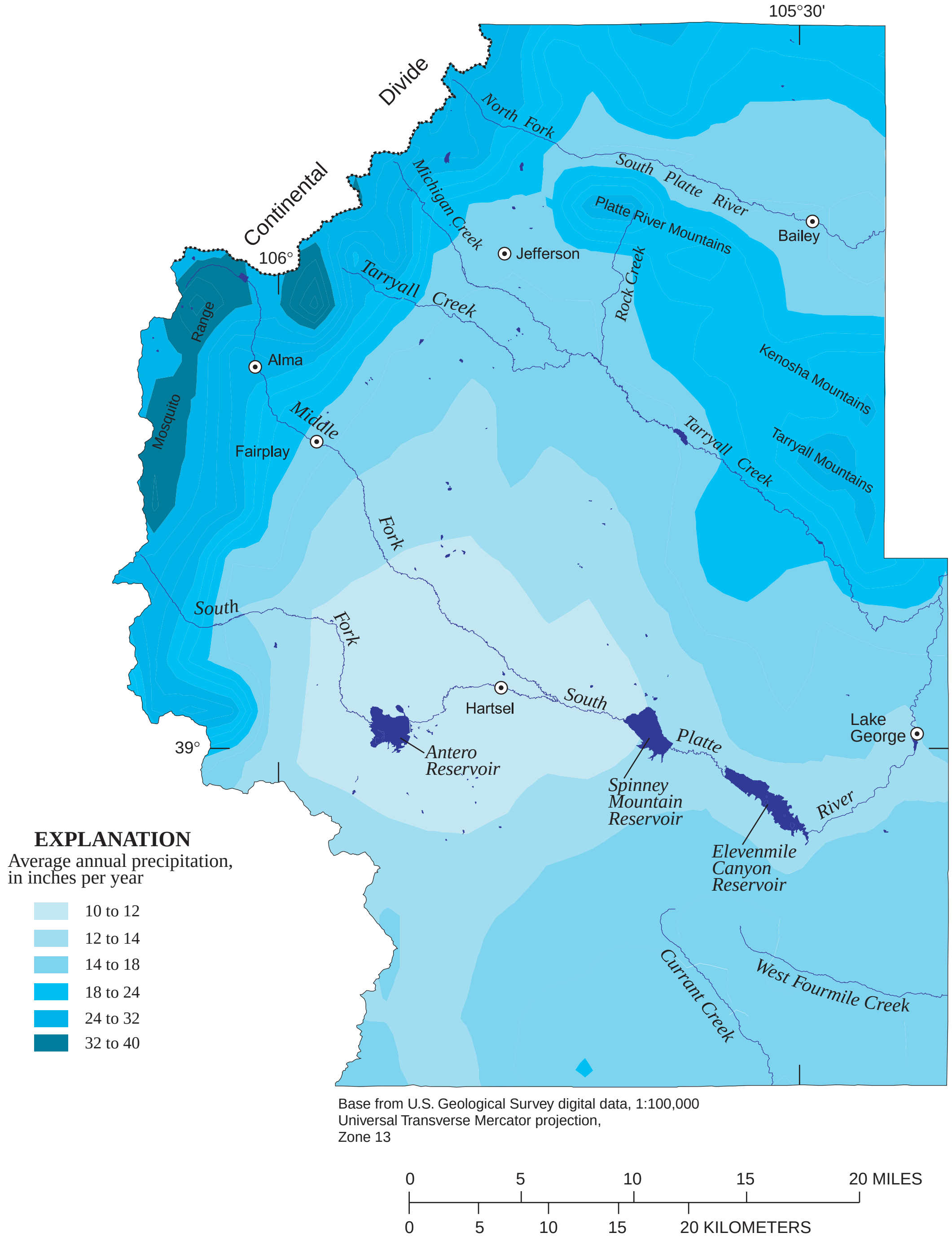

Figure 2. Average annual precipitation in Park County, 1961–90.

youngest rocks in Park County are the unconsolidated alluvial deposits of Quaternary age. Glacial material consisting of gravel, cobbles, and boulders in or near the mountains are the most extensive alluvial deposits, and valley-fill material consisting predominantly of sand and gravel occurs along all major and most minor streams throughout the county. Located in middle Park County in north-south-trending bands are outcrops of the South Park Formation, a sedimentary rock of Tertiary age. Other sedimentary rocks of Tertiary age include the Wagontongue and Antero Formations, which occur in the vicinity of Hartsel and in the southwest part of the county. The Wagontongue Formation contains reworked volcanic material; the Antero Formation is composed of conglomerate, sandstone, lacustrine limestone, and interbedded volcanic flows.

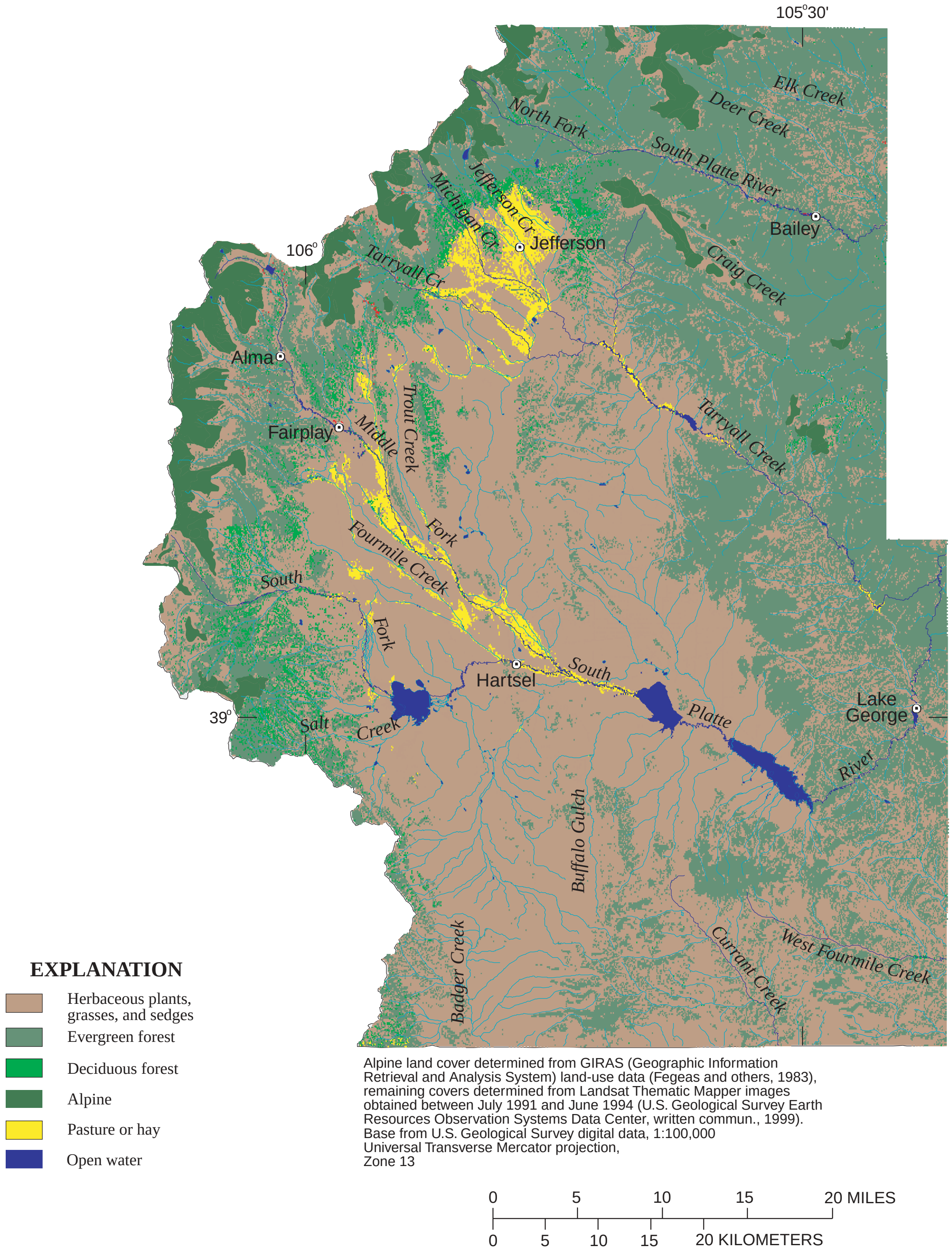

Figure 3. Land cover for Park County.

An extensive series of intrusive and volcanic rocks of Tertiary and Cretaceous age cover a large part of southern Park County extending from near Hartsel, south to the county line. These rocks primarily consist of pre-ash and intra-ash-flow andesitic lava, breccia, tuff, and conglomerate. Sedimentary rocks of Cretaceous and Jurassic age form north-south-trending bands in middle Park County and are predominantly composed of Pierre Shale and, to a lesser extent, the Niobrara Shale and Dakota Sandstone of Cretaceous age, and the Morrison and Entrada Formations of Jurassic age. The sedimentary rocks of Paleozoic age on the eastern flanks of the Mosquito Range in western Park County consist of the Leadville Limestone and Sawatch Sandstone Formations of pre-Pennsylvanian age and arkosic sandstone, conglomerate, shale, and limestone of Pennsylvanian age. The crystalline rocks of Precambrian age occupy about 45 percent of the land surface in the county, primarily on the eastern side, and include igneous granites belonging to three distinct age groups of 1, 1.4, and 1.7 billion years and metamorphic rocks composed of gneiss, schist, and migmatite that are 1.7 to 1.8 billion years old.

The four primary aquifer types in Park County are alluvial aquifers of Quaternary age; sedimentary-rock aquifers of Tertiary, Cretaceous, Jurassic, and Paleozoic age; volcanic-rock aquifers of Tertiary age; and crystalline-rock aquifers of Precambrian age (Klein and others, 1978). Alluvial aquifers are

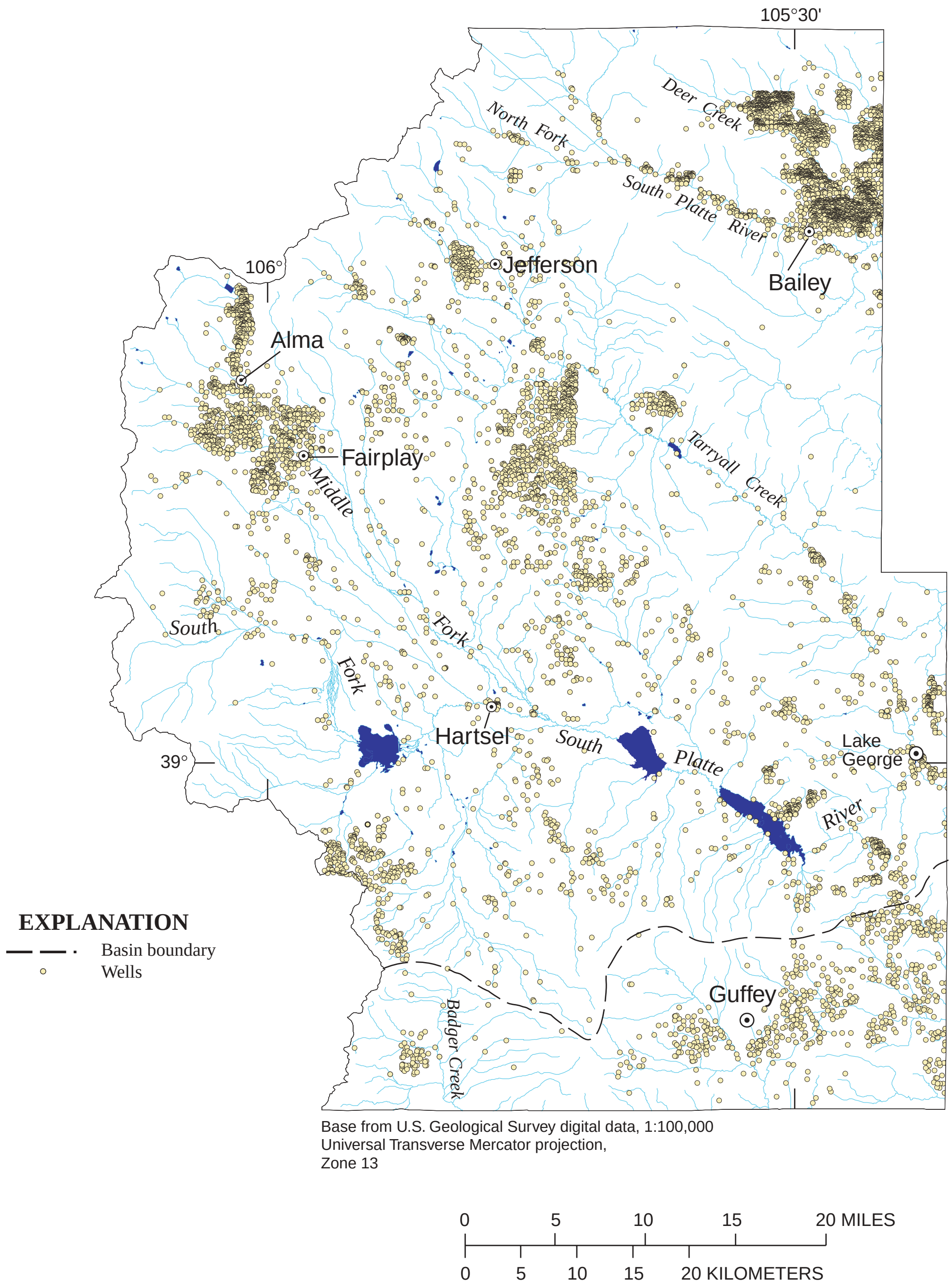

Figure 4. Locations of wells in Park County, 1996 (Office of the State Engineer, Colorado Division of Water Resources, written commun., 1999).

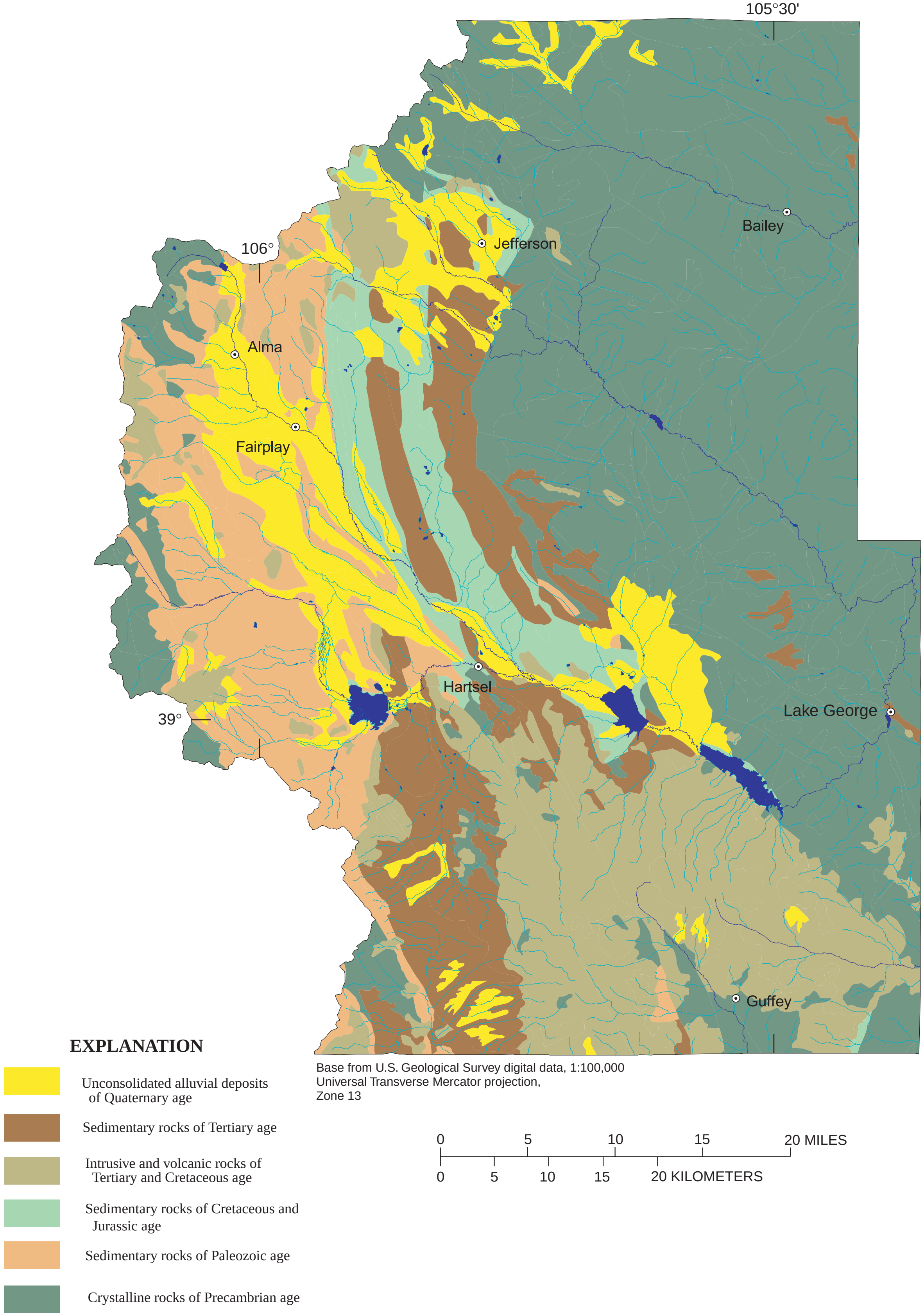

Figure 5. Generalized surficial geology of Park County (Green, 1992; Tweto, 1979).

composed of unconsolidated alluvial deposits of Quaternary age. The principal geologic units of the sedimentary-rock aquifers include the Antero, Florissant Lake Beds, South Park, and Wagontongue Formations of Tertiary age; the Pierre Shale and Dakota Sandstone of Cretaceous age; the Entrada Formation of Jurassic age, and the Leadville and Maroon Formations of Paleozoic age. A principal geologic unit of the volcanic-rock aquifers is the Thirtynine Mile Andesite of Tertiary age. The principal geologic units of the crystalline-rock aquifers are the Boulder Creek, Silver Plume, and Pikes Peak Granite of Precambrian age.

DATA SOURCES AND COMPILATION

Data collected by a variety of Federal, State, and local agencies during1962–98 are used in this report. Sources for surface-water-, ground-water-, and springwater-quality data are listed in table 1. Streamflow data were retrieved in electronic format from the USGS National Water Information System (NWIS) data base and from the Office of the State Engineer, Colorado Division of Water Resources (SEO). Most water-quality data were obtained from the U.S. Environmental Protection Agency's (USEPA) Storage and Retrieval (STORET) system, the USGS NWIS data base, or data bases maintained on personal

Table 1. Sources of water-related data for Park County, 1962–98

[E, electronic; P, paper; WEB, World Wide Web; NWIS, U.S. Geological Survey National Water Information System; STORET, U.S. Environmental Protection Agency Storage and Retrieval System; PC, personal computer]

Agency	Number of sites/samples	Data format	Data source (data-base name, data-base type, or publication)
Streamflow			
Office of the State Engineer, Colorado Division of Water Resources	24 sites	E	WEB-accessed data base.
U.S. Geological Survey	19 sites	E	NWIS data base.
Surface-water quality			
City of Aurora	2/97	E	PC-based data base.
Colorado Department of Public Health and Environment	58/95	E, P	STORET data base, and Simsiman, 1998.
Colorado Division of Wildlife, Rivers of Colorado Water Watch Network	7/311	E	WEB-accessed data base.
Colorado Geological Survey	2/50	E	STORET data base.
Denver Water	15/1,145	E	STORET and PC-based data bases.
National Park Service	11/11	E	STORET data base.
Park County Department of Environmental Health	24/159	P	McBride and Cooper, 1991, Johnson and Cooper, 1993, Johnson, 1993, 1994.
U.S. Forest Service	12/63	E	STORET data base.
U.S. Geological Survey	72/3, 970	E, P	NWIS data base.
Ground-water quality			
Park County Department of Environmental Health	194/194	P	Nitrate in domestic wells, 1994–95, unpublished data.
U.S. Forest Service	24/75	P	Nitrate in campground wells, Pike National Forest, unpublished data.
U.S. Geological Survey	180/180	E	NWIS data base.
Springwater quality			
National Park Service	7/7	E	STORET data base.
U.S. Geological Survey	23/30	E	NWIS data base.

computers (PC) by individual agencies. Some of the information was accessed using the internet through the World Wide Web. A small amount of data was obtained from written documents or reports. Detailed information on sample-collection procedures and analysis was not available for all of the water-quality data; however, the water-quality data summarized in this report were assumed to be reliable for the general assessment of water-quality conditions in Park County. Acquired water-quality data were entered into a PC-based relational data base to facilitate the analysis of historical and current (1998) water-quality conditions in Park County.

METHODS OF WATER-QUALITY DATA REVIEW AND ANALYSIS

This report includes statistical summaries of constituent concentrations and physical properties in surface water, ground water, and springs. Because laboratory analytical methods differed among agencies, the laboratory analytical reporting (or detection) limits for given constituents were not consistent. Data that are less than reporting limits are censored data. In order to statistically summarize constituent concentrations and not exclude all of the censored data, a common reporting limit is desirable. For the data used in this report, the most common reporting limit was kept, values that were censored above the most common reporting limit were deleted, and censored values below the most common reporting limit were converted to the most common limit. Statistical summaries also may be influenced by the occurrence of more frequent sampling at a particular site. To reduce this bias, the number of analyses used for the statistical summaries was limited to two samples per month per site.

Water-quality results are graphically displayed in this report. Boxplots are used primarily for displaying the variability in a concentration data set (fig. 6). These plots show five percentiles of the data distribution: the 10th, 25th, 50th (median), 75th, and 90th percentiles. Boxplots are only displayed for data sets with at least nine samples. Data sets with fewer than nine samples are plotted as individual data points (fig. 6). A constituent reporting limit typically is the lower limit on a concentration plot (fig. 6); thus, individual data points less than the reporting limit are not shown. Similarly, a part of a concentration boxplot may be missing from the graph if a particular constituent has several concentrations less than the reporting limit. A second graphical technique used in this report shows the spatial distribution of median constituent concentrations at sampling sites throughout Park County in map form. The concentration intervals used in figures 11, 13, 14, 21, and 25 are (1) less than the 25th percentile (white dots), (2) between the 25th and 50th percentiles (yellow dots), (3) between the 50th and 75th percentiles (orange dots), (4) between the 75th and 90th percentiles (red dots), and (5) greater than the 90th percentile (red triangles). The values of the percentiles in these figures were obtained from the statistical summary tables (tables 4, 8, and 11). In order to use all data compiled for Park County, the median concentration at some sites may be the constituent concentration determined from a single sample. Larger data sets are desired to determine more accurately the actual variability of a constituent concentration at a particular site.

Water-quality data were analyzed using nonparametric statistical methods. Nonparametric methods are not strongly influenced by outliers, require few assumptions about the statistical properties of a data set, and are suitable for use with small data sets. The Mann-Whitney U test (Helsel and Hirsch, 1992) was used to determine if significant statistical differences exist between two data sets. Attained significance levels, or p-values, were reported to determine the strength of each test at a 95-percent confidence level. A statistical difference in median values for three or more data sets was evaluated with the Kruskal-Wallis test (Helsel and Hirsch, 1992). If a significant difference between medians was indicated, individual differences between medians were evaluated by applying Tukey’s multiple comparison test (Helsel and Hirsch, 1992) to the rank-transformed data. Letters were placed next to the median of each boxplot (fig. 6) to show the results of the multiple comparison tests. Boxplots identified by the same letter indicate that the medians were not significantly different, whereas differing letters indicate significantly different medians. For the Mann-Whitney, Kruskal-Wallis, and Tukey’s tests, an alpha value of 0.05 was used to evaluate the significance of test results, and censored values in the tested data sets were treated as equal to the reporting limit.

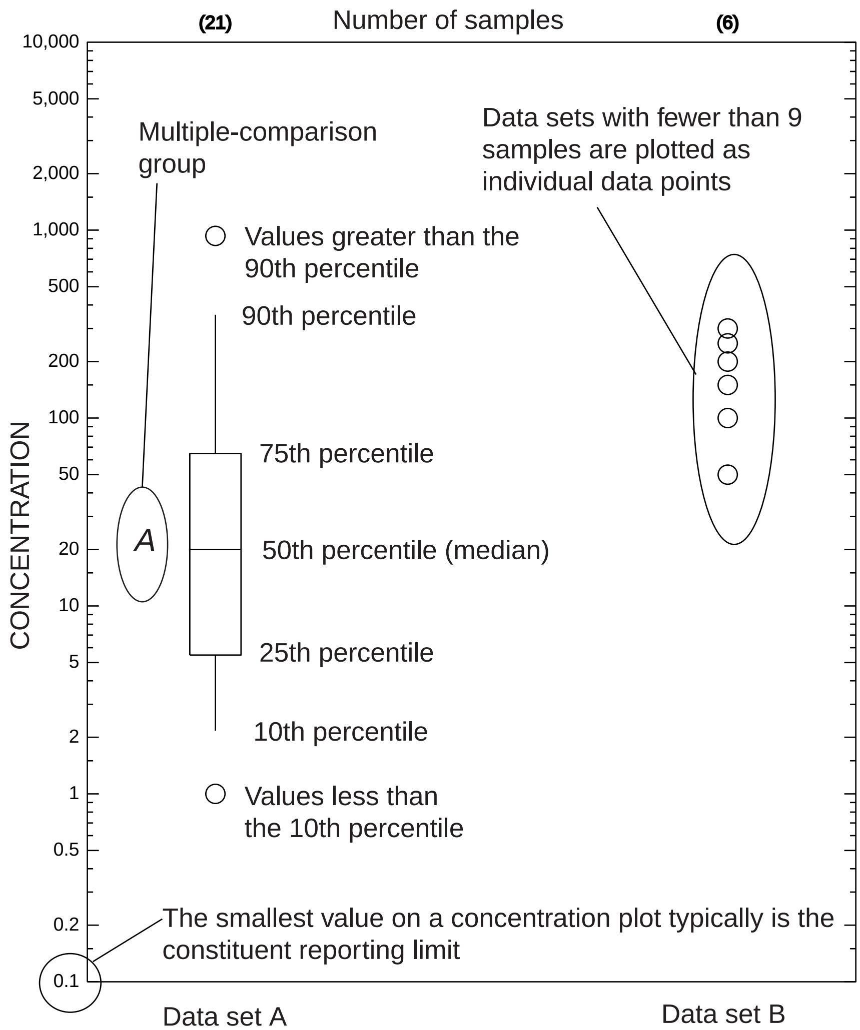

Figure 6. Explanation of a concentration plot.

Nutrient concentrations at selected sites were tested for time trends by using the seasonal Kendall test (Hirsch and others, 1991). In order to provide current information on nutrient trends in surface water, only sites having nutrient data from samples collected in the 1990's were considered for testing. The Kendall test accounts for seasonal effects on nutrient concentrations by comparing data within the same season; therefore, sites used for calculating trends needed a data set with a minimum of quarterly sampling. Additionally, at least one-half of the data must have been uncensored and present in the first and last one-third of the record (Lanfear and Alexander, 1990). Concentrations used for trend analysis were not adjusted for variability due to streamflow because correlations were not observed between discharge and concentrations.

The nutrient data obtained from various sources for this report were reported using several different conventions. For example, nitrate nitrogen data were reported as dissolved nitrate as nitrogen, total nitrate as nitrogen, and dissolved nitrate as nitrate. In order to reduce the number of nutrient species discussed, nutrient data in this report have been grouped into equivalent nitrogen and phosphorus species using methods described by Mueller and others (1995). The nutrient species summarized in this report are ammonia and un-ionized ammonia as nitrogen (hereinafter referred to as ammonia), nitrite as nitrogen (hereinafter referred to as nitrite), nitrate as nitrogen (hereinafter referred to as nitrate), dissolved orthophosphorus as phosphorus (hereinafter referred to as orthophosphorus), and total phosphorus.

The distribution of nitrate and total phosphorus in surface water is classified by land use/land cover in this report. The land-use/land-cover classifications were determined by the land use/land cover upstream from or in the vicinity of the surface-water sampling sites. Land-use/land-cover classifications used in the analysis of the data were urban and built-up land use, rangeland (herbaceous rangeland at lower altitude and pasture), and forest (deciduous and evergreen). Land-use/land-cover classifications were determined only for sites with nitrate and total phosphorus data.

The water-quality data have been compared to standards or guidelines where applicable. Standards for several constituents have been set for most stream segments in Park County (Colorado Department of Public Health and Environment, 1998a, 1999a). Standards are based on a stream's designated classification with regard to aquatic life, recreation, drinking-water supply, and agriculture. Standards for several trace elements are site specific because a mean stream hardness value is needed to calculate the numerical standard by using a formula. These types of standards, referred to as Table Value Standards by the Colorado Department of Public Health and Environment (CDPHE), are not calculated in this report. Trace-element standards also are designated as acute or chronic. Acute standards, which apply to 24-hour periods, usually are higher than chronic standards, which apply to 30-day periods. When both standards apply, the lower numerical standards are used for comparison with water-quality data in this report. All standards are levels not to be exceeded more than once every 3 years on average; therefore, constituent concentrations in individual samples that exceed these criteria may not necessarily indicate a violation of a standard.

Most ground-water-quality data for Park County were obtained from domestic wells that are a source of drinking water in individual homes; therefore, the ground-water data have been compared to USEPA maximum contaminant levels (MCL's) and secondary maximum contaminant levels (SMCL's) for drinking water (U.S. Environmental Protection Agency, 1996). Water-quality data for springs also are compared to USEPA drinking-water standards. The USEPA MCL's are enforceable standards that apply to finished drinking water in all public water-supply systems and are not legally applicable to individual domestic wells. Comparisons between the USEPA criteria and Park County ground-water and springs data are offered only as a point of reference for the constituents and physical properties measured in Park County.

STREAMFLOW

Streamflow has been monitored at more than 40 streamflow-gaging stations in Park County with data for some sites dating back to the early 1900's (fig. 7, table 2). Streamflow is currently (1998) monitored at 30 sites (table 2), although flow data are currently archived or stored in USGS or SEO data bases for only 10 of the 30 sites (table 2). Aside from the three sites where interbasin water transfers are monitored (sites SG1, SG20, SG37, table 2), active sites with currently archived data are located on the South Fork, North Fork, and Tarryall Creek (one site per stream); on the main-stem South Platte River (three sites), and on Badger Creek in the Arkansas River Basin (fig. 7). Active sites without archived data are concentrated in the Middle Fork and Tarryall Creek Basins (fig. 7) and are primarily operated for the purpose of administering water rights on a daily or real-time basis from April through September. Streamflow data are not currently collected or archived on the North Fork South Platte near the county line, anywhere along the Middle Fork South Platte, nor on the main-stem South Platte at the county line (fig. 7).

In the South Platte River Basin in Park County, most streamflow is derived from snowmelt in the mountainous areas of the watersheds and more than one-half the annual streamflow occurs in May, June, and July (fig. 8A and B). During the remainder of the year, streamflow is typically less than one-third the mean annual flow. With the absence of high mountain peaks and a large winter snowpack, the annual distribution and magnitude of streamflow in the Arkansas River Basin in Park County differs from that in the South Platte. Aside from a small snowmelt peak in April and May, average monthly streamflow in Badger Creek remains fairly consistent throughout the year (fig. 8C).

The influence of physiography on streamflow also is indicated by measures of runoff (table 2). Runoff is largest at stations located near the mountains where precipitation amounts are highest. Runoff decreases with increasing drainage area, indicating that areas at lower altitude contribute less runoff than the mountain areas.

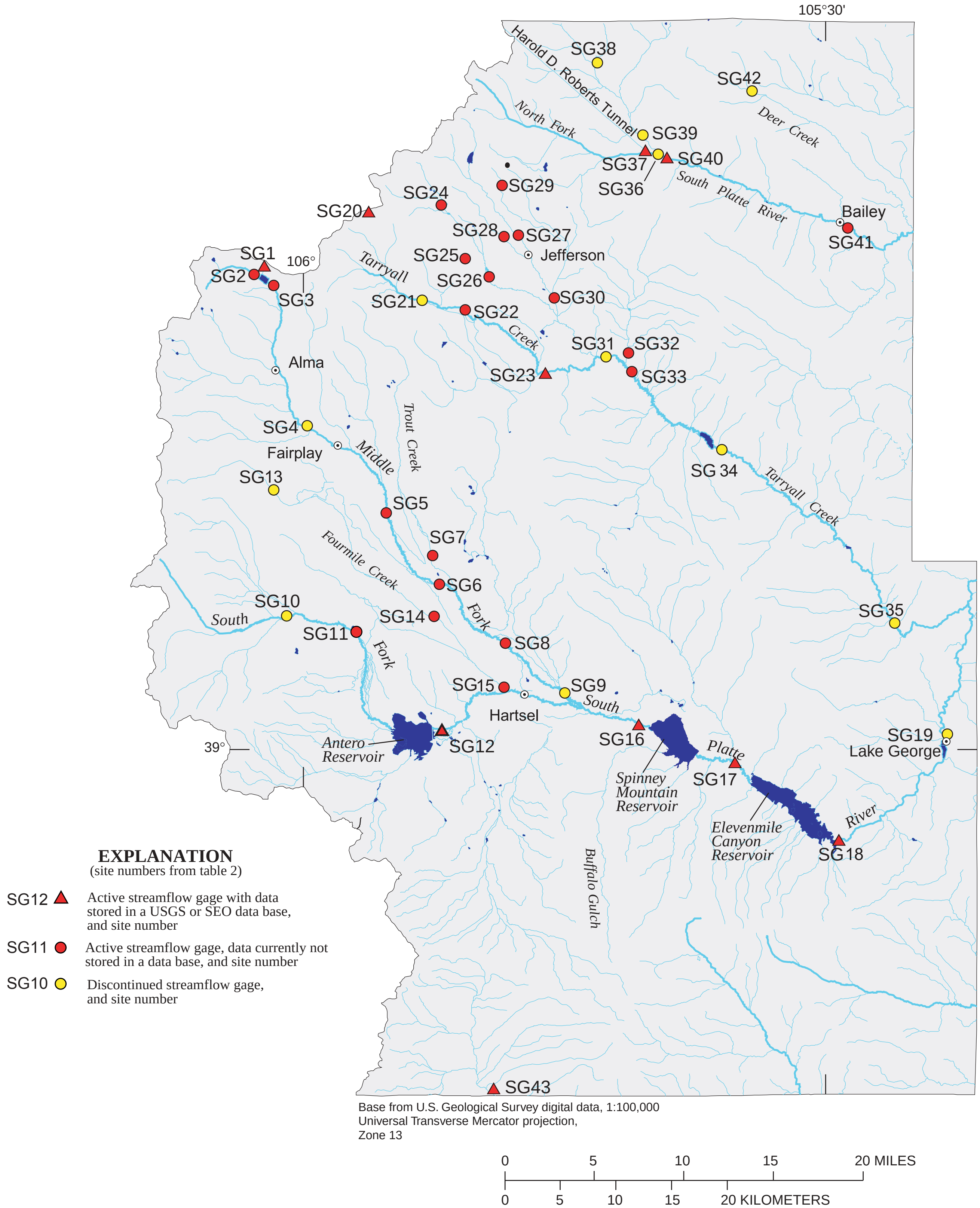

Figure 7. Selected streamflow-gaging stations in Park County (USGS, U.S. Geological Survey; SEO, Office of the State Engineer, Colorado Division of Water Resources).

Table 2. Hydrologic characteristics for selected streamflow-gaging stations in Park County

[--, no data or not computed]

Site no. (fig. 7)	Site name	Site identifier	Period of record stored in a data base, in water years[1]	Drainage area, in square miles	Mean annual streamflow, in cubic feet per second	Mean annual runoff, in inches	Gage status, as of December 1998
SG1	Hoosier Pass Tunnel at Montgomery Reservoir	09042000	1953–98	28	11.8	--	Active
SG2	Middle Fork South Platte River above Montgomery Reservoir	MFKABMCO	None	--	--	--	Active
SG3	Middle Fork South Platte River below Montgomery Reservoir	MFKBLMCO	None	--	--	--	Active
SG4	Middle Fork South Platte River above Fairplay	06693980	1979–80	62.2	50.5	11.0	Discontinued
SG5	Spring Branch above Middle Fork South Platte River, near Fairplay	SPRBRNCO	None	--	--	--	Active
SG6	Middle Fork South Platte River near Prince Ditch at Garo	MFKPRICO	None	--	--	--	Active
SG7	Trout Creek near Garo	TROGARO	None	--	--	--	Active
SG8	Middle Fork South Platte River at Santa Maria Ranch	MFSTMCO	None	--	--	--	Active
SG9	Middle Fork South Platte River near Hartsel	06694100	1979–80	250	60.5	3.3	Discontinued
SG10	South Fork South Platte River above Fairplay	06694400	1979–80	50.3	28.4	7.7	Discontinued
SG11	South Fork South Platte River above Antero Reservoir	SFKANTCO	None	--	--	--	Active
SG12	South Fork South Platte River below Antero Reservoir	06694650	1976–98	--	28.3	--	Active
SG13	Fourmile Creek near Fairplay	06694700	1979–80	12.0	13.4	15.2	Discontinued
SG14	Fourmile Creek at High Creek Ranch	FOUHIGCO	None	--	--	--	Active
SG15	Fourmile Creek near Hartsel	FOUHARCO	None	--	--	--	Active
SG16	South Platte River above Spinney Mountain Reservoir	06694920	1986–98	--	102	--	Active
SG17	South Platte River above Elevenmile Canyon Reservoir	06695000	1940–98	880	88.5	1.4	Active
SG18	South Platte River near Lake George	06696000	1930–98	963	83.1	1.2	Active
SG19	South Platte River at Lake George	06696200	1912–29	1,084	114	1.4	Discontinued
SG20	Boreas Pass Ditch at Boreas Pass	09046000	1933–40, 1949–98	--	0.14	--	Active
SG21	Tarryall Creek at Upper Station near Como	06696980	1979–86	--	20.7	11.9	Discontinued
SG22	Tarryall Creek at U.S. Highway 285 near Como	TARCOMCO	None	23.7	--	--	Active
SG23	Tarryall Creek below Park Gulch near Como	06697100	1998	72.9	12.4	2.3	Active
SG24	French Creek near Jefferson	06697200	1986–90	4.6	--	--	Active
SG25	Schattinger Flume above Michigan Creek	SCHFLMCO	None	--	--	--	Active
SG26	Michigan Creek near Jefferson	06697450	1979–86	23.1	15.0	8.8	Active
SG27	Jefferson Creek near Jefferson	06698000	1979–86	11.8	8.9	10.2	Active
SG28	Ohler Gulch near Jefferson	OHGJEFCO	None	--	--	--	Active

Table 2. Hydrologic characteristics for selected streamflow-gaging stations in Park County—Continued

[--, no data or not computed]

Site no. (fig. 7)	Site name	Site identifier	Period of record stored in a data base, in water years[1]	Drainage area, in square miles	Mean annual streamflow, in cubic feet per second	Mean annual runoff, in inches	Gage status, as of December 1998
SG29	Deadman Gulch near Jefferson	DEDJEFCO	None	--	--	--	Active
SG30	Jefferson Creek below Snyder Creek	JEFSYNCO	None	--	--	--	Active
SG31	Tarryall Creek near Jefferson	06698500	1913–17, 1978–81	183	42.2	3.1	Discontinued
SG32	Rock Creek above Tarryall Creek	06699000	1987–90	45.5	--	--	Active
SG33	Tarryall Creek below Rock Creek near Jefferson	06699005	1984–97	230	50.8	3.0	Active
SG34	Tarryall Creek below Tarryall Reservoir	TARCRECO	1975–80	--	--	--	Discontinued
SG35	Tarryall Creek near Lake George	06699500	1944, 1950–55	434	29.0	1.7	Discontinued
SG36	North Fork South Platte River at Grant	06722500	1911–17	49.0	31.2	8.6	Discontinued
SG37	East Portal Harold D. Roberts Tunnel near Grant	09050590	1964–98	--	67.2	--	Active
SG38	Duck Creek near Grant	06704500	1995–97	7.8	6.3	11.0	Discontinued
SG39	Geneva Creek at Grant	06705500	1914–17, 1995–97	74.6	74.2	13.5	Discontinued
SG40	North Fork South Platte River below Geneva Creek at Grant	06706000	1909–98	127	[2]72.0	7.7	Active
SG41	North Fork South Platte River at Bailey	PLABAICO	None	--	--	--	Active
SG42	Deer Creek near Bailey	393040105340400	1997	13.4	16.6	16.8	Discontinued
SG43	Badger Creek, upper station, near Howard[3]	07093740	1982–98	106	[4]5.9	0.8	Active

[1]Data bases maintained by the U.S. Geological Survey or Colorado State Engineers Office.
[2]Adjusted for inflow from Harold D. Roberts Tunnel since 1964.
[3]Located about 3 miles downstream from the Park County boundary.
[4]Computed with 1982–86 data (gage operation has been seasonal since 1987).

The natural hydrology of the South Platte River in Park County has been affected by water management. The timing and magnitude of streamflow have been altered by a network of irrigation ditches, reservoirs, and interbasin water transfers from the Arkansas and Colorado River Basins. The effects of reservoir management on a 15-mile reach of the main-stem South Platte River are illustrated in figure 8D. Streamflow in this reach of the river is routed through two main-stem reservoirs: Spinney Mountain and Elevenmile Canyon Reservoirs. The hydrograph for the South Platte River upstream from Spinney Mountain Reservoir (site SG16) shows characteristics of flow in a natural mountain stream. After peaking in June from snowmelt runoff, streamflow progressively decreases through February until snowmelt begins again in March. Ground-water return flows are the predominant source of water in the river from October through February. The hydrograph for the South Platte River downstream from Elevenmile Canyon Reservoir (site SG18) shows how reservoir operations affect both the timing and magnitude of streamflow. Downstream from Elevenmile Canyon Reservoir, the annual streamflow peak has shifted to later in the year (July). In addition, the magnitude of the annual peak is reduced so that water stored in the reservoir may be released at a higher rate throughout the remainder of the year.

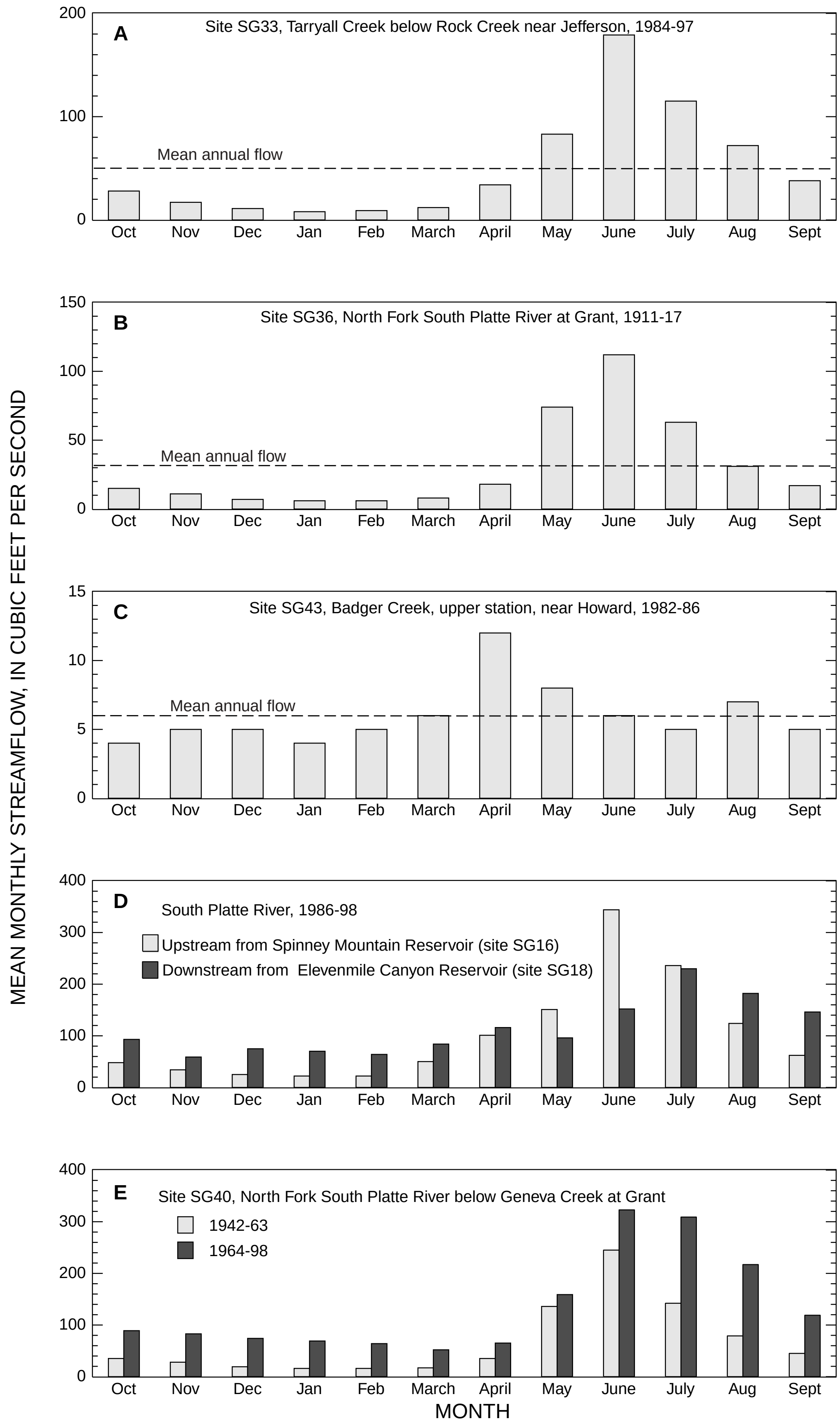

Figure 8. Mean monthly streamflow at selected surface-water sites in Park County (site numbers from table 2).

The magnitude of increases in streamflow from an interbasin water transfer is shown for the North Fork South Platte River in figure 8E. Diversions beginning in 1964 from Lake Dillon in the Colorado River Basin have increased the mean annual flow in the North Fork by about 90 percent, and mean streamflow has increased during every month. Additions to streamflow as a percentage of pretransfer mean monthly flow are largest from July through March, when the percentage of increase ranges from 100 percent in July to almost 300 percent in January and February.

SURFACE-WATER QUALITY

Surface-water-quality data were obtained for 125 sites in Park County (figs. 9 and 10, table 3). Sites sampled in close proximity to each other by various agencies have been combined under one site number in table 3, but information pertaining to data gathered by each sampling agency is provided. The period of record, total number of samples collected, and types of acquired data varied considerably among the 125 sites. More than one-half (79) of the sites have had fewer than 10 samples collected, whereas 15 sites have had more than 100 samples collected. A few sites were sampled several times in each decade since the 1960's including site 36 on the South Fork, site 46 on the main-stem South Platte River, sites 89 and 110 on the North Fork, and site 92, the East Portal of the Harold D. Roberts Tunnel.

Water-quality data for surface water in Park County are summarized in table 4. The physical properties usually measured in the field (water temperature, dissolved oxygen, pH, and specific conductance) have been measured at most surface-water sites. Constituents commonly sampled for include major ions, nutrients (nitrogen and phosphorus), and trace elements. Physical properties and constituents sampled for less frequently are alkalinity, hardness, turbidity, bacteria, organic carbon, radionuclides, and suspended sediment.

Physical Properties

Water temperatures ranged from 0° to 26.0° C in surface water, and only 1 percent of the temperatures were higher than 20° C, the CDPHE in-stream standard for streams in Park County. Most dissolved-oxygen concentrations were larger than the CDPHE minimum in-stream standard of 6.0 mg/L. Four of five dissolved-oxygen concentrations less than the standard were from the South Fork downstream from Antero Reservoir (sites 36 and 39, fig. 9) and may be indicative of dissolved-oxygen concentrations in water released from the bottom of the reservoir. Most pH values were within the 6.5 to 9.0 standard for surface water set by the CDPHE. About 9 percent of the pH values were less than 6.5, and almost all of these were from the North Fork upstream from Geneva Creek and in the tributaries Handcart Gulch and Geneva Creek (fig. 10B). About 1 percent of the pH values were larger than 9.0, and most of these were from the South Fork downstream from Antero Reservoir (site 36, fig. 9).

Specific conductance is an indirect measure of the dissolved-solids concentration (the dissolved-solids component of surface water is discussed in more detail in the next section). The conversion factor between specific conductance and dissolved solids is usually between 0.55 and 0.75 (Hem, 1989). Because it is easily obtained with a field meter, measurement of specific conductance has been done at many surface-water sites in Park County, and the number of measurements is greater than the number of dissolved-solids analyses.

Specific conductance in surface water ranged from 8 to 24,000 μS/cm. Specific conductance was lowest at sites in the mountains near the headwaters of the Middle and North Forks and Tarryall Creek watersheds in the northern one-half of the county (fig. 11) (primarily Elk Creek, Deer Creek, and tributaries in upper Geneva, Tarryall, and Mosquito Creeks) (figs. 9 and 10). Specific-conductance values in the interquartile range of all values (indicated by yellow and orange dots in fig. 11) were primarily in the North Fork, Tarryall, and Middle Fork Basins. The highest values of specific conductance generally were detected in the southern one-half of the county in the main-stem South Platte River or Arkansas River Basin but also were found in Handcart Gulch in the North Fork Basin (sites 82 and 83); along Park Gulch in the Tarryall Creek Basin (sites 57–60); and Trout Creek in the Middle Fork Basin (site 31). With a value of 20,600 μS/cm, the median specific conductance in Salt Creek (site 35) was at least one order of magnitude larger than the median of any other stream in the county.

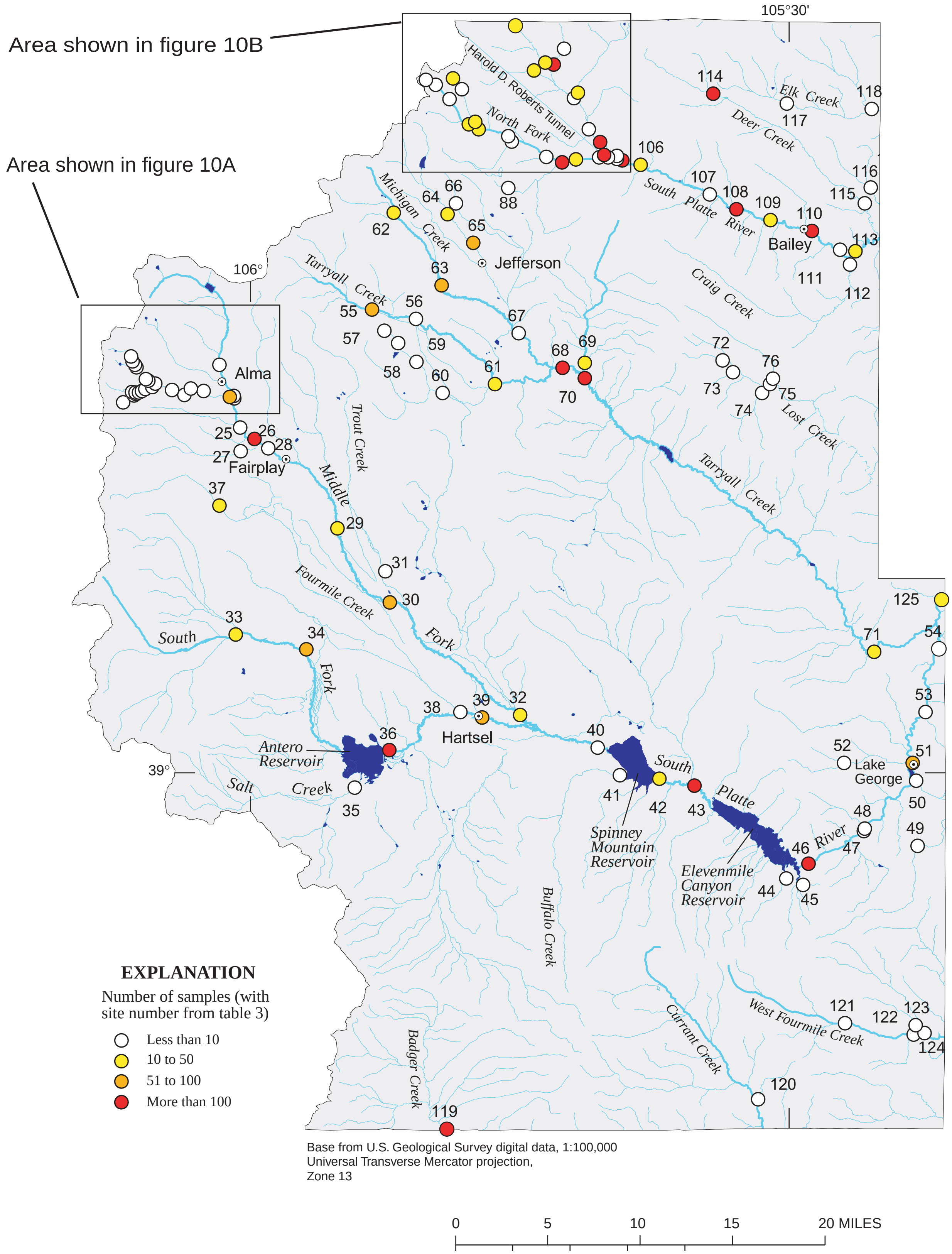

Figure 9. Surface-water-quality sites in Park County, 1962–98.

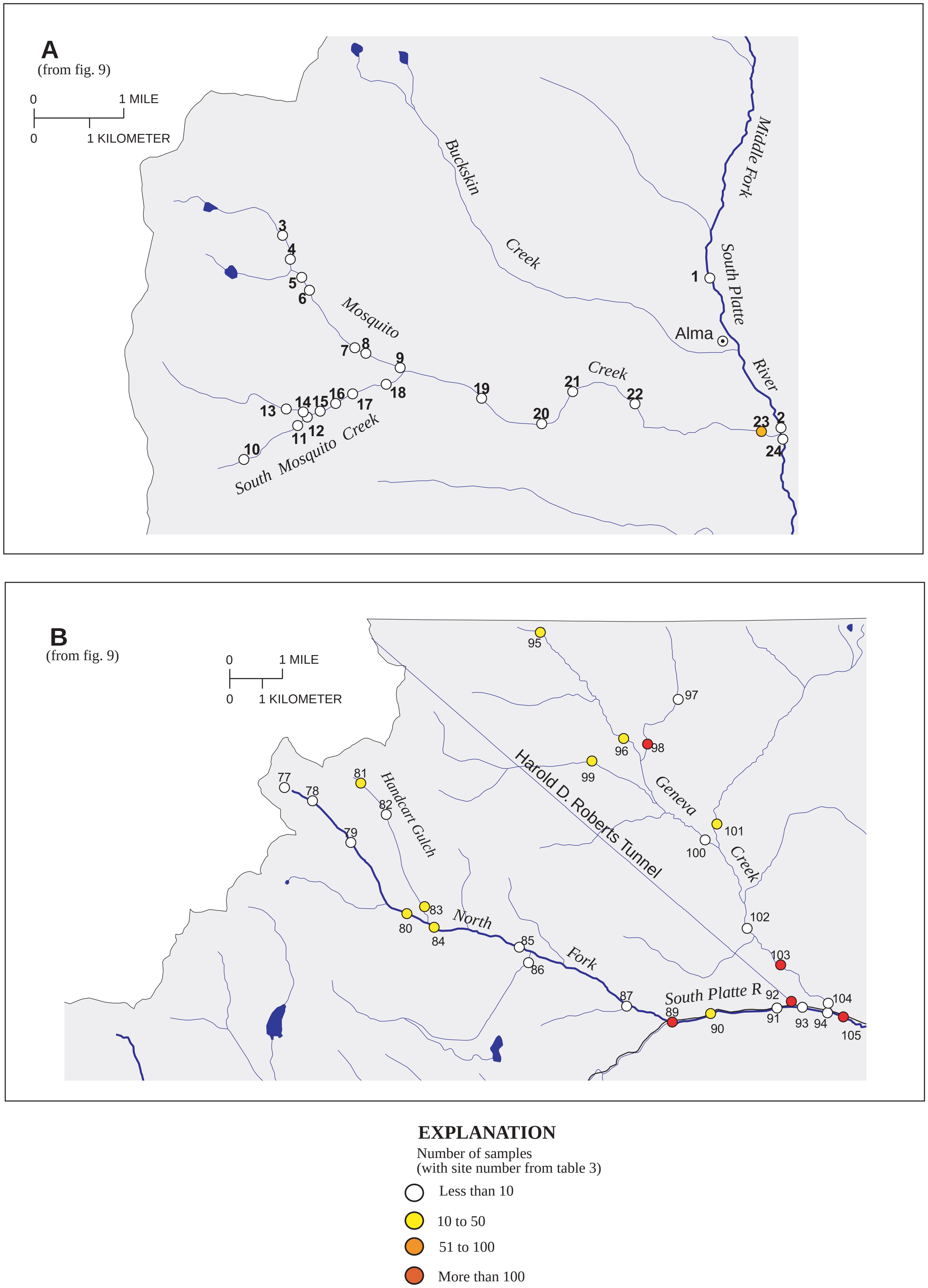

Figure 10. Surface-water-quality sites in the (A) Mosquito Creek Basin and (B) upper North Fork South Platte River Basin, Park County, 1962–98.

Table 3. Characteristics of surface-water-quality sites in Park County, 1962–98

[no., number; latitude and longitude in degrees, minutes, and seconds; USGS, U.S. Geological Survey; CDPHE, Colorado Department of Public Health and Environment; PCDEH, Park County Department of Environmental Health; ROCWWN, Rivers of Colorado Water Watch Network; CGS, Colorado Geological Survey; DW, Denver Water; USFS, U.S. Forest Service; NPS, National Park Service; PP, physical properties; MI, major ions; TE, trace elements; N, nutrients; B, bacteria; R, radionuclides; O, other constituents (carbon, turbidity, or suspended sediment); Urban/BU, Urban or built up; --, not determined]

Site no. (figs. 9–10)	Site Name	Site identifier	Latitude	Longitude	Data source	Period of record	No. of samples	Type of data collected	Land use/ land cover
1	Middle Fork South Platte River above Alma, CO	391740106035400	391740	1060354	USGS	1971 and 1974	3	PP, MI, TE, N, O	Urban/BU
2	Middle Fork South Platte River above Mosquito Creek	LM–SW20	391613	1060304	CDPHE	1996	1	PP, TE	--
		MCBRIDE8	391613	1060302	PCDEH	1990	3	PP, MI, TE, N	
		MF1	391617	1060302	CDPHE	1988–99	2	PP, TE	
3	Upper Mosquito Creek	LM–SW01	391801	1060916	CDPHE	1996	1	PP, TE	--
		M9	391800	1060912	CDPHE	1990	2	PP, MI	
4	Mosquito Creek above the North London Mill	M8	391748	1060909	CDPHE	1990	1	PP	--
5	Mosquito Creek below Tributary from Oliver Twist Mine	LM–SW03	391741	1060908	CDPHE	1996	1	PP, TE	--
		M6	391736	1060858	CDPHE	1990	1	PP, TE	
6	Mosquito Creek below North London Mine	LM–SW07	391729	1060856	CDPHE	1996	1	PP, TE	--
7	Mosquito Creek above road to Alma-American Mine	M3	391704	1060811	CDPHE	1990	2	PP, MI, TE	--
8	Mosquito Creek below Alma-American tailings	M2	391654	1060811	CDPHE	1988–90	4	PP, MI, TE	--
		MC1	391654	1060811	CDPHE	1988–89	2	PP, TE	
9	Mosquito Creek above road to London Mine	LM–SW08	391654	1060736	CDPHE	1996	1	PP, TE	--
		M1	391647	1060745	CDPHE	1988–90	4	PP, MI, TE	
		MC2	391647	1060745	CDPHE	1988–89	2	PP, TE	
10	South Mosquito Creek headwaters area	LM–SW09	391551	1060942	CDPHE	1996	1	PP, TE	--
11	South Mosquito Creek above Butte tailings	SMC1	391612	1060903	CDPHE	1988–89	2	PP, TE	--
12	South Mosquito Creek above No Name Creek	LM–SW10	391619	1060857	CDPHE	1996	1	PP, TE	--
		SMC2	391616	1060855	CDPHE	1988	1	PP, TE	
13	No Name Creek above London Extension Mine Discharge	LM–SW12	391618	1060910	CDPHE	1996	1	PP, TE	--
		NN1	391621	1060911	CDPHE	1988	1	PP	
14	No Name Creek above South Mosquito Creek	LM–SW13	391619	1060858	CDPHE	1996	1	PP, TE	--
		NN2	391618	1060903	CDPHE	1988–89	2	PP, TE	
15	South Mosquito Creek below No Name Creek	LM–SW14	391621	1060846	CDPHE	1996	1	PP, TE	--

Table 3. Characteristics of surface-water-quality sites in Park County, 1962–98—Continued

[no., number; latitude and longitude in degrees, minutes, and seconds; USGS, U.S. Geological Survey; CDPHE, Colorado Department of Public Health and Environment; PCDEH, Park County Department of Environmental Health; ROCWWN, Rivers of Colorado Water Watch Network; CGS, Colorado Geological Survey; DW, Denver Water; USFS, U.S. Forest Service; NPS, National Park Service; PP, physical properties; MI, major ions; TE, trace elements; N, nutrients; B, bacteria; R, radionuclides; O, other constituents (carbon, turbidity, or suspended sediment); Urban/BU, Urban or built up; --, not determined]

Site no. (figs. 9–10)	Site Name	Site identifier	Latitude	Longitude	Data source	Period of record	No. of samples	Type of data collected	Land use/ land cover
16	South Mosquito Creek below London Mine Discharge	SMC3	391625	1060834	CDPHE	1988–89	2	PP, TE	--
17	South Mosquito Creek next to London Mine tailings	SMC4	391631	1060822	CDPHE	1988–89	2	PP, TE	--
18	South Mosquito Creek below London Mine tailings	LM–SW15	391637	1060757	CDPHE	1996	1	PP, TE	--
		SMC5	391637	1060753	CDPHE	1988–89	2	PP, TE	
19	Mosquito Creek below South Mosquito Creek	MC3	391628	1060645	CDPHE	1988–89	2	PP, TE	--
20	Mosquito Creek below Montgomery-Alma/Betts Mill tailings	LM–SW17	391614	1060559	CDPHE	1996	1	PP, TE	--
21	Mosquito Creek at Park City	MC4	391634	1060537	CDPHE	1988–89	2	PP, TE	--
22	Mosquito Creek at Kootchie Kootchie Road	LM–SW18	391626	1060450	CDPHE	1996	1	PP, TE	--
23	Mosquito Creek at mouth	5988	391613	1060314	CDPHE	1997–98	4	PP, MI, TE, N, B	Urban/BU
		BELOW PC	391608	1060307	ROCWWN	1993–95	46	PP, TE	
		LM–SW19	391614	1060322	CDPHE	1996	1	PP, TE	
		MC5	391612	1060304	CDPHE	1988–89	2	PP, TE	
		MCBRIDE9	391609	1060305	PCDEH	1990	3	PP, MI, TE, N	
24	Middle Fork South Platte River below Mosquito Creek	LM–SW21	391606	1060259	CDPHE	1996	1	PP, TE	--
		MF2	391603	1060257	CDPHE	1988–89	2	PP, TE	
25	Middle Fork South Platte River below Pennsylvania Creek	LM–SW22	391444	1060236	CDPHE	1996	1	PP, TE	--
		MF3	391438	1060235	CDPHE	1988	1	PP, TE	
26	Middle Fork South Platte River above Fairplay, CO	06693980	391412	1060143	USGS	1977–80	37	PP	Urban/BU
		391412106014200	391412	1060142	CGS	1973–76	30	PP. MI, TE, N, R	
		COUNTY RD 14	391410	1060143	ROCWWN	1992–95	46	PP, TE	
		LM–SW23	391408	1060143	CDPHE	1996	1	PP, TE	
27	Sacramento Creek near mouth near Fairplay, CO	391338106023300	391338	1060233	USGS	1971	1	PP, MI, TE, O	--
28	Middle Fork South Platte River below Sacramento Creek	LM–SW24	391641	1060124	CDPHE	1996	1	PP, TE	--
		MF4	391346	1060052	CDPHE	1988–89	2	PP, TE	
29	Middle Fork South Platte River below Fairplay, CO	391002105563800	391002	1055638	USGS	1972 and 1974	3	PP, MI, TE, N, B	Rangeland
		391309105593500	391309	1055935	CGS	1972–76	20	R	
		MF5	391000	1055608	CDPHE	1989	1	TE	

Table 3. Characteristics of surface-water-quality sites in Park County, 1962–98—Continued

[no., number; latitude and longitude in degrees, minutes, and seconds; USGS, U.S. Geological Survey; CDPHE, Colorado Department of Public Health and Environment; PCDEH, Park County Department of Environmental Health; ROCWWN, Rivers of Colorado Water Watch Network; CGS, Colorado Geological Survey; DW, Denver Water; USFS, U.S. Forest Service; NPS, National Park Service; PP, physical properties; MI, major ions; TE, trace elements; N, nutrients; B, bacteria; R, radionuclides; O, other constituents (carbon, turbidity, or suspended sediment); Urban/BU, Urban or built up; --, not determined]

Site no. (figs. 9–10)	Site Name	Site identifier	Latitude	Longitude	Data source	Period of record	No. of samples	Type of data collected	Land use/ land cover
30	Middle Fork South Platte River at Highway 9 near Garo	001103	390631	1055326	DW	1973–81, 1983–91, 1994	80	PP, MI, TE, N, B, R, O	Rangeland
		MCBRIDE11	390653	1055434	PCDEH	1990	3	PP, MI, TE, N	
31	Trout Creek near mouth near Garo	390802105534200	390802	1055342	USGS	1974	2	PP, MI, TE, N	Rangeland
32	Middle Fork South Platte River near Hartsel, CO	06694100	390120	1054529	USGS	1977–79	36	PP	Rangeland
		390105105451800	390105	1054518	USGS	1974	2	PP, MI, TE, N	
33	South Fork South Platte River below Rough and Tumbling Creek	06694400	390457	1060252	USGS	1977–80	34	PP	Forest
		390458105024900	390458	1050249	USGS	1974	2	PP, MI, TE, N	
34	South Fork South Platte River above Antero Reservoir	001101	390422	1055827	DW	1971, 1973–92, 1994, 1997–98	65	PP, MI, TE, N, B, R, O	Rangeland
		390419105582600	390419	1055826	USGS	1972	1	PP, MI, TE, N	
		MCBRIDE10	390415	1055825	PCDEH	1990	3	PP, MI, TE, N	
35	Salt Creek above Antero Reservoir	385750105552500	385750	1055525	USGS	1974	2	PP, MI, TE, N	Rangeland
36	South Fork South Platte River below Antero Reservoir	001102	385940	1055345	DW	1962–63, 1965, 1967–82, 1984–98	134	PP, MI, TE, N, B, R, O	Rangeland
37	Fourmile Creek near Fairplay, CO	06694700	391104	1060347	USGS	1977–80	36	PP	--
		089801	391031	1060306	USFS	1968–72	10	PP, MI, B, O	
38	Four Mile Creek at mouth	390126105490500	390126	1054905	USGS	1974	2	PP, MI, TE, N	Rangeland
39	South Fork South Platte River at Hartsel, CO	001104	390115	1054815	DW	1973–81, 1984–88, 1994, 1997–98	54	PP, MI, TE, N, B, R, O	Urban/BU
		390112105474600	390112	1054746	USGS	1974	2	PP, MI, TE, N, B	
40	South Platte River above Spinney Mountain Reservoir	001125	385910	1054052	DW	1997–98	5	PP, TE, N, B, O	Rangeland
41	Buffalo Gulch at mouth	385831105384000	385831	1053840	USGS	1974	2	PP, MI, TE, N	Rangeland
42	South Platte River below Spinney Mountain Reservoir	BLWSPINNEYAUR	385822	1053702	AURORA	1992–98	34	PP, MI, TE, N, O	Rangeland
43	South Platte River above Elevenmile Canyon Reservoir	001105	385804	1053454	DW	1967, 1971, 1973–80, 1984–92, 1997–98	73	PP, MI, TE, N, B, R, O	Rangeland
		06695000	385803	1053451	USGS	1972, 1978–86, 1992	191	PP, MI, TE, N, O	
		385804105345500	385804	1053455	USGS	1974	2	PP, MI, TE, N	

Table 3. Characteristics of surface-water-quality sites in Park County, 1962–98—Continued

[no., number; latitude and longitude in degrees, minutes, and seconds; USGS, U.S. Geological Survey; CDPHE, Colorado Department of Public Health and Environment; PCDEH, Park County Department of Environmental Health; ROCWWN, Rivers of Colorado Water Watch Network; CGS, Colorado Geological Survey; DW, Denver Water; USFS, U.S. Forest Service; NPS, National Park Service; PP, physical properties; MI, major ions; TE, trace elements; N, nutrients; B, bacteria; R, radionuclides; O, other constituents (carbon, turbidity, or suspended sediment); Urban/BU, Urban or built up; --, not determined]

Site no. (figs. 9–10)	Site Name	Site identifier	Latitude	Longitude	Data source	Period of record	No. of samples	Type of data collected	Land use/ land cover
44	Simms Creek above Elevenmile Canyon Reservoir	FLFO_NURE_21	385342	1052921	NPS	1976	1	PP, MI, TE	--
45	Ranger Station Gulch above Elevenmile Canyon Reservoir	FLFO_NURE_04	385335	1052841	NPS	1976	1	PP, MI, TE	--
46	South Platte River below Elevenmile Canyon Reservoir	001106	385418	1052821	DW	1962–98	142	PP, MI, TE, N, B, R, O	Urban/BU
		06696000	385419	1052822	USGS	1975, 1978–87	204	PP, MI, TE, N, O	
47	South Platte River above Messenger Gulch	FLFO_NURE_22	385557	1052442	NPS	1976	1	PP, MI, TE	--
48	Messenger Gulch at Mouth	FLFO_NURE_20	385604	1052438	NPS	1976	1	PP, MI, TE	--
49	Fish Creek above County Line	FLFO_NURE_62	385516	1052127	NPS	1976	1	PP, MI, TE	--
50	Twin Creek at mouth	385821105213300	385821	1052133	USGS	1974–75	3	PP, MI, TE, N	Urban/BU
		FLFO_NURE_19	385822	1052124	NPS	1976	1	PP, MI, TE	
51	South Platte River below Lake George at Lake George, CO	001113	385911	1052146	DW	1975–81, 1984–90, 1998	49	PP, MI, TE, N, B, O	Urban/BU
		SCHOOL BRIDGE	385822	1053702	ROCWWN	1993–94, 1996–97	36	PP, TE	
52	Adamans Creek above Link Creek	FLFO_NURE_23	385910	1052554	NPS	1976	1	PP, MI, TE	--
53	South Platte River below Lake George, CO	390135105205900	390135	1052059	USGS	1974–75	3	PP, MI, TE, N, B	Urban/BU
54	South Platte River above Cheesman	080401	390423	1051813	USFS	1968–71	7	PP, MI, B, O	--
55	Tarryall Creek above Como, CO	06696980	392022	1055437	USGS	1977–86	97	PP	Forest
		392022105543900	392022	1055439	USGS	1974	2	PP, MI, TE, N	
56	Tarryall Creek at U.S. Highway 285 near Como, CO	391958105520200	391958	1055202	USGS	1998	1	PP, MI, TE, N, O	Rangeland
		MCBRIDE7	391956	1055201	PCDEH	1990	3	PP, MI, TE, N	Rangeland
57	Park Gulch above Como, CO	391922105535400	391922	1055354	USGS	1997	1	PP, MI, TE, N, O	Rangeland
58	Park Gulch below Como, CO	391847105530400	391847	1055304	USGS	1997	1	PP, MI, TE, N, O	Rangeland
59	Park Gulch above King Mine near Como, CO	391755105515600	391755	1055156	USGS	1997	1	PP, MI, TE, N, O	Rangeland
60	Park Gulch above Slater Ditch near Como, CO	391628105502100	391628	1055021	USGS	1997	1	PP, MI, TE, N, O	Rangeland
61	Tarryall Creek below Park Gulch near Como, CO	06697100	391654	1054711	USGS	1997–98	29	PP, MI, TE, N, O	Rangeland
		391653105471200	391653	1054712	USGS	1974	2	PP, MI, TE, N, O	
62	French Creek near Jefferson, CO	06697200	392321	1053807	USGS	1986–90	39	PP	--
63	Michigan Creek above Jefferson, CO	06697450	392132	1055027	USGS	1977–86, 1998	95	PP, MI, TE, N, O	Rangeland
		MCBRIDE6	392103	1054955	PCDEH	1990	3	PP, MI, TE, N	

Table 3. Characteristics of surface-water-quality sites in Park County, 1962–98—Continued

[no., number; latitude and longitude in degrees, minutes, and seconds; USGS, U.S. Geological Survey; CDPHE, Colorado Department of Public Health and Environment; PCDEH, Park County Department of Environmental Health; ROCWWN, Rivers of Colorado Water Watch Network; CGS, Colorado Geological Survey; DW, Denver Water; USFS, U.S. Forest Service; NPS, National Park Service; PP, physical properties; MI, major ions; TE, trace elements; N, nutrients; B, bacteria; R, radionuclides; O, other constituents (carbon, turbidity, or suspended sediment); Urban/BU, Urban or built up; --, not determined]

Site no. (figs. 9–10)	Site Name	Site identifier	Latitude	Longitude	Data source	Period of record	No. of samples	Type of data collected	Land use/ land cover
64	Jefferson Creek below Jefferson Lake near Jefferson, CO	392453105501100	392453	1055011	USGS	1998	1	PP, MI, TE, N, O	Forest
		FS0212001000001	392500	1055000	USFS	1976–80	11	PP, MI, TE, N, B, O	
65	Jefferson Creek near Jefferson, CO	06698000	392324	1054838	USGS	1977–86	92	PP	--
		MCBRIDE5	392334	1054838	PCDEH	1990	3	PP, MI, TE, N	
66	Deadman Creek near Jefferson Creek	FS0212001000002	392600	1053000	USFS	1976–80	9	PP, MI, TE, N, B, O	Forest
67	Michigan Creek below Jefferson, CO	391918105454500	391918	1054545	USGS	1974	2	PP, MI, TE, N, B	Rangeland
68	Tarryall Creek near Jefferson, CO	06698500	391742	1054305	USGS	1977–81	109	PP, MI, TE, N, B, R, O	Rangeland
69	Rock Creek near Jefferson, CO	06699000	391729	1054143	USGS	1986–90, 1995	45	PP	--
70	Tarryall Creek below Rock Creek near Jefferson, CO	06699005	391713	1054143	USGS	1983–97	137	PP, N	Rangeland
71	Tarryall Creek near mouth	001107	390448	1052526	DW	1967–68, 1970–71, 1973–74, 1981, 1984–90	38	PP, MI, TE, N, B, R, O	Rangeland
		080201	390455	1052442	USFS	1968–72	7	PP, MI, B, O	
		390425105240600	390425	1052406	USGS	1972	1	PP, MI, TE, N	
		390426105240500	390426	1052405	USGS	1974–75	3	PP, MI, TE, N	
72	Monkey Creek	FS0212004000007	391730	1053330	USFS	1980	1	PP, MI, O	--
73	No Name Creek	FS0212004000006	391715	1053245	USFS	1980	1	PP, MI, O	--
74	Indian Creek	FS0212004000005	391645	1053100	USFS	1980	1	PP, MI, O	--
75	South Fork Lost Creek	FS0212004000003	391700	1053030	USFS	1980	2	PP, MI, B, O	--
76	North Fork Lost Creek	FS0212004000004	391715	1053020	USFS	1980	2	PP, MI, B, O	--
77	Tributary northwest of Missouri Mine	NFSP15	393112	1055132	CDPHE	1990	1	PP	--
78	North Fork South Platte River	NFSP9	393059	1055056	CDPHE	1990	1	TE	--
79	North Fork South Platte River above Gibson Lake Trail	NFSP6	392929	1054927	CDPHE	1990	1	PP, TE	--
		NFSP7	393018	1055006	CDPHE	1990	1	PP, TE	
80	North Fork South Platte River above Hall Creek Campground	BJOHNSON5	392903	1054839	PCDEH	1992–94	13	PP, MI, TE, N	--
		MCBRIDE3	392904	1054840	PCDEH	1990	3	PP, MI, TE, N	
		NFSP17	392910	1054859	CDPHE	1990	1	PP, TE	
		NFSP5	392908	1054848	CDPHE	1990	1	PP, TE	
81	Handcart Gulch near headwaters	113	393117	1054954	USGS	1979	1	PP, MI, TE	--
		BJOHNSON1	393115	1055006	PCDEH	1992	6	PP, MI, TE, N	
		BJOHNSON2	393117	1054955	PCDEH	1992–94	10	PP, MI, TE, N	

Table 3. Characteristics of surface-water-quality sites in Park County, 1962–98—Continued

[no., number; latitude and longitude in degrees, minutes, and seconds; USGS, U.S. Geological Survey; CDPHE, Colorado Department of Public Health and Environment; PCDEH, Park County Department of Environmental Health; ROCWWN, Rivers of Colorado Water Watch Network; CGS, Colorado Geological Survey; DW, Denver Water; USFS, U.S. Forest Service; NPS, National Park Service; PP, physical properties; MI, major ions; TE, trace elements; N, nutrients; B, bacteria; R, radionuclides; O, other constituents (carbon, turbidity, or suspended sediment); Urban/BU, Urban or built up; --, not determined]

Site no. (figs. 9–10)	Site Name	Site identifier	Latitude	Longitude	Data source	Period of record	No. of samples	Type of data collected	Land use/ land cover
82	Handcart Gulch below headwaters	BJOHNSON3	393046	1054923	PCDEH	1992	6	PP, MI, TE, N	--
83	Handcart Gulch at mouth	147	392904	1054827	USGS	1979	1	PP, MI, TE	--
		BJOHNSON4	392905	1054829	PCDEH	1992–94	13	PP, MI, TE, N	
		HANDCART	392905	1054827	CDPHE	1990	1	PP, TE	
		MCBRIDE2	392906	1054830	PCDEH	1990	3	PP, MI, TE, N	
84	North Fork South Platte River below Handcart Gulch	BJOHNSON6	392858	1054824	PCDEH	1992–94	13	PP, MI, TE, N	--
85	North Fork South Platte River above Beaver Creek	392832105461700	392832	1054617	USGS	1971	1	PP, MI, TE, O	--
		NFSP4	392833	1054620	CDPHE	1990	1	PP, TE	
86	Beaver Creek	BEAVER	392830	1054616	CDPHE	1990	1	PP, TE	--
87	North Fork South Platte River 1 mile above Webster	MCBRIDE4	392738	1054411	PCDEH	1990	3	PP, MI, TE, N	--
88	Hoosier Creek	FS0212007000002	392600	1054630	USFS	1980	4	PP, O	--
89	North Fork South Platte River at Webster, CO	001201	392724	1054312	DW	1967–81, 1983–90, 1994	134	PP, MI, TE, N, B, R, O	Forest
		392725105432400	392725	1054324	USGS	1972	1	PP, MI, TE, N	
		5915	392709	1054323	CDPHE	1997–98	5	PP, MI, TE, N, B	
		NFSP2	392724	1054314	CDPHE	1990	1	PP, TE	
		NFSP3	392726	1054321	CDPHE	1990	1	PP, TE	
90	North Fork South Platte River 1.5 miles above Roberts Tunnel	BJOHNSON7	392731	1054223	PCDEH	1992–94	13	PP, MI, TE, N	--
91	North Fork South Platte River above Roberts Tunnel	392740105404400	392740	1054044	USGS	1974	1	PP, MI, TE, N	Forest
		5913	392739	1054045	CDPHE	1997–98	5	PP, MI, TE, N, B	
92	East Portal Harold D. Roberts Tunnel	002402	392741	1054043	DW	1966–71, 1974–83, 1985, 1987–98	144	PP, MI, TE, N, B, O	Urban/BU
		392742105403500	392742	1054035	USGS	1974	1	PP, MI, TE, N, B	
93	North Fork South Platte River below Roberts Tunnel	BJOHNSON8	392739	1054037	PCDEH	1992	6	PP, MI, TE, N	--
94	North Fork South Platte River at Grant, CO	06702500	392733	1053949	USGS	1968	1	PP	Urban/BU
		392737105394700	392737	1053947	USGS	1974	1	PP, MI, TE, N, B	
95	Geneva Creek above Smelter Gulch	102	393348	1054607	USGS	1979	1	PP, MI, TE	Forest
		393348105460415	393348	1054604	USGS	1995	3	PP, MI, TE, N, O	
		BJOHNSON11	393351	1054620	PCDEH	1992–94	13	PP, MI, TE, N	

Table 3. Characteristics of surface-water-quality sites in Park County, 1962–98—Continued

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Site no. (figs. 9–10)	Site Name	Site identifier	Latitude	Longitude	Data source	Period of record	No. of samples	Type of data collected	Land use/ land cover
96	Geneva Creek above Duck Creek near Grant, CO	393148105435600	393148	1054356	USGS	1971–72	2	PP, MI, TE, N, O	Forest
		393153105440109	393153	1054401	USGS	1994–97	26	PP, MI, TE, N, O	
		BJOHNSON10	393152	1054403	PCDEH	1992–94	13	PP, MI, TE, N	
97	Duck Creek above Mill Gulch near Grant, CO	393243105430814	393243	1054308	USGS	1995	3	PP, MI, TE, N, O	Forest
98	Duck Creek near Grant, CO	06704500	393149	1054350	USGS	1994–97	702	PP, MI, TE, N, O	Forest
99	Bruno Gulch above Geneva Park near Grant, CO	393141105445808	393141	1054458	USGS	1995–97	18	PP, MI, TE, N, O	Forest
100	Geneva Creek above Scott Gomer Creek	393018105421707	393018	1054217	USGS	1994–95	5	PP, MI, TE, N, O	Forest
101	Scott Gomer Creek at mouth near Grant, CO	393028105421706	393028	1054217	USGS	1994–97	22	PP, MI, TE, N, O	Forest
102	Geneva Creek above Callahan Gulch near Grant, CO	392856105413700	392856	1054137	USGS	1972	1	PP, MI, TE, O	--
103	Geneva Creek near Grant, CO	06705500	392820	1054054	USGS	1994–97	797	PP, MI, TE, N, O	Forest
		080701	392836	1054100	USFS	1968–71	8	PP, MI, TE, B, O	
		5980	392829	1054107	CDPHE	1997	2	PP, MI, TE, N, B	
		BJOHNSON9	392802	1054029	PCDEH	1992	6	PP, MI, TE, N	
		MCBRIDE1	392803	1054030	PCDEH	1990	3	PP, MI, TE, N	
104	Geneva Creek at mouth at Grant, CO	146	392737	1053948	USGS	1979	1	PP, MI, TE	Forest
		392735105394705	392735	1053947	USGS	1995	4	PP, MI, TE, N, O	
		392738105394600	392738	1053946	USGS	1974	2	PP, MI, TE, N	
105	North Fork South Platte River below Geneva Creek	001205	392733	1053947	DW	1975–80, 1984–92, 1994	62	PP, MI, TE, N, B, O	Urban/BU
		06706000	392726	1053929	USGS	1972, 1978–87	181	PP, MI, TE, N, O	
		5910	392734	1053949	CDPHE	1997–98	5	PP, MI, TE, N, B	
		NFSP1	392733	1053945	CDPHE	1990	1	PP, TE	
106	North Fork South Platte River at Bridge G14E	BJOHNSON12	392717	1053826	PCDEH	1992–94	12	PP, MI, TE, N	--
107	North Fork South Platte River below Long Meadows Farm	BJOHNSON13	392555	1053414	PCDEH	1994	2	PP, MI, TE, N	--
108	North Fork South Platte River near Fitzsimmons Middle School	FITZ	392512	1053206	ROCWWN	1993–97	68	PP, TE	--
		RANCH	392512	1053237	ROCWWN	1992–97	71	PP, TE	

Table 3. Characteristics of surface-water-quality sites in Park County, 1962–98—Continued

[no., number; latitude and longitude in degrees, minutes, and seconds; USGS, U.S. Geological Survey; CDPHE, Colorado Department of Public Health and Environment; PCDEH, Park County Department of Environmental Health; ROCWWN, Rivers of Colorado Water Watch Network; CGS, Colorado Geological Survey; DW, Denver Water; USFS, U.S. Forest Service; NPS, National Park Service; PP, physical properties; MI, major ions; TE, trace elements; N, nutrients; B, bacteria; R, radionuclides; O, other constituents (carbon, turbidity, or suspended sediment); Urban/BU, Urban or built up; --, not determined]

Site no. (figs. 9–10)	Site Name	Site identifier	Latitude	Longitude	Data source	Period of record	No. of samples	Type of data collected	Land use/ land cover
109	North Fork South Platte River near Glenn Isle Rock	GI ROCK	392443	1053032	ROCWWN	1992–94	22	PP, TE	--
110	North Fork South Platte River at Bailey, CO	001202	392408	1052754	DW	1967–74, 1981, 1983–90, 1994	96	PP, MI, TE, N, B, R, O	Urban/BU
		FU BRIDGE	392411	1052758	ROCWWN	1992–94	22	PP, TE	
		NFORKAURORA	392413	1052800	AURORA	1993–98	63	PP, MI, TE, N, O	
111	North Fork South Platte River above Craig Creek	392258105254400	392258	1052544	USGS	1974	2	PP, MI, TE, N, B	--
112	Craig Creek at mouth	392258105254500	392258	1052545	USGS	1974	2	PP, MI, TE, N, B	Forest
113	North Fork South Platte River below Craig Creek	001206	392300	1052545	DW	1975–80, 1983–88	41	PP, MI, TE, N, B, O	Urban/BU
114	Deer Creek near Bailey, CO	393040105340400	393040	1053404	USGS	1996–97	617	PP, MI, TE, N, O	Forest
115	Deer Creek above County Line	392532105244900	392532	1052449	USGS	1974	2	PP, MI, TE, N, B	Urban/BU
116	Roland Gulch	392617105242700	392617	1052427	USGS	1974	1	PP, MI, TE, N, B	Urban/BU
117	Elk Creek near Harris Park, CO	393013105293500	393013	1052935	USGS	1972–73	4	PP, MI, TE, N, B	Urban/BU
118	Elk Creek above County Line	392958105242400	392958	1052424	USGS	1974	2	PP, MI, TE, N, B	Urban/BU
119	Badger Creek above County Line	384148105494000	384148	1054940	USGS	1974	2	PP, MI, TE, N	Rangeland
		[1]07093740	383932	1054848	USGS	1981–84, 1987–98	333	PP, MI, TE, N, B, O	
120	Currant Creek above County Line	384318105305900	384318	1053059	USGS	1974	2	PP, MI, TE, N	Urban/BU
121	West Fourmile Creek below Bumgarner Creek	FLFO_NURE_39	384654	1052546	NPS	1976	1	PP, MI, TE	--
122	West Fourmile Creek above Cottonwood Creek	FLFO_NURE_41	384623	1052138	NPS	1976	1	PP, MI, TE	--
123	Cottonwood Creek at mouth	FLFO_NURE_67	384649	1052131	NPS	1976	1	PP, MI, TE	--
124	Cobb Creek at mouth	FLFO_NURE_40	384627	1052058	NPS	1976	1	PP, MI, TE	--
125	South Platte River above Cheesman Lake[2]	001116	390946	1051835	DW	1984–92, 1997–98	28	PP, TE, N, B, O	Forest

[1]Located in Fremont County 3 miles downstream from county line.

[2]Located in Jefferson County 3 miles downstream from county line.

Table 4. Summary of surface-water-quality data for Park County, 1962–98

[--, no data; <, less than; no., number; mg/L, milligrams per liter; µg/L, micrograms per liter; TVS, table value standard; pCi/L, picocuries per liter; cols/100 mL, colonies per 100 milliliters; µS/cm, microsiemens per centimeter at 25 degrees Celsius; ° C, degrees Celsius; $CaCO_3$, calcium carbonate]

Constituent or property	Number of analyses	Mini-mum	Concentration or value at indicated percentile					Maxi-mum	Standard or guideline[1]
			10	25	50	75	90		
Physical properties									
Water temperature (° C)	2,614	0.0	0.0	2.0	6.0	10.5	15.0	26.0	20.0
Oxygen, dissolved (mg/L)	517	0.1	7.5	8.1	9.0	10.0	10.9	20.0	6.0
pH (standard units)	1,516	2.9	6.6	7.4	7.8	8.2	8.5	10.5	6.5–9.0
Specific conductance (µS/cm)	1,750	8	60	90	170	320	720	24,000	--
Major ions and dissolved solids, in mg/L									
Bicarbonate, dissolved	119	3	21	71	120	180	243	520	--
Calcium, dissolved	382	<0.1	4.5	6.7	12.3	31.5	53.0	770	--
Chloride, dissolved	734	<0.1	0.4	2.0	5.0	80.0	221	7,600	[2]250
Fluoride, dissolved	198	<0.1	<0.1	0.1	0.2	0.4	0.7	3.0	--
Magnesium, dissolved	769	<0.1	1.6	2.9	5.6	21.8	34.0	318	--
Potassium, dissolved	241	<0.5	0.6	0.8	1.0	1.6	2.7	80	--
Silica, dissolved	311	0.5	2.2	4.5	8.0	10.7	17.0	42.0	--
Sodium, dissolved	311	<0.1	1.0	1.6	2.9	5.3	13.0	4,900	--
Sulfate, dissolved	748	<0.3	6.7	23.0	45.0	99.0	196	2,100	[2]250
Dissolved solids	504	16	48	86	142	242	394	15,700	--
Nutrients, in mg/L									
Ammonia	478	<0.05	<0.05	<0.05	<0.05	0.05	0.11	1.0	--
Un-ionized ammonia	301	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.05	0.02
Nitrate	804	<0.05	<0.05	<0.05	0.06	0.12	0.23	1.1	[2]10
Nitrite	240	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Orthophosphorus	230	<0.01	<0.01	<0.01	<0.01	0.02	0.03	0.1	[3]0.05
Phosphorus, total	861	<0.01	<0.01	<0.01	0.02	0.04	0.08	2.6	[4]0.1
Trace elements, in µg/L									
Aluminum, dissolved	252	<50	<50	<50	100	1,600	6,460	18,600	--
Aluminum, total	331	<1	10	30	70	218	696	16,000	--
Arsenic, dissolved	163	<1	<1	<1	<1	<1	1	9	--
Arsenic, total	101	<1	<1	<1	<1	<1	<1	<1	[5]50
Barium, dissolved	59	11	20	30	58	71	79	200	--
Barium, total	346	<10	10	29	50	76	100	371	--
Boron, total	48	<12	<12	<12	<12	55	105	142	[6]750
Cadmium, dissolved	193	<1	<1	<1	<1	2	10	60	[7]TVS
Cadmium, total	797	<1	<1	<1	<1	<1	1	60	--

Table 4. Summary of surface-water-quality data for Park County, 1962–98—Continued

[--, no data; <, less than; no., number; mg/L, milligrams per liter; µg/L, micrograms per liter; TVS, table value standard; pCi/L, picocuries per liter; cols/100 mL, colonies per 100 milliliters; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; $CaCO_3$, calcium carbonate]

Constituent or property	Number of analyses	Minimum	Concentration or value at indicated percentile					Maximum	Standard or guideline[1]
			10	25	50	75	90		
Trace elements, in µg/L—Continued									
Chromium, dissolved	170	<1	<1	<1	<1	10	50	80	[8]11
Chromium, total	451	<1	<1	<1	<1	1	3	82	--
Copper, dissolved	313	<1	<1	<1	5	30	72	220	[9]TVS
Copper, total	821	<1	<1	2	5	10	20	590	--
Iron, dissolved	449	<10	<10	40	110	280	1,020	24,800	[2]300
Iron, total	1,056	<10	30	70	170	396	920	47,000	[10]1,000
Lead, dissolved	226	<2	<2	<2	<2	9	210	370	[11]TVS
Lead, total	723	<1	<1	<1	<1	3	11	480	--
Manganese, dissolved	428	<5	<5	10	40	127	317	2,715	[2,12]50
Manganese, total	979	<5	8	19	40	77	131	970	[13]1,000
Mercury, dissolved	58	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.8	--
Mercury, total	309	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	1	[14]0.01
Molybdenum, dissolved	224	<10	<10	<10	<10	10	40	150	--
Molybdenum, total	329	<2	<2	<2	2	52	164	509	--
Nickel, dissolved	153	<1	<1	<1	10	30	60	110	[15]TVS
Nickel, total	261	<5	<5	<5	<5	5	10	300	--
Selenium, dissolved	70	<1	<1	<1	<1	<1	2	15	[16]5
Selenium, total	186	<5	<5	<5	<5	<5	<5	<5	[17]10
Silver, dissolved	104	<1	<1	<1	<1	<1	<1	2	[18]TVS
Silver, total	476	<1	<1	<1	<1	<1	1	26	--
Uranium, dissolved	194	<1	<1	1	2	3	4	85	--
Zinc, dissolved	390	<3	<3	5	30	80	190	5,300	[19]TVS
Zinc, total	833	<4	4	11	26	45	126	7,000	--
Other constituents or properties									
Alkalinity, total (as $CaCO_3$)	1,145	1	18	38	84	127	160	350	--
Alpha, dissolved gross (µg/L)	38	<1	1	3	6	9	10	12	--
Alpha, total (pCi/L)	26	<1	<1	<1	2	7	14	28	--
Beta, dissolved gross (µg/L)	40	<1	2	2	3	3	4	6	--
Beta, total (pCi/L)	26	<1	<1	<1	7	60	186	314	--
Carbon, organic, dissolved (mg/L)	82	<0.1	1.1	1.9	3.8	8.3	13	110	--
Carbon, organic, total (mg/L)	250	<0.1	0.8	1.4	2.3	3.6	4.4	33	--
Fecal coliform (cols/100 mL)	630	<1	<1	<1	<1	6	32	4,000	[20]2,000

Table 4. Summary of surface-water-quality data for Park County, 1962–98—Continued

[--, no data; <, less than; no., number; mg/L, milligrams per liter; µg/L, micrograms per liter; TVS, table value standard; pCi/L, picocuries per liter; cols/100 mL, colonies per 100 milliliters; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; $CaCO_3$, calcium carbonate]

Constituent or property	Number of analyses	Minimum	Concentration or value at indicated percentile					Maximum	Standard or guideline[1]
			10	25	50	75	90		
Other constituents or properties—Continued									
Fecal streptococcus (cols/100 mL)	572	<1	<1	<1	1	14	48	1,140	--
Hardness, total (mg/L as $CaCO_3$)	1,390	2.4	30	56	105	182	262	2,600	--
Sediment, suspended (mg/L)	341	<1	2	6	21	86	182	2,990	--

[1]Acute or chronic water-quality standards for most streams in Park County (Colorado Department of Public Health and Environment, 1998a, 1999a).

[2]Not applicable to Geneva Creek and tributaries of Geneva Creek downstream from Scott Gomer Creek (Colorado Department of Public Health and Environment, 1999a).

[3]Recommended limit for orthophosphate where rivers enter lakes and reservoirs (U.S. Environmental Protection Agency, 1986).

[4]Recommended limit for controlling eutrophication in rivers (U.S. Environmental Protection Agency, 1986).

[5]Geneva Creek and tributaries of Geneva Creek downstream from Scott Gomer Creek, 100 µg/L (Colorado Department of Public Health and Environment, 1999a).

[6]Not applicable to Geneva Creek upstream from Scott Gomer Creek (Colorado Department of Public Health and Environment, 1999a).

[7]South Mosquito Creek, 1.9 µg/L; Geneva Creek upstream from Scott Gomer Creek, 2 µg/L (Colorado Department of Public Health and Environment, 1999a).

[8]Geneva Creek upstream from Scott Gomer Creek, 25 µg/L (Colorado Department of Public Health and Environment, 1999a).

[9]Geneva Creek upstream from Scott Gomer Creek, 70 µg/L (Colorado Department of Public Health and Environment, 1999a).

[10]Geneva Creek upstream from Scott Gomer Creek, 1,200 µg/L (Colorado Department of Public Health and Environment, 1999a).

[11]Geneva Creek upstream from Scott Gomer Creek, 4 µg/L (Colorado Department of Public Health and Environment, 1999a).

[12]West Fourmile Creek, 99 µg/L; South Mosquito Creek, 118 µg/L (Colorado Department of Public Health and Environment, 1998a, 1999a).

[13]Geneva Creek upstream from Scott Gomer Creek, 1,700 µg/L; not applicable in Arkansas River Basin (Colorado Department of Public Health and Environment, 1998a, 1999a).

[14]Geneva Creek upstream from Scott Gomer Creek, 0.05 µg/L (Colorado Department of Public Health and Environment, 1999a).

[15]Geneva Creek upstream from Scott Gomer Creek, 50 µg/L (Colorado Department of Public Health and Environment, 1999a).

[16]Dissolved selenium standard only applicable in Arkansas River Basin (Colorado Department of Public Health and Environment, 1998a, 1999a).

[17]Geneva Creek upstream from Scott Gomer Creek, 50 µg/L; not applicable in Arkansas River Basin (Colorado Department of Public Health and Environment, 1998a, 1999a).

[18]Geneva Creek upstream from Scott Gomer Creek, 1 µg/L (Colorado Department of Public Health and Environment, 1999a).

[19]Mosquito Creek downstream from South Mosquito Creek, 220 µg/L; South Mosquito Creek, 580 µg/L; Geneva Creek upstream from Scott Gomer Creek, 540 µg/L (Colorado Department of Public Health and Environment, 1999a).

[20]Tributaries to South and Middle Fork South Platte River, Mosquito Creek downstream from South Mosquito Creek, South Mosquito Creek, Arkansas River Basin, 200 colonies per 100 mL (Colorado Department of Public Health and Environment, 1998a, 1999a).

Major Ions and Dissolved Solids

The major ions summarized in this report (bicarbonate, calcium, chloride, fluoride, magnesium, potassium, silica, sodium, and sulfate) are constituents commonly dissolved in most natural waters. For watersheds without substantial development, the presence of major ions dissolved in water is the result of interactions between surface and ground water, soils, and the aquifer material.

In many Park County streams, the dominant ions in solution are the cations calcium and magnesium and the anion bicarbonate. Calcium-magnesium-bicarbonate type waters are found in the mountain tributaries in the South and North Fork Basins (sites 33, 115, 118), throughout the Middle Fork and Tarryall Creek Basins, and in Badger and Currant Creeks in the Arkansas River Basin (fig. 11). In some streams of the upper North Fork Basin (site 89 on the North Fork, site 96 on Geneva Creek), sulfate replaces bicarbonate as the dominant anion. Sulfate in surface water of the upper North Fork Basin has been attributed to the weathering of pyrite-bearing rocks in that part of the county (Bassett and others, 1992). The presence of several ions at nearly equivalent concentrations in the main-stem South Platte River downstream from Hartsel to the county line (for example,

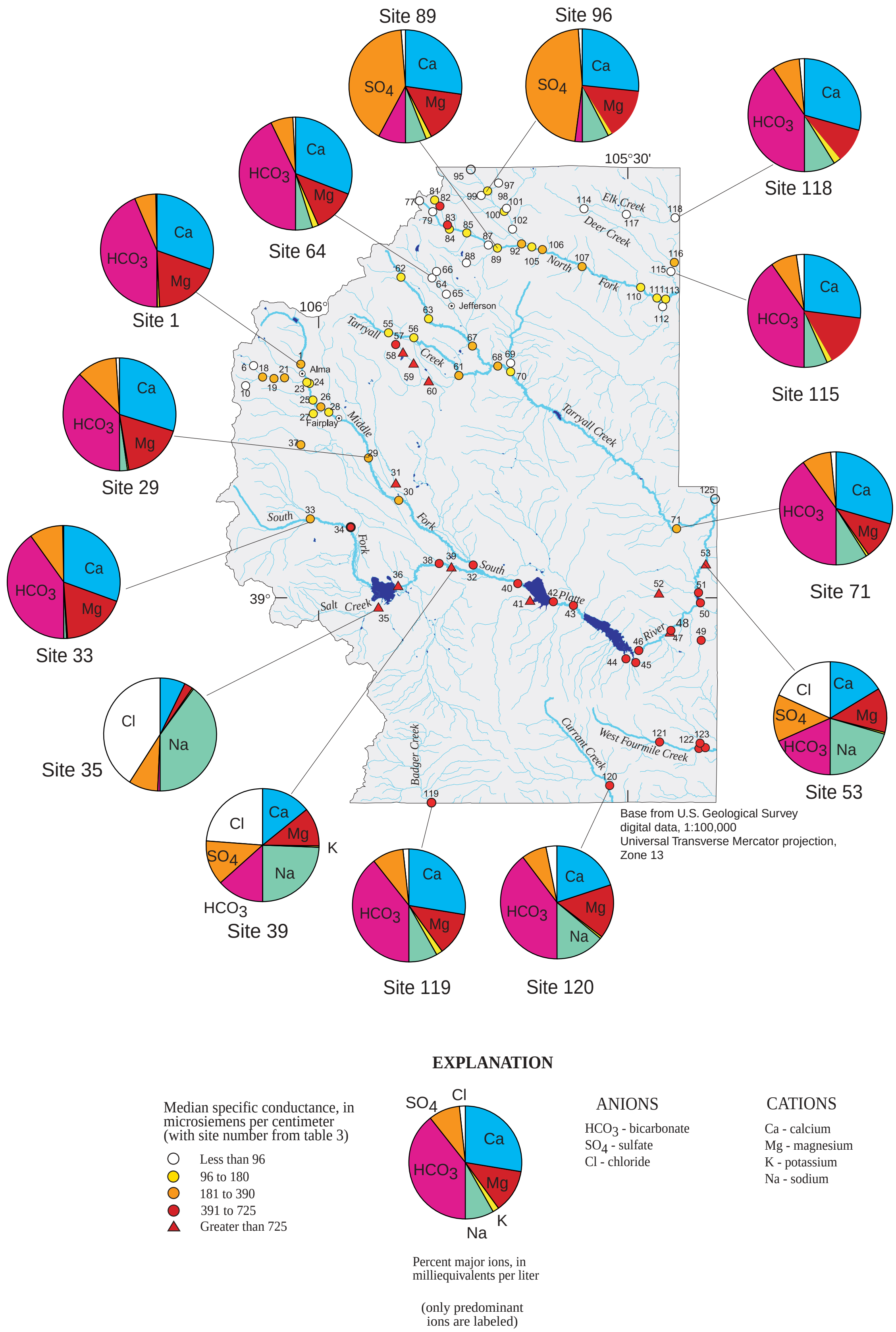


Figure 11. Water types and median specific conductance at selected surface-water sites in Park County.

site 53 in fig. 11) probably results from the mixing of sodium-chloride type water in the lower South Fork with calcium-magnesium-bicarbonate water in the Middle Fork. The source of sodium and chloride in the lower South Fork is Salt Creek (site 35, fig. 11), a saline tributary that flows into the South Fork at Antero Reservoir. Springs discharging from evaporite beds in the Maroon Formation of Pennsylvanian and Permian age are the likely source of sodium and chloride in Salt Creek (Klein and others, 1978).

The CDPHE has set in-stream standards of 250 mg/L for two of the major ions—chloride and sulfate—that are applicable to most surface waters in Park County. The sites where chloride and sulfate concentrations have exceeded the standards in at least one sample are listed in table 5. Several of the sites with higher chloride and sulfate concentrations are located on the South Fork and main-stem South Platte River downstream from Antero Reservoir. The source of chloride and sulfate in this reach may be Salt Creek (site 35, fig. 9), where chloride and sulfate concentrations as high as 7,600 and 2,100 mg/L, respectively, have been measured.

Dissolved solids is a computed or direct measurement of the total dissolved-constituent concentration. Major ions make up the bulk of dissolved-solids concentration; other constituents such as nitrogen, phosphorus, organic carbon, and the trace elements listed in table 4 account for the remainder. The CDPHE has not set standards for dissolved solids in State waters; however, there is a recommended limit for treated drinking water of 500 mg/L (U.S. Environmental Protection Agency, 1996). Additionally, crop losses might occur when dissolved-solids concentrations reach about 700–850 mg/L in irrigation water (U.S. Department of the Interior, 1994). At least 90 percent of the dissolved-solids concentrations in surface-water samples collected in Park County were less than 500 mg/L. Dissolved solids were highest in Salt Creek (site 35, fig. 9) where concentrations were at least one order of magnitude larger than at any other site.

Nutrients

Nitrogen and phosphorus are essential nutrients for plant growth; however, excessive nutrient concentrations accelerate the growth of algae and other aquatic plants, which may lead to degraded aquatic habitat. Additionally, high nitrogen concentrations, in the form of un-ionized ammonia, can be toxic to fish. Natural sources of nutrients include atmospheric inputs, phosphate minerals in rocks and soils, and breakdown products from the decomposition of organic matter. Elevated nutrient levels in water may

Table 5. Surface-water sites in Park County having chloride or sulfate concentrations larger than 250 milligrams per liter in at least one sample

[--, not computed or concentration less than 250 milligrams per liter]

Site no. (fig. 9)	Site name	Period of sampling	Number of samples	Concentration, in milligrams per liter					
				Chloride			Sulfate		
				Minimum	Maximum	Median	Minimum	Maximum	Median
31	Trout Creek near mouth near Garo	1974	2	--	--	--	170	380	275
35	Salt Creek above Antero Reservoir	1974	2	5,100	7,600	6,350	1,800	2,100	1,950
36	South Fork South Platte River below Antero Reservoir	1962–82	52	125	1,020	348	65	780	256
39	South Fork South Platte River at Hartsel, CO	1973–81	29	70	532	209	50	450	186
41	Buffalo Gulch at mouth	1974	2	--	--	--	380	410	395
43	South Platte River above Elevenmile Canyon Reservoir	1967–80	31	12	460	140	46	300	150
46	South Platte River below Elevenmile Canyon Reservoir	1962–82	51	--	--	--	48	325	140
58	Park Gulch below Como, CO	1997	1	--	--	--	--	1,990	--
59	Park Gulch above King Mine near Como, CO	1997	1	--	--	--	--	1,580	--

originate from anthropogenic sources such as phosphate detergents, wastewater discharges, seepage from septic systems, and fertilizers.

The surface-water sites at which selected nutrient species have been collected and the dates of sample collection are presented in figure 12. Nutrient data have been collected in most of the subbasins in the county; however, data for ammonia or total phosphorus for the Arkansas River Basin were not found during the data search. Most ammonia data were collected after 1983, and most nitrate and total phosphorus data were collected after the early 1970’s. Several sites have data for ammonia from the mid-1980’s to present (1998), and total phosphorus from the early 1970’s to present, but at some of these same sites, sampling for nitrate was discontinued in the early 1990’s. Several sites in the upper Tarryall Creek Basin (sites 56–61, 63, 64) and the Geneva Creek Basin in the upper North Fork Basin (sites 95–101, 103, 104) were sampled for all three constituents in the latter 1990’s.

Historical nitrogen concentrations in surface water in Park County were small (table 4). Nitrite was not detected and most un-ionized ammonia concentrations were less than the CDPHE chronic standard of 0.02 mg/L, and all nitrate concentrations were less than the CDPHE in-stream standard of 10 mg/L. Even though nitrate concentrations were small, there was some variability in concentration among the major land-use/land-cover classifications and among sites throughout the county (fig. 13A–C). Nitrate concentrations in surface water were significantly higher in urban and built-up areas than in rangeland and forest areas (fig. 13A). In the North Fork Basin, median nitrate concentrations primarily were between 0.05 and 0.12 mg/L and were highest (0.19 mg/L) at the East Portal of the Harold D. Roberts Tunnel (site 92) (fig. 13B, C). With the exception of sites 64 and 66, all median nitrate concentrations in the Tarryall Creek Basin were below the detection limit of 0.05 mg/L (fig. 13B, C). Some of the highest median nitrate concentrations were in the Middle Fork upstream and downstream from Fairplay (sites 26 and 29); however, the median concentrations at these sites were determined from only two samples collected at each site in the early 1970’s. Median nitrate concentrations at other sites on the Middle Fork, South Fork, and main-stem South Platte River ranged from less than 0.05 mg/L to 0.13 mg/L.

There are no CDPHE standards for phosphorus in surface water; however, for controlling eutrophication, the USEPA has recommended that concentrations of total phosphorus be less than 0.1 mg/L in rivers and orthophosphorus be less than 0.05 mg/L where rivers enter lakes and reservoirs (U.S. Environmental Protection Agency, 1986). Most phosphorus concentrations in Park County surface water were less than the USEPA recommendations (table 4).

Among the nutrients listed in table 4, analyses were most numerous for total phosphorus. Total phosphorus concentrations were not significantly different among urban and built-up, rangeland, and forest land-use/land-cover classifications, and for each classification median concentrations were less than 0.05 mg/L (fig. 14A). Median total phosphorus concentrations were less than 0.1 mg/L at all surface-water sites and less than 0.05 mg/L at most sites (fig. 14B, C). Median total phosphorus concentrations were lowest at sites in the upstream areas of the South Platte watershed—for example, sites 96, 97, 99, and 114 in the North Fork Basin, sites 56, 57, 63 and 64 in the Tarryall Creek Basin, and site 23 in the Middle Fork Basin. Median total phosphorus concentrations were highest in the South Platte River above Spinney Mountain Reservoir (site 40), Park Gulch above Slater Ditch (site 60), Tarryall Creek near mouth (site 71), and the main-stem South Platte River near the county line (site 125) (median concentrations at sites 40 and 60 were determined from fewer than 10 samples).

Temporal Trends in Nutrient Concentrations

Concentrations of nitrate or total phosphorus were tested for time trends at four sites having data that met the statistical requirements discussed in the “Methods of Water-Quality Data Review and Analysis” section of this report. Data for other nutrient species such as ammonia, nitrite, and orthophosphorus did not meet the requirements for trend testing either because most of the results were less than the detection limit or because continuous seasonal data were not available for the 1990’s.

At three of four sites, the period of record for analyzing trends in total phosphorus extended from the 1970’s to the 1990’s, whereas data for analyzing nitrate trend at one site were limited to the 1990’s (table 6). As indicated by p-values greater than 0.05 in table 6, no trend was observed for nitrate, and with the exception of site 92, no trends were observed for total phosphorus. Total phosphorus showed a statistically significant (p-value less than 0.05) upward trend at site 92, the East Portal of the Harold D. Roberts Tunnel; however, the trend may not be of great environmental importance because the rate of change

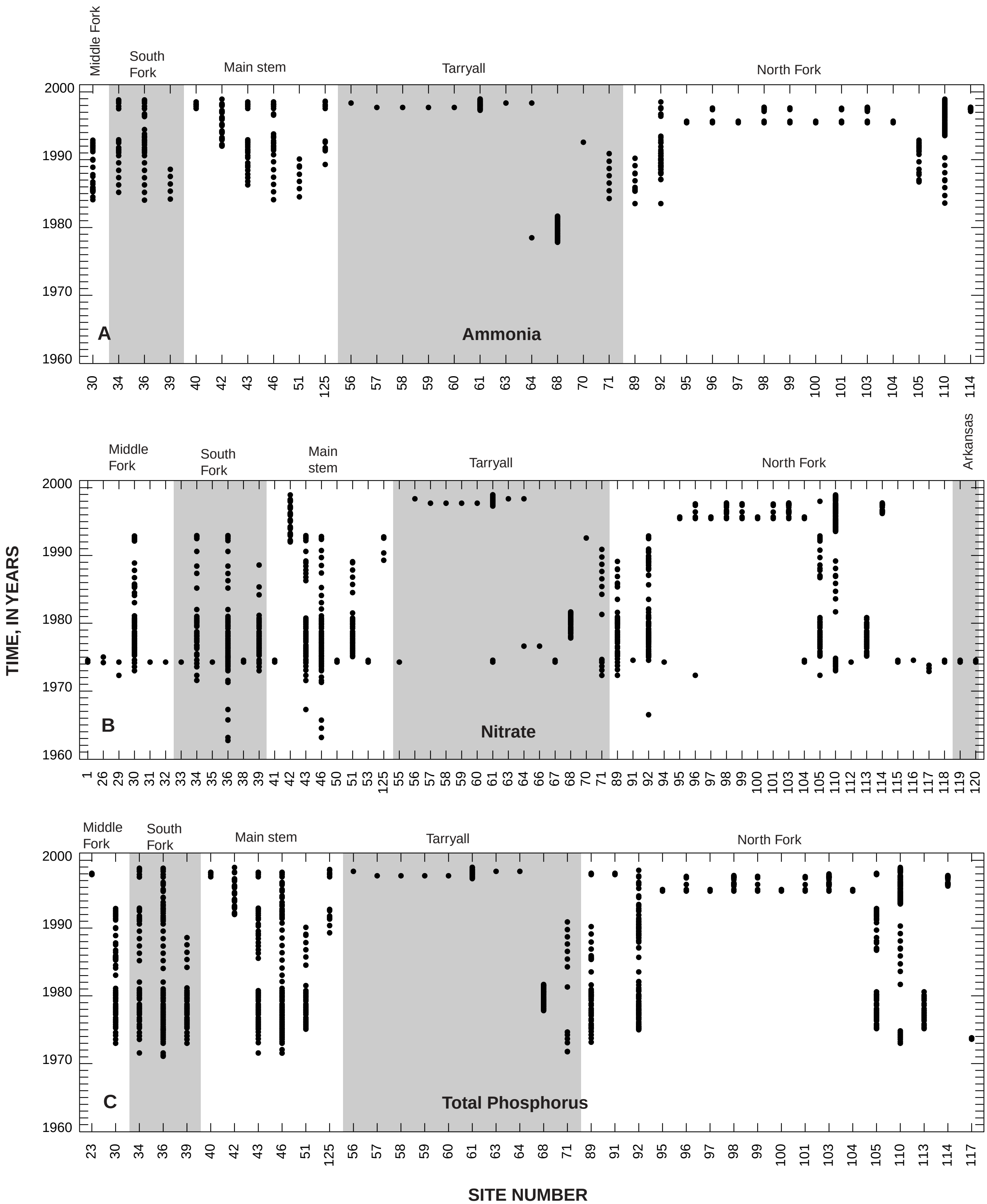


Figure 12. Distribution of surface-water sampling dates for (A) ammonia, (B) nitrate, and (C) total phosphorus (site numbers from table 3).

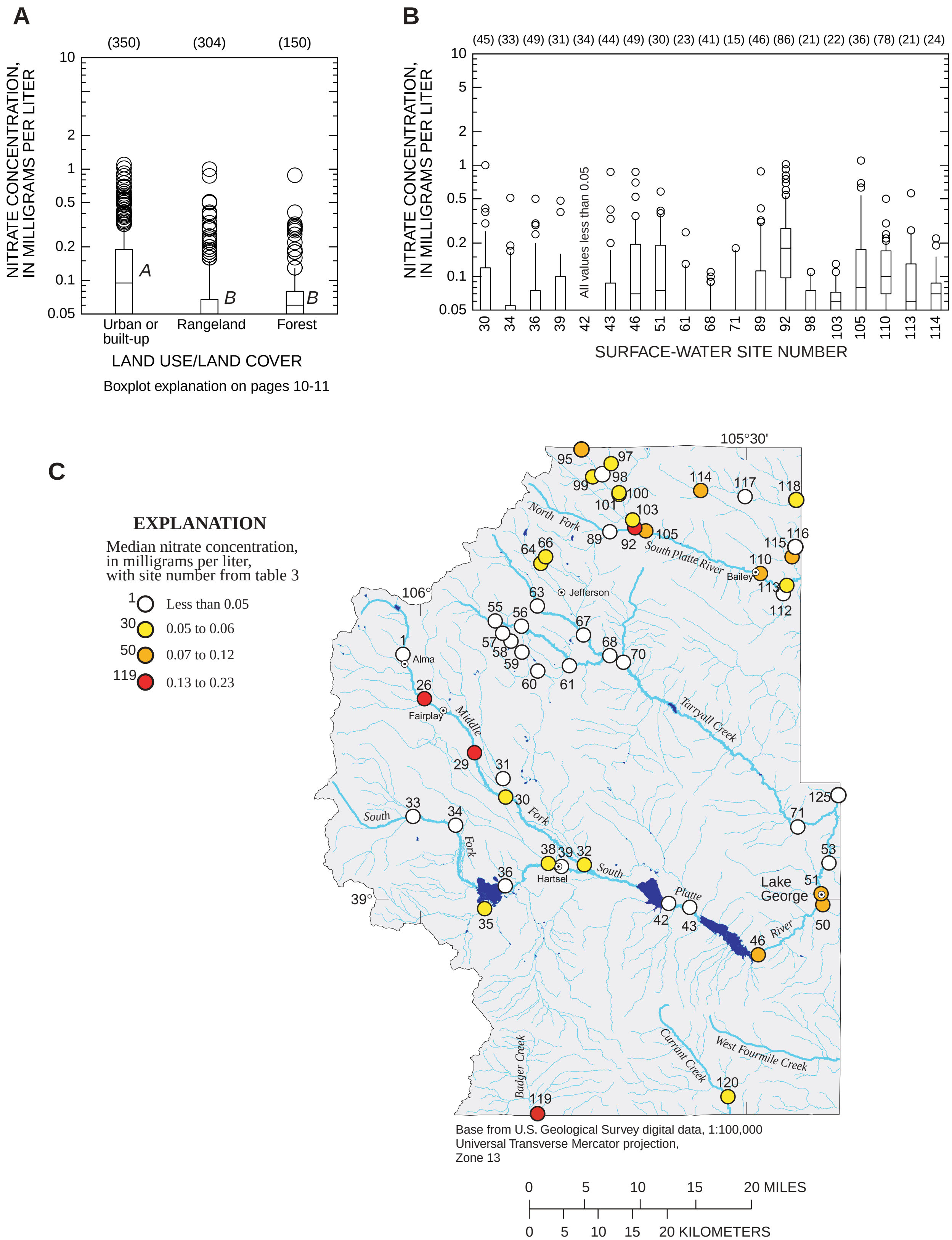


Figure 13. Distribution of (A) nitrate concentrations by land use/land cover, (B) nitrate concentrations at sites with 10 or more samples, and (C) median nitrate concentrations at all surface-water sites sampled.

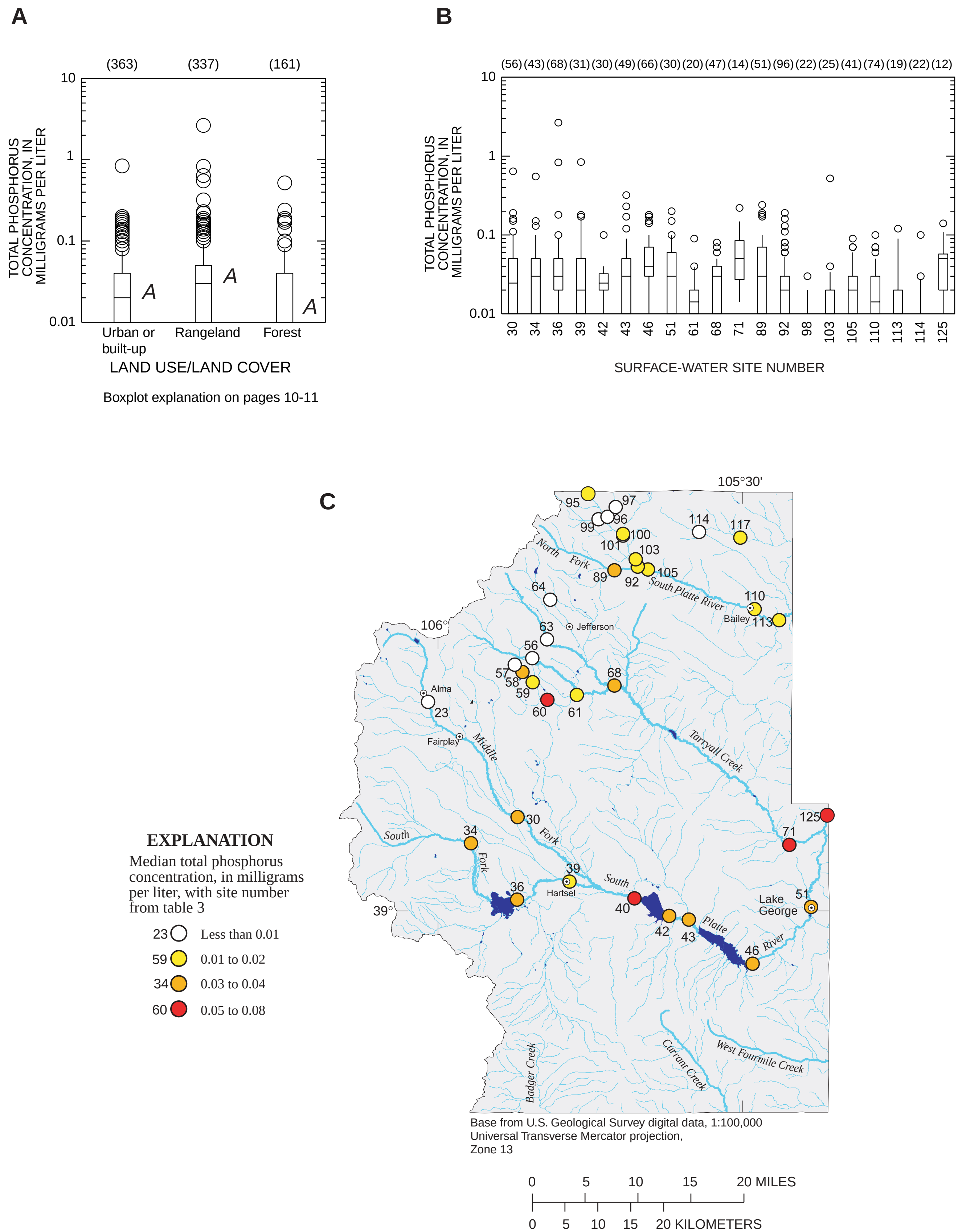


Figure 14. Distribution of (A) total phosphorus concentrations by land use/land cover, (B) total phosphorus concentrations at sites with 10 or more samples, and (C) median total phosphorus concentrations at all surface-water sites sampled.

Table 6. Results of seasonal Kendall test for trends of selected nutrient species in Park County

[mg/L, milligrams per liter]

Site no. (figs. 9, 10)	Site name	Period of analysis	Trend direction	p-value of tau test	Magnitude of trend slope, in percent per year	Median concentration (mg/L)
		Nitrate				
110	North Fork South Platte River at Bailey	1993–98	None	0.737	--	0.10
		Total phosphorus				
36	South Fork South Platte River below Antero Reservoir	1971–98	None	0.212	--	0.03
46	South Platte River below Elevenmile Canyon Reservoir	1971-98	None	0.838	--	0.04
92	East Portal Harold D. Roberts Tunnel	1975–95	Upward	0.006	0.1	0.02
110	North Fork South Platte River at Bailey, CO	1993–98	None	0.145	--	0.01

(slope) of the trend line is small and the trend is evident in very low concentrations that are equal or nearly equal to the detection limit of 0.01 mg/L. Continued phosphorus sampling would help to better define this apparently upward trend at site 92.

Phosphorus Loads at Selected Surface-Water Sites in the South Platte River Basin

Loads are the amount of a constituent transported in streamflow and are calculated by multiplying stream discharge and concentration. Phosphorus loads in the upper South Platte River Basin are of particular concern because limits on phosphorus loading into Chatfield Reservoir from the upper South Platte River watershed have been proposed (Colorado Department of Public Health and Environment, 1999c). Load calculations for two sites with substantial total phosphorus data—the South Platte River below Elevenmile Canyon Reservoir (site 46) and the North Fork South Platte River at Bailey (site 110)—give an indication of the amount of phosphorus that may be transported out of Park County in the South Platte River. Load calculations for the East Portal Harold D. Roberts Tunnel (site 92) provide an estimate of the amount of phosphorus in surface water diverted from Summit County to the North Fork Basin in Park County.

The phosphorus concentrations and streamflow measured at each of the three sites during 1971–98 and the resultant phosphorus loads are presented in figure 15. Streamflow data were not available for the North Fork South Platte River at Bailey, so daily mean discharges for a site on the North Fork 10 miles upstream from Bailey (site SG40, table 2) were used instead. To examine seasonal variability, the values for each parameter are grouped into two time periods: April through September and October through March. At all three sites, significantly higher ($p<0.05$) phosphorus loads during April through September coinciding with significantly higher ($p<0.05$) streamflow for the same time period indicates that streamflow influences the variability in load more than phosphorus concentration. Even though larger phosphorus concentrations were more frequent during low flow (October through March) than high flow, concentrations were not significantly ($p>0.05$) different between the two time periods.

During April through September, median total phosphorus loads ranged from about 15 pounds per day at the East Portal Harold D. Roberts Tunnel and North Fork South Platte River at Bailey to about 25 pounds per day at the South Platte River below Elevenmile Canyon Reservoir. Median total phosphorus loads during the low-flow time of year (October–March) ranged from 6 to 12 pounds per day. Using the seasonal median phosphorus loads for the two South Platte River sites, the annual phosphorus load transported out of Park County in the South Platte River was calculated to be about 10,000 pounds.

Trace Elements

The term “trace elements” commonly refers to substances that almost always occur in concentrations less than 1.0 mg/L in natural water. As a result, trace-element concentrations are usually reported in “micrograms per liter” (equivalent to “parts per billion”).

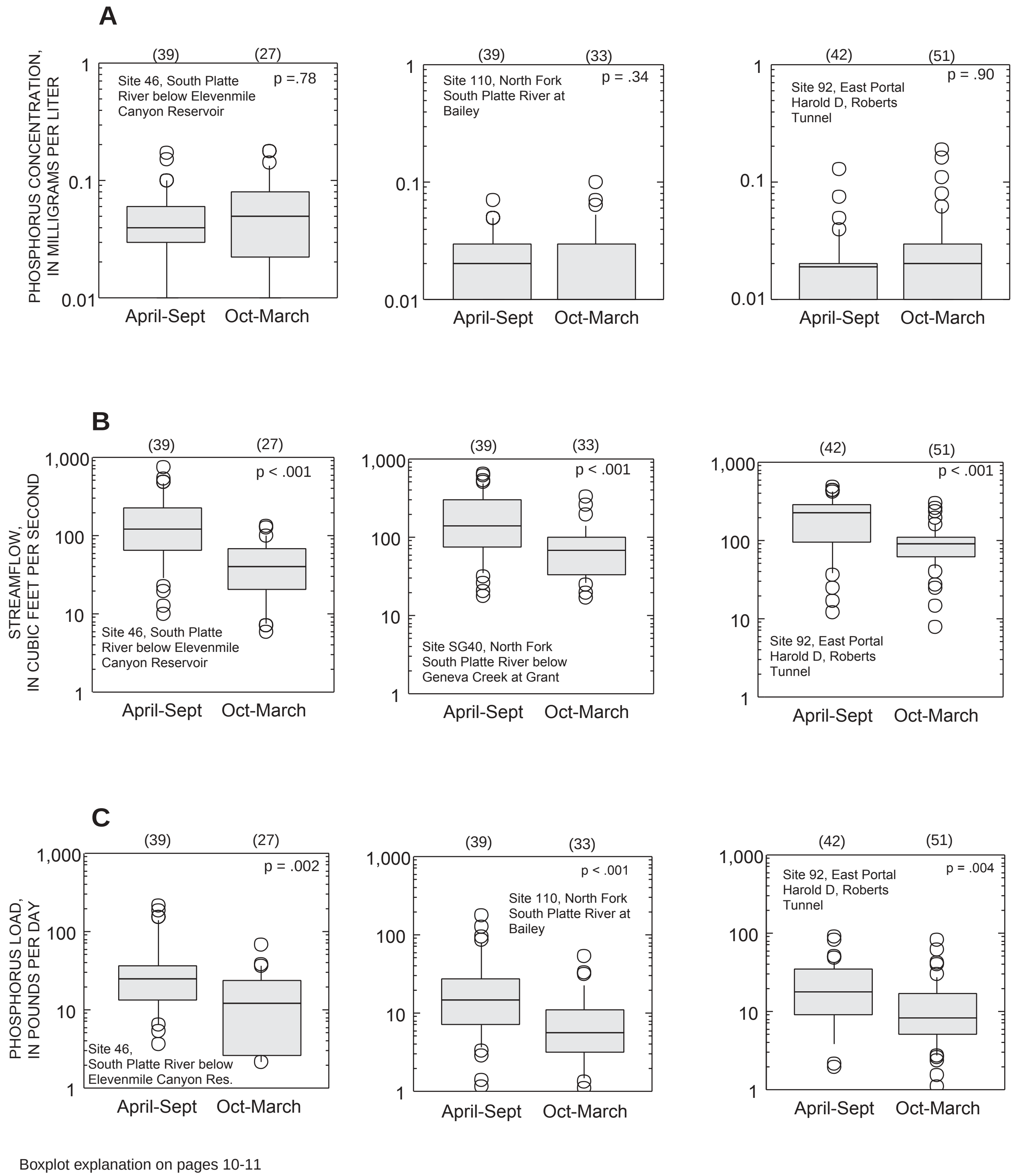


Figure 15. Distribution of (A) phosphorus concentrations, (B) streamflow, and (C) phosphorus loads for selected sites in Park County (site numbers from table 3).

Trace-element concentrations in Park County have been reported as “total” or “dissolved.” Total concentrations are determined from aliquots of unfiltered sample water, whereas dissolved concentrations are determined from water that has been passed through a filter prior to analysis (usually a 0.45-μm pore-size filter). Total concentrations also are reported as “total recoverable,” meaning the sample has gone through a more rigorous digestion procedure prior to analysis. Most unfiltered trace-element data for Park County have been reported as “total” concentrations. Some total recoverable concentrations were acquired during the historical data compilation, and these values are grouped with the “total” concentrations in table 4.

Surface-water-quality data were compiled for 17 trace elements (table 4). Most of the trace elements have dissolved and total analyses but not always at the same sites; thus, the maximum dissolved concentration for an element may be larger than the maximum total concentration (for example, aluminum in table 4). Many trace elements were detected in less than one-half the analyses, as indicated by the “less than” values at the 50th percentile (table 4). Trace elements such as aluminum, barium, iron, and manganese may have been more commonly detected because they are abundant in the types of igneous and sedimentary rocks in Park County.

Several of the trace-element water-quality standards listed in table 4 have not been exceeded, including standards for total and dissolved selenium and for total arsenic, boron, and manganese. Standards have been exceeded for dissolved chromium, iron, and manganese and for total iron and mercury. Evidence for total mercury concentrations exceeding the standard is weak because most total mercury detections (29 of 47 detections) were equal to the analytical reporting limit of 0.2 μg/L. In the future, use of a mercury analysis with a lower reporting limit is probably warranted because of the relatively low standard for mercury (0.01 μg/L).

Concentrations of selected trace elements have been plotted in boxplots and are grouped by areas of the county (fig. 16). The areas primarily are the major subwatersheds in the county or specific areas where numerous trace-element data have been collected. The North Fork Basin has been divided into two areas for trace-element analysis, and the most upstream site in the lower part is the North Fork South Platte River below Geneva Creek (site 105). The Mosquito Creek Basin (in the Middle Fork Basin, fig. 10A) and the upper North Fork Basin are two areas where extensive trace-element sampling has occurred, primarily because acidic, trace-element-enriched waters are present in these areas (McHugh and others, 1988; McBride and Cooper, 1991; Bassett and others, 1992; Johnson and Cooper, 1993; Johnson, 1993, 1994; Colorado Department of Public Health and Environment, 1998b; Simsiman, 1998; and Stevens, 1999). Drainage from abandoned mines is the source of acidic water in the Mosquito Creek Basin and parts of the North Fork Basin. Acidic waters also occur naturally in parts of the North Fork Basin, primarily in the upper parts of the Geneva Creek Basin.

Historical trace-element analyses were most numerous for iron and manganese. Median iron concentrations in each area of Park County were less than the CDPHE in-stream standards (300 μg/L for dissolved iron, 1,000 μg/L for total recoverable iron), even though several individual concentrations were one to two orders of magnitude larger than the standards (fig. 16). Some of the largest iron concentrations occurred in South Mosquito Creek in the Mosquito Creek Basin (fig. 10A); and at several sites in the upper North Fork Basin, including Handcart Gulch, the North Fork South Platte River downstream from Handcart Gulch, and upper Geneva Creek (fig. 10B). The small amount of data for these stream segments (most sites were sampled fewer than five times) indicates that iron standards probably are exceeded in these waters. Large iron concentrations also occurred in the lower North Fork Basin, primarily in the North Fork South Platte River near Bailey (fig. 9). Large total iron concentrations in the North Fork South Platte River near Bailey were infrequent and were probably caused by the transport of total iron in streamflow from the upper part of the basin to the lower part.

All concentrations of total manganese in each area of Park County were less than the CDPHE in-stream standard of 1,000 μg/L, and with the exception of the upper North Fork, all median concentrations of dissolved manganese in each area were less than the CDPHE in-stream standard of 50 μg/L (fig. 16). In the upper North Fork, dissolved manganese concentrations ranging between 200 and 1,500 μg/L primarily occurred in Handcart Gulch and upper Geneva Creek (fig. 10B), indicating that manganese standards may be exceeded in these areas. The largest concentrations of dissolved manganese were not measured in the upper North Fork Basin but in Park Gulch in the Tarryall Creek Basin. The streamflow associated with the Park Gulch manganese concentrations was very small (0.01 ft^3/s).

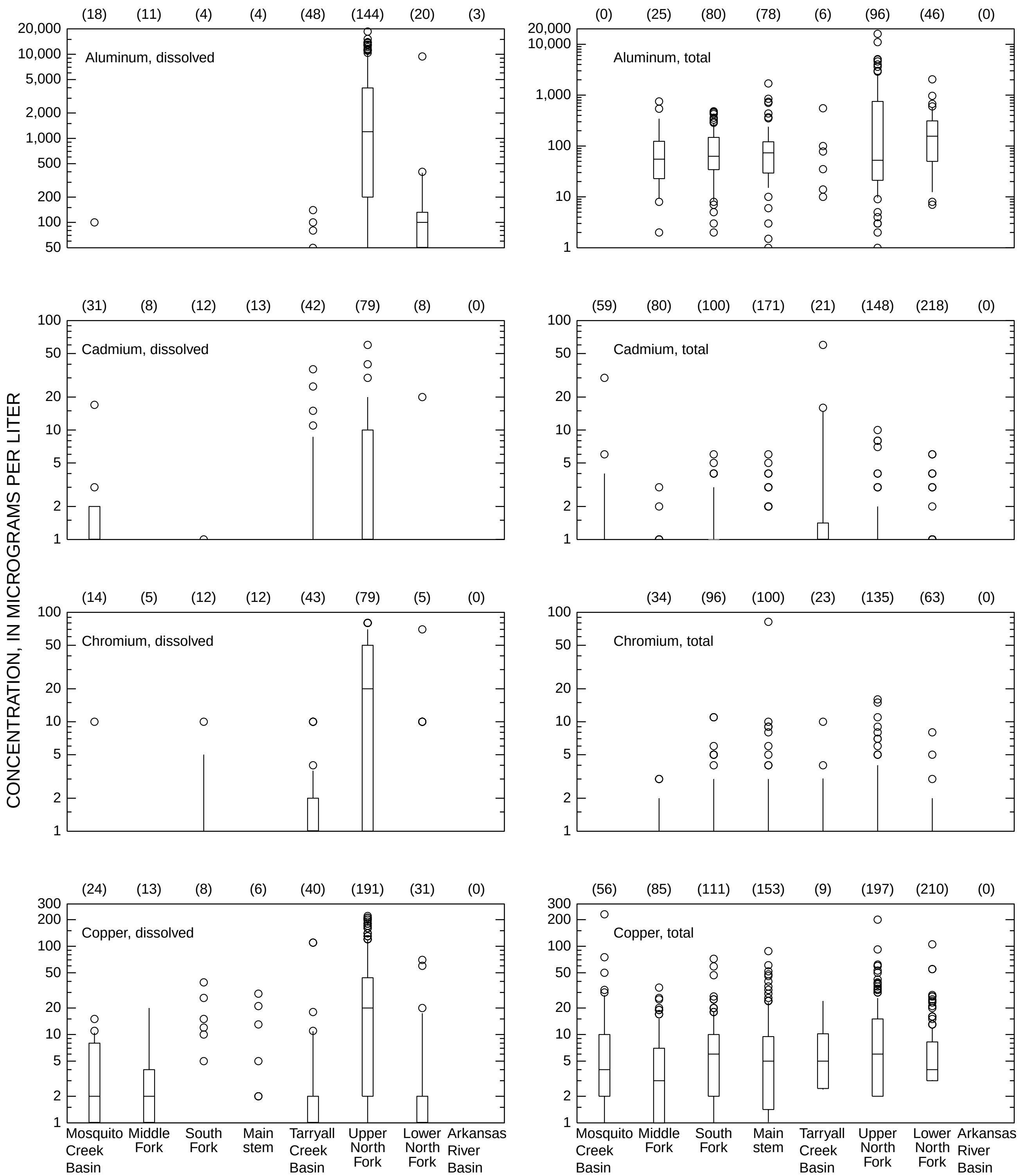


Figure 16. Distribution of trace-element concentrations for areas of Park County, 1962–98. (Dashed lines for iron and manganese are in-stream water-quality standards set by the Colorado Department of Public Health and Environment [1998a, 1999a].) Boxplot explanation on pages 10–11.

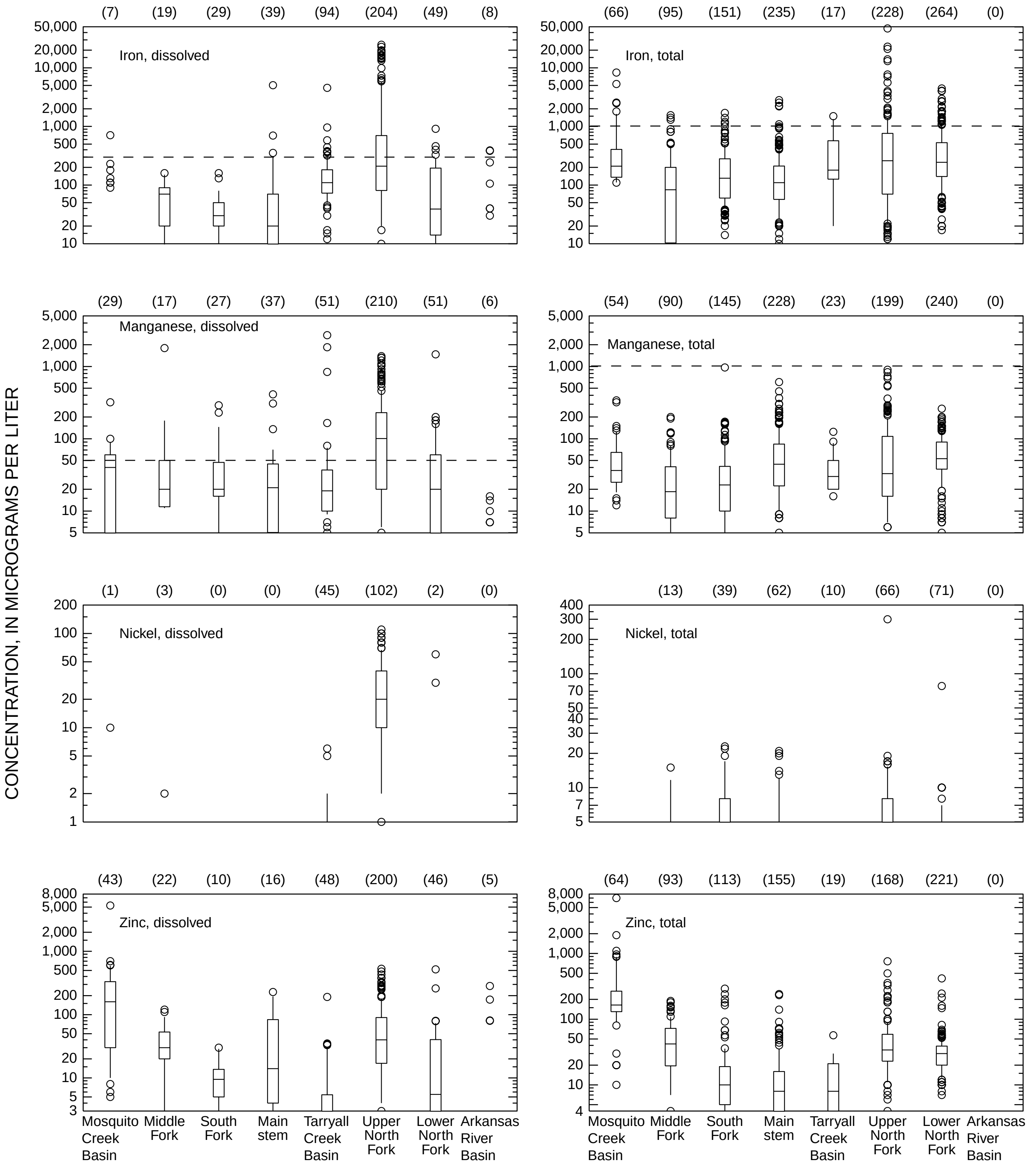


Figure 16. Distribution of trace-element concentrations for areas of Park County, 1962–98. (Dashed lines for iron and manganese are in-stream water-quality standards set by the Colorado Department of Public Health and Environment [1998a, 1999a]). Boxplot explanation on pages 10–11—Continued.

Other trace elements in addition to iron or manganese also were measured in large concentrations in either the Mosquito Creek or upper North Fork Basins (fig. 16). Large zinc concentrations primarily occurred in South Mosquito Creek and in Mosquito Creek downstream from South Mosquito Creek (fig. 10A) but also occurred in Geneva Creek (fig. 10B). Large concentrations of aluminum, cadmium, chromium, copper, and nickel were most common in Handcart Gulch, the North Fork South Platte River downstream from Handcart Gulch, and upper Geneva Creek (fig. 10B).

Mosquito Creek, South Mosquito Creek, sections of the North Fork South Platte River downstream from Handcart Gulch, and Geneva Creek have been identified as being impaired with respect to elevated trace-element concentrations and are listed on the 1998 303(d) list (Colorado Department of Public Health and Environment, 1998b). The 303(d) list identifies water-quality-limited segments within Colorado and is prepared by the CDPHE, Water Quality Control Division (WQCD), to fulfill section 303(d) of the Federal Clean Water Act.

Suspended Sediment

Suspended sediment is fragments of rock and soil transported in suspension by streams. Overland flow and channel scour are natural erosional sources of suspended sediment in streams and are influenced by soils, land cover, slope, aspect, climate, and streamflow. In Park County, activities that may disturb land surfaces and increase erosion and subsequent suspended-sediment concentrations are urban and suburban development, mining, logging, agriculture (primarily grazing), and pedestrian (recreation) traffic along streambanks.

The CDPHE has not set numeric standards for suspended-sediment concentrations in streams; however, a narrative standard pertaining more to sediment deposition states that surface waters shall be free from substances attributable to human activities which can settle to form bottom deposits that are detrimental to beneficial uses (Colorado Department of Public Health and Environment, 1999b). Based primarily on evaluations by the U.S. Forest Service, the WQCD has listed the South Platte River downstream from Elevenmile Canyon Reservoir to the county line on the 1998 303(d) list for impairment by sediment (Colorado Department of Public Health and Environment, 1998b). Additionally, several tributaries to the South Platte River between Hartsel and Lake George (fig. 17B) may be considered for future listing because of sediment issues (Colorado Department of Public Health and Environment, 1998b).

Suspended-sediment data for streams in Park County are scarce, and at most sites where data are available, fewer than 10 samples have been collected (fig. 17B). Most sampling was done in the Geneva Creek Basin (sites 98, 103, table 3) as part of a water-quality study in the Guanella Pass area (Stevens, 1998) or at a site on Badger Creek in the Arkansas River Basin (site 119). Infrequent sampling for suspended sediment has occurred in the upper Tarryall Creek Basin and in the Lost Creek Basin (sites 73–76). Only one sample was collected from the main-stem South Platte River (site 46).

Sampling conducted over an entire flow regime is needed to define the variability of suspended-sediment concentration in streams. Data for Geneva and Badger Creeks (sites 103 and 119) show that suspended-sediment concentration generally increases with discharge as overland flow from snowmelt or precipitation transports sediment to streams (fig. 17A).

GROUND-WATER QUALITY

Data collected by the USGS from 180 wells in Park County primarily were used in the statistical summaries of ground-water quality in this report (tables 7, 8). Additionally, nitrate data collected by the Park County Department of Environmental Health (PCDEH) and the U.S. Forest Service were included with the USGS data for the statistical summaries of nitrate in ground water (table 8). Most of the wells (162 of 180) were sampled once in the 1970’s as part of two USGS studies assessing ground-water quality throughout the county or in the vicinity of Lake George (Goddard, 1978; Klein and others, 1978). The remaining wells were sampled once in the 1990’s, primarily in 1998 as part of a ground-water quality study in north-central Park County (Bruce and Kimbrough, 1999).

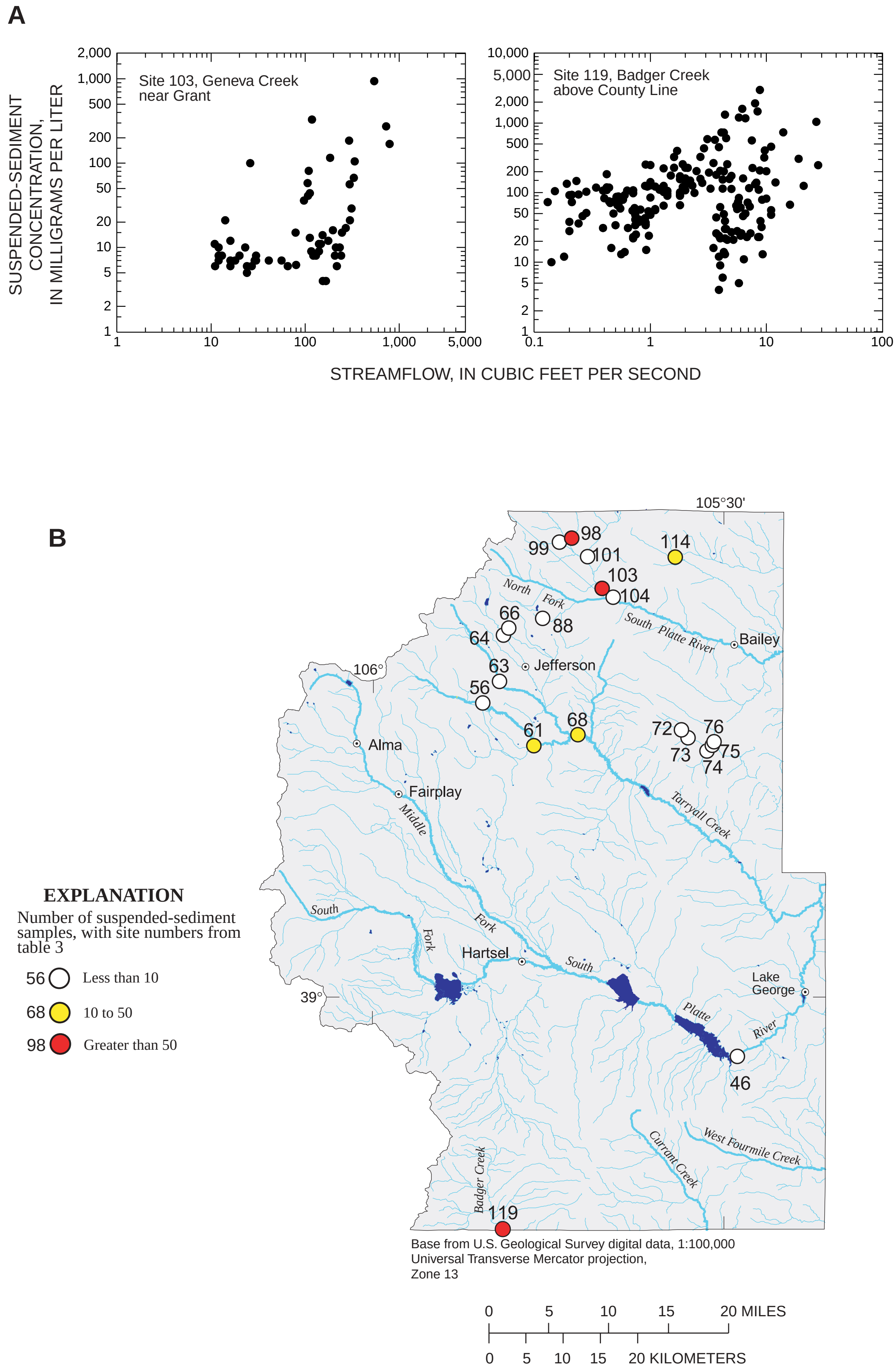


Figure 17. (A) Relation between streamflow and suspended-sediment concentrations for sites 103 and 119, and (B) the number of suspended-sediment samples per site, Park County, 1962–98.

Table 7. Characteristics of ground-water-quality sites in Park County, 1962–98

[USGS, U.S. Geological Survey; --, no data; PP, physical properties; MI, major ions; TE, trace elements; N, nutrients; B, bacteria; C, carbon]

Site no.	Site identification number	Data Source	Sampling date (month, day, year)	Water level[1] (feet)	Apparent aquifer near well screen	Type of data
1	393057105301200	USGS	06/26/74	85	Precambrian crystalline rocks	PP, MI, TE, N, B
2	393053105312600	USGS	06/26/74	150	Precambrian crystalline rocks	PP, MI, TE, N, B
3	393053105303200	USGS	06/27/74	148	Precambrian crystalline rocks	PP, MI, TE, N, B
4	393052105423300	USGS	09/07/95	--	--	PP, MI, TE, N, C
5	393041105305700	USGS	06/27/74	283	Precambrian crystalline rocks	PP, MI, TE, N, B
6	393041105302500	USGS	06/19/74	--	Precambrian crystalline rocks	PP, MI, TE, N, B
7	393040105295400	USGS	06/24/74	110	Precambrian crystalline rocks	PP, MI, TE, N, B
8	393030105334300	USGS	06/26/74	167	Precambrian crystalline rocks	PP, MI, TE, N, B
9	393029105320800	USGS	06/26/74	--	Precambrian crystalline rocks	PP, MI, TE, N, B
10	393028105301700	USGS	06/27/74	50	Precambrian crystalline rocks	PP, MI, TE, N, B
11	393023105302000	USGS	06/27/74	388	Precambrian crystalline rocks	PP, MI, TE, N, B
12	393015105324700	USGS	06/26/74	90	Precambrian crystalline rocks	PP, MI, TE, N, B
13	393011105315600	USGS	06/27/74	140	Precambrian crystalline rocks	PP, MI, TE, N, B
14	393006105314600	USGS	06/25/74	--	Precambrian crystalline rocks	PP, MI, TE, N
15	393004105313700	USGS	06/27/74	50	Precambrian crystalline rocks	PP, MI, TE, N, B
16	393001105240300	USGS	06/18/74	--	Precambrian crystalline rocks	PP, MI, TE, N, B
17	392957105322500	USGS	06/26/74	90	Precambrian crystalline rocks	PP, MI, TE, N, B
18	392940105313800	USGS	06/25/74	--	Precambrian crystalline rocks	PP, MI, TE, N, B
19	392935105301600	USGS	06/24/74	--	Precambrian crystalline rocks	PP, MI, TE, N, B
20	392935105290400	USGS	06/24/74	--	Precambrian crystalline rocks	PP, MI, TE, N, B
21	392933105414700	USGS	07/18/74	--	Quaternary unconsolidated deposits	PP, MI, TE, N, B
22	392925105284900	USGS	06/20/74	225	Precambrian crystalline rocks	PP, MI, TE, N, B
23	392923105244700	USGS	06/19/74	--	Precambrian crystalline rocks	PP, MI, TE, N, B
24	392920105303000	USGS	06/25/74	275	Precambrian crystalline rocks	PP, MI, TE, N, B
25	392920105285400	USGS	06/21/74	145	Precambrian crystalline rocks	PP, MI, TE, N, B
26	392918105294800	USGS	06/25/74	--	Precambrian crystalline rocks	PP, MI, TE, N, B
27	392911105241600	USGS	06/18/74	--	Precambrian crystalline rocks	PP, MI, TE, N, B
28	392908105311500	USGS	06/25/74	85	Quaternary unconsolidated deposits	PP, MI, TE, N, B
29	392907105320000	USGS	06/24/74	250	Precambrian crystalline rocks	PP, MI, TE, N, B
30	392853105405800	USGS	09/07/95	--	--	PP, MI, TE, N, C
31	392814105293700	USGS	06/20/74	--	Quaternary unconsolidated deposits	PP, MI, TE, N, B
32	392813105240800	USGS	06/18/74	--	Precambrian crystalline rocks	PP, MI, TE, N, B
33	392751105395900	USGS	07/18/74	--	Precambrian crystalline rocks	PP, MI, N, B
34	392744105230900	USGS	06/19/74	--	Precambrian crystalline rocks	PP, MI, TE, N, B
35	392734105434800	USGS	07/19/74	--	Precambrian crystalline rocks	PP, MI, N, B
36	392734105235500	USGS	06/19/74	--	Precambrian crystalline rocks	PP, MI, TE, N, B
37	392732105235300	USGS	06/18/74	--	Precambrian crystalline rocks	PP, MI, TE, N, B

Table 7. Characteristics of ground-water-quality sites in Park County, 1962–98—Continued

[USGS, U.S. Geological Survey; --, no data; PP, physical properties; MI, major ions; TE, trace elements; N, nutrients; B, bacteria; C, carbon]

Site no.	Site identification number	Data Source	Sampling date (month, day, year)	Water level[1] (feet)	Apparent aquifer near well screen	Type of data
38	392727105292000	USGS	06/20/74	80	Quaternary unconsolidated deposits	PP, MI, TE, N, B
39	392720105383600	USGS	07/18/74	--	Precambrian crystalline rocks	PP, MI, N, B
40	392701105464500	USGS	07/18/74	--	Precambrian crystalline rocks	PP, MI, N, B
41	392659105280300	USGS	06/20/74	26	Quaternary unconsolidated deposits	PP, MI, TE, N, B
42	392646105280300	USGS	06/20/74	175	Precambrian crystalline rocks	PP, MI, TE, N, B
43	392645105364300	USGS	07/16/74	--	Quaternary unconsolidated deposits	PP, MI, N, B
44	392641105470200	USGS	07/18/74	--	Precambrian crystalline rocks	PP, MI, TE, N
45	392637105261700	USGS	06/19/74	--	Quaternary unconsolidated deposits	PP, MI, TE, N
46	392634105251200	USGS	07/12/74	--	Precambrian crystalline rocks	PP, MI, N, B
47	392632105275000	USGS	06/20/74	180	Precambrian crystalline rocks	PP, MI, TE, N, B
48	392632105274100	USGS	06/19/74	--	Precambrian crystalline rocks	PP, MI, TE, N, B
49	392623105354900	USGS	07/16/74	--	Precambrian crystalline rocks	PP, MI, N, B
50	392612105251000	USGS	07/12/74	--	Precambrian crystalline rocks	PP, MI, TE, N, B
51	392612105242500	USGS	07/12/74	--	Precambrian crystalline rocks	PP, MI, N, B
52	392610105280500	USGS	07/09/74	--	Quaternary unconsolidated deposits	PP, MI, N, B
53	392607105245200	USGS	07/12/74	--	Precambrian crystalline rocks	PP, MI, N, B
54	392557105262100	USGS	07/11/74	--	Quaternary unconsolidated deposits	PP, MI, N
55	392546105270300	USGS	07/10/74	--	Precambrian crystalline rocks	PP, MI, N, B
56	392545105342200	USGS	07/16/74	--	Precambrian crystalline rocks	PP, MI, TE, N, B
57	392539105281200	USGS	07/09/74	--	Precambrian crystalline rocks	PP, MI, TE, N, B
58	392538105254900	USGS	07/11/74	--	Precambrian crystalline rocks	PP, MI, N, B
59	392533105274500	USGS	07/10/74	--	Precambrian crystalline rocks	PP, MI, N, B
60	392528105331800	USGS	07/17/74	--	Quaternary unconsolidated deposits	PP, MI, N, B
61	392527105244200	USGS	07/12/74	--	Precambrian crystalline rocks	PP, MI, N, B
62	392525105282800	USGS	07/09/74	--	Quaternary unconsolidated deposits	PP, MI, N, B
63	392523105270500	USGS	07/10/74	--	--	PP, MI, N, B
64	392520105270700	USGS	06/27/74	260	Precambrian crystalline rocks	PP, MI, TE, N, B
65	392518105254000	USGS	07/11/74	--	Precambrian crystalline rocks	PP, MI, N, B
66	392518105242700	USGS	07/12/74	--	Precambrian crystalline rocks	PP, MI, N, B
67	392516105331900	USGS	07/17/74	--	Precambrian crystalline rocks	PP, MI, TE, N, B
68	392516105272900	USGS	07/10/74	--	Precambrian crystalline rocks	PP, MI, TE, N, B
69	392516105260800	USGS	07/10/74	--	Precambrian crystalline rocks	PP, MI, N, B
70	392515105315800	USGS	07/17/74	--	Precambrian crystalline rocks	PP, MI, N, B
71	392515105244800	USGS	07/11/74	--	Precambrian crystalline rocks	PP, MI, N, B
72	392512105252400	USGS	07/11/74	--	Precambrian crystalline rocks	PP, MI, TE, N, B
73	392503105263700	USGS	07/10/74	--	Precambrian crystalline rocks	PP, MI, N, B
74	392503105244800	USGS	07/11/74	--	Precambrian crystalline rocks	PP, MI, N, B

Table 7. Characteristics of ground-water-quality sites in Park County, 1962–98—Continued

[USGS, U.S. Geological Survey; --, no data; PP, physical properties; MI, major ions; TE, trace elements; N, nutrients; B, bacteria; C, carbon]

Site no.	Site identification number	Data Source	Sampling date (month, day, year)	Water level[1] (feet)	Apparent aquifer near well screen	Type of data
75	392501105322900	USGS	07/19/74	--	Precambrian crystalline rocks	PP, MI, N, B
76	392501105250800	USGS	07/11/74	--	Precambrian crystalline rocks	PP, MI, N, B
77	392454105334400	USGS	07/17/74	--	Precambrian crystalline rocks	PP, MI, N, B
78	392440105264600	USGS	07/09/74	--	Precambrian crystalline rocks	PP, MI, N, B
79	392437105305800	USGS	07/19/74	--	Quaternary unconsolidated deposits	PP, MI, N, B
80	392434105295900	USGS	07/17/74	--	Quaternary unconsolidated deposits	PP, MI, N, B
81	392427105252300	USGS	07/11/74	--	Precambrian crystalline rocks	PP, MI, TE, N, B
82	392425105441600	USGS	07/23/74	10	Quaternary unconsolidated deposits	PP, MI, N
83	392421105283000	USGS	07/17/74	--	Quaternary unconsolidated deposits	PP, MI, TE, N, B
84	392415105512500	USGS	07/23/74	--	Quaternary unconsolidated deposits	PP, MI, TE, N
85	392402105293100	USGS	07/19/74	106	Precambrian crystalline rocks	PP, MI, TE, N, B
86	392402105274400	USGS	07/10/74	--	Quaternary unconsolidated deposits	PP, MI, N, B
87	392336105265200	USGS	07/09/74	--	Quaternary unconsolidated deposits	PP, MI, N, B
88	392332105244300	USGS	06/18/74	--	Precambrian crystalline rocks	PP, MI, TE, N, B
89	392329105472300	USGS	07/23/74	100	Quaternary unconsolidated deposits	PP, MI, TE, N
90	392300105255900	USGS	07/09/74	--	Quaternary unconsolidated deposits	PP, MI, N, B
91	392238105475800	USGS	07/23/74	--	Quaternary unconsolidated deposits	PP, MI, TE, N
92	392236105475900	USGS	07/23/74	12	Quaternary unconsolidated deposits	PP, MI, N
93	392202105493501	USGS	05/07/98	--	Tertiary sedimentary rocks	PP, MI, TE, N, C
94	392111106034200	USGS	07/24/74	100	Paleozoic sedimentary rocks	PP, MI, TE, N
95	391958106034500	USGS	07/24/74	185	Paleozoic sedimentary rocks	PP, MI, TE, N
96	391830105500801	USGS	05/05/98	--	Tertiary sedimentary rocks	PP, MI, TE, N, C
97	391717106040000	USGS	07/24/74	67	Quaternary unconsolidated deposits	PP, MI, TE, N
98	391716105494401	USGS	05/05/98	--	Tertiary sedimentary rocks	PP, MI, TE, N, C
99	391631105480404	USGS	05/06/98	--	Tertiary sedimentary rocks	PP, MI, TE, N, C
100	391631105480402	USGS	05/06/98	--	Tertiary sedimentary rocks	PP, MI, TE, N, C
101	391631105480401	USGS	05/06/98	--	Tertiary sedimentary rocks	PP, MI, TE, N, C
102	391631105461301	USGS	05/12/98	--	Precambrian crystalline rocks	PP, MI, TE, N, C
103	391625105501001	USGS	05/04/98	--	Tertiary sedimentary rocks	PP, MI, TE, N, C
104	391619106031400	USGS	07/25/74	45	Quaternary unconsolidated deposits	PP, MI, TE, N
105	391602105473801	USGS	05/14/98	--	Precambrian crystalline rocks	PP, MI, TE, N, C
106	391556106034600	USGS	07/25/74	--	Quaternary unconsolidated deposits	PP, MI, TE, N
107	391511105500301	USGS	05/04/98	--	Tertiary sedimentary rocks	PP, MI, TE, N, C
108	391452105483503	USGS	06/16/98	--	Precambrian crystalline rocks	PP, MI, TE, N, C
109	391452105483502	USGS	06/17/98	--	Tertiary sedimentary rocks	PP, MI, TE, N, C
110	391452105483501	USGS	06/17/98	--	Precambrian crystalline rocks	PP, MI, TE, N, C
111	391441105474501	USGS	05/12/98	--	Precambrian crystalline rocks	PP, MI, TE, N, C

Table 7. Characteristics of ground-water-quality sites in Park County, 1962–98—Continued

[USGS, U.S. Geological Survey; --, no data; PP, physical properties; MI, major ions; TE, trace elements; N, nutrients; B, bacteria; C, carbon]

Site no.	Site identification number	Data Source	Sampling date (month, day, year)	Water level[1] (feet)	Apparent aquifer near well screen	Type of data
112	391416106004800	USGS	07/25/74	240	Paleozoic sedimentary rocks	PP, MI, TE, N
113	391337105484301	USGS	05/28/98	--	Tertiary sedimentary rocks	PP, MI, TE, N, C
114	391314105465501	USGS	06/15/98	--	Precambrian crystalline rocks	PP, MI, TE, N, C
115	391112105435600	USGS	09/18/74	--	Quaternary unconsolidated deposits	PP, MI, TE, N
116	391103105453500	USGS	09/18/74	--	Precambrian crystalline rocks	PP, MI, TE, N
117	390921105453100	USGS	09/17/74	46	Quaternary unconsolidated deposits	PP, MI, TE, N
118	390903105422300	USGS	09/17/74	40	Quaternary unconsolidated deposits	PP, MI, TE, N
119	390853105434600	USGS	09/17/74	--	Tertiary sedimentary rocks	PP, MI, TE, N
120	390831105554200	USGS	09/09/74	10	Quaternary unconsolidated deposits	PP, MI, TE, N
121	390807105535500	USGS	09/13/74	36	Quaternary unconsolidated deposits	PP, MI, TE, N
122	390719105282900	USGS	11/06/75	--	Precambrian crystalline rocks	PP, MI, TE, N
123	390653105591900	USGS	09/11/74	--	Quaternary unconsolidated deposits	PP, MI, TE, N
124	390638105532200	USGS	09/09/74	20	Quaternary unconsolidated deposits	PP, MI, TE, N
125	390638105260700	USGS	08/14/75	50	Precambrian crystalline rocks	PP, MI, TE, N
126	390613105494900	USGS	09/12/74	--	Cretaceous and Jurassic sedimentary rocks	PP, MI, TE, N
127	390605106011600	USGS	07/24/74	4	Quaternary unconsolidated deposits	PP, MI, TE, N
128	390602105255500	USGS	08/14/75	100	Precambrian crystalline rocks	PP, MI, TE, N
129	390552105254500	USGS	08/14/75	120	Precambrian crystalline rocks	PP, MI, TE, N
130	390523105440800	USGS	09/17/74	--	Quaternary unconsolidated deposits	PP, MI, TE, N
131	390514105252800	USGS	11/05/75	--	Precambrian crystalline rocks	PP, MI, TE, N
132	390424105513800	USGS	09/13/74	20	Cretaceous and Jurassic sedimentary rocks	PP, MI, TE, N
133	390344105434700	USGS	07/26/74	--	Tertiary sedimentary rocks	PP, MI, TE, N
134	390323105582600	USGS	09/11/74	--	Paleozoic sedimentary rocks	PP, MI, TE, N
135	390244105432200	USGS	09/18/74	--	Cretaceous and Jurassic sedimentary rocks	PP, MI, TE, N
136	390205105203400	USGS	08/15/75	--	Precambrian crystalline rocks	PP, MI, TE, N
137	390201105415200	USGS	09/16/74	--	Cretaceous and Jurassic sedimentary rocks	PP, MI, TE, N
138	390143105210300	USGS	08/15/75	140	Precambrian crystalline rocks	PP, MI, TE, N
139	390142105205700	USGS	08/15/75	65	Quaternary unconsolidated deposits	PP, MI, TE, N
140	390140105204700	USGS	08/15/75	170	Precambrian crystalline rocks	PP, MI, TE, N
141	390125105475300	USGS	09/12/74	58	Quaternary unconsolidated deposits	PP, MI, TE, N
142	390121105294700	USGS	08/14/75	200	Precambrian crystalline rocks	PP, MI, TE, N
143	390117105302500	USGS	08/13/75	75	Precambrian crystalline rocks	PP, MI, TE, N
144	390117105223700	USGS	11/05/75	80	Precambrian crystalline rocks	PP, MI, TE, N
145	390100105452200	USGS	09/12/74	--	Quaternary unconsolidated deposits	PP, MI, TE, N

Table 7. Characteristics of ground-water-quality sites in Park County, 1962–98—Continued

[USGS, U.S. Geological Survey; --, no data; PP, physical properties; MI, major ions; TE, trace elements; N, nutrients; B, bacteria; C, carbon]

Site no.	Site identification number	Data Source	Sampling date (month, day, year)	Water level[1] (feet)	Apparent aquifer near well screen	Type of data
146	390038105282000	USGS	11/05/75	--	Precambrian crystalline rocks	PP, MI, TE, N
147	385936105342500	USGS	09/10/74	--	Quaternary unconsolidated deposits	PP, MI, TE, N
148	385932105452100	USGS	09/10/74	--	Tertiary sedimentary rocks	PP, MI, TE, N
149	385902105214000	USGS	11/06/75	--	Precambrian crystalline rocks	PP, MI, TE, N
150	385900105434000	USGS	09/10/74	--	Tertiary volcanic rock	PP, MI, TE, N
151	385850105221200	USGS	08/13/75	65	Quaternary unconsolidated deposits	PP, MI, TE, N
152	385848105212700	USGS	11/04/75	35	Precambrian crystalline rocks	PP, MI, TE, N
153	385834105205600	USGS	11/04/75	85	Tertiary sedimentary rocks	PP, MI, TE, N
154	385815105200500	USGS	11/04/75	--	Precambrian crystalline rocks	PP, MI, TE, N
155	385813105301500	USGS	08/13/75	75	Precambrian crystalline rocks	PP, MI, TE, N
156	385804105202200	USGS	11/04/75	--	Tertiary sedimentary rocks	PP, MI, TE, N
157	385737105273600	USGS	08/13/75	122	Precambrian crystalline rocks	PP, MI, TE, N
158	385733105503200	USGS	09/11/74	--	Tertiary sedimentary rocks	PP, MI, TE, N
159	385730105284000	USGS	08/13/75	300	Precambrian crystalline rocks	PP, MI, TE, N
160	385715105522600	USGS	09/11/74	--	Tertiary sedimentary rocks	PP, MI, TE, N
161	385633105295200	USGS	08/13/75	--	Precambrian crystalline rocks	PP, MI, TE, N
162	385630105290500	USGS	08/14/75	90	Precambrian crystalline rocks	PP, MI, TE, N
163	385625105483900	USGS	09/11/74	--	Tertiary sedimentary rocks	PP, MI, TE, N
164	385620105304700	USGS	11/05/75	--	Precambrian crystalline rocks	PP, MI, TE, N
165	385605105293500	USGS	08/14/75	96	Precambrian crystalline rocks	PP, MI, TE, N
166	385512105222200	USGS	11/04/75	165	Precambrian crystalline rocks	PP, MI, TE, N
167	385456105235300	USGS	11/04/75	--	Precambrian crystalline rocks	PP, MI, TE, N
168	385426105235100	USGS	11/04/75	--	Precambrian crystalline rocks	PP, MI, TE, N
169	385349105393800	USGS	09/10/74	50	--	PP, MI, TE, N
170	385208105465500	USGS	09/11/74	--	Tertiary sedimentary rocks	PP, MI, TE, N
171	385100105205200	USGS	08/12/75	285	Precambrian crystalline rocks	PP, MI, TE, N
172	385050105455600	USGS	09/19/74	--	Quaternary unconsolidated deposits	PP, MI, TE, N
173	385050105213800	USGS	08/12/75	225	Tertiary volcanic rock	PP, MI, TE, N
174	385046105215000	USGS	08/12/75	--	Quaternary unconsolidated deposits	PP, MI, TE, N
175	384857105230800	USGS	08/12/75	113	Tertiary volcanic rock	PP, MI, TE, N
176	384754105480400	USGS	09/19/74	--	Tertiary sedimentary rocks	PP, MI, TE, N
177	384630105474000	USGS	09/19/74	--	Tertiary sedimentary rocks	PP, MI, TE, N
178	384508105312100	USGS	09/19/74	110	--	PP, MI, TE, N
179	384500105311200	USGS	09/19/74	18	Quaternary unconsolidated deposits	PP, MI, TE, N
180	384440105532200	USGS	09/19/74	--	Quaternary unconsolidated deposits	PP, MI, TE, N

[1]Water level in feet below land surface measured on sampling date.

Table 8. Summary of ground-water-quality data for Park County, 1962–98

[No., number; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; --, no data; <, less than; µg/L, micrograms per liter; pCi/L, picocuries per liter; cols/100 mL, colonies per 100 milliliters; SMCL, secondary maximum contaminant level; MCL, maximum contaminant level; PMCL, proposed maximum contaminant level; $CaCO_3$, calcium carbonate; diss., dissolved; strep., streptococcus]

Constituent or property	No. of analyses	Minimum	Concentration or value at indicated percentile					Maximum	Standard or guideline for drinking water[1]
			10	25	50	75	90		
Physical properties									
Water temperature (°C)	170	5.0	7.0	8.5	9.5	11.0	13.0	19.0	--
Oxygen, dissolved (mg/L)	16	0.1	0.1	0.3	0.7	1.6	4.9	6.5	--
pH (standard units)	133	5.4	6.1	6.3	6.8	7.2	7.9	9.7	6.5–8.5 (SMCL)
Specific conductance	180	42	114	210	328	450	742	3,920	--
Major ions and dissolved solids, in mg/L									
Calcium, dissolved	144	1.0	13	23	37	56	85	420	--
Chloride, dissolved	180	<0.1	1.0	1.9	4.1	9.7	22	220	250 (SMCL)
Fluoride, dissolved	180	0.1	0.2	0.3	0.5	1.3	2.2	5.6	2 (SMCL)
Magnesium, dissolved	144	0.005	1.8	4.0	8.4	15	28	260	--
Potassium, dissolved	180	<0.1	0.8	1.2	1.9	2.7	4.6	16	--
Sodium, dissolved	144	0.3	3.7	5.9	12	20	54	290	--
Silica, dissolved	144	5.6	9.9	13	17	22	27	73	--
Sulfate, dissolved	144	4.3	7.5	9.9	20	39	136	1,800	250 (SMCL)
Dissolved solids	144	46	77	130	202	284	520	3,310	500 (SMCL)
Nutrients, dissolved, in mg/L									
Ammonia	18	<0.02	<0.02	0.02	0.04	0.08	0.11	0.12	--
Nitrate	440	<0.05	<0.05	0.12	0.84	2.7	6.1	24	10 (MCL)
Nitrite	18	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	1 (MCL)
Orthophosphorus	180	<0.01	<0.01	0.01	0.01	0.02	0.06	0.6	--
Trace elements, dissolved, in µg/L; and radon, in pCi/L									
Aluminum	36	3	4	5	10	12	20	80	50–200 (SMCL)
Arsenic	16	<1	<1	<1	<1	<1	<1	<1	50 (MCL)
Barium	18	2	4	8	19	35	63	78	2,000 (MCL)
Cadmium	18	<1	<1	<1	<1	<1	<1	<1	5.0 (MCL)
Chromium	18	<1	<1	<1	1	2	6	7	100 (MCL)
Copper	54	<2	<2	<2	2	7	24	50	1,000 (SMCL)
Iron	144	<10	<10	20	30	60	787	18,000	300 (SMCL)
Lead	54	<2	<2	<2	<2	3	8	12	--
Manganese	143	<10	<10	<10	<10	40	156	3,900	50 (SMCL)
Molybdenum	18	<1	<1	<1	2	7	18	28	--
Nickel	18	<1	<1	<1	<1	1	1	1	100 (MCL)
Selenium	16	<1	<1	<1	<1	<1	1	2.2	50 (MCL)
Silver	18	<1	<1	<1	<1	<1	<1	<1	100 (SMCL)
Uranium	18	<1	<1	1	3	11	17	19	20 (PMCL)
Zinc	63	<1	<1	20	110	622	3,680	11,000	5,000 (SMCL)
Radon	16	1,900	2,000	2,500	4,200	6,300	12,600	27,800	300 (PMCL)
Other constituents or properties									
Alkalinity (as $CaCO_3$)	127	5.0	35	68	129	179	216	818	--
Carbon, organic, diss. (mg/L)	18	0.2	0.4	0.6	1.1	2.1	2.9	9.2	--
Fecal coliform (cols/100 mL)	81	<1	<1	<1	<1	<1	<1	80	--
Fecal strep. (cols/100 mL)	81	<1	<1	<1	<1	<1	1	9	--
Hardness (mg/L as $CaCO_3$)	144	3.0	40	74	135	215	302	2,100	--

[1]U.S. Environmental Protection Agency, 1996.

Almost all of the wells in table 7 were sampled for physical properties (water temperature, dissolved oxygen, pH, specific conductance), major ions, nutrients, and trace elements, and about one-half of the wells were sampled for bacteria (table 7). In 1994–95, the PCDEH sampled for nitrate in 194 domestic wells in subdivisions northeast of Bailey (Tom Eisenman, Park County Department of Environmental Health, written commun., 1999). Since 1993, the U.S. Forest Service has periodically sampled for nitrate in 21 wells located in Forest Service campgrounds in Park County (U.S. Forest Service, Pike National Forest, South Park Ranger District, written commun., 1999).

Well-completion data were available for 175 of the wells sampled by the USGS (table 7). Forty-three wells were completed in alluvial aquifers composed of unconsolidated valley-fill or glacial deposits of Quaternary age. Alluvial wells were located throughout the county, primarily near streams (fig. 18). More than one-half the wells were completed in crystalline-rock aquifers of Precambrian age, and most of these were in the northeastern corner of the county, north of Bailey, and in the vicinity of Lake George (fig. 18). Twenty-nine wells were completed in sedimentary-rock aquifers of varying age and composition. Most of the wells completed in sedimentary-rock aquifers were located in a north-south-trending band extending from near Jefferson in the north to the Hartsel area in the south. Three wells were completed in volcanic-rock aquifers of Tertiary age and were located near Hartsel and in the West Fourmile Creek drainage in the Arkansas River Basin (fig. 18).

Physical Properties

Water temperature was measured in most of the wells sampled by the USGS and ranged from 5° to 19° C with a median of 9.5° C (table 8). Dissolved oxygen—measured in 16 wells sampled in 1998 by the USGS (Bruce and Kimbrough, 1999)—ranged from 0.1 to 6.5 mg/L and was less than 1.0 mg/L in at least one-half of the wells (table 8). Values for pH in ground water (obtained in 133 of 180 wells) ranged from 5.4 to 9.7. A small number of pH measurements were outside the 6.5–8.5 range that is the SMCL for drinking water (U.S. Environmental Protection Agency, 1996). Values of pH less than 6.5 primarily were in samples from the alluvial and crystalline-rock aquifers, whereas the few values larger than 8.5 were from the sedimentary and volcanic-rock aquifers (fig. 19).

Major Ions and Dissolved Solids

Water from similar aquifers tends to have a similar ionic chemical composition based on the percentage of milliequivalents per liter of the major ions present. Calcium-bicarbonate-type water was found in each aquifer type and predominated in the alluvial and crystalline-rock aquifers (table 9). Water types found in sedimentary-rock aquifers included calcium-sulfate and sodium-sulfate water in aquifers composed of the South Park Formation; sodium-sulfate and sodium-bicarbonate water in aquifers composed of the Pierre Shale; and magnesium-bicarbonate water in sedimentary-rock aquifers of Paleozoic age. In the volcanic-rock aquifer, the predominant water type was different in each of the three wells sampled (table 9).

Among the major ions, Federal drinking-water standards have been set for chloride, sulfate, and fluoride (table 8). About 90 percent of all chloride concentrations in ground water were at least one order of magnitude lower than the USEPA drinking-water standard of 250 mg/L (table 8) and no concentrations exceeded the standard. A few sulfate concentrations (8 of 144) were larger than the drinking-water standard of 250 mg/L and occurred primarily in wells completed in sedimentary and volcanic-rock aquifers. The USEPA guideline for sulfate is based on esthetic effects such as taste and odor. Health concerns regarding sulfate in drinking water have been raised because of its potential laxative effects in infants or in people who experience an abrupt change from low-sulfate drinking water to high-sulfate drinking water (U.S. Environmental Protection Agency, 1999a).

Fluoride was detected in every ground-water sample at concentrations ranging from 0.1 to 5.6 mg/L, although only about 10 percent of the concentrations exceeded the USEPA drinking-water standard of 2 mg/L (table 8). Concentrations larger than 2 mg/L almost exclusively were limited to wells completed in crystalline-rock aquifers composed of the Pikes Peak Granite (fig. 20), an igneous rock of Precambrian age. The Pikes Peak Granite crops out only on the eastern edge of central Park County and in the northeast corner of the county north of Bailey. Fluoride concentrations in drinking water greater than 2 mg/L may cause dental fluorosis in children, and long-term exposure to drinking-water levels greater than 4 mg/L may result in serious bone disorders (U.S. Environmental Protection Agency, 1999b).

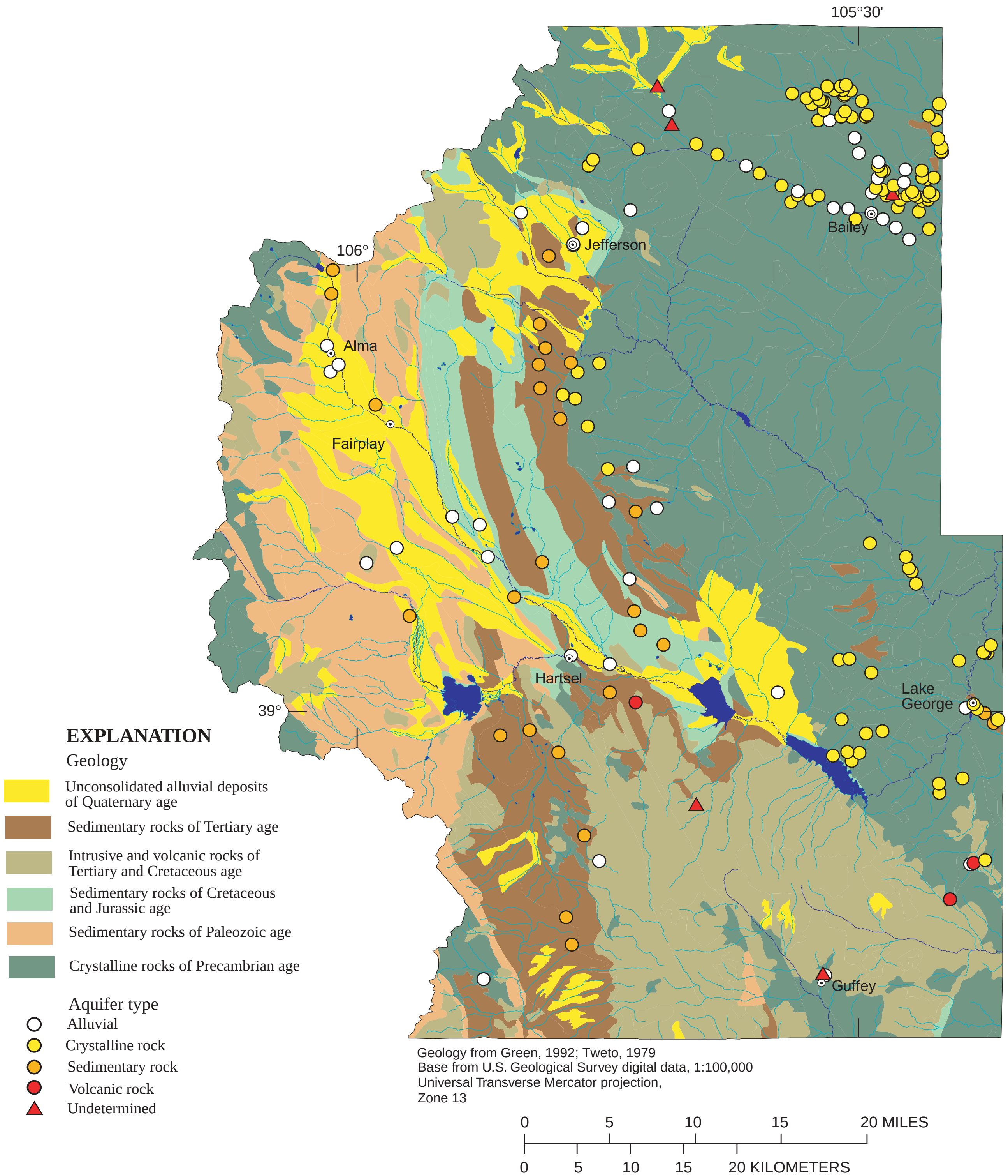


Figure 18. Aquifer type determined from screened interval for wells sampled by the U.S. Geological Survey in Park County.

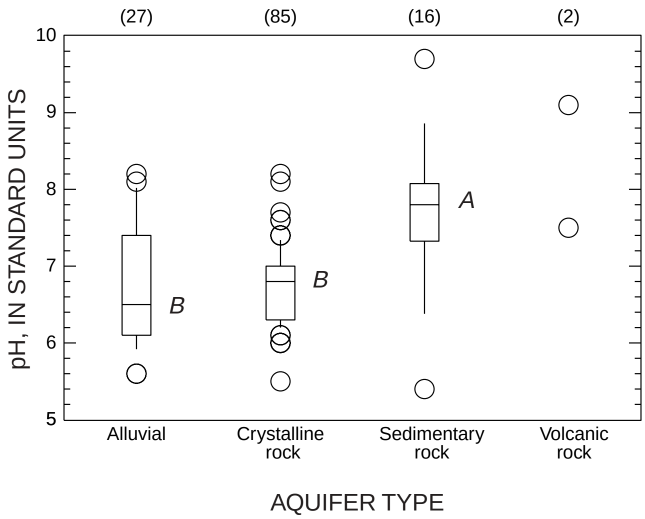


Figure 19. Distribution of pH by aquifer type for wells in Park County, 1974–75, 1998. Boxplot explanation on pages 10–11.

Dissolved-solids concentrations were measured in 80 percent of the wells, and median concentrations were higher in the alluvial aquifers (252 mg/L) and the sedimentary-rock aquifers (257 mg/L) and lower in the crystalline-rock aquifers (160 mg/L) (fig. 21A). Data for the volcanic-rock aquifers were not included in the multiple comparison test because of the small number of samples. Dissolved-solids concentrations less than 130 mg/L (value at the 25th percentile, table 8) primarily occurred in wells completed in the alluvial or crystalline-rock aquifers near Jefferson and north of Bailey (fig. 21B). Dissolved-solids concentrations greater than the USEPA SMCL of 500 mg/L were measured in about 10 percent of the wells (table 8) sampled and in all aquifer types (fig. 21A) but were most common in wells completed in sedimentary-rock aquifers between Jefferson and Hartsel (fig. 21B). Most wells that exceeded the SMCL for dissolved solids also exceeded the SMCL for sulfate (fig. 22).

Nutrients

Ground-water data for the nutrients nitrogen and phosphorus are summarized in table 8. The relatively small number of ammonia and nitrite analyses were collected by the USGS in the 1990's, whereas most of the orthophosphorus analyses (162 analyses) were collected in the 1970's. Some of the nitrate data were collected in the 1970's by the USGS (176 analyses) but most (264 analyses) were collected in the 1990's by the PCDEH, USGS, and U.S. Forest Service.

The USEPA (1996) has established MCL's for two species of nitrogen—nitrite and nitrate (table 8). All nitrite concentrations in ground water were at least one order of magnitude lower than the 1 mg/L MCL for nitrite. Most nitrate concentrations in ground water were less than the 10 mg/L MCL for nitrate (table 8). The few nitrate concentrations larger than 10 mg/L primarily were in samples from domestic wells in subdivisions northeast of Bailey in the 1990's.

Elevated nitrate concentrations in ground water may result from the seepage of animal waste or septic tank effluent. In the crystalline-rock aquifers of Park County and nearby Jefferson County, nitrate concentrations above 0.2 mg/L may result from waste contamination (Hofstra and Hall, 1975; Goddard, 1978); thus, many of the wells in the crystalline-rock aquifers in Park County may have had some level of contamination as early as the 1970's (fig. 23A). Figure 23A also indicates that nitrate concentrations were not significantly different between aquifer types in the 1970's, even though some of the highest concentrations occurred in the alluvial and crystalline-rock aquifers (the small data set for the volcanic-rock aquifers was not included in the multiple comparison test).

In figure 23B, the PCDEH nitrate data for domestic wells located in subdivisions northeast of Bailey are plotted with USGS nitrate data for domestic wells located in the same subdivisions. The nitrate concentrations in samples collected in the 1990's by the PCDEH were significantly higher ($p<0.001$) than the nitrate concentrations in samples collected in the 1970's by the USGS. Although different wells were sampled by each agency, higher nitrate concentrations for the 1990's data set may indicate that ground-water contamination is increasing in this part of the county. Resampling some of the wells that were sampled in the 1970's could verify these results.

Trace Elements and Radon

Federal drinking-water standards exist for most of the trace elements that have been analyzed in Park County ground water (table 8). Most trace-element concentrations were less than the standards; however, the standards for iron, manganese, and zinc were exceeded in a small number of samples. Trace-element concentrations greater than the standards occurred in samples from each aquifer type, and median concentrations of iron, manganese, and zinc were similar among aquifer types (fig. 24). Some concentrations of dissolved iron and manganese

Table 9. General description of selected aquifers sampled in Park County

[No., number, Ca, calcium; HCO_3, bicarbonate; Na, sodium; SO_4, sulfate; Mg, magnesium]

Aquifer age	Principal geologic unit(s)	General lithology	No. of wells	Predominant water types (and number of wells)
		Alluvial aquifers		
Quaternary	Alluvium	Valley-fill and glacial material consisting of sand, gravel, cobbles, and boulders	43	$CaHCO_3$ (27), $NaHCO_3$ (2), $NaSO_4$ (2)
		Crystalline-rock aquifers		
Precambrian	Boulder Creek, Silver Plume, and Pikes Peak Granites	Granite, gneiss, and schist	100	$CaHCO_3$ (69)
		Sedimentary-rock aquifers		
Tertiary	South Park Formation	Arkosic sandstone and shale, volcaniclastic conglomerate	13	$CaSO_4$ (10), $NaSO_4$ (2)
Tertiary	Antero Formation	Limestone, tuff, tuffaceous sandstone, conglomerate	4	$CaHCO_3$
Tertiary	Florissant Lake Beds	Tuffaceous shale and tuff	2	$CaHCO_3$, $CaSO_4$
Tertiary	Wagontongue Formation	Volcaniclastic conglomerate	2	$CaHCO_3$
Cretaceous	Pierre Shale	Shale with sandstone interbeds	3	$NaSO_4$ (2), $NaHCO_3$ (1)
Jurassic	Entrada Formation	Sandstone	1	$CaHCO_3$
Paleozoic	not determined	Sandstone, shale, and limestone	4	$MgHCO_3$ (3), $CaHCO_3$ (1)
		Volcanic-rock aquifers		
Tertiary	Thirtynine Mile Andesite	Andesitic lavas, breccias, tuffs, and conglomerates	3	$MgSO_4$, $NaHCO_3$, $CaHCO_3$

were two orders of magnitude larger than the USEPA drinking-water standards of 300 and 50 μg/L for iron and manganese, respectively. Elevated manganese and iron concentrations do not constitute a health hazard but may form red precipitates that stain laundry and plumbing fixtures (iron) or black-oxide precipitates that affect the taste and esthetics of drinking water (manganese) (Hem, 1989). High iron and manganese concentrations in the crystalline-rock aquifers may be related to localized mineralized zones found along fractured areas in the aquifer (Goddard, 1978). The distribution of trace-element concentrations greater than the standards is not localized and occurs throughout Park County.

Naturally occurring radon gas is formed by the radioactive decay of uranium. A drinking-water standard of 300 pCi/L was proposed for radon by the USEPA (1996); however, the standard has not yet been adopted. The national average concentration of radon in ground water is 350 pCi/L (Paulsen, 1991). In 1998, the USGS sampled for radon in 16 wells east of Fairplay that were completed in either crystalline-rock aquifers of Precambrian age or the sedimentary-rock aquifer of Tertiary age composed of the South Park Formation. Radon concentrations in the 16 wells were larger than the national average and ranged from 1,900 to 27,800 pCi/L with a median of 4,200 pCi/L. Radon concentrations in ground water in other areas of the South Platte River Basin also are higher than the national average. Bruce and McMahon (1998) reported median radon concentrations of 4,400 pCi/L for a part of the crystalline-rock aquifer in the Front Range and 1,100 pCi/L for the alluvial aquifer adjacent to the South Platte River and its tributaries in Denver.

SPRINGWATER QUALITY

Water-quality data are summarized for 30 springs in Park County (fig. 25; tables 10, 11). Nineteen of the springs were sampled by the USGS in the 1970's, 4 springs east of Fairplay were sampled by the USGS in 1998 (Bruce and Kimbrough, 1999), and 7 springs were sampled in the 1970's by the National Park Service as part of a reconnaissance sampling completed near the Florissant Fossil Beds National Monument. Almost all of the springs were sampled for physical properties, major ions, and trace elements, and some of the springs were sampled for nutrients and organic carbon. Source aquifers for the springs include alluvial aquifers of Quaternary age, sedimentary-rock aquifers of Tertiary, Cretaceous, Jurassic, and Paleozoic age, and crystalline-rock aquifers of Precambrian age.

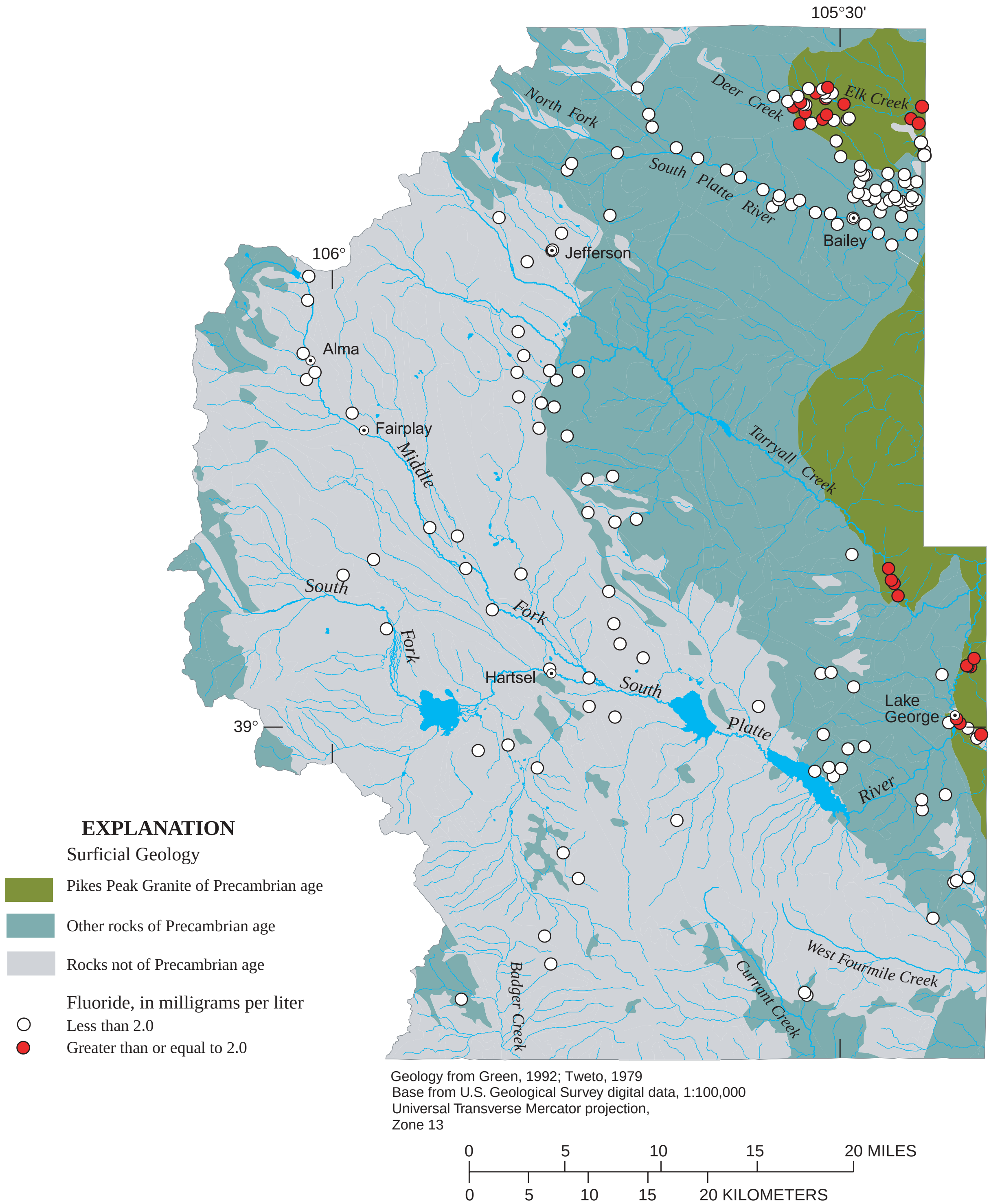
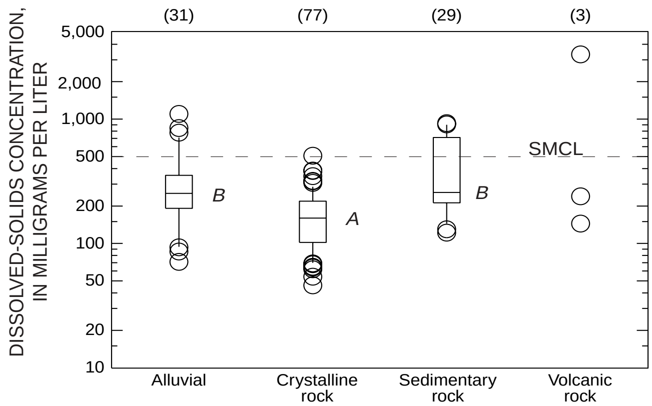


Figure 20. Fluoride concentrations in ground water, Park County, 1974–75, 1998.

A



Boxplot explanation on pages 10-11

B

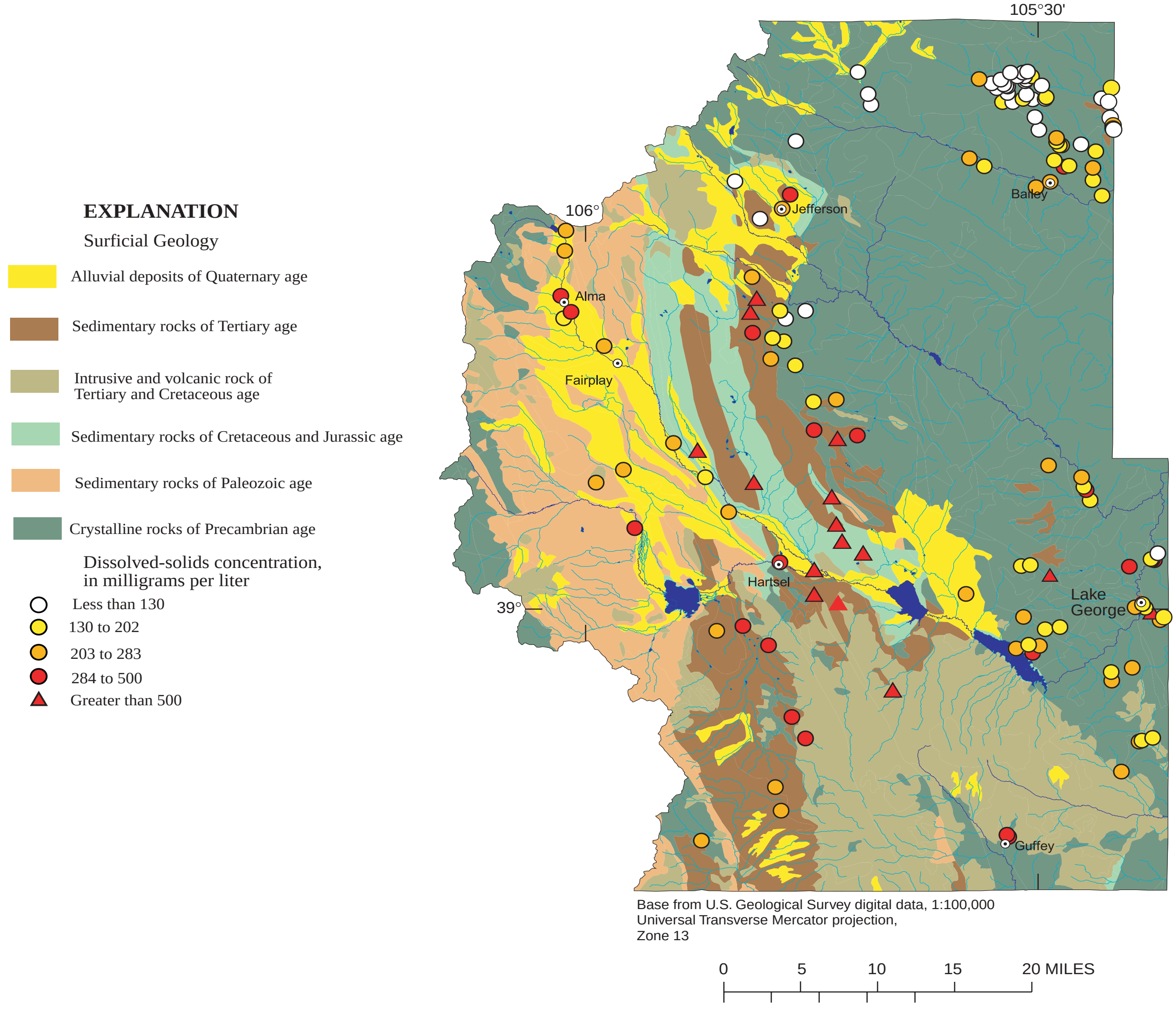


Figure 21. Distribution of dissolved solids (A) by aquifer type, and (B) in Park County (dashed line in figure A is the Secondary Maximum Contaminant Level for dissolved solids [U.S. Environmental Protection Agency, 1996]; geology from Green, 1992, and Tweto, 1979).

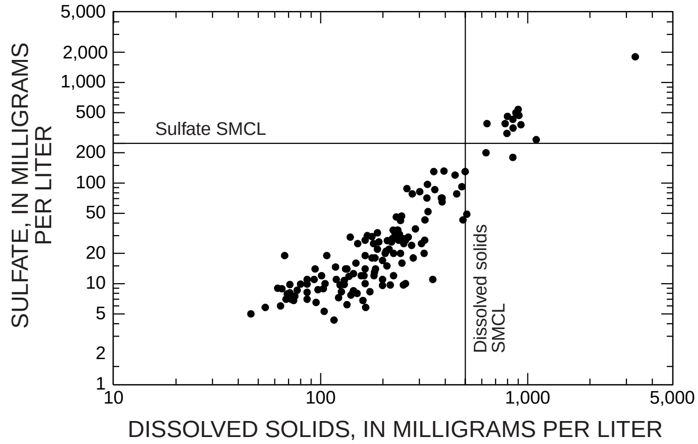
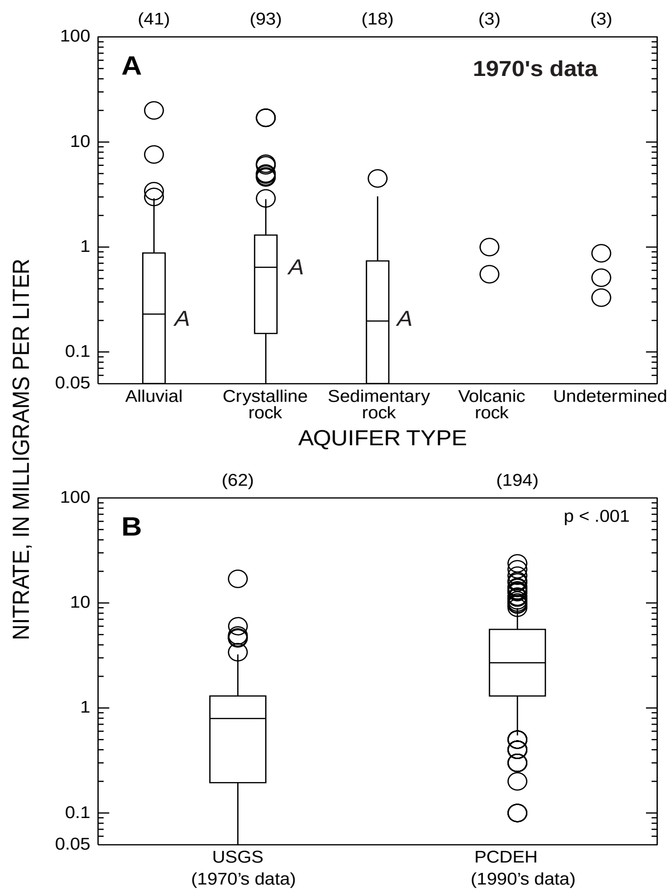
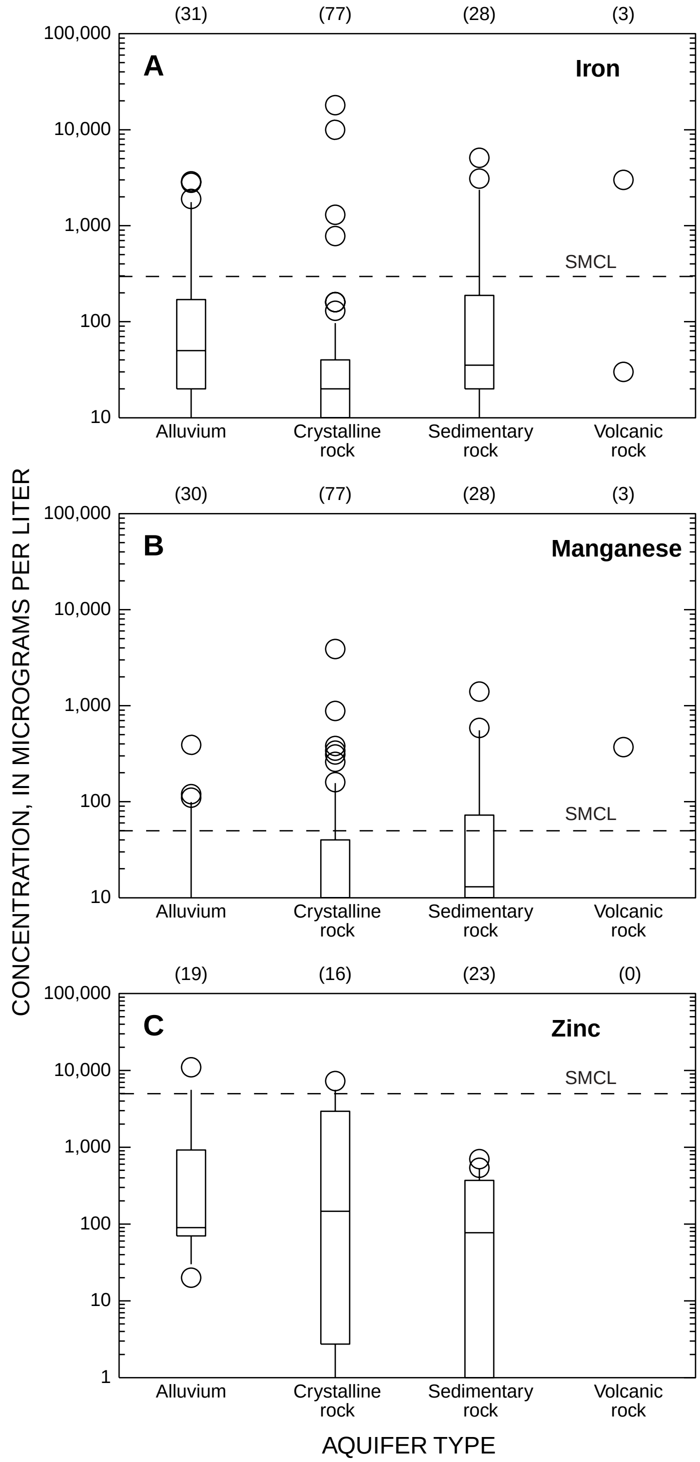


Figure 22. Relation between dissolved-sulfate and dissolved-solids concentrations in ground water, 1974–75, 1998 (SMCL, secondary maximum contaminant level for drinking water [U.S. Environmental Protection Agency, 1996]).



Boxplot explanation on pages 10-11

Figure 23. Nitrate concentrations (A) by aquifer types in Park County in the 1970's, and (B) in domestic wells in subdivisions northeast of Bailey, Colorado (USGS, U.S. Geological Survey; PCDEH, Park County Department of Environmental Health).



Boxplot explanation on pages 10-11

Figure 24. Concentrations of dissolved (A) iron, (B) manganese, and (C) zinc in aquifer types in Park County, 1974–75, 1998 (dashed lines are secondary maximum contaminant levels for drinking water [U.S. Environmental Protection Agency, 1996]).

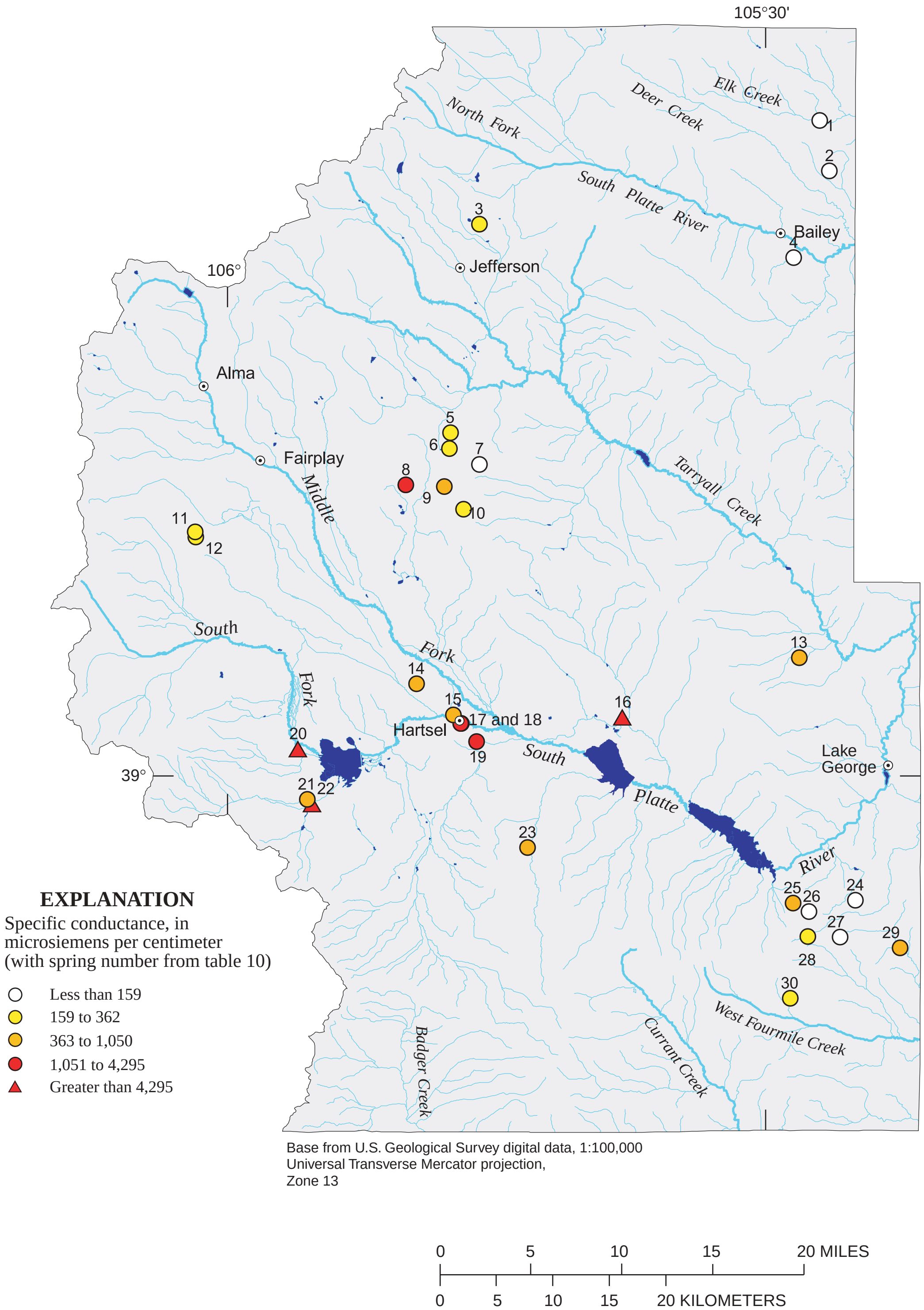


Figure 25. Specific conductance in springwater, Park County, 1974–75, 1998.

Table 10. Characteristics of springwater-quality sites in Park County, 1962–98

[USGS, U.S. Geological Survey; --, no data; Ca, calcium; HCO_3, bicarbonate; Na, sodium, SO_4, sulfate; Cl, chloride; PP, physical properties; MI, major ions; TE, trace elements; N, nutrients; C, carbon; NPS, National Park Service]

Spring number (fig. 25)	Site identifier	Data Source	Sampling dates (month, year)	Aquifer source	Principal geologic unit	Predominant chemical constituents	Type of data
1	392942105260500	USGS	6/74	Crystalline-rock aquifer of Precambrian age	Pikes Peak Granite	Ca-HCO_3	PP, MI, TE, N
2	392718105252800	USGS	6/74	Crystalline-rock aquifer of Precambrian age	--	Ca-HCO_3	PP, MI, TE, N
3	392440105464900	USGS	7/74	Alluvial aquifer of Quaternary age	Alluvium	Ca-Na-HCO_3	PP, MI, TE, N
4	392312105273700	USGS	774	Alluvial aquifer of Quaternary age	--	--	PP, MI, N
5	391449105482801	USGS	5/98	Crystalline-rock aquifer of Precambrian age	Silver Plume Granite	--	PP, MI, TE, N, C
6	391438105483600	USGS	5/98	Sedimentary-rock aquifer of Tertiary age	South Park Formation	--	PP, MI, TE, N, C
7	391320105464000	USGS	5/98	Crystalline-rock aquifer of Precambrian age	--	--	PP, MI, TE, N, C
8	391220105510800	USGS	9/74	Sedimentary-rock aquifer of Cretaceous age	Pierre Shale	Ca-Na-SO_4	PP, MI, TE, N
9	391216105484801	USGS	5/98	Sedimentary-rock aquifer of Tertiary age	South Park Formation	--	PP, MI, TE, N, C
10	391112105473800	USGS	9/74	Crystalline-rock aquifer of Precambrian age	Silver Plume Granite	Ca-HCO_3	PP, MI, TE, N
11	390949106035300	USGS	7/74, 6/75, 10/75, 7/76	Sedimentary-rock aquifer of Paleozoic age	Leadville Limestone	Ca-HCO_3	PP, MI, TE, N
12	390946106035300	USGS	7/76	--	--	--	--
13	390417105271100	USGS	8/75	Alluvial aquifer of Quaternary age	--	Ca-HCO_3	PP, MI, TE, N
14	390256105502300	USGS	9/74	Sedimentary-rock aquifer of Jurassic age	Entrada Formation	Ca-HCO_3	PP, MI, TE, N
15	390129105480800	USGS	4/76	--	--	Na-Cl-HCO_3	PP, MI
16	390125105375100	USGS	7/74	--	--	--	PP, MI, TE, N
17	390105105474000	USGS	6/75	Sedimentary-rock aquifer of Cretaceous age	Dakota Sandstone	Na-Cl	PP, MI, TE, N
18	390105105473900	USGS	7/74, 6/75, 10/75, 1/76, 4/76	Sedimentary-rock aquifer of Cretaceous age	Dakota Sandstone	Na-Cl	PP, MI, TE, N
19	390014105464300	USGS	9/74	--	--	Na-Cl	PP, MI, TE, N
20	385947105573000	USGS	7/74	Sedimentary-rock aquifer of Paleozoic age	--	Na-Cl	PP, MI, TE, N
21	385725105565700	USGS	7/74	Alluvial aquifer of Quaternary age	--	Ca-HCO_3-SO_4	PP, MI, TE, N
22	385712105563700	USGS	7/74	Sedimentary-rock aquifer of Paleozoic age	Maroon Formation	Na-Cl	PP, MI, TE, N
23	385514105433400	USGS	9/74	Alluvial aquifer of Quaternary age	--	--	PP, MI, TE, N
24	FLFO_NURE_01	NPS	8/76	Crystalline-rock aquifer of Precambrian age	Silver Plume Granite	--	PP, MI, TE
25	FLFO_NURE_05	NPS	8/76	--	--	--	PP, MI, TE
26	FLFO_NURE_02	NPS	8/76	Crystalline-rock aquifer of Precambrian age	Silver Plume Granite	--	PP, MI, TE
27	FLFO_NURE_15	NPS	8/76	Crystalline-rock aquifer of Precambrian age	Silver Plume Granite	--	PP, MI, TE
28	FLFO_NURE_03	NPS	8/76	--	--	--	PP, MI, TE
29	FLFO_NURE_18	NPS	8/76	--	--	--	PP, MI, TE
30	FLFO_NURE_16	NPS	8/76	--	--	--	PP, MI, TE

Table 11. Summary of springwater-quality data for Park County, 1962–98

[No., number; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; --, no data or not computed; <, less than; µg/L, micrograms per liter; SMCL, secondary maximum contaminant level; MCL, maximum contaminant level; PMCL, proposed maximum contaminant level; $CaCO_3$, calcium carbonate]

Constituent or property	Number of analyses	Mini-mum	Concentration or value at indicated percentile					Maxi-mum	Standard or guideline for drinking water[1]
			10	25	50	75	90		
Physical properties									
Water temperature (°C)	37	2.5	6.5	9.0	11.0	24.0	45.0	57.0	--
Oxygen, dissolved,	4	0.6	--	--	3.4	--	--	6.6	--
pH (standard units)	30	6.0	6.6	6.8	7.2	8.0	8.2	8.7	--
Specific conductance (µS/cm)	37	120	130	231	375	2,860	4,580	41,400	--
Major ions and dissolved solids, in mg/L									
Bicarbonate, dissolved	23	51	71	197	317	483	501	2,030	--
Calcium, dissolved	34	14	18	29	41	110	120	920	--
Chloride, dissolved	28	1.1	1.5	2.4	6.8	820	1,107	15,000	250 (SMCL)
Fluoride, dissolved	28	0.1	0.2	0.2	0.4	2.0	2.9	8.9	2.0 (SMCL)
Magnesium, dissolved	34	1.8	3.0	4.9	18	21	34	180	--
Potassium, dissolved	28	<0.1	1.0	1.1	2.9	32	36	170	--
Sodium, dissolved	27	4.9	5.6	7.9	25	670	902	9,400	--
Silica, dissolved	29	9.0	11	13	19	32	38	44	--
Sulfate, dissolved	27	7.5	10	14	57	307	375	2,300	250 (SMCL)
Dissolved solids	27	87	100	186	379	2,280	2,670	28,200	500 (SMCL)
Nutrients, dissolved, in mg/L									
Ammonia	4	0.02	--	--	0.07	--	--	1.1	--
Nitrate	27	<0.05	<0.05	<0.05	0.08	0.24	0.43	0.48	10 (MCL)
Nitrite	4	<0.01	--	--	<0.01	--	--	0.01	1 (MCL)
Orthophosphorus	27	<0.01	<0.01	<0.01	0.01	0.04	0.10	0.14	--
Trace elements, dissolved, in µg/L									
Aluminum	7	4	--	--	10	--	--	680	50–200
Arsenic	12	<1	<1	<1	1	2	3	6	50 (MCL)
Barium	6	3	--	--	23	--	--	500	2,000 (MCL)
Cadmium	9	<2	--	--	<2	--	--	<2	5.0 (MCL)
Chromium	4	<1	--	--	1	--	--	1	100 (MCL)
Copper	19	<4	<4	<4	<4	<4	<4	4	1,000 (SMCL)
Iron	33	<10	20	31	210	428	872	31,890	300 (SMCL)
Lead	8	<1	--	--	<1	--	--	4	--
Manganese	33	<10	<10	<10	<10	172	217	3,000	50 (SMCL)
Mercury	4	<0.5	--	--	<0.5	--	--	<0.5	--
Molybdenum	5	<6	--	--	<6	--	--	14	
Nickel	5	<1	--	--	1	--	--	71	100 (MCL)
Selenium	10	<1	<1	<1	<1	<1	1	1	50 (MCL)
Silver	5	<2	--	--	<2	--	--	<2	100 (SMCL)
Uranium	11	<1	1	1	2	3	8	8	20 (PMCL)
Zinc	27	<20	<20	<20	<20	60	187	695	5,000 (SMCL)
Other constituents									
Alkalinity, (mg/L as $CaCO_3$)	23	42	58	162	260	396	411	1,670	--
Hardness, (mg/L as $CaCO_3$)	27	42	54	120	210	380	468	3,100	--

[1]U.S. Environmental Protection Agency, 1996.

Physical Properties

The temperature of springwater ranged from 2.5° to 57° C with a median of 11° C. Water temperatures greater than 20° C (68° F) were measured at three springs. Water temperature in spring 11 (fig. 25), also known as the Rhodes Warm Spring, ranged from 24° to 27° C. Water temperatures ranging from 45° to 57° C (113–135° F) were measured in springs 17 and 18 (fig. 25), also known as the Hartsel Hot Springs. McCarthy and others (1982) indicate that granites of Precambrian age are most likely the heat source for the Hartsel Hot Springs, and the Dakota Sandstone of Cretaceous age is the water source. Dissolved oxygen was measured in four springs east of Fairplay (springs 5, 6, 7, and 9, fig. 25) and values ranged from 0.6 to 6.6 mg/L (table 11). Values for pH ranged from 6.0 to 8.7 with a median of 7.2. Measurements of specific conductance were obtained for each spring listed in this report, and the number of measurements was larger than the number of dissolved-solids-concentration analyses. Specific conductance, an indirect measure of the dissolved-solids concentration, was low in springs originating in crystalline-rock aquifers (springs 1, 2, 5, 7, 10, 24, 26, 27) (fig. 25, table 10). Specific conductance was highest in spring number 22, which is believed to originate in evaporite beds in the Maroon Formation of Paleozoic age (Klein and others, 1978). Spring 22 is located upstream from Antero Reservoir and is thought to be the source of high specific conductance and dissolved-solids concentrations in Salt Creek (surface-water site 35, fig. 9).

Major Ions and Dissolved Solids

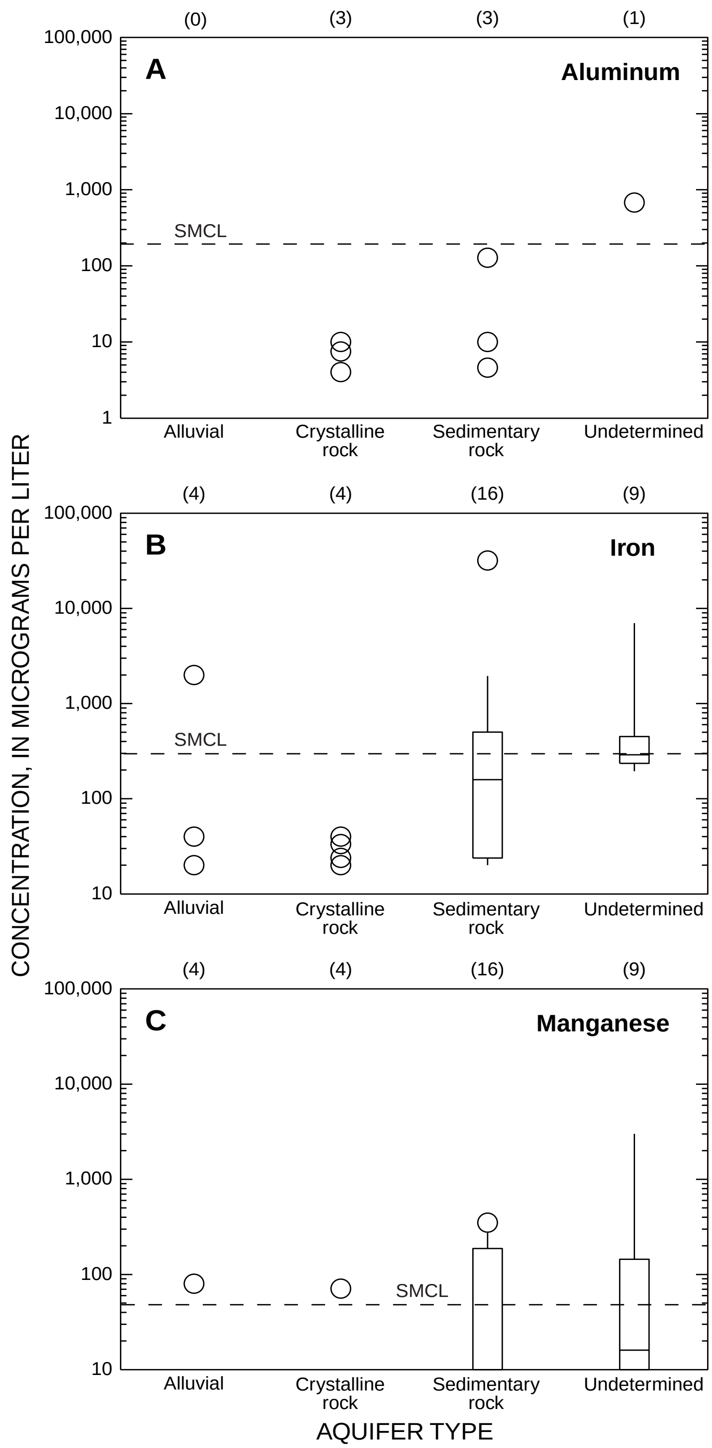
Major-ion concentrations in springwater varied greatly and were influenced by the type of rock in which the water originated. Concentrations of chloride and sulfate larger than the 250-mg/L USEPA SMCL primarily occurred in springs originating from sedimentary-rock aquifers (springs 8, 9, 17, 18, 20, 22) (table 10). Similar to fluoride concentrations in ground water, fluoride concentrations larger than the USEPA SMCL of 2 mg/L occurred in springs originating from crystalline-rock aquifers (springs 1 and 2) but also occurred in a spring originating from a sedimentary-rock aquifer composed of the Dakota Sandstone (spring 17) and from two springs with undocumented sources (springs 16 and 19). With the exception of bicarbonate, fluoride, and silica, the maximum concentrations of all major ions (table 11) were from spring 22. Dissolved-solids concentrations were determined for samples from 20 of the 30 springs listed in this report. Several springs had dissolved-solids concentrations larger than the 500-mg/L USEPA SMCL, including springs 8, 9, and 16–22.

Nutrients

Analyses of ammonia and nitrite for springwater were available only for the four springs sampled by the USGS in 1998. Ammonia concentrations in the four springs ranged from 0.02 to 1.1 mg/L, and nitrite concentrations were less than or equal to 0.01 mg/L. Nitrate and orthophosphorus were analyzed in samples from 20 of the 30 springs. Nitrate concentrations, ranging from less than 0.05 to 0.48 mg/L, were less than the 10-mg/L USEPA MCL. Dissolved orthophosphorus concentrations in springwater ranged from less than 0.01 to 0.14 mg/L.

Trace Elements

With few exceptions, most trace-element concentrations in springwater were less than USEPA drinking-water standards (table 11). The concentration of dissolved aluminum in spring 16, a spring emanating from an undetermined aquifer type, was larger than the USEPA SMCL of 200 µg/L (fig. 26). Concentrations of dissolved iron larger than the USEPA SMCL of 300 µg/L occurred in springs originating in alluvial and sedimentary-rock aquifers and in an undetermined aquifer but not in the four springs originating in crystalline-rock aquifers (fig. 26). Dissolved manganese concentrations larger than the USEPA SMCL of 50 µg/L occurred in springs originating from all aquifer types (fig. 26).



Boxplot explanation on pages 10-11

Figure 26. Concentrations of dissolved (A) aluminum, (B), iron, and (C) manganese in springs emanating from aquifer types, Park County, 1974–75, 1998 (dashed lines are secondary maximum levels for drinking water [U.S. Environmental Protection Agency, 1996]).

SUMMARY

In 1999, the USGS, in cooperation with Park County and the Center of Colorado Water Conservancy District, compiled and analyzed available information on streamflow and surface-water and ground-water quality in Park County for 1962–98. A review of historical data helps to identify gaps in available data and allows for prioritizing and focusing future studies.

Park County is primarily drained by headwater streams in the South Platte River Basin and to a lesser extent by streams in the Arkansas River Basin. Land-surface altitude ranges from about 7,200 to 14,000 feet, and average annual precipitation ranges from 10 to 40 inches. Igneous and metamorphic rocks of Precambrian age occupy about 45 percent of the land surface, primarily in eastern Park County. Sedimentary rocks of Paleozoic age occur on the eastern flanks of the Mosquito Range in western Park County and sedimentary rocks of Cretaceous, Jurassic, and Tertiary age occur in central Park County. Volcanic rocks of Cretaceous and Tertiary age cover a large portion of southern Park County. Major land-cover classifications in Park County are natural herbaceous vegetation, primarily rangeland and tundra (53 percent) and forest (39 percent). Built-up areas, a subcategory of urban land use, occur throughout Park County as evidenced by the large number of domestic wells.

Streamflow has been monitored at more than 40 sites in the county and is currently (1998) monitored at 30 sites. Streamflow data currently (1998) are archived in a data base for only 10 sites because most sites are operated for the purpose of administering water rights on a daily basis. In the South Platte River Basin in Park County, most streamflow is derived from snowmelt, and more than one-half the annual streamflow occurs in May, June, and July. In some streams, both the timing and magnitude of streamflow have been altered by reservoirs operations or by interbasin water transfers.

Surface-water-quality data collected between 1962 and 1998 were obtained for 125 sites. Constituents typically sampled for at most sites include physical properties (water temperature, specific conductance, pH, and dissolved oxygen), nutrients (nitrogen and phosphorus), major ions, and trace elements. Constituents sampled for less frequently included turbidity, bacteria, organic carbon, radionuclides, and suspended sediment.

Most values of water temperature, dissolved oxygen, and pH in surface water were within recommended limits set by the CDPHE. Specific conductance (an indirect measure of the dissolved-solids concentration) generally was lowest in mountain streams of the South Platte River Basin. Higher values for specific conductance occurred in the main-stem South Platte River downstream from Hartsel, the Arkansas River Basin, Handcart Gulch in the North Fork Basin, Park Gulch in the Tarryall Creek Basin, and Trout Creek in the Middle Fork Basin. The median specific conductance in Salt Creek, which flows into Antero Reservoir, was at least one order of magnitude larger than the median in any other stream in the county.

Concentrations of chloride and sulfate in a small number of samples from the South Fork and main-stem South Platte River downstream from Antero Reservoir have exceeded the CDPHE in-stream standard of 250 mg/L and may result from inflow from Salt Creek, where chloride and sulfate concentrations as high as 7,600 and 2,100 mg/L, respectively, have been measured.

Historical nitrogen concentrations in surface water in Park County were small. Nitrite was not detected, and most un-ionized ammonia concentrations were less than the CDPHE chronic standard of 0.02 mg/L. All nitrate concentrations were less than 1.2 mg/L, well below the CDPHE in-stream standard of 10 mg/L. Nitrate concentrations were significantly larger in urban and built-up areas than rangeland and forest areas. Most median concentrations of total phosphorus in surface water were less than 0.05 mg/L. Median total phosphorus concentrations were not significantly different among sites in urban and built-up, rangeland, and forest land-use/land-cover settings.

With one exception, no temporal trends were detected in nitrate or total phosphorus concentrations at four surface-water sites. An upward trend in total phosphorus concentration was determined for the East Portal of the Harold D. Roberts Tunnel, but the slope of the trend line was small and the concentrations were near the detection limit of 0.01 mg/L.

Using data collected from 1971–98, phosphorus loads were computed for the South Platte River below Elevenmile Canyon Reservoir, the North Fork South Platte River at Bailey, and the East Portal of the Harold D. Roberts Tunnel. At all three sites, significantly higher phosphorus loads during April through

September than during October through March coincided with significantly higher streamflows; streamflow influences the variability in load more than phosphorus concentration. Using the median phosphorus loads for the two South Platte River sites, the annual phosphorus load transported out of Park County in the South Platte River was about 10,000 pounds.

Iron and manganese concentrations in surface water larger than CDPHE instream standards primarily occurred in upper North Fork South Platte Basin. Large zinc concentrations have been measured in the Mosquito Creek Basin. Concentrations of aluminum, cadmium, chromium, copper, and nickel were largest in the North Fork Basin, primarily in Handcart Gulch, the North Fork South Platte River downstream from Handcart Gulch, and upper Geneva Creek. Mosquito Creek, South Mosquito Creek, and sections of the North Fork and Geneva Creek have been identified by the CDPHE as being impaired by elevated trace-element concentrations.

Suspended-sediment data for streams in Park County are scarce, and most sampling has occurred at a few sites in Geneva and Badger Creeks. Data for Geneva and Badger Creeks show that suspended-sediment concentration generally increases with discharge.

Ground-water-quality data exist for alluvial aquifers of Quaternary age, crystalline-rock aquifers of Precambrian age, sedimentary-rock aquifers of varying age and lithology, and volcanic-rock aquifers of Tertiary age. Calcium-bicarbonate type water was found in each aquifer type and predominated in the alluvial and crystalline-rock aquifers. Water types were more variable in the sedimentary-rock aquifers and included calcium-sulfate and sodium-sulfate water in aquifers composed of the South Park Formation of Tertiary age, sodium-sulfate and sodium-bicarbonate water in aquifers composed of the Pierre Shale of Cretaceous age, and magnesium bicarbonate water in the aquifers of Paleozoic age.

All chloride concentrations in ground water were less than the USEPA drinking-water standard of 250 mg/L. Sulfate concentrations larger than the 250 mg/L USEPA drinking-water standard occurred in a small number of samples and primarily in wells completed in sedimentary and volcanic-rock aquifers. Fluoride was detected in every ground-water sample, although only about 10 percent of the concentrations exceeded the USEPA drinking-water standard of 2 mg/L. Concentrations larger than 2 mg/L were almost exclusively limited to samples from wells completed in the crystalline-rock aquifer composed of the Pikes Peak Granite.

Median dissolved-solids concentrations were similar among aquifer types and ranged from 160 mg/L in the crystalline-rock aquifers to 257 mg/L in the sedimentary-rock aquifers. Dissolved-solids concentrations less than 130 mg/L primarily occurred in the alluvial or crystalline-rock aquifers near Jefferson or north of Bailey. Dissolved-solids concentrations greater than the USEPA drinking-water standard of 500 mg/L occurred in about 10 percent of the wells and were most common in the sedimentary-rock aquifers between Jefferson and Hartsel.

Most nitrate concentrations in ground water were less than the USEPA drinking-water standard of 10 mg/L. The few concentrations larger than 10 mg/L primarily occurred in samples collected during the 1990’s from domestic wells located in subdivisions northeast of Bailey. The nitrate concentrations in samples collected from domestic wells northeast of Bailey in the 1990’s were significantly higher than nitrate concentrations measured in wells in the same subdivisions in the 1970’s. Although different wells were sampled during each decade, higher nitrate values for the 1990’s sampling may indicate that contamination is increasing in this part of the county. Resampling some of the wells that were sampled in the 1970’s may verify these results.

Most trace-element concentrations measured in Park County ground water were less than USEPA drinking-water standards; however; standards for iron, manganese, and zinc were exceeded in a small number of samples. A median radon concentration of 4,200 pCi/L for samples from 16 wells located east of Fairplay was higher than the national average concentration of 350 pCi/L.

Water-quality data were summarized for 30 springs in Park County. Sources for the springs included alluvial aquifers of Quaternary age, sedimentary-rock aquifers of Tertiary, Cretaceous, Jurassic, and Paleozoic age; and crystalline-rock aquifers of Precambrian age.

Water temperatures were higher than 20° C in three springs: the Rhodes Warm Spring and in two springs collectively referred to as the Hartsel Hot Springs. Specific conductance was lowest in springs originating from crystalline-rock aquifers of Precambrian age and highest in a spring that is believed to originate from a sedimentary-rock aquifer that contains evaporite beds of the Maroon Formation of Paleozoic age. Several springs had dissolved-solids concentrations larger than the USEPA drinking-water standard of 500 mg/L.

Analyses of ammonia and nitrite were available for only 4 springs, but nitrate and orthophosphorus were analyzed in samples from 20 springs. Nitrate concentrations, ranging from less than 0.05 to 0.48 mg/L, were less than the USEPA drinking-water standard of 10 mg/L. Dissolved orthophosphorus concentrations in springwater ranged from less than 0.01 to 0.14 mg/L.

With few exceptions, trace-element concentrations in springwater were less than Federal drinking-water standards. Concentrations of dissolved iron larger than the USEPA drinking-water standard of 300 μg/L occurred in springs originating in alluvial and sedimentary-rock aquifers and from an undetermined aquifer type but not in the four springs originating in crystalline-rock aquifers. Dissolved manganese concentrations larger than the drinking-water standard of 50 μg/L occurred in springs originating from all aquifer types sampled.

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