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Summary of Surface-Water-Quality Data Collected for the Northern Rockies Intermontane Basins National Water-Quality Assessment Program in the Clark Fork-Pend Oreille and Spokane River Basins, Montana, Idaho, and Washington, Water Years 1999-2001

Open-File Report 02–472

National Water-Quality Assessment Program

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By Michael A. Beckwith

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FOREWORD

The U.S. Geological Survey (USGS) is committed to serve the Nation with accurate and timely scientific information that helps enhance and protect the overall quality of life, and facilitates effective management of water, biological, energy, and mineral resources. (http://www.usgs.gov/). Information on the quality of the Nation's water resources is of critical interest to the USGS because it is so integrally linked to the long-term availability of water that is clean and safe for drinking and recreation and that is suitable for industry, irrigation, and habitat for fish and wildlife. Escalating population growth and increasing demands for the multiple water uses make water availability, now measured in terms of quantity and quality, even more critical to the long-term sustainability of our communities and ecosystems.

The USGS implemented the National Water-Quality Assessment (NAWQA) Program to support national, regional, and local information needs and decisions related to water-quality management and policy. (http://water.usgs.gov/nawqa/). Shaped by and coordinated with ongoing efforts of other Federal, State, and local agencies, the NAWQA Program is designed to answer: What is the condition of our Nation's streams and ground water? How are the conditions changing over time? How do natural features and human activities affect the quality of streams and ground water, and where are those effects most pronounced? By combining information on water chemistry, physical characteristics, stream habitat, and aquatic life, the NAWQA Program aims to provide science-based insights for current and emerging water issues and priorities. NAWQA results can contribute to informed decisions that result in practical and effective water-resource management and strategies that protect and restore water quality.

Since 1991, the NAWQA Program has implemented interdisciplinary assessments in more than 50 of the Nation's most important river basins and aquifers, referred to as Study Units. (http://water.usgs.gov/nawqa/nawqamap.html). Collectively, these Study Units account for more than 60 percent of the overall water use and population served by public water supply, and are representative of the Nation's major hydrologic landscapes, priority ecological resources, and agricultural, urban, and natural sources of contamination.

Each assessment is guided by a nationally consistent study design and methods of sampling and analysis. The assessments thereby build local knowledge about water-quality issues and trends in a particular stream or aquifer while providing an understanding of how and why water quality varies regionally and nationally. The consistent, multi-scale approach helps to determine if certain types of water-quality issues are isolated or pervasive, and allows direct comparisons of how human activities and natural processes affect water quality and ecological health in the Nation's diverse geographic and environmental settings. Comprehensive assessments on pesticides, nutrients, volatile organic compounds, trace metals, and aquatic ecology are developed at the national scale through comparative analysis of the Study-Unit findings. (http://water.usgs.gov/nawqa/natsyn.html).

The USGS places high value on the communication and dissemination of credible, timely, and relevant science so that the most recent and available knowledge about water resources can be applied in management and policy decisions. We hope this NAWQA publication will provide you the needed insights and information to meet your needs, and thereby foster increased awareness and involvement in the protection and restoration of our Nation's waters.

The NAWQA Program recognizes that a national assessment by a single program cannot address all water-resource issues of interest. External coordination at all levels is critical for a fully integrated understanding of watersheds and for cost-effective management, regulation, and conservation of our Nation's water resources. The Program, therefore, depends extensively on the advice, cooperation, and information from other Federal, State, interstate, Tribal, and local agencies, non-government organizations, industry, academia, and other stakeholder groups. The assistance and suggestions of all are greatly appreciated.

Robert M. Hirsch
Associate Director for Water

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CONVERSION FACTORS AND OTHER ABBREVIATED UNITS

Multiply	By	To obtain
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic mile (mi^3)	4.168	cubic kilometer (km^3)
foot (ft)	0.3048	meter (m)
inch (in.)	2.54	centimeter (cm)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
ton	0.9072	metric ton

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

$$°F=(1.8)\ (°C) + 32$$

Other abbreviated units:

microgram per liter (μg/L)
milligram per liter (mg/L)

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By Michael A. Beckwith

Abstract

Water-quality samples were collected at 10 sites in the Clark Fork-Pend Oreille and Spokane River Basins in water years 1999 – 2001 as part of the Northern Rockies Intermontane Basins (NROK) National Water-Quality Assessment (NAWQA) Program. Sampling sites were located in varied environments ranging from small streams and rivers in forested, mountainous headwater areas to large rivers draining diverse landscapes. Two sampling sites were located immediately downstream from the large lakes; five sites were located downstream from large-scale historical mining and ore-processing areas, which are now the two largest “Superfund” (environmental remediation) sites in the Nation. Samples were collected during a wide range of streamflow conditions, more frequently during increasing and high streamflow and less frequently during receding and base-flow conditions. Sample analyses emphasized major ions, nutrients, and selected trace elements.

Streamflow during the study ranged from more than 130 percent of the long-term average in 1999 at some sites to 40 percent of the long-term average in 2001. River and stream water in the study area exhibited small values for specific conductance, hardness, alkalinity, and dissolved solids. Dissolved oxygen concentrations in almost all samples were near saturation. Median total nitrogen and total phosphorus concentrations in samples from most sites were smaller than median concentrations reported for many national programs and other NAWQA Program study areas. The only exceptions were two sites downstream from large wastewater-treatment facilities, where median concentrations of total nitrogen exceeded the national median. Maximum concentrations of total phosphorus in samples from six sites exceeded the 0.1 milligram per liter threshold recommended for limiting nuisance aquatic growth. Concentrations of arsenic, cadmium, copper, lead, mercury, and zinc were largest in samples from sites downstream from historical mining and ore-processing areas in the upper Clark Fork in Montana and the South Fork Coeur d’Alene River in Idaho. Concentrations of dissolved lead in all 32 samples from the South Fork Coeur d’Alene River exceeded the Idaho chronic criterion for the protection of aquatic life at the median hardness level measured during the study. Concentrations of dissolved zinc in all samples collected at this site exceeded both the chronic and acute criteria at all hardness levels measured.

When all data from all NROK sites were combined, median concentrations of dissolved arsenic, dissolved and total recoverable copper, total recoverable lead, and total recoverable zinc in the NROK study area appeared to be similar to or slightly smaller than median concentrations at sites in other NAWQA Program study areas in the Western United States affected by historical mining activi-

ties. Although the NROK median total recoverable lead concentration was the smallest among the three Western study areas compared, concentrations in several NROK samples were an order of magnitude larger than the maximum concentrations measured in the Upper Colorado River and Great Salt Lake Basins. Dissolved cadmium, dissolved lead, and total recoverable zinc concentrations at NROK sites were more variable than in the other study areas; concentrations ranged over almost three orders of magnitude between minimum and maximum values; the range of dissolved zinc concentrations in the NROK study area exceeded three orders of magnitude.

INTRODUCTION

The U.S. Geological Survey (USGS) National Water-Quality Assessment (NAWQA) Program began at full scale in 1991 (Hirsch and others, 1988). Goals of the NAWQA Program are to assess the quality of surface and ground water and aquatic biological conditions in the Nation's major river basins and aquifer systems. Included in the assessments are attempts to characterize both the natural and human factors affecting environmental conditions, determine spatial patterns of variability, and identify trends over time. NAWQA Program studies employ consistent data-collection and analysis methods, thus allowing for aggregation of the information at the regional and national levels and for comparisons over a wide range of geographic and environmental settings.

Typically, NAWQA Program studies consist of an initial phase of planning and review of existing information. A sampling strategy is designed to build upon previous information and to address water-quality issues of concern in the study area. An intensive data-collection, interpretation, and reporting phase follows for 3 to 4 years. Low-intensity data collection then is conducted for 5 to 6 years at a few key sites to maintain data continuity over time and to monitor trends and identify emerging water-quality issues. NAWQA studies are intended to repeat monitoring cycles at approximately 10-year intervals. However, several NAWQA studies will end after the first phase of intensive data collection and reporting because of program funding constraints. Among the studies to be discontinued is the subject of this report, the Northern Rockies Intermontane Basins (NROK).

Purpose and Scope

This report summarizes water-quality data collected at 10 sampling sites in the NROK study area during water years 1999–2001. Selected data also are compared with regulatory standards and guidelines and with data from other NAWQA Program studies.

Description of Study Area

The NROK study area includes the Clark Fork-Pend Oreille and Spokane River Basins in northwestern Montana, northern Idaho, and northeastern Washington (table 1, fig. 1). It also contains two extensive valley-fill aquifers designated by the U.S. Environmental Protection Agency as the sole source of water for Spokane, Washington; Missoula, Montana; and their surrounding suburban areas.

The headwaters of the Clark Fork begin along the continental divide near Butte, Montana. At St. Regis, Montana, upstream from its confluence with the Flathead River, the Clark Fork has an annual mean discharge of 7,225 ft^3/s (Shields and others, 2001). The three forks of the Flathead River drain much of Glacier National Park and surrounding wilderness areas and include Hungry Horse Reservoir, one of the largest hydroelectric reservoirs in the Columbia River system. The Flathead River flows into Flathead Lake, the largest freshwater lake in the Western United States, having a surface area of 192 mi^2. Flowing out through a hydroelectric dam that regulates the level of Flathead Lake, the Flathead River joins the Clark Fork as its largest tributary with an annual mean discharge of 11,850 ft^3/s (Shields and others, 2001). More than 350 mi downstream from its headwaters, the Clark Fork enters Pend Oreille Lake in Idaho (after passing through three relatively small hydroelectric reservoirs at Thompson Falls and Noxon, Montana, and Cabinet Gorge at the Montana-Idaho State boundary). With a depth of about 1,170 ft and containing about 13 mi^3 of water, Pend Oreille Lake is one of the deepest and largest lakes (in volume) in the Western United States. The Pend Oreille River flows out of Pend Oreille Lake through a hydroelectric dam, through northeastern Washington and two more hydroelectric reservoirs, and joins the Columbia River in British Columbia, Canada. At the international

Table 1. Surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area

[No., number; USGS, U.S. Geological Survey; mi^2, square miles; ft, feet; MT, Montana; ID, Idaho; WA, Washington; Stream order, U.S. Geological Survey (1999)]

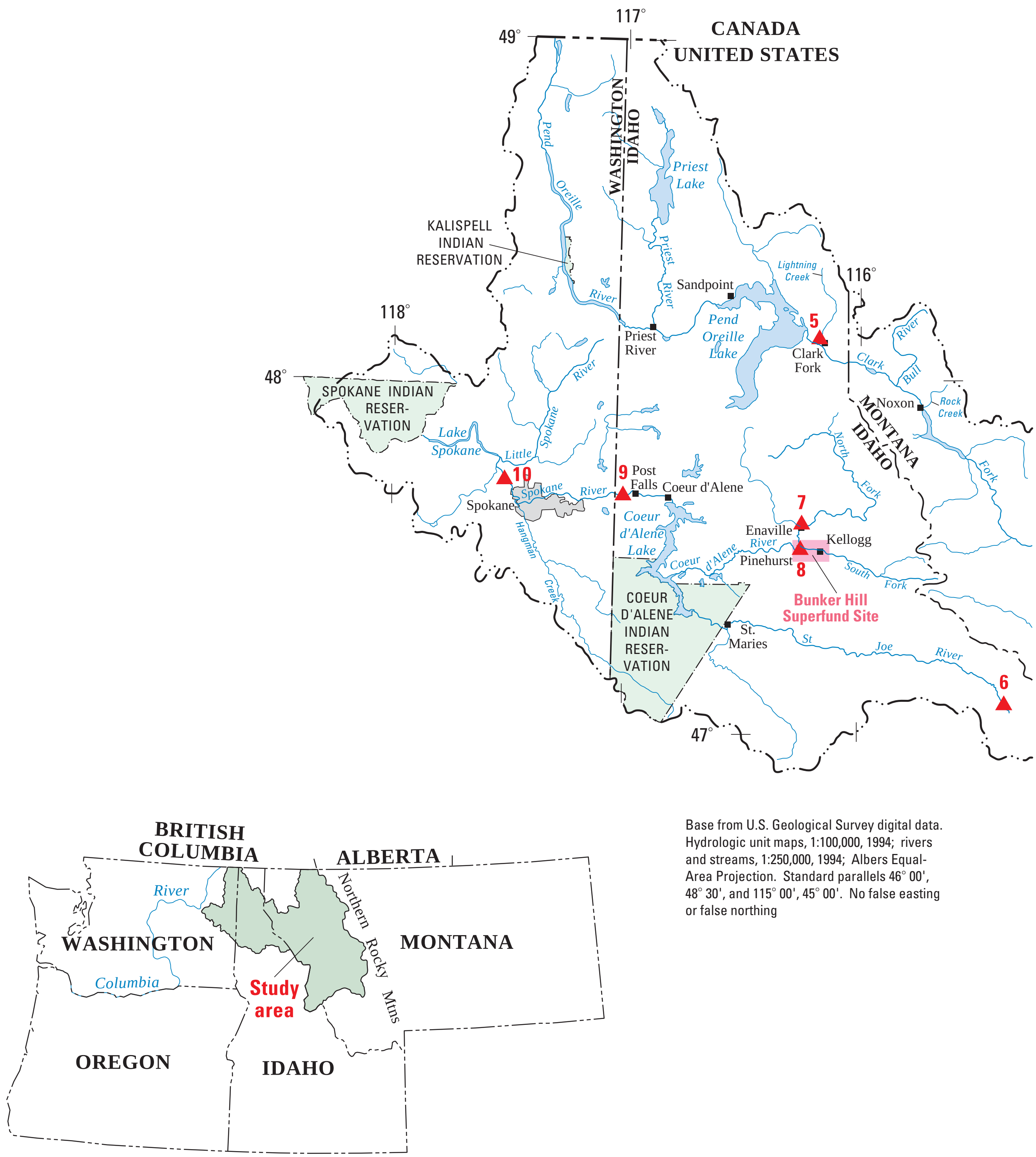
Site No. (fig. 1)	Site name	USGS gaging-station No.	Latitude	Longitude	Drainage area (mi^2 upstream from gaging station)	Elevation (ft above sea level)	Stream order
	Clark Fork - Pend Oreille River Basin						
1	Clark Fork at Turah Bridge near Bonner, MT	12334550	46°49'34"	113°48'48"	3,641	3,320	4
2	Bitterroot River near Missoula, MT	12352500	46°49'55"	114°03'11"	2,814	3,110	4
3	Clark Fork at St. Regis, MT	12354500	47°18'07"	115°05'11"	10,709	2,600	5
4	Flathead River at Perma, MT	12388700	47°22'03"	114°35'03"	8,795	2,469	5
5	Lightning Creek at Clark Fork, ID	12392155	48°09'04"	116°10'56"	115	2,094	2
	Spokane River Basin						
6	St. Joe River at Red Ives Ranger Station, ID	12413875	47°03'22"	115°21'08"	108	3,710	1
7	North Fork Coeur d'Alene River at Enaville, ID	12413000	47°34'08"	116°15'06"	895	2,180	3
8	South Fork Coeur d'Alene River near Pinehurst, ID	12413470	47°33'06"	116°14'13"	299	2,190	3
9	Spokane River near Post Falls, ID	12419000	47°42'11"	116°58'37"	3,840	2,003	5
10	Spokane River at 7 Mile Bridge near Spokane, WA	12424500	47°44'25"	117°31'10"	5,020	1,624	5

boundary, the Pend Oreille River drains an area of about 25,200 mi^2 (or about 79 percent of the study area) and has an annual mean discharge of 26,760 ft^3/s (Kimbrough and others, 2001).

The Spokane River Basin covers approximately 6,600 mi^2, or about 21 percent of the study area. The Spokane River begins at the outlet of Coeur d'Alene Lake in northern Idaho. Coeur d'Alene Lake covers about 50 mi^2; its two primary inflows are the Coeur d'Alene and St. Joe Rivers, whose headwaters are in subranges of the Bitterroot Mountains west of the Idaho-Montana boundary. A hydroelectric dam on the Spokane River downstream from the lake outlet also regulates the Coeur d'Alene Lake level. After flowing through three more hydroelectric dams, the Spokane River near downtown Spokane, Washington, has an annual mean discharge of 6,765 ft^3/s (Kimbrough and others, 2001). Downstream from the city is yet another small hydroelectric dam, and a large hydroelectric reservoir (Lake Spokane, also known as Long Lake) created in the early 1900s. The Spokane River then enters Lake Roosevelt, the reservoir on the Columbia River created by Grand Coulee Dam in eastern Washington.

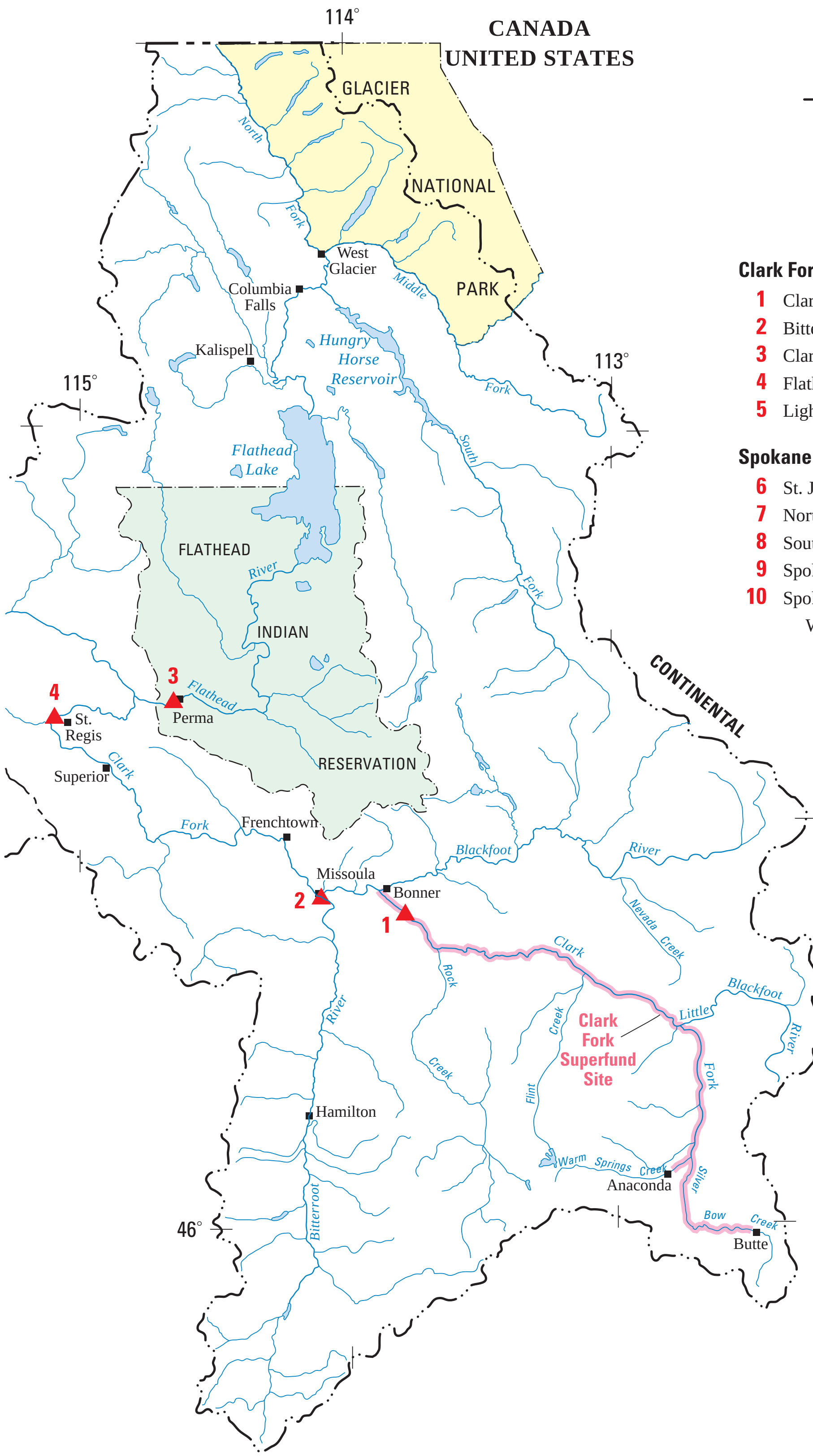
The study area has a complex geologic history involving multiple episodes of uplift, igneous activity, erosion, and sedimentation caused primarily by glacial and fluvial processes. The area consists mainly of coniferous forest-covered mountains and ridges interspersed with river valleys. Elevations range from more than 10,000 ft above sea level in the mountains of northwestern Montana and Glacier National Park to less than 1,500 ft at the confluence of the Spokane and Columbia Rivers.

Both continental and maritime influences affect the climate of the study area. Most of the annual precipitation falls between late autumn and spring, much of it as snow. Precipitation ranges from approximately 100 in. in the mountains of northwestern Montana and northern Idaho to less than 15 in. in the drier intermontane valleys in Montana and plateau areas near the confluence of the Spokane and Columbia Rivers in eastern Washington. Mountain snowmelt runoff from April through July dominates streamflow conditions. Typically, major floods are caused by weather systems from the Pacific Ocean bringing warm wind and rain that rapidly melt snowpack accumulated at low to middle elevations.



Base from U.S. Geological Survey digital data. Hydrologic unit maps, 1:100,000, 1994; rivers and streams, 1:250,000, 1994; Albers Equal-Area Projection. Standard parallels 46° 00', 48° 30', and 115° 00', 45° 00'. No false easting or false northing

Figure 1. Location of the Northern Rockies Intermontane Basins study area and surface-water-quality sampling sites in Montana, Idaho, and Washington.



EXPLANATION

Superfund site

Basin boundary

Surface-water sampling site and number (site names listed in table below)

Clark Fork - Pend Oreille River Basin

1 Clark Fork at Turah Bridge near Bonner, Montana
2 Bitterroot River near Missoula, Montana
3 Clark Fork at St. Regis, Montana
4 Flathead River at Perma, Montana
5 Lightning Creek at Clark Fork, Idaho

Spokane River Basin

6 St. Joe River at Red Ives Ranger Station, Idaho
7 North Fork Coeur d'Alene River at Enaville, Idaho
8 South Fork Coeur d'Alene River near Pinehurst, Idaho
9 Spokane River near Post Falls, Idaho
10 Spokane River at Seven Mile Bridge near Spokane, Washington

0 10 20 30 40 50 MILES
0 10 20 30 40 50 KILOMETERS

Table 2. Land cover in the Northern Rockies Intermontane Basins study area

[mi^2, square miles]

Classification	Area (mi^2)	Percent
Forest	23,534	74.8
Rangeland	3,364	10.7
Agricultural (including orchards)	2,626	8.4
Bare land (including rock, mountain peaks above tree line, glaciers, snowfields, tundra)	821	2.6
Water and wetlands	762	2.4
Urban	356	1.1
Total	31,463	100

Approximately 56 percent of the land in the study area is publicly owned (primarily national and State forests, Glacier National Park, and designated wilderness areas). About 37 percent is privately owned and about 7 percent is within the Coeur d'Alene, Flathead, Kalispell, and Spokane Indian Reservations (Maret and Dutton, 1999). Almost 75 percent of the study area is covered by forest. Rangeland and agricultural land make up about 11 and 8 percent, respectively (table 2). Only slightly more than 1 percent of the study area is classified as urban (U.S. Geological Survey, 1996).

The population of the NROK study area was about 720,000 in the 2000 census: 250,000 in Montana, 110,000 in Idaho, and 360,000 in Washington. Population in the study area increased by more than 20 percent between 1990 and 2000. Kootenai County in Idaho, containing the cities of Coeur d'Alene and Post Falls, grew by almost 56 percent. Ravalli County in Montana (covering much of the Bitterroot River drainage) increased almost 45 percent in population in the 1990s. Population in Stevens and Pend Oreille Counties (adjacent to the Spokane, Washington, metropolitan and suburban areas) grew about 30 percent (U.S. Census Bureau Website http://quickfacts.census.gov/qfd). Much of this low-density population growth occurred in suburban, undeveloped forest, agricultural, or rangeland areas.

Environmental History

About 1,600 active and abandoned hard-rock mines are known to exist in the NROK study area (Maret and Dutton, 1999). Placer gold deposits brought the first miners to the upper Clark Fork Basin in Montana in the 1860s and to north Idaho's Coeur d'Alene mining district in the 1880s. By the early 1900s, the mines and smelters surrounding Butte, Montana, and the South Fork Coeur d'Alene River valley were among the largest mining and industrial areas in the Nation. In Montana, copper was the major product. However (in order of the quantity extracted between 1880 and 1972), the area also produced zinc, manganese, lead, silver, cadmium, bismuth, selenium, tellurium, and gold (Shavers and others, 1991). In Idaho, silver was the primary product, as well as large amounts of lead and zinc. In both areas, large-scale ore processing and mining ended in the early 1980s; however, some mining continues on a much-reduced basis compared with historical levels.

Mining and ore-processing activities generated large amounts of metal-enriched waste materials that entered the Clark Fork and the South Fork Coeur d'Alene River and their tributaries. An estimated 100 million tons of mining and ore-processing wastes were produced and discharged to the headwaters of the Clark Fork and its tributaries during 1880 to 1982 (Andrews, 1987). A similar amount was produced in Idaho, more than half of which is estimated to have entered the South Fork Coeur d'Alene River and its tributaries (Long, 1998).

Elevated concentrations of trace elements (metals) in streams and rivers, channel and flood-plain sediments, and aquatic biota have been documented in the Clark Fork-Pend Oreille and Spokane River Basins downstream from historical mining and ore-processing areas (Johns and Moore, 1987; Moore and Luoma, 1990; Lambing, 1991; Phillips and Lipton, 1995; Horowitz and others, 1993, 1995a, 1995b; Beckwith, 1996; Beckwith and others, 1997; Hornberger and others, 1997; Woods and Beckwith, 1997; Maret and Dutton, 1999; Maret and Skinner, 2000; Grosbois and others, 2001; Beckwith, 2002). As a result, several operable units along Silver Bow Creek and the Clark Fork (including their flood plains) downstream from Butte, Montana, to Milltown Reservoir (a small hydroelectric reservoir at the confluence with the Blackfoot River) collectively make up the largest contiguous "Superfund" (U.S. Environmental Protection Agency environmental remediation) site in the Nation. Metal-enriched sediments also appear to have been transported as far downstream as Priest River, Idaho, where Pend Oreille River bed sediments contain elevated concentrations of arsenic, cadmium, copper, lead, mercury, and zinc, compared with background concentrations (Beckwith, 2002).

A 21-mi^2 area of the lower South Fork Coeur d'Alene River valley is the Nation's next-largest Superfund site. Metal-enriched sediments have been transported downstream and deposited in the bed, banks, and extensive flood plain and wetlands of the Coeur d'Alene River, as well as on the bottom of Coeur d'Alene Lake (Horowitz and others, 1993, 1995a, 1995b; Woods and Beckwith, 1997). Elevated concentrations of trace elements also have been reported in the bed and bank sediments of the Spokane River as far downstream as its confluence with the Columbia River in Washington (Bortleson and others, 1994; Grosbois and others, 2001; Beckwith, 2002).

Mining activities also have affected ground-water quality, which has the potential to further affect surface-water quality. For example, when large-scale mining ended in the Butte, Montana, area in the early 1980s, pumping to remove water from the vast complex of underground mine shafts and the mile-wide, 1,300-ft-deep open-pit mine ceased. Surface runoff and ground water continues filling these abandoned workings. Without intervention, highly acidic, metal-enriched water could overtop the pit, enter adjacent alluvial aquifers, and eventually reach the Clark Fork early in the 21st century (Moore and Luoma, 1990). In Idaho, ground water flowing under and through deposits of mine wastes and metal-enriched sediments is a continuing source of dissolved lead and zinc to the South Fork Coeur d'Alene River and its tributaries (Barton, 2002).

Extensive timber harvest also occurred throughout the forested mountains of the NROK study area. Early logging practices were highly disruptive and produced large-scale deforestation, erosion, sedimentation, and destabilized streambanks and channels (Rabe and Flaherty, 1974). For example, entire drainages were clear-cut and "splash dams" were built, which formed temporary lakes that were periodically and suddenly breached (often with explosives), thereby releasing a torrent of cut logs, logging debris, and sediment downstream. Natural forest fires, combined with uncontrolled burning of logging debris, disturbed additional large areas of forest. Also, large areas surrounding the smelters in Idaho and Montana were devegetated by acidic precipitation and toxic fumes. Consequently, many watersheds in the NROK study area show the cumulative effects of deforestation, destabilization of stream channels and drainage systems, and altered flood and runoff patterns (Rabe and Flaherty, 1974).

Early municipal and industrial sewer systems discharged directly to nearby rivers and streams with little or no treatment. In the Butte-Anaconda, Montana, area, settling ponds for controlling mine and smelter wastes were constructed in the early 1900s, and more advanced treatment such as liming/precipitation was initiated in the 1950s (Phillips and Lipton, 1995). Other than low, wooden dams constructed at various points across the South Fork Coeur d'Alene River valley, a system of settling ponds was not constructed in this mining district until the late 1960s, and some of these received municipal wastewater as well (Cornell, Howland, Hayes and Merryfield, Engineers and Planners, 1964).

Although municipal and industrial dischargers now employ advanced wastewater-treatment processes, in late summer the wastewater discharges from Missoula, Montana; Coeur d'Alene and Post Falls, Idaho; and Spokane, Washington, contribute significant proportions of the streamflow and nutrient loads carried by the Clark Fork and Spokane Rivers. Interstate nutrient-management efforts have been underway in both the Clark Fork and Spokane River Basins since the 1980s. Nevertheless, in late summer thick mats of attached, filamentous, green algae grow in the Clark Fork (Land and Water Consulting, Inc., written commun., 1998), and Lake Spokane has a history of nuisance algae blooms, including toxic blue-green strains (Soltero and others, 1973, 1974; Raymond A. Soltero, Eastern Washington University, oral and written communs., 1975–2001; Ken Merrill, Washington Department of Ecology, oral and written communs., 2001–2002).

The effects of agriculture on water quality in the NROK study area are less pronounced than in many other NAWQA Program study areas. However, as in many other parts of the West, livestock grazing has altered riparian areas, stream channels, and flood plains. Large tracts of forest land were cleared for large-scale dryland agriculture in the extreme southwestern portion of the study area, beginning in the early 1900s. Soil-erosion rates from agricultural areas south and west of Coeur d'Alene Lake can be among the highest in the Nation (Rabe and Flaherty, 1974).

Water-Quality Sampling and Analysis

Water-quality samples were collected at 10 NAWQA sites throughout the Clark Fork-Pend Oreille and

Spokane River Basins (fig. 1, table 1). These sites represent major subbasins and stream reaches or specific hydrologic and environmental areas of interest. For example, the sites at the Clark Fork at Turah Bridge near Bonner, Montana (site 1), and the South Fork Coeur d'Alene River near Pinehurst, Idaho (site 8), are located near the downstream boundaries of the Superfund sites and represent those areas in the respective river basins affected by large-scale, mining-associated contamination. Lightning Creek at Clark Fork, Idaho (site 5), represents a forested, mountainous basin where considerable logging and road-building activities have occurred. The sites on the Flathead River at Perma, Montana (site 4), and the Spokane River near Post Falls, Idaho (site 9), are downstream from large lakes.

All but two NROK NAWQA sampling sites were located at USGS gaging stations where streamflow data were being collected. A new gaging station was established in water year 1999 at the St. Joe River at Red Ives Ranger Station, Idaho (site 6), to represent relatively undisturbed reference conditions in the forested, mountainous watersheds of the Northern Rocky Mountains. Another NROK NAWQA sampling site was established on the Spokane River at 7 Mile Bridge near Spokane, Washington (site 10), downstream from the wastewater-treatment facility and storm-sewer outfalls of the city and surrounding metropolitan area. Streamflow at this site was determined by adding the discharge values from the wastewater-treatment facility and from gaging stations on the Spokane River and near the mouth of Hangman Creek approximately 10 mi upstream; little additional inflow occurs in this reach where the river is confined in a bedrock canyon.

Water-quality samples were collected approximately 9 to 12 times per year at each site from late 1998 to mid-2001 (water years 1999 – 2001). Samples were collected more frequently during periods of increasing and high streamflow (spring snowmelt runoff) and less frequently during receding or base-flow conditions. Considerable effort was made to collect approximately similar numbers of samples in each increment (deciles) of streamflow (figs. 2 – 11, back of report).

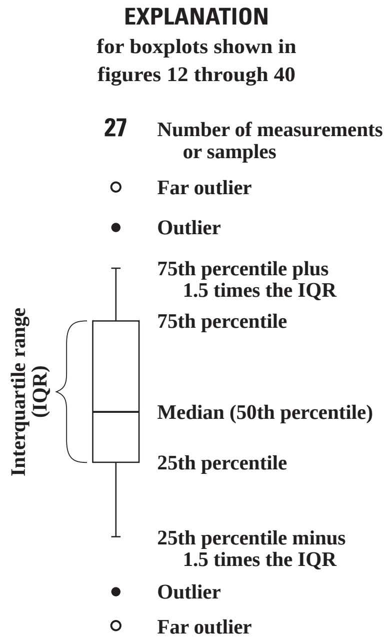
Water samples for analysis of chemical constituents and suspended sediment were collected using standard USGS depth-integrating samplers and using isokinetic and cross-section integrating sampling methods (Edwards and Glysson, 1988; Ward and Harr, 1990). Specific conductance, pH, water temperature, and alkalinity were determined in the field using standard instruments and methods as specified for the NAWQA Program (Shelton, 1994). Subsamples for chemical analysis were split and processed in the field in mobile laboratories. Documented protocols used consistently by all NAWQA Program studies included the use of a 10-port cone splitter constructed of Teflon (to produce representative subsamples of solid-phase constituents), specific procedures for positive-pressure filtration (using capsule filters with a nominal pore size of 0.45 micrometer), sample preservation (conducted in isolation chambers), and rigorous equipment cleaning to minimize contamination during sampling and sample processing (Shelton, 1994).

Major ion and nutrient concentrations were analyzed by the USGS National Water Quality Laboratory according to methods described by Fishman and Friedman (1989) and Fishman (1993). Trace elements (except for mercury) were analyzed by inductively coupled plasma-mass spectrometry as described by Faires (1993) and Jones and Garbarino (1999). Organic carbon was analyzed according to the method of Brenton and Arnett (1993). Total recoverable mercury was analyzed by cold vapor atomic absorption by methods described by Fishman and Friedman (1989).

STREAMFLOW AND WATER-QUALITY DATA

Summaries and Graphical Displays of Data

Boxplots are used throughout this report as a convenient means of graphically portraying the distribution of the data. In a boxplot, the middle line within the box represents the median, or 50th percentile, value. When arranged in ascending order, one-half of the values are greater than the median and one-half are less than the median. The top of the box represents the 75th percentile (75 percent of the values are less than this value). The bottom of the box represents the 25th percentile (25 percent of the values are less than this value). The difference between the 25th and 75th percentile values (and comprising half of the values) is the interquartile range. In the boxplots presented in this report, the lines (called whiskers) extending from the top of the box represent values that are as much as 1.5 times the interquartile range greater than the 75th percentile value. Conversely, the whiskers extending from the bottom of the box represent values as much as 1.5 times the interquartile range less than the 25th percen-



tile value. Values that lie outside the ranges indicated by the whiskers are shown as solid dots (outliers) and as circles (far outliers). These extreme values do not imply a problem with the quality of the data, but indicate the rareness of such values within the overall data set.

Physical and Chemical Characteristics

Common physical and chemical characteristics of rivers and streams at the 10 surface-water sampling sites in the NROK NAWQA study area are statistically summarized in table 3 and depicted in boxplots in figures 12 –19 (back of report). In general, rivers and streams in the study area contain small concentrations of dissolved substances and exhibit small values for specific conductance, hardness, alkalinity, and dissolved solids.   Dissolved oxygen concentrations generally were near saturation at all sites during the study and, therefore, were not included in the tables or figures.

STREAMFLOW

In water year 1999, streamflow at NROK sampling sites was greater than or near (96 – 131 percent) the mean daily values for the respective periods of record (figs. 2–5 and 8–11). At three sites—Lightning Creek at Clark Fork, Idaho; St. Joe River at Red Ives Ranger Station, Idaho; and Spokane River at 7 Mile Bridge near Spokane, Washington—the hydrologic data period of streamflow record was insufficient to compute long-term statistics. Therefore, only sampling dates are plotted on the study-period hydrograph for these sites for water years 1999 – 2001 in figures 6, 7, and 11. In water year 2000, streamflow at sites in the Spokane River Basin was near or slightly greater than the long-term mean, but at Clark Fork sites, streamflow was less than the long-term mean. Streamflow in water year 2001 was considerably less than the long-term mean at all sites, ranging from about 75 percent of the mean at the Clark Fork at Turah Bridge near Bonner, Montana, to about 40 percent at the North Fork Coeur d'Alene River at Enaville, Idaho.

NUTRIENTS

Concentrations of dissolved ammonia, nitrite plus nitrate, ammonia plus total organic nitrogen, orthophosphorus, total phosphorus, suspended organic carbon, and dissolved organic carbon are summarized in table 4. Also included for comparison in table 4 are median values from 85 relatively undisturbed watersheds across the Nation from NAWQA and other national program studies (Clark and others, 2000). Nutrient data from the NROK NAWQA study include many censored or estimated values, not only because of the small concentrations present in rivers and streams in the NROK NAWQA study area, but also because of changes in analytical methodology and data reporting conventions at the USGS National Water Quality Laboratory that occurred during the study. Therefore, for the graphical depiction (boxplots) of nutrient data provided in figures 20 and 21, censored data were assigned a value of one-half the reported "less than" value, and estimated values were used directly.

The median total nitrogen concentration at most NROK sites was smaller than the median concentrations reported by Clark and others (2000) at 85 relatively undisturbed sites from around the Nation. However, the median total nitrogen concentration at the South Fork Coeur d'Alene River near Pinehurst, Idaho, was 106 percent of the national median, and the median concentration at the Spokane River at 7 Mile Bridge near Spokane, Washington, was more than double the national median. Both of these sites are down-

Table 3. Selected physical and chemical characteristics for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001

[No., number; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25°C; °C, degrees Celsius; mg/L, milligrams per liter; $CaCO_3$, calcium carbonate, µm, micrometers; MT, Montana; ID, Idaho; WA, Washington]

Site No. (fig. 1)	Site name	Streamflow (ft^3/s)	Specific conductance (µS/cm)	pH, field (standard units)	Water temperature (°C)	Hardness (mg/L as $CaCO_3$)	Alkalinity, field (mg/L as $CaCO_3$)	Suspended sediment (mg/L)	Suspended sediment (percent less than 62 µm)	Dissolved solids, calculated (mg/L)
1	Clark Fork at Turah Bridge near Bonner, MT									
	No. of samples	27	27	27	27	27	27	26	23	27
	Minimum	287	153	7.5	0	64	46	3	48	88
	Maximum	5,280	413	8.5	19.0	192	148	131	95	257
	Median	929	352	8.1	7.0	160	128	9	80	214
2	Bitterroot River near Missoula, MT									
	No. of samples	27	27	27	27	27	27	27	27	27
	Minimum	482	39	7.1	2.0	15	14	1	29	26
	Maximum	13,700	177	8.6	21.5	77	86	168	92	107
	Median	1,415	117	7.8	9.5	51	48	6	72	73
3	Clark Fork at St. Regis, MT									
	No. of samples	24	20	24	24	24	24	23	23	24
	Minimum	1,660	95	7.5	0	106	41	1	30	57
	Maximum	35,300	277	8.5	22.0	124	120	280	94	160
	Median	4,160	224	8.1	6.8	97	97	6	81	131
4	Flathead River at Perma, MT									
	No. of samples	21	20	21	21	21	21	20	20	19
	Minimum	4,090	158	7.8	0	81	83	1	45	89
	Maximum	32,400	193	8.4	23.0	94	96	13	98	106
	Median	10,100	173	8.2	8.0	89	87	3	81	94
5	Lightning Creek at Clark Fork, ID									
	No. of samples	18	18	18	18	18	18	18	18	8
	Minimum	6	12	6.6	3.0	4	4	1	50	13
	Maximum	2,120	36	7.5	25.0	15	13	6	80	25
	Median	162	26	7.1	6.0	10	10	1	69	21

Table 3. Selected physical and chemical characteristics for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001 — Continued

Site No. (fig. 1)	Site name	Streamflow (ft^3/s)	Specific conductance (µS/cm)	pH, field (standard units)	Water temperature (°C)	Hardness (mg/L as $CaCO_3$)	Alkalinity, field (mg/L as $CaCO_3$)	Suspended sediment (mg/L)	Suspended sediment (percent less than 62 µm)	Dissolved solids, calculated (mg/L)
6	St. Joe River at Red Ives Ranger Station, ID									
	No. of samples	17	17	17	17	17	17	17	17	8
	Minimum	46	26	6.7	0	12	12	1	40	22
	Maximum	2,190	51	8.0	15.0	24	25	9	92	34
	Median	181	41	7.5	6.0	18	19	1	70	0
7	North Fork Coeur d'Alene River at Enaville, ID									
	No. of samples	28	28	28	28	28	28	28	28	15
	Minimum	144	25	6.7	1.5	10	10	1	60	21
	Maximum	18,200	62	7.7	15.5	23	41	207	93	34
	Median	1,465	41	7.3	5.8	19	18	1	79	31
8	South Fork Coeur d'Alene River near Pinehurst, ID									
	No. of samples	33	33	33	33	33	33	32	30	33
	Minimum	82	46	6.6	1.5	18	12	1	55	31
	Maximum	4,890	328	7.5	18.0	136	38	302	88	203
	Median	413	147	7.2	7.5	56	25	3	75	87
9	Spokane River near Post Falls, ID									
	No. of samples	29	29	29	29	29	28	29	29	29
	Minimum	242	41	7.0	2.0	16	16	1	50	29
	Maximum	28,000	71	7.7	25.0	23	21	3	89	39
	Median	4,510	50	7.4	8.5	20	18	1	75	35
10	Spokane River at 7 Mile Bridge near Spokane, WA									
	No. of samples	27	26	27	27	27	27	27	26	27
	Minimum	680	57	6.9	3.5	23	21	1	4	38
	Maximum	26,800	303	8.1	16.0	133	115	116	96	170
	Median	5,940	95	7.6	8.5	39	35	3	79	59

Table 4. Nutrient and organic carbon concentrations in samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001, and comparative median concentrations in samples collected for the National Water-Quality Assessment Program and other national monitoring programs

[No., number; mg/L, milligrams per liter; N, nitrogen; P, phosphorus; C, carbon; MT, Montana; ID, Idaho; WA, Washington; %, percent; e, estimated value; <, less than; >, greater than; —, no data available]

Site No. (fig. 1)	Site name	Ammonia, dissolved (mg/L as N)	Nitrite plus nitrate, dissolved (mg/L as N)	Ammonia plus organic nitrogen, total (mg/L as N)	Total nitrogen, nitrite+nitrate-N added to ammonia+organic-N (mg/L as N)	Ortho-phosphorus, dissolved (mg/L as P)	Total phosphorus (mg/L as P)	Carbon, organic, suspended (mg/L as C)	Carbon, organic, dissolved (mg/L as C)
1	Clark Fork at Turah Bridge near Bonner, MT								
	No. of samples	27	27	27		27	27	11	10
	No. of censored or e values	9	2	2		7	0	0	0
	% censored or e values	33.3	7.4	7.4		25.9	0	0	0
	Minimum	<.002	<.005	e.08		<.001	.011	.2	1.1
	Maximum	.011	.20	.86		.023	.172	4.5	5.1
	Median	.003	.017	.23	0.247	.007	.029	.5	3.3
2	Bitterroot River near Missoula, MT								
	No. of samples	27	27	27		27	27	11	12
	No. of censored or e values	8	5	3		9	1	0	0
	% censored or e values	29.6	18.5	11.1		33.3	3.7	0	0
	Minimum	<.002	<.005	e.05		<.001	.004	.2	1.3
	Maximum	.017	.102	.62		.008	.117	2.8	4.6
	Median	.004	.019	.17	.189	.002	.02	.2	2.35
3	Clark Fork at St. Regis, MT								
	No. of samples	24	24	24		24	24	10	11
	No. of censored or e values	5	4	2		8	3	1	0
	% censored or e values	20.8	16.7	8.3		33.3	12.5	10	0
	Minimum	<.002	<.005	e.06		<.001	.004	<.2	1.4
	Maximum	.018	.159	.66		.01	.183	3.4	2.9
	Median	.0045	.0385	.20	.2385	.002	.0185	.2	1.8
4	Flathead River at Perma, MT								
	No. of samples	21	21	21		21	21	9	9
	No. of censored or e values	9	2	7		13	13	5	0
	% censored or e values	42.9	9.5	33.3		61.9	61.9	55.6	0
	Minimum	<.002	<.005	e.07		<.001	e.002	<.2	1.3
	Maximum	.045	.064	.30		.007	.038	.3	2.6
	Median	.002	.022	.115	.137	.001	.0045	<.2	1.6
5	Lightning Creek at Clark Fork, ID								
	No. of samples	18	18	18		18	18	4	4
	No. of censored or e values	8	0	16		13	16	4	0
	% censored or e values	44.4	0	88.9		72.2	88.9	100	0
	Minimum	<.002	.025	e.06		<.001	e.002	<.2	.5
	Maximum	.024	.247	.19		.003	.004	>.2	.7
	Median	.002	.101	e.07	e.171	.001	.0035	<.2	.55

Table 4. Nutrient and organic carbon concentrations in samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001, and comparative median concentrations in samples collected for the National Water-Quality Assessment Program and other national monitoring programs —Continued

Site No. (fig. 1)	Site name	Ammonia, dissolved (mg/L as N)	Nitrite plus nitrate, dissolved (mg/L as N)	Ammonia plus organic nitrogen, total (mg/L as N)	Total nitrogen, nitrite+nitrate-N added to ammonia+organic-N (mg/L as N)	Ortho-phosphorus, dissolved (mg/L as P)	Total phosphorus (mg/L as P)	Carbon, organic, suspended (mg/L as C)	Carbon, organic, dissolved (mg/L as C)
6	St. Joe River at Red Ives Ranger Station, ID								6
	No. of samples	17	17	17		17	17	7	0
	No. of censored or e values	13	4	13		7	9	4	0
	% censored or e values	76.5	23.5	76.5		41.2	52.9	57.1	0
	Minimum	<.002	<.005	e.05		<.001	e.003	<.2	.6
	Maximum	.011	.053	.16		.004	.012	.2	1.7
	Median	<.002	.009	.075	0.084	.0015	.005	<.2	.7
7	North Fork Coeur d'Alene River at Enaville, ID								
	No. of samples	28	28	28		28	28	11	11
	No. of censored or e values	12	5	21		11	13	8	0
	% censored or e values	42.9	17.9	75		39.3	46.4	72.7	0
	Minimum	<.002	<.005	e.06		<.001	e.003	<.2	0
	Maximum	.014	.048	.36		.008	.189	1.5	1.3
	Median	.002	.013	e.08	e.21	.003	.006	<.2	.74
8	South Fork Coeur d'Alene River near Pinehurst, ID								
	No. of samples	33	33	33		32	33	13	14
	No. of censored or e values	0	0	7		1	0	5	0
	% censored or e values	0	0	21.9		3.1	0	38.5	0
	Minimum	.006	.025	e.06		.002	.012	<.2	.4
	Maximum	.408	.448	.62		.027	.171	1.5	.9
	Median	.07	.128	.21	.338	.009	.032	.2	.6
9	Spokane River near Post Falls, ID								
	No. of samples	27	27	27		27	27	10	11
	No. of censored or e values	6	1	5		10	3	1	0
	% censored or e values	22.2	3.7	18.5		37	11.1	10	0
	Minimum	<.002	<.005	e.05		<.001	e.005	.2	1.3
	Maximum	.052	.257	.65		.133	.057	.5	3.7
	Median	.004	.054	.13	.184	.0015	.011	.2	1.4
10	Spokane River at 7 Mile Bridge near Spokane, WA								
	No. of samples	27	27	27		27	27	11	11
	No. of censored or e values	8	0	5		4	0	1	0
	% censored or e values	29.6	0	18.5		14.8	0	9.1	0
	Minimum	<.002	.101	e.06		<.001	.006	<.2	1.1
	Maximum	.067	2.86	.31		.108	.118	.4	2
	Median	.004	.591	.15	.741	.012	.027	.2	1.6
National median for 85 undisturbed sites (Clark and others, 2000)		.020	.080	—	.32	.010	.037	—	—

stream from wastewater-treatment facilities. Under conditions of low streamflow, treated wastewater from the city of Spokane composed as much as 9 to 11 percent of the discharge in the Spokane River at 7 Mile Bridge in the late summer and early autumn in water years 1999 – 2001 (fig. 11).

The median total phosphorus concentration at all NROK sites was smaller (often by a considerable amount) than the median concentration at 85 undisturbed sites reported by Clark and others (2000). However, the maximum concentration of total phosphorus measured at six NROK NAWQA sites exceeded the 0.1 mg/L threshold recommended for limiting nuisance aquatic algae and plant growth in rivers or streams (U.S. Environmental Protection Agency, 1986). These sites were the Clark Fork at Turah Bridge, Bitterroot River near Missoula, and Clark Fork at St. Regis, in Montana; the North Fork Coeur d'Alene River at Enaville and the South Fork Coeur d'Alene River near Pinehurst, in Idaho; and the Spokane River at 7 Mile Bridge near Spokane, in Washington.

ORGANIC CARBON

Dissolved and suspended organic carbon were sampled and analyzed at most NROK sites from late 1998 to early 2000 (table 4). Analyses for carbon were discontinued in 2000, primarily because of the small concentrations routinely measured at NROK NAWQA sites and also because of methodological changes at the USGS National Water Quality Laboratory.

TRACE ELEMENTS

Concentrations of selected trace elements of environmental concern in the NROK study area are summarized in table 5. Methodological changes, varying analytical detection and data reporting (censoring) limits during the NROK NAWQA study made data analysis, interpretation, and reporting difficult. These varying reporting limits affected statistical treatment of censored values, resulting in intervals rather than discrete values for some medians (table 5). For the graphical depictions (boxplots) of selected trace-element data in figures 22 – 32 (back of report), censored data were assigned values of one-half the reported "less than" value, and estimated values were used directly. Nevertheless, some of the boxplots appear distorted. For example, at sites having a large proportion of censored values, the boxplots appear compressed, either because of limited variation in the values or because of analytical reporting limits that were too large to observe variation over much of the range of ambient concentrations.

Dissolved arsenic concentrations were largest at the Clark Fork at Turah Bridge and at St. Regis, Montana, and the Spokane River at 7 Mile Bridge near Spokane, Washington (table 5, fig. 22). These sites are downstream from the historical Butte-Anaconda mining and ore-processing areas in Montana and the city of Spokane, Washington, metropolitan area. A similar pattern was apparent for total recoverable arsenic (fig. 23). In addition, several total recoverable arsenic concentrations (measured during high streamflow) at the South Fork Coeur d'Alene River near Pinehurst, Idaho, (downstream from the historical Coeur d'Alene mining and ore-processing district) exceeded the maximum concentration at the Clark Fork at Turah Bridge (table 5).

Median dissolved and total recoverable cadmium concentrations were substantially larger at the South Fork Coeur d'Alene River near Pinehurst, Idaho, compared with other sites. Concentrations were moderately elevated, relative to concentrations at the remaining sites, at the Spokane River near Post Falls, Idaho, and at 7 Mile Bridge near Spokane, Washington (table 5, figs. 24 and 25).

Dissolved copper concentrations were largest at the Clark Fork at Turah Bridge near Bonner and at St. Regis, Montana (table 5, fig. 26). Total recoverable copper concentrations also were largest at the Clark Fork at Turah Bridge (fig. 27).

Dissolved lead concentrations were largest at the South Fork Coeur d'Alene River near Pinehurst, Idaho (fig. 28), and generally were less than 1 μg/L at the remaining sites. Total recoverable lead concentrations also were largest at the South Fork Coeur d'Alene River near Pinehurst and were one or more orders of magnitude larger than at the main-stem Clark Fork and Spokane River sites (fig. 29), which also are downstream from historical mining areas (fig. 1).

At the minimum and median hardness levels measured throughout the NROK NAWQA study, dissolved lead concentrations in all 32 samples collected at the South Fork Coeur d'Alene River near Pinehurst, Idaho, exceeded the Idaho criterion for chronic toxicity designated for the protection of aquatic life; 75 percent of the dissolved lead concentrations exceeded the criterion at the maximum hardness level measured. The hardness-dependent chronic criterion is the 4-day average concentration not to be exceeded more than once every 3 years on average (Idaho Department of Envi-

Table 5. Selected trace-element data for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999 –2001

[No., number; µg/L, micrograms per liter; MT, Montana; ID, Idaho; WA, Washington; e, estimated value; %, percent; <, less than]

Site No. (fig. 1)	Site name	Arsenic, dissolved (µg/L as As)	Arsenic, total recoverable (µg/L as As)	Cadmium, dissolved (µg/L as Cd)	Cadmium, total recoverable (µg/L as Cd)	Copper, dissolved (µg/L as Cu)	Copper, total recoverable (µg/L as Cu)	Lead, dissolved (µg/L as Pb)	Lead, total recoverable (µg/L as Pb)	Mercury, total recoverable (µg/L as Hg)	Zinc, dissolved (µg/L as Zn)	Zinc, total recoverable (µg/L as Zn)
1	Clark Fork at Turah Bridge near Bonner, MT											
	No. of samples	24	23	24	23	24	23	24	23	16	24	22
	No. of censored or e values	0	0	22	17	0	14	21	9	15	0	14
	% of censored or e values	0	0	91.7	73.9	0	60.9	87.5	39.1	93.8	0	63.6
	Minimum	3.1	3	e.02	.04	1.9	3.5	e.04	e.50	<.10	2.2	8
	Maximum	7.9	11	.04	<1.0	6.5	48.4	.10	10	<.30	8.1	90
	Median	5.5	6	<1.0	<.11	2.65	17.4	<1.0	1.2	<.30	3.9	<31
2	Bitterroot River near Missoula, MT											
	No. of samples	19	18	19	18	19	18	19	18	13	19	18
	No. of censored or e values	13	18	19	17	14	15	19	18	13	15	15
	% of censored or e values	68.4	100	100	94.4	73.7	83.3	100	100	100	78.9	83.3
	Minimum	.24	<1.0	e.02	<.04	.52	e.52	<.08	<1.0	<.10	<1.0	<1.0
	Maximum	<2.0	<2.6	<1.0	1.9	.86	<20	<1.0	e1.0	<.30	<1.0	<40
	Median	<1.0	<1.9	<1.0	<.11	<1.0	<12	<1.0	<1.0	<.30	<2.5	<31
3	Clark Fork at St. Regis, MT											
	No. of samples	22	22	22	22	22	22	22	22	16	22	22
	No. of censored or e values	5	14	22	22	5	15	21	19	16	7	16
	% of censored or e values	22.7	63.6	100	100	22.7	68.2	95	86.4	100	31.8	72.7
	Minimum	e.67	<1.0	e.02	e.02	<1.0	1.0	e.04	e.62	<.10	<1.0	1.5
	Maximum	2.4	3.1	<1.0	<1.0	2.4	21	.10	6.7	<.30	1.3	<40
	Median	e1.6	2.2	<1.0	<.11	1.2	<12 – e12	<1.0	<1.0	<.30	<3.9	<31
4	Flathead River at Perma, MT											
	No. of samples	14	14	14	14	14	14	14	14	8	14	14
	No. of censored or e values	8	13	14	13	8	12	14	14	8	13	11
	% of censored or e values	57.1	92.9	100	92.9	57.1	85.7	100	100	100	92.9	78.6
	Minimum	.37	<1.0	e.02	<.04	.4	e.41	e.04	<1.0	<.10	<1.0	<1.0
	Maximum	<2.0	<2.6	<1.0	<1.0	<1.0	<20.0	<1.0	<1.0	<.30	<3.0	<40
	Median	.56 – <.9	<1.9	<1.0	.11	<1.0	<12	<1.0	<1.0	<.10 – <.30	<1.0	e17–<31
5	Lightning Creek at Clark Fork, ID											
	No. of samples	17	17	17	17	17	17	17	17	10	17	17
	No. of censored or e values	17	17	16	17	13	17	11	17	10	13	16
	% of censored or e values	100	100	94.1	100	76.5	100	64.7	100	100	76.5	94.1
	Minimum	e.11	<1.9	e.02	<.04	e.16	e.41	e.05	e.51	<.30	<1.0	<1
	Maximum	<2.0	<2.6	<1.0	<.11	<1.0	<20.0	<1.0	<1.0	<.30	<1.0	<31
	Median	<.90	<2.6	<1.0	<.11	<1.0	<20.0	<1.0	<1.0	<.30	<3.6	<31

Table 5. Selected trace-element data for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999 – 2001—Continued

Site No. (fig. 1)	Site name	Arsenic, dissolved (µg/L as As)	Arsenic, total recoverable (µg/L as As)	Cadmium, dissolved (µg/L as Cd)	Cadmium, total recoverable (µg/L as Cd)	Copper, dissolved (µg/L as Cu)	Copper, total recoverable (µg/L as Cu)	Lead, dissolved (µg/L as Pb)	Lead, total recoverable (µg/L as Pb)	Mercury, total recoverable (µg/L as Hg)	Zinc, dissolved (µg/L as Zn)	Zinc, total recoverable (µg/L as Zn)
6	St. Joe River at Red Ives Ranger Station, ID											
	No. of samples	16	15	17	16	17	16	16	15	12	16	15
	No. of censored or e values	15	15	17	16	14	16	15	15	12	15	15
	% of censored or e values	93.8	100	100	100	82.4	100	93.8	100	100	93.8	100
	Minimum	e.11	<1.0	e.02	<.04	e.16	e.31	<.08	<1.0	<.10	<1.0	<1.0
	Maximum	<2.0	<2.6	<1.0	<1.0	<1.0	<20	<1.0	<1.0	<.30	<3.5	<40
	Median	<.90	<1.9	<1.0	<.11	<1.0	<12	<1.0	<1.0	<.30	<1.0	<31
7	North Fork Coeur d'Alene River at Enaville, ID											
	No. of samples	21	22	21	22	21	22	21	22	15	21	22
	No. of censored or e values	20	20	21	21	17	22	20	17	15	3	13
	% of censored or e values	95	91	100	95	81	100	95.2	77.3	100	14.3	59.1
	Minimum	e.09	<1.0	e.02	e.02	e.18	e.30	e.04	<1.0	<.10	1.8	2.1
	Maximum	<2.0	3.0	<1.0	<1.0	<1.0	<20	<1.0	24	<.30	66	84
	Median	<1.0	<1.9	<1.0	<.11	<1.0	e11 – <12	<1.0	<1.0	<.30	4.5	<31
8	South Fork Coeur d'Alene River near Pinehurst, ID											
	No. of samples	32	31	32	30	32	31	32	31	23	32	31
	No. of censored or e values	22	22	0	0	18	21	0	0	19	0	0
	% of censored or e values	69	71	0	0	56	68	0	0	83	0	0
	Minimum	.30	<1.0	1.5	2.6	.84	1.2	2.1	13	<.10	227	363
	Maximum	<2.0	13	18	19	<3.0	<20	12	790	.66	2,120	2,190
	Median	<1.0	<2.6	6.55	6.4	<1.0	14	4.4	20	<.30	913	927
9	Spokane River near Post Falls, ID											
	No. of samples	26	26	26	26	26	26	26	26	17	26	26
	No. of censored or e values	17	25	17	6	16	18	17	8	17	0	2
	% of censored or e values	65	96	65	23	62	69	65	31	100	0	8
	Minimum	<1.0	<1.0	.08	.10	.5	e.58	e.04	e.59	<.10	22	e26
	Maximum	<2.0	<2.6	<1.0	<1.0	1.5	<20	1.6	7.8	<.30	90	96
	Median	<.90	<1.9 – <2.6	<.10	.23	<10	<12	<.10	1.15	<.30	53.5	63
10	Spokane River at 7 Mile Bridge near Spokane, WA											
	No. of samples	25	24	25	24	25	24	25	24	18	24	24
	No. of censored or e values	13	23	18	7	18	17	19	10	18	0	4
	% of censored or e values	52	95.8	72	29.2	72	70.8	76	41.7	100	0	16.7
	Minimum	e.51	<1.0	.05	e.08	.54	.67	e.06	e.88	<.10	8.5	e20
	Maximum	3.2	2.7	<1.0	<1.0	<1.0	1.3	1.4	16	<.30	76	114
	Median	<1.0	1.9 – e2.0	<1.0	.185	<1.0	<12 – <20	<1.0	1.5	<.30	39.5	46

ronmental Quality, 1999; U.S. Environmental Protection Agency, 2000).

Although most total recoverable mercury concentrations were reported either as less than 0.10 or less than 0.30 μg/L (table 5), mercury was measured at detectable or estimated concentrations on one occasion at the Clark Fork at Turah Bridge and on four occasions at the South Fork Coeur d'Alene River near Pinehurst (fig. 30). The concentration reported for the Clark Fork at Turah Bridge was 0.12 μg/L from a sample collected during high streamflow. At the South Fork Coeur d'Alene River near Pinehurst, three concentrations ranging from 0.30 to 0.66 μg/L were measured in samples collected during high streamflow, and a concentration of 0.15 μg/L was measured in a sample collected during low streamflow.

Dissolved zinc concentrations were substantially elevated at the South Fork Coeur d'Alene and Spokane River sites (table 5, fig. 31). These sites are downstream from historical mining areas (fig. 1); sites on the Spokane River are also downstream from Coeur d'Alene Lake. The elevated concentrations of zinc in the Spokane River indicate that a portion of the upstream zinc input passes through Coeur d'Alene Lake. A similar pattern also was evident for total recoverable zinc concentrations (fig. 32). At the South Fork Coeur d'Alene River near Pinehurst, Idaho, dissolved zinc concentrations in all 32 samples exceeded both the chronic and acute criteria for the protection of aquatic life at all hardness levels measured throughout the study (Idaho Department of Environmental Quality, 1999; U.S. Environmental Protection Agency, 2000). The acute criterion is the 1-hour average concentration not to be exceeded more than once every 3 years on average. At the Spokane River near Post Falls, Idaho, 22 of 26 (85 percent) dissolved zinc concentrations exceeded both the chronic and acute criteria. At the Spokane River at 7 Mile Bridge near Spokane, Washington, at the median hardness level, 9 of 24 (38 percent) dissolved zinc concentrations exceeded the chronic criterion, and 5 of 24 concentrations (21 percent) exceeded the acute criterion.

COMPARISON WITH OTHER NATIONAL WATER-QUALITY ASSESSMENT PROGRAM STUDIES

Trace-element data from sites in other NAWQA Program study areas in the Western United States that have a history of mining activities were obtained for comparison with results from the NROK NAWQA study. These studies covered the following geographic areas: Upper Colorado River Basin (UCOL); Sacramento River Basin (SACR); Great Salt Lake Basins (GRSL); and Nevada Basins and Range (NVBR). Censored values were set to one-half the reporting value, and "estimated" values were used directly. Along with the NROK data, the distributions of these data are graphically depicted (boxplots) in figures 33 – 40 (back of report).

Overall, median concentrations of dissolved arsenic, dissolved and total recoverable copper, total recoverable lead, and total recoverable zinc in the NROK study area appeared to be similar to or slightly smaller than those reported for other Western NAWQA study areas affected by historical mining activities (figs. 33, 35, 36, 38, and 40). Although the NROK median total recoverable lead concentration was the smallest among the three Western study areas compared (fig. 38), concentrations in several samples from the NROK study area were an order of magnitude larger than the maximum concentrations in samples from the UCOL or GRSL study areas. Dissolved cadmium, dissolved lead, and total recoverable zinc at NROK sites were more variable than in the other study areas; concentrations ranged over nearly three orders of magnitude between the minimum and maximum values. The largest range in concentration was measured for dissolved zinc, which exceeded three orders of magnitude in the NROK study area.

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Figures 2 -40

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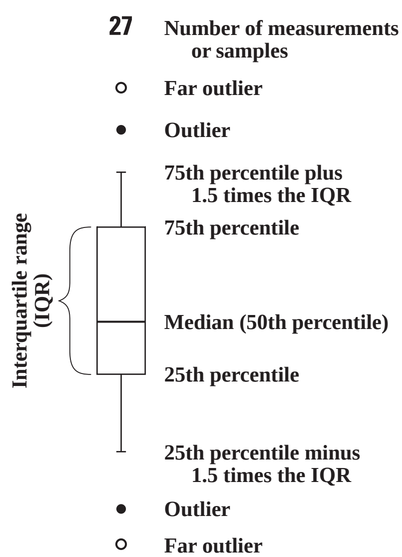
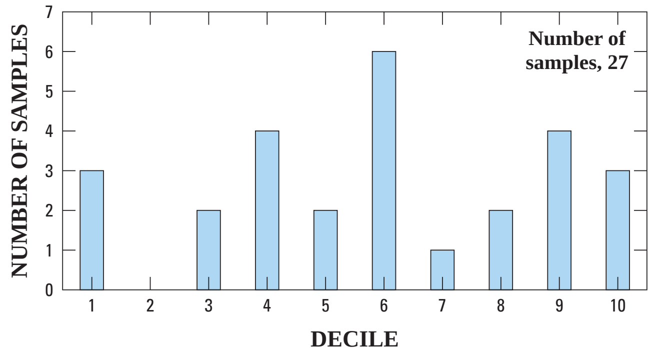
FIGURES 2–40

EXPLANATION
for boxplots shown in figures 12 through 40



Percent of time streamflow is equaled or exceeded	Streamflow, in cubic feet per second	Decile
90	Less than 500	1
80	500 to 621	2
70	622 to 705	3
60	706 to 787	4
50	788 to 869	5
40	870 to 978	6
30	979 to 1,122	7
20	1,123 to 1,479	8
10	1,480 to 2,321	9
Less than 10	Greater than 2,321	10

Number of occasions samples were collected at Clark Fork at Turah Bridge near Bonner, Montana (12334550), water years 1999–2001



Water year	Mean daily streamflow, in cubic feet per second	Percent of mean daily streamflow for the period of record
1985–2001 (period of record)	1,218	
1999	1,374	114
2000	764	63
2001	908	75

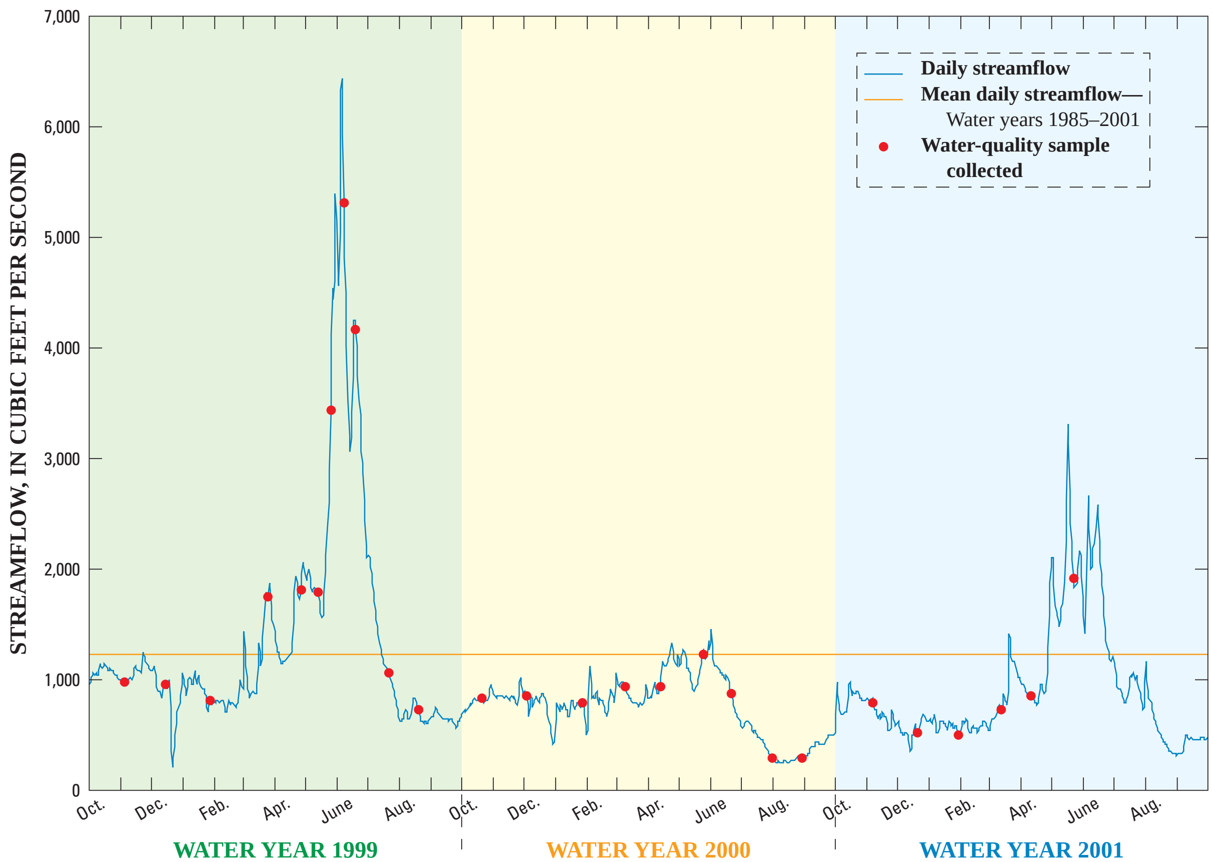
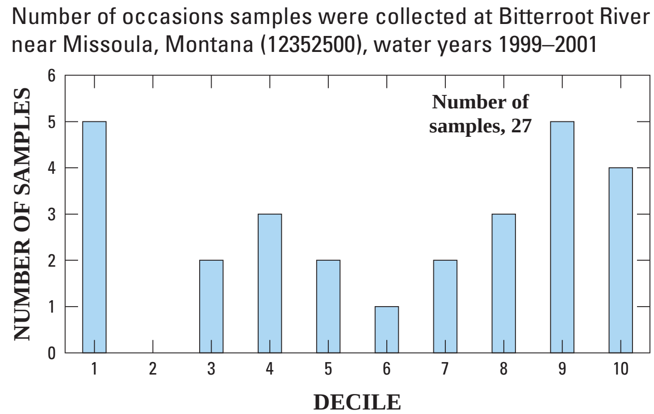


Figure 2. Selected streamflow statistics and water-quality sampling dates for the Clark Fork at Turah Bridge near Bonner, Montana (12334550). (Site 1 in figure 1)

Percent of time streamflow is equaled or exceeded	Streamflow, in cubic feet per second	Decile
90	Less than 637	1
80	637 to 758	2
70	759 to 871	3
60	872 to 995	4
50	996 to 1,137	5
40	1,138 to 1,357	6
30	1,358 to 1,830	7
20	1,831 to 3,288	8
10	3,289 to 6,281	9
Less than 10	Greater than 6,281	10



Water year	Mean daily streamflow, in cubic feet per second	Percent of mean daily streamflow for the period of record
1898–2001 (period of record)	2,460	
1999	2,484	96
2000	1,689	65
2001	1,440	56

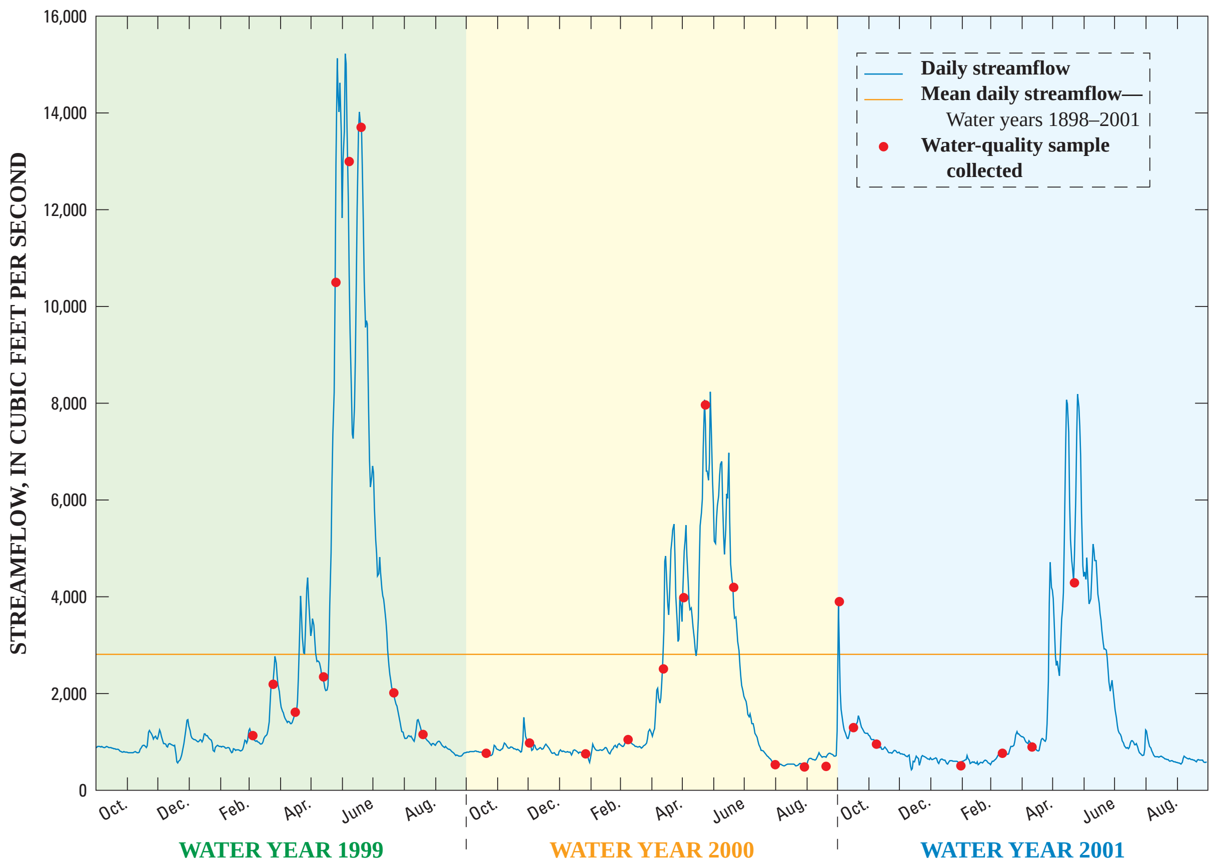
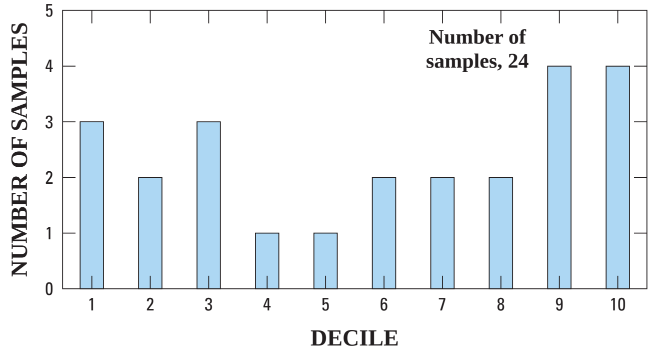


Figure 3. Selected streamflow statistics and water-quality sampling dates for the Bitterroot River near Missoula, Montana (12352500). (Site 2 in figure 1)

Percent of time streamflow is equaled or exceeded	Streamflow, in cubic feet per second	Decile
90	Less than 2,237	1
80	2,237 to 2,655	2
70	2,656 to 2,993	3
60	2,994 to 3,340	4
50	3,341 to 3,784	5
40	3,785 to 4,482	6
30	4,483 to 5,971	7
20	5,972 to 10,156	8
10	10,157 to 18,544	9
Less than 10	Greater than 18,544	10

Number of occasions samples were collected at Clark Fork at St. Regis, Montana (12354500), water years 1999–2001



Water year	Mean daily streamflow, in cubic feet per second	Percent of mean daily streamflow for the period of record
1930–2001 (period of record)	7,183	
1999	7,674	106
2000	5,229	72
2001	4,223	58

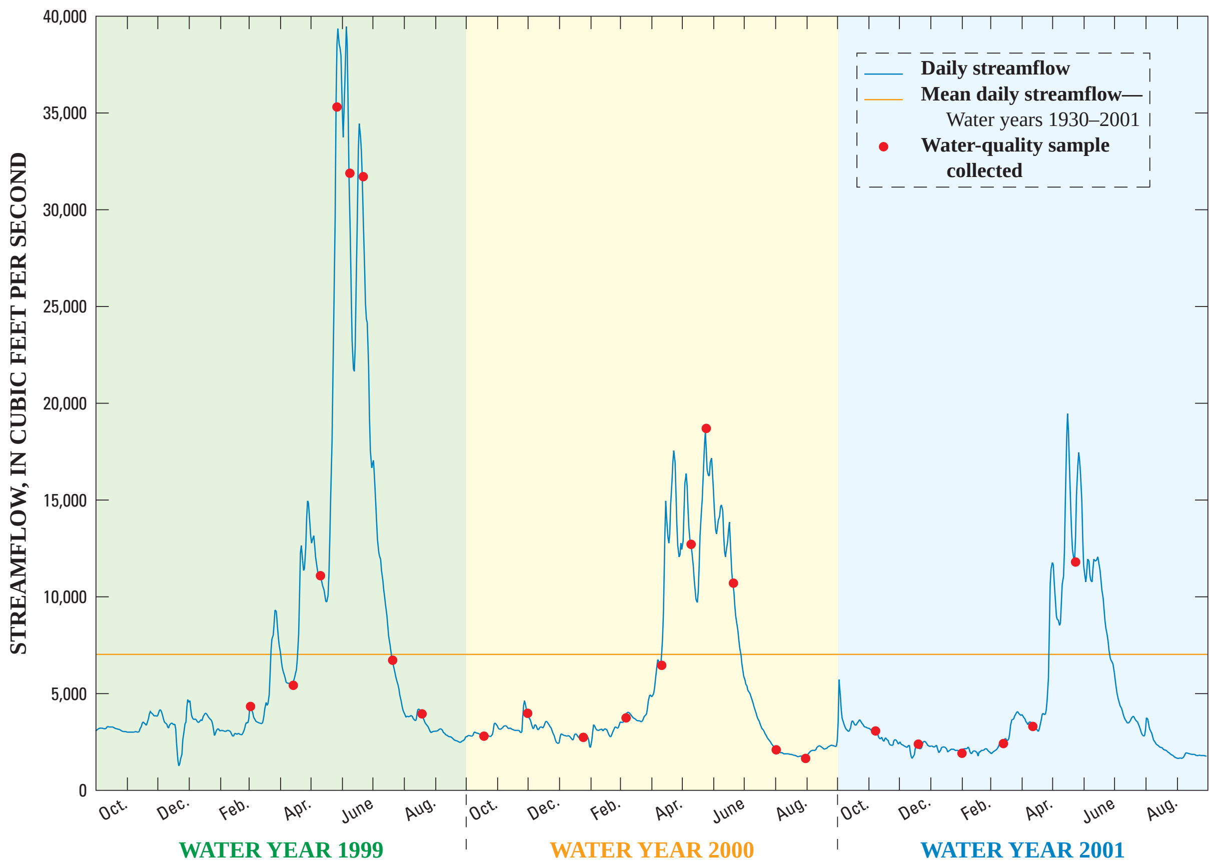
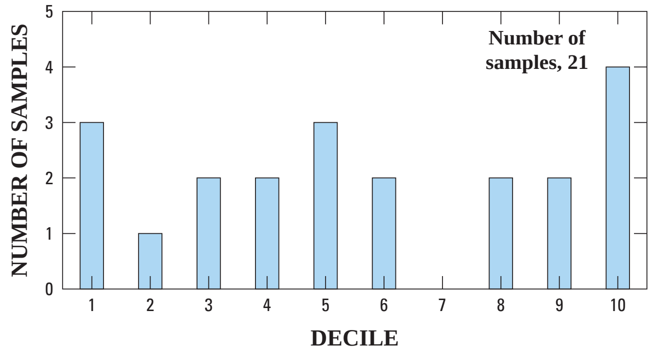


Figure 4. Selected streamflow statistics and water-quality sampling dates for the Clark Fork at St. Regis, Montana (12354500). (Site 3 in figure 1)

Percent of time streamflow is equaled or exceeded	Streamflow, in cubic feet per second	Decile
90	Less than 5,736	1
80	5,736 to 6,986	2
70	6,987 to 8,282	3
60	8,283 to 9,404	4
50	9,405 to 10,549	5
40	10,550 to 11,578	6
30	11,579 to 12,576	7
20	12,577 to 13,797	8
10	13,798 to 17,216	9
Less than 10	Greater than 17,216	10

Number of occasions samples were collected at Flathead River at Perma, Montana (12388700), water years 1999–2001



Water year	Mean daily streamflow, in cubic feet per second	Percent of mean daily streamflow for the period of record
1984–2001 (period of record)	11,580	
1999	11,120	96
2000	11,545	99
2001	7,040	61

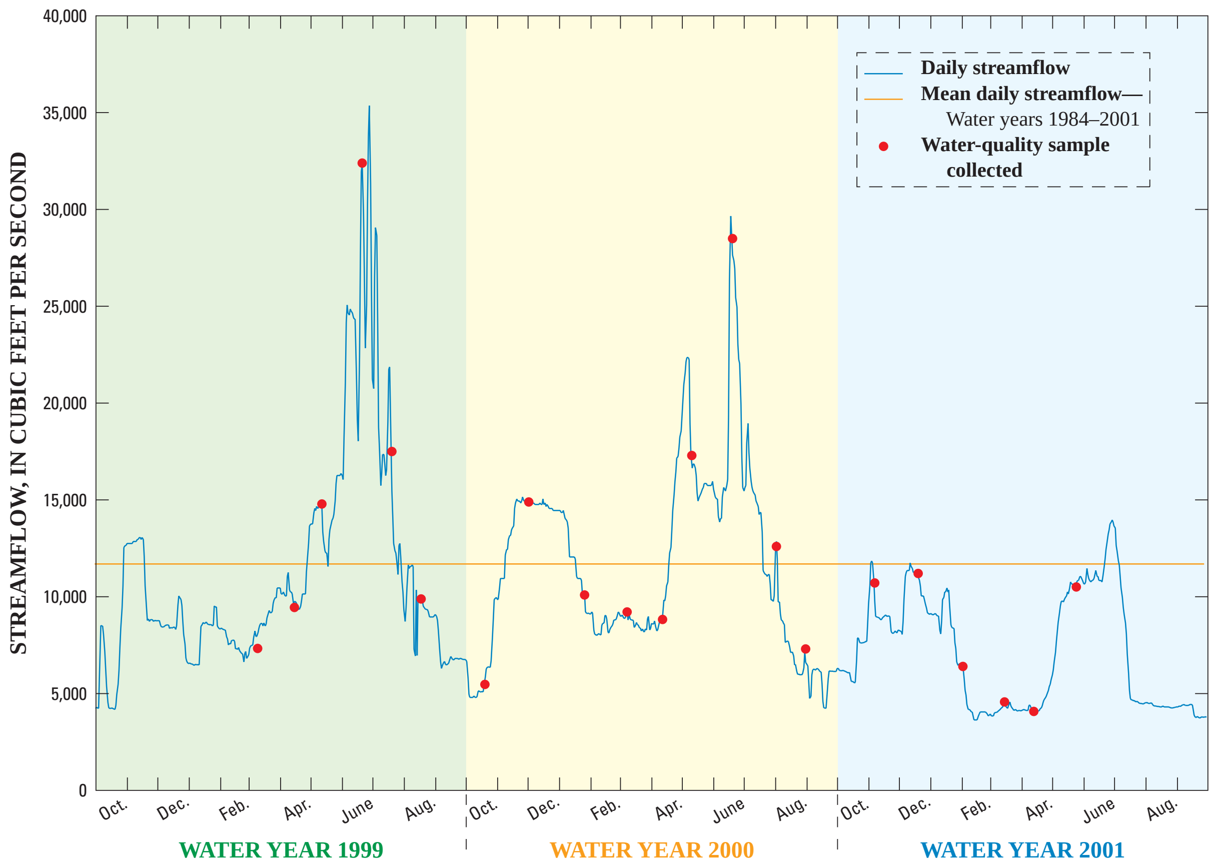


Figure 5. Selected streamflow statistics and water-quality sampling dates for the Flathead River at Perma, Montana (12388700). (Site 4 in figure 1)

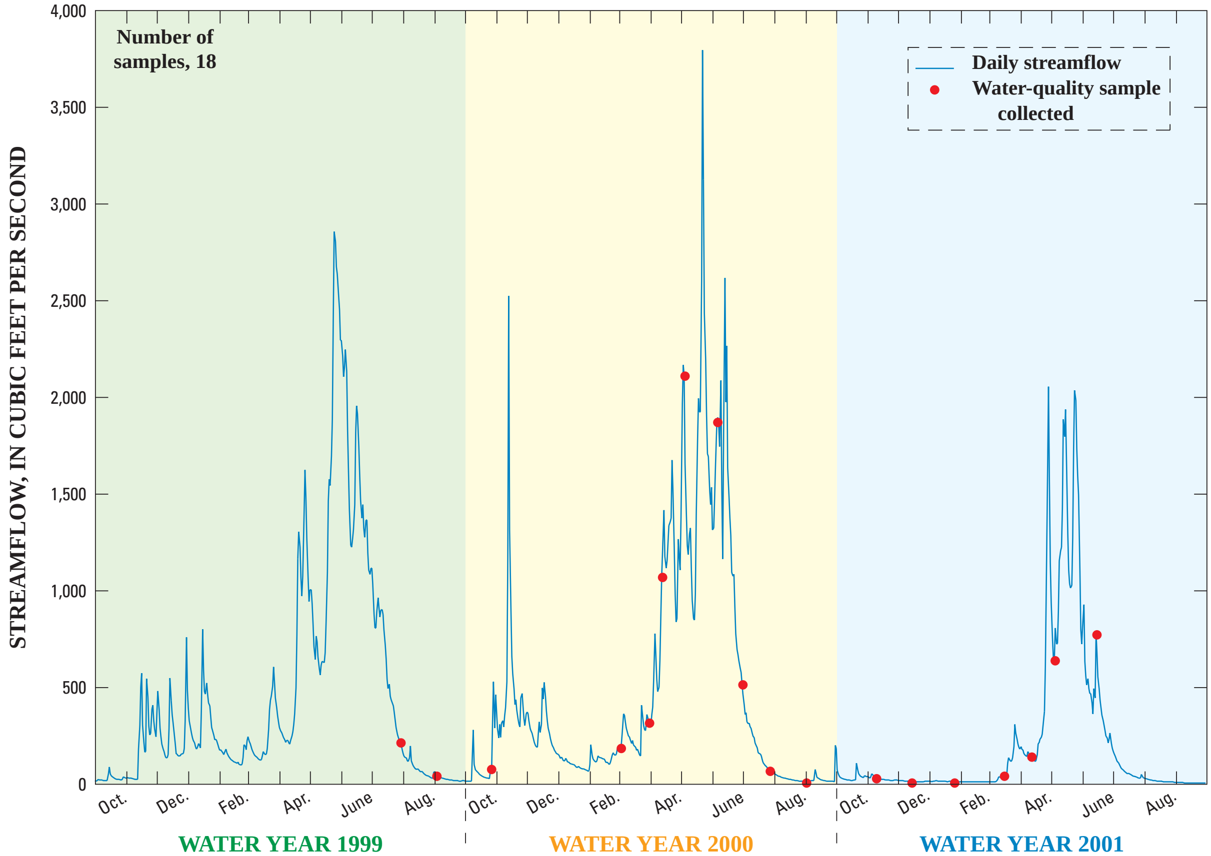


Figure 6. Daily streamflow and water-quality sampling dates for Lightning Creek at Clark Fork, Idaho (12392155). (Site 5 in figure 1)

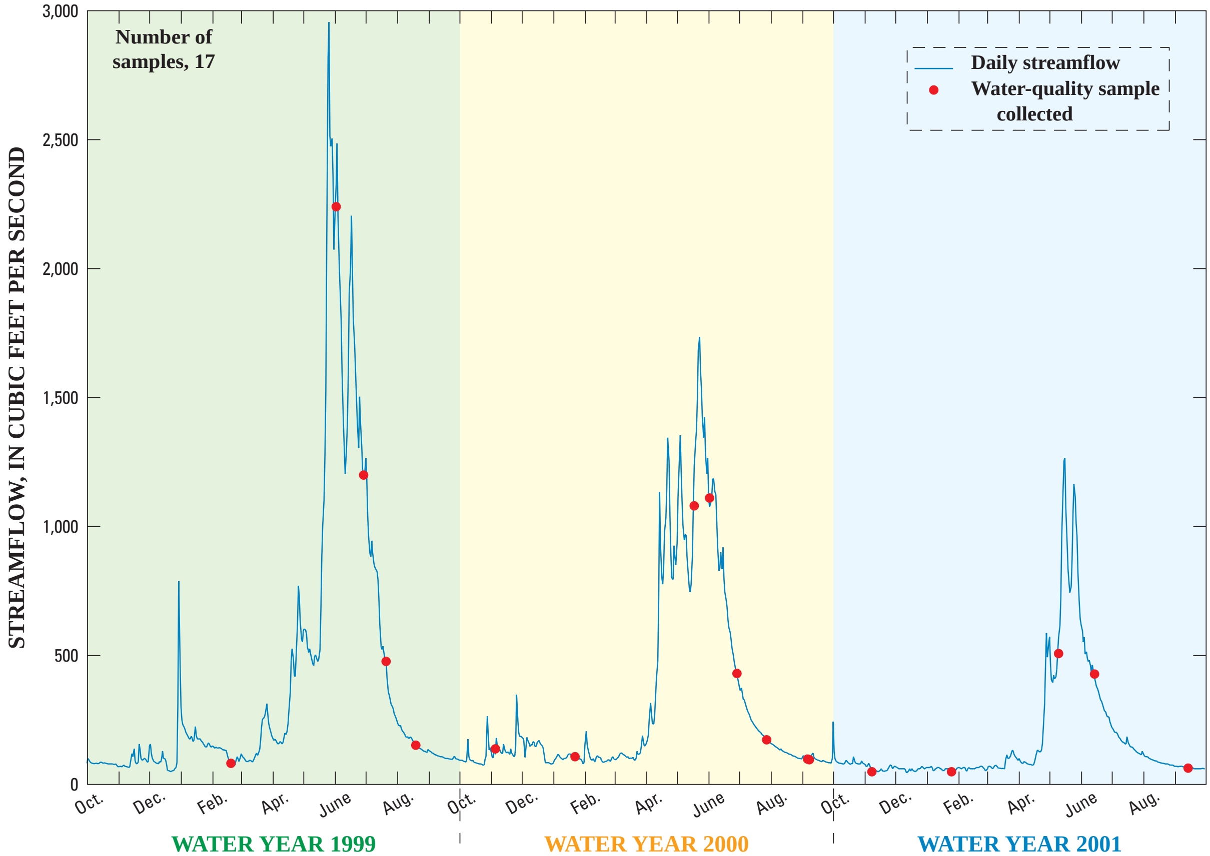
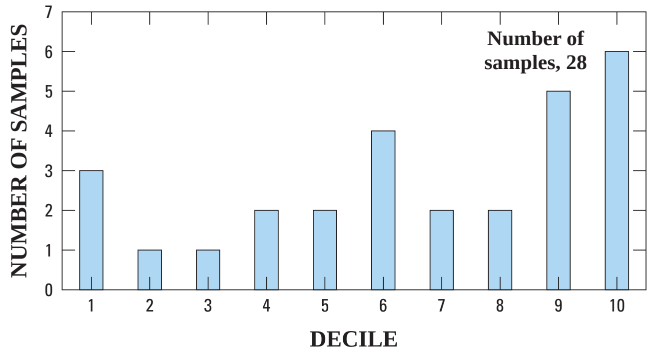


Figure 7. Daily streamflow and water-quality sampling dates for the St. Joe River at Red Ives Ranger Station, Idaho (12413875). (Site 6 in figure 1)

Percent of time streamflow is equaled or exceeded	Streamflow, in cubic feet per second	Decile
90	Less than 250	1
80	250 to 314	2
70	315 to 410	3
60	411 to 562	4
50	563 to 843	5
40	844 to 1,266	6
30	1,267 to 1,912	7
20	1,913 to 2,988	8
10	2,989 to 5,033	9
Less than 10	Greater than 5,033	10

Number of occasions samples were collected at the North Fork Coeur d'Alene River at Enaville, Idaho (12413000), water years 1999–2001



Water year	Mean daily streamflow, in cubic feet per second	Percent of mean daily streamflow for the period of record
1911–2001 (period of record)	1,892	
1999	2,243	119
2000	2,029	107
2001	763	40

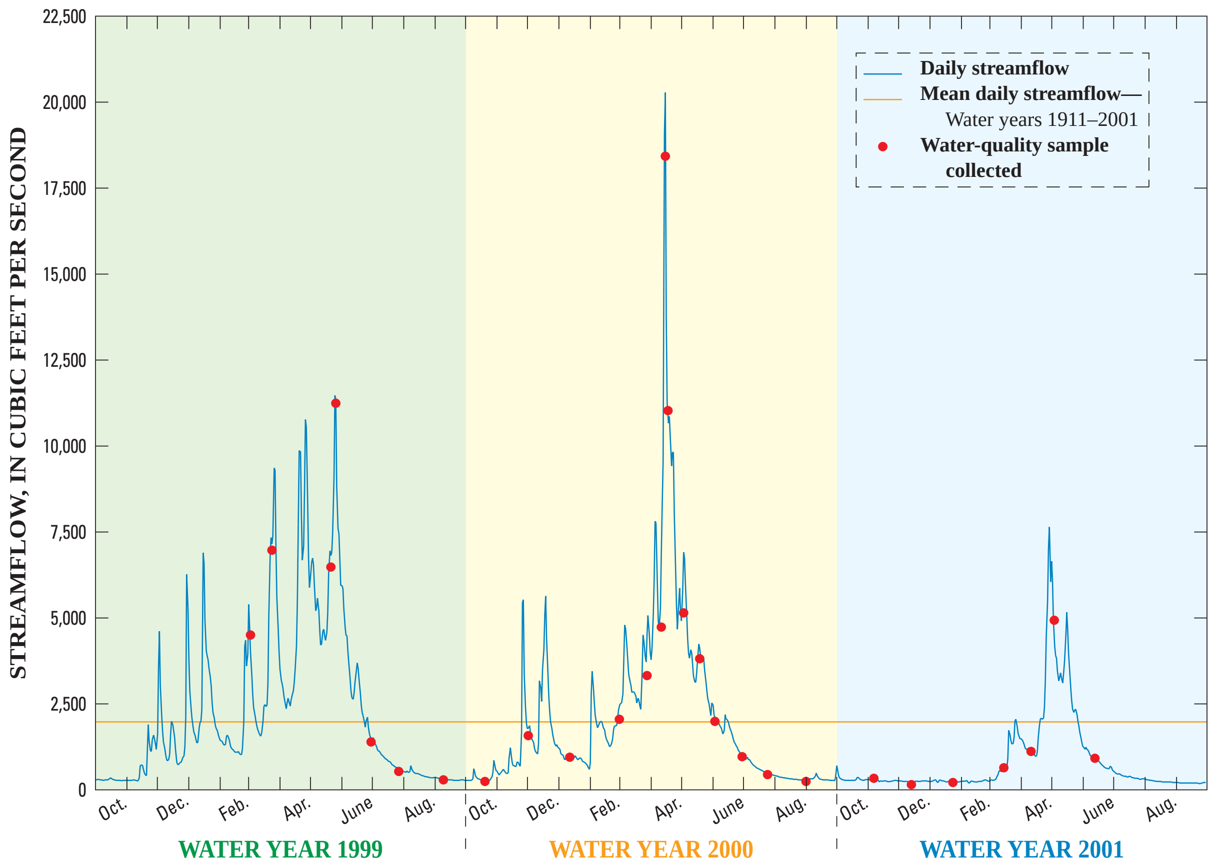
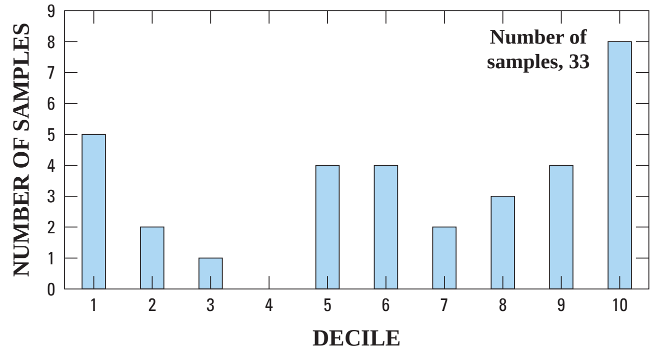


Figure 8. Selected streamflow statistics and water-quality sampling dates for the North Fork Coeur d'Alene River at Enaville, Idaho (12413000). (Site 7 in figure 1)

Percent of time streamflow is equaled or exceeded	Streamflow, in cubic feet per second	Decile
90	Less than 97	1
80	97 to 118	2
70	119 to 147	3
60	148 to 192	4
50	193 to 272	5
40	273 to 392	6
30	393 to 573	7
20	574 to 821	8
10	822 to 1,298	9
Less than 10	Greater than 1,298	10

Number of occasions samples were collected at the South Fork Coeur d'Alene River near Pinehurst, Idaho (12413470), water years 1999–2001



Water year	Mean daily streamflow, in cubic feet per second	Percent of mean daily streamflow for the period of record
1987–2001 (period of record)	526	
1999	687	131
2000	584	111
2001	232	44

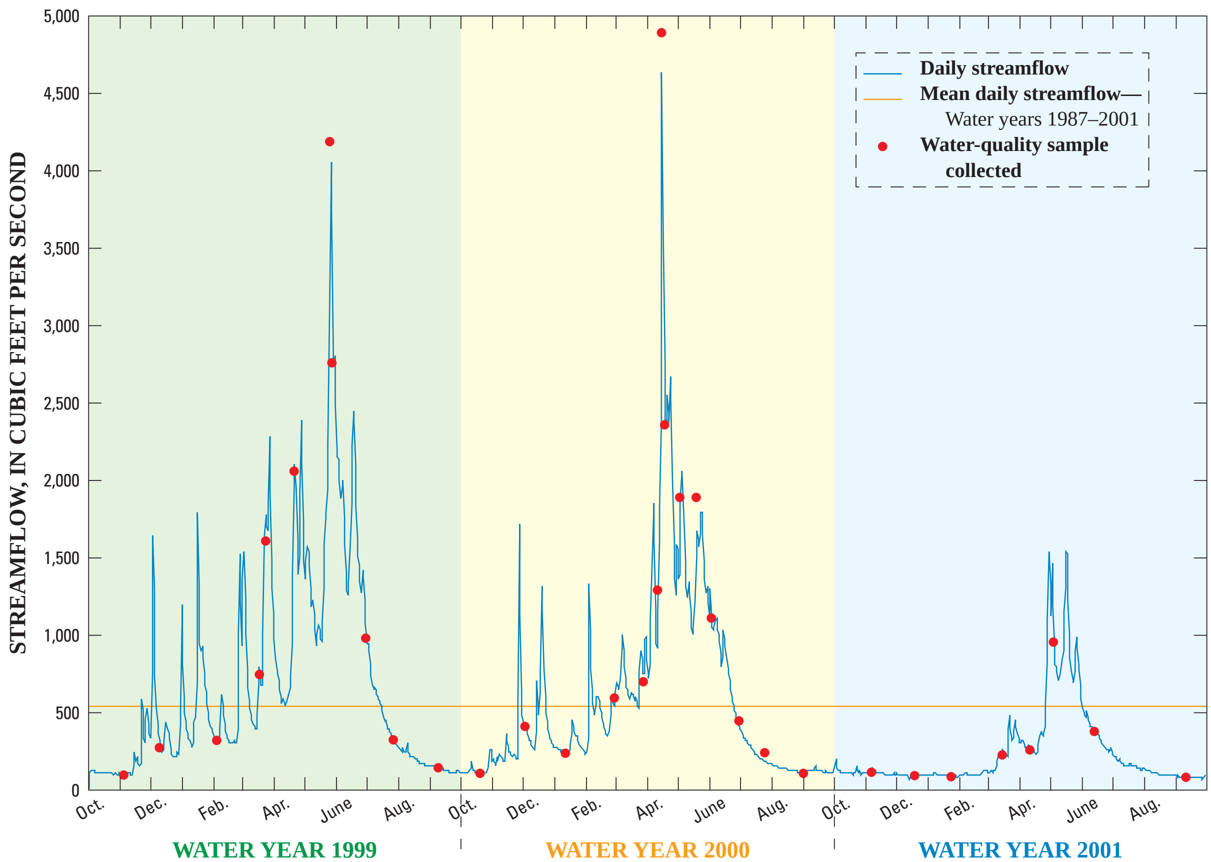
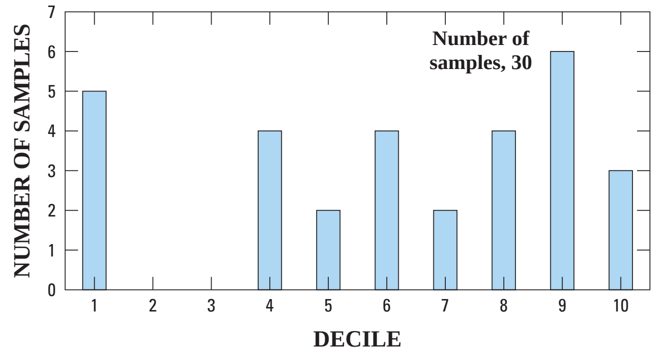


Figure 9. Selected streamflow statistics and water-quality sampling dates for the South Fork Coeur d'Alene River near Pinehurst, Idaho (12413470). (Site 8 in figure 1)

Percent of time streamflow is equaled or exceeded	Streamflow, in cubic feet per second	Decile
90	Less than 911	1
80	911 to 1,266	2
70	1,267 to 1,612	3
60	1,613 to 2,084	4
50	2,085 to 2,988	5
40	2,989 to 4,526	6
30	4,527 to 6,884	7
20	6,885 to 11,215	8
10	11,216 to 17,206	9
Less than 10	Greater than 17,206	10

Number of occasions samples were collected at the Spokane River near Post Falls, Idaho (12419000), water years 1999–2001



Water year	Mean daily streamflow, in cubic feet per second	Percent of mean daily streamflow for the period of record
1913–2001 (period of record)	6,206	
1999	7,534	121
2000	6,853	110
2001	2,691	43

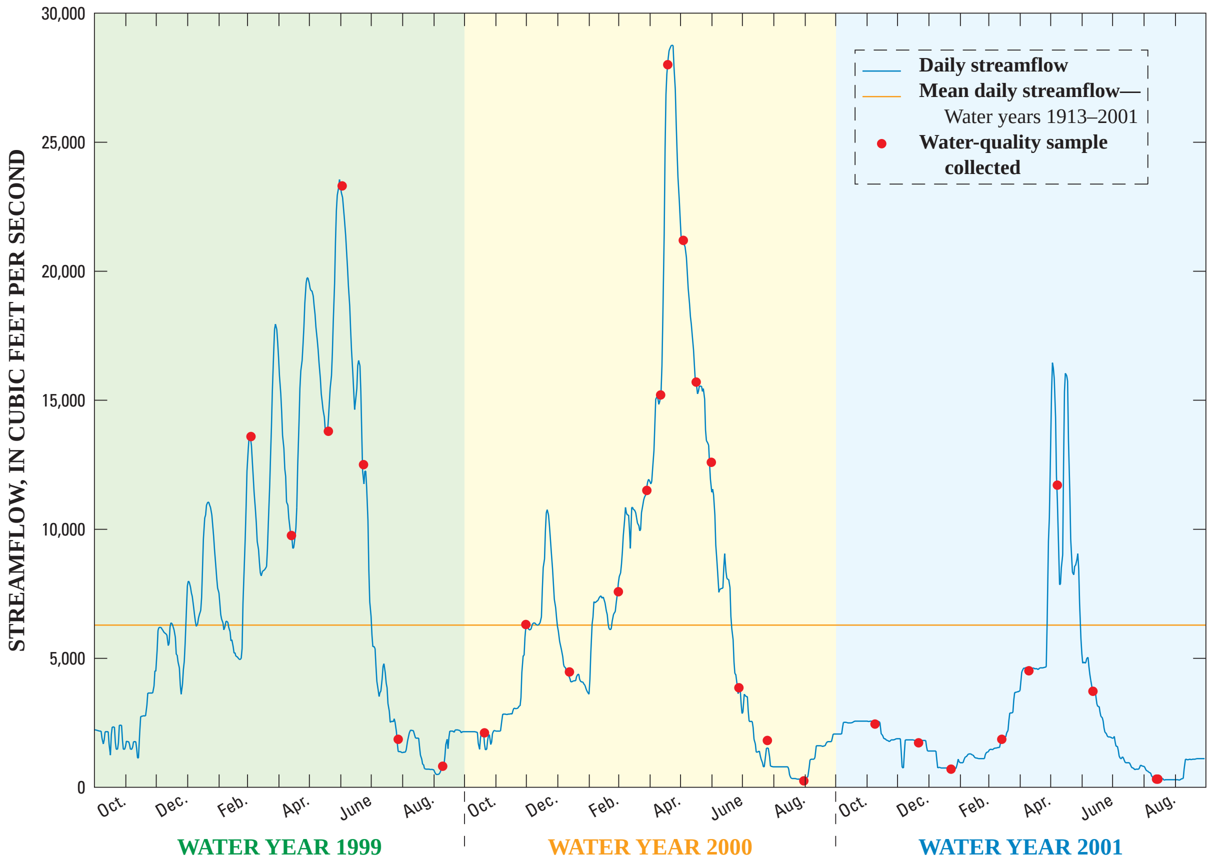


Figure 10. Selected streamflow statistics and water-quality sampling dates for the Spokane River near Post Falls, Idaho (12419000). (Site 9 in figure 1)

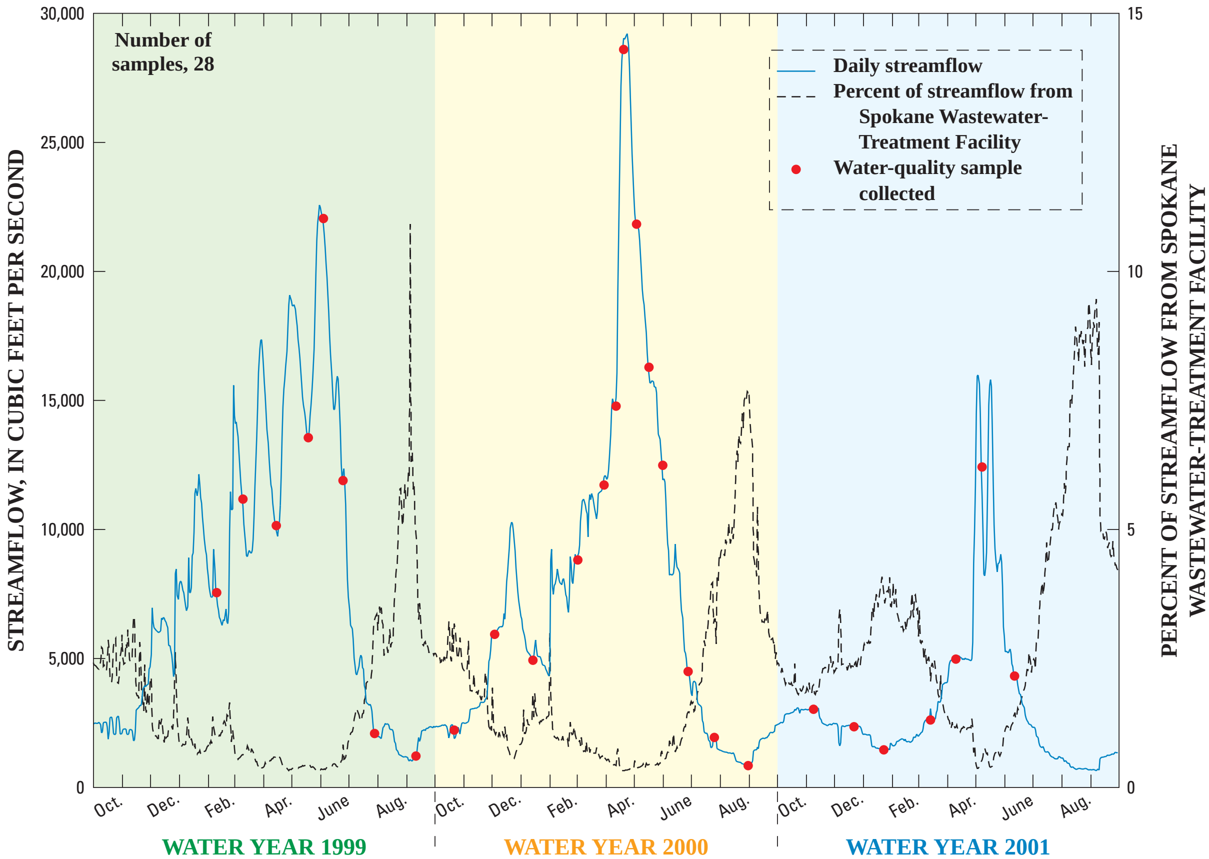


Figure 11. Daily streamflow and water-quality sampling dates for the Spokane River at Seven Mile Bridge near Spokane, Washington (12424500). (Site 10 in figure 1)

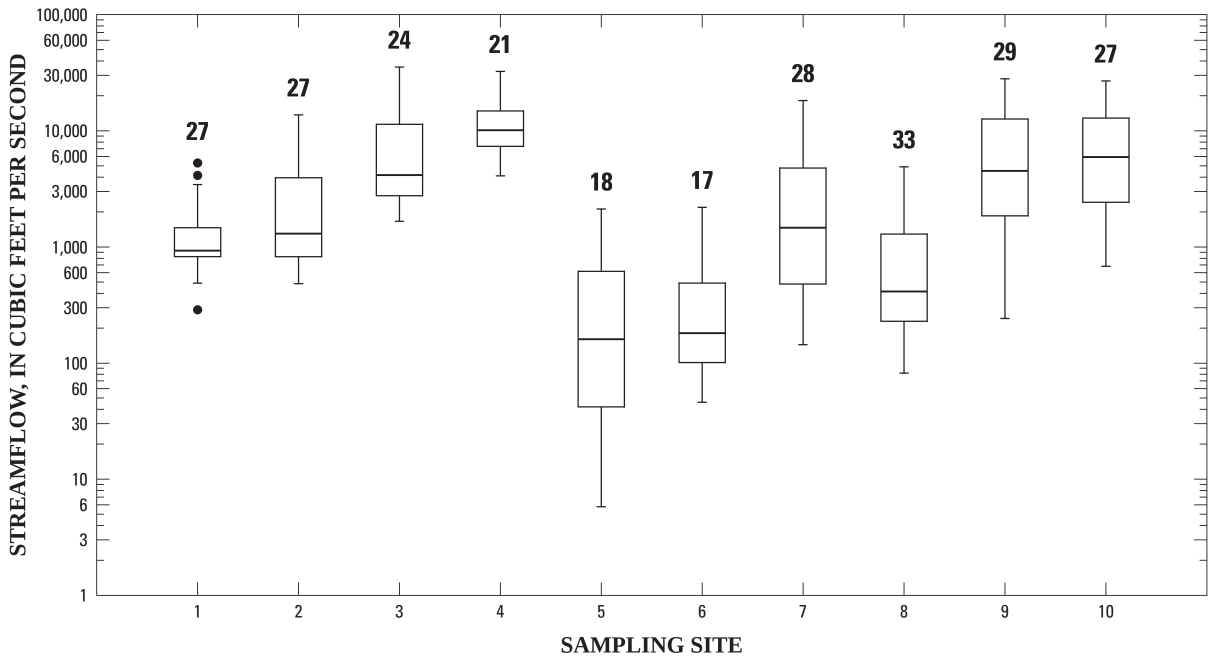


Figure 12. Distribution of streamflow values for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001. (Site locations shown in figure 1 and described in table 1)

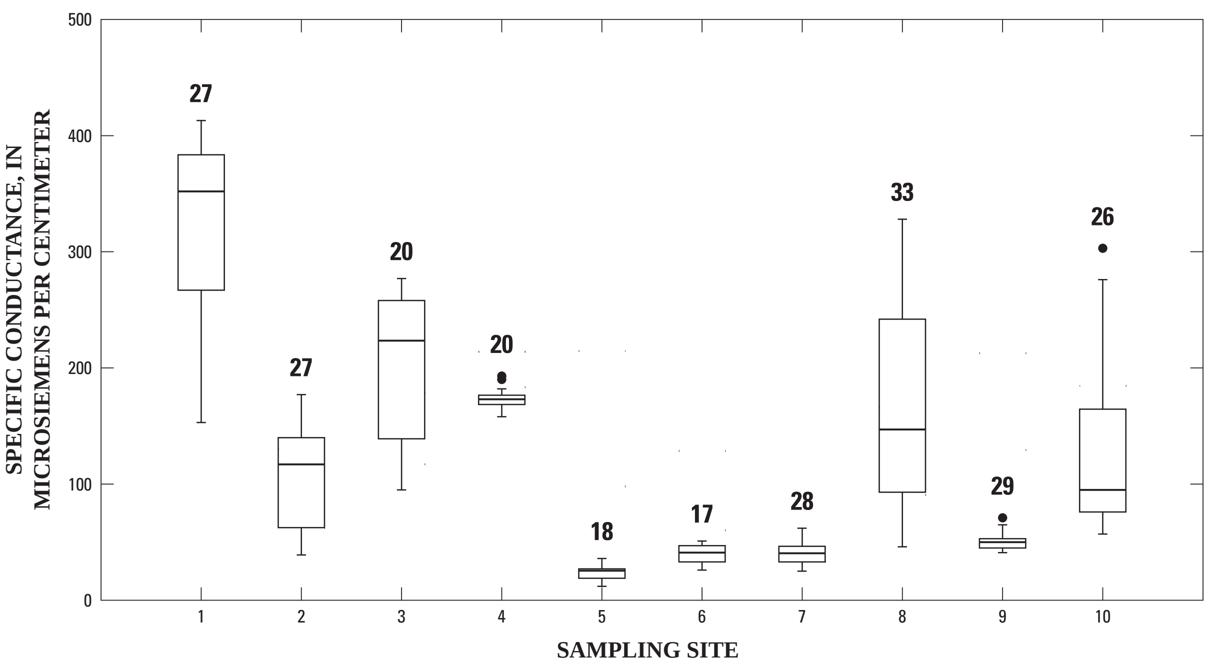


Figure 13. Distribution of specific conductance values for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001. (Site locations shown in figure 1 and described in table 1)

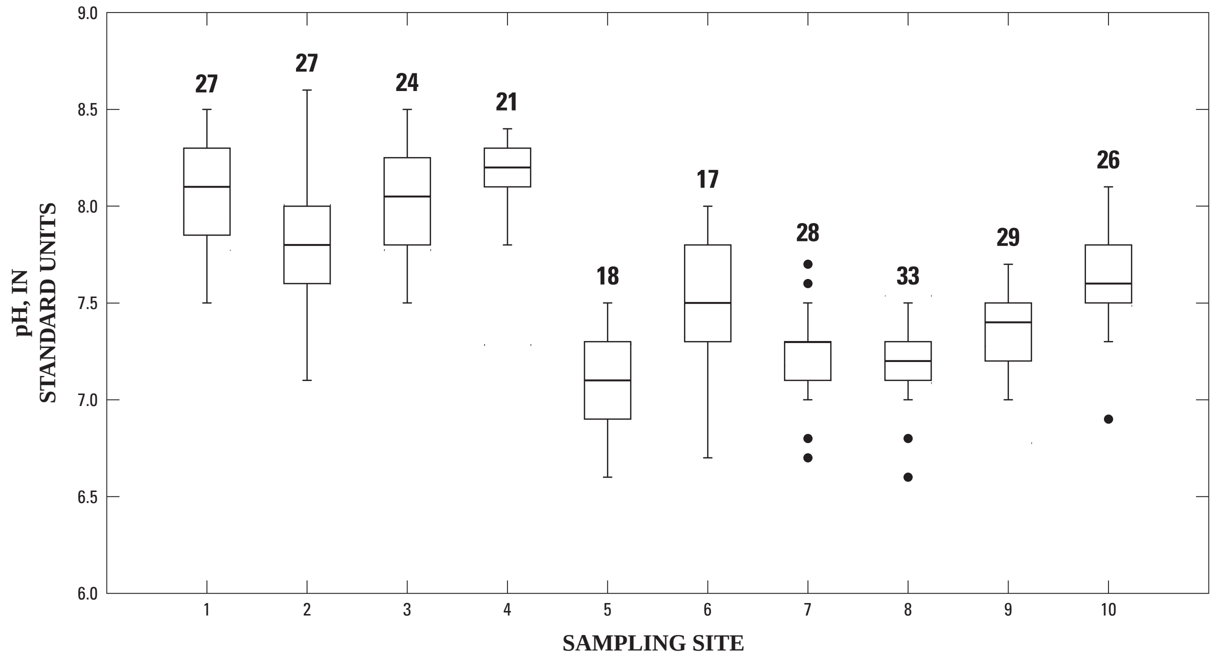


Figure 14. Distribution of onsite pH values for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001. (Site locations shown in figure 1 and described in table 1)

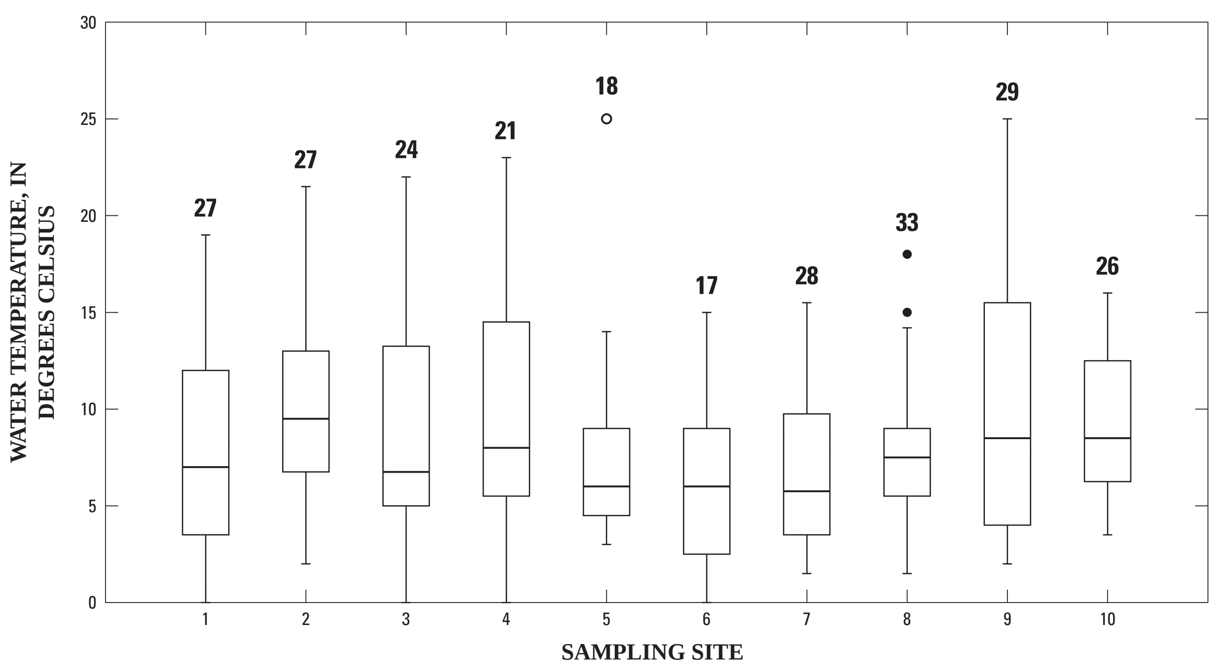


Figure 15. Distribution of water temperature values for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001. (Site locations shown in figure 1 and described in table 1)

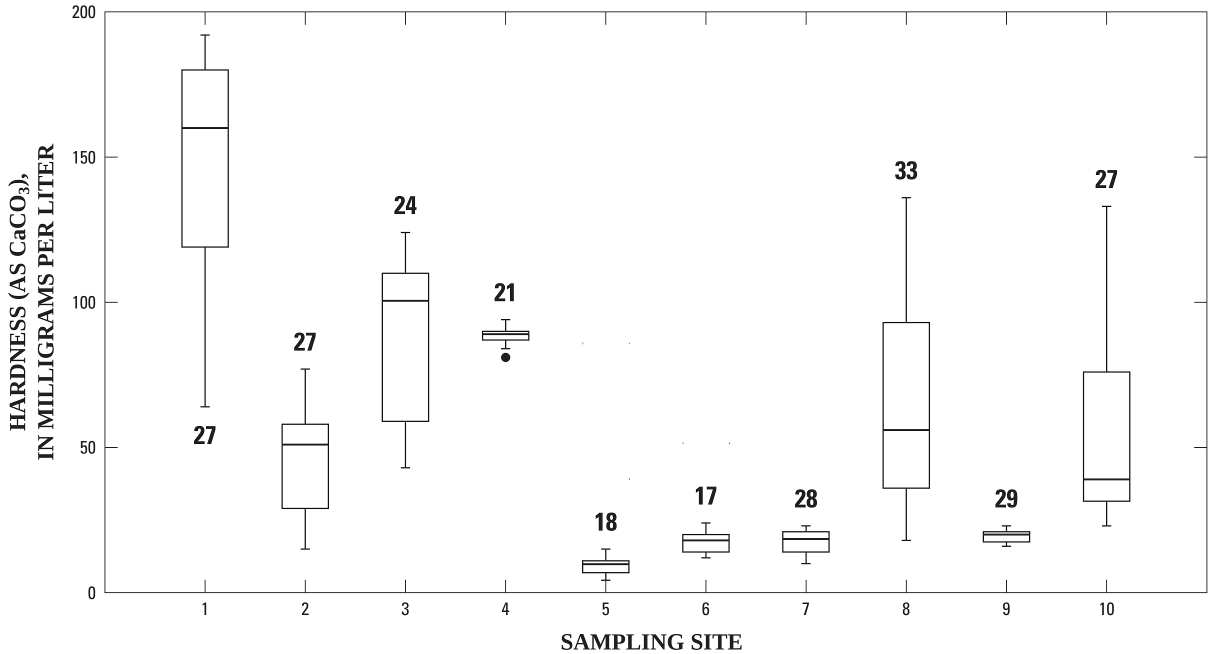


Figure 16. Distribution of hardness values for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001. (Site locations shown in figure 1 and described in table 1)

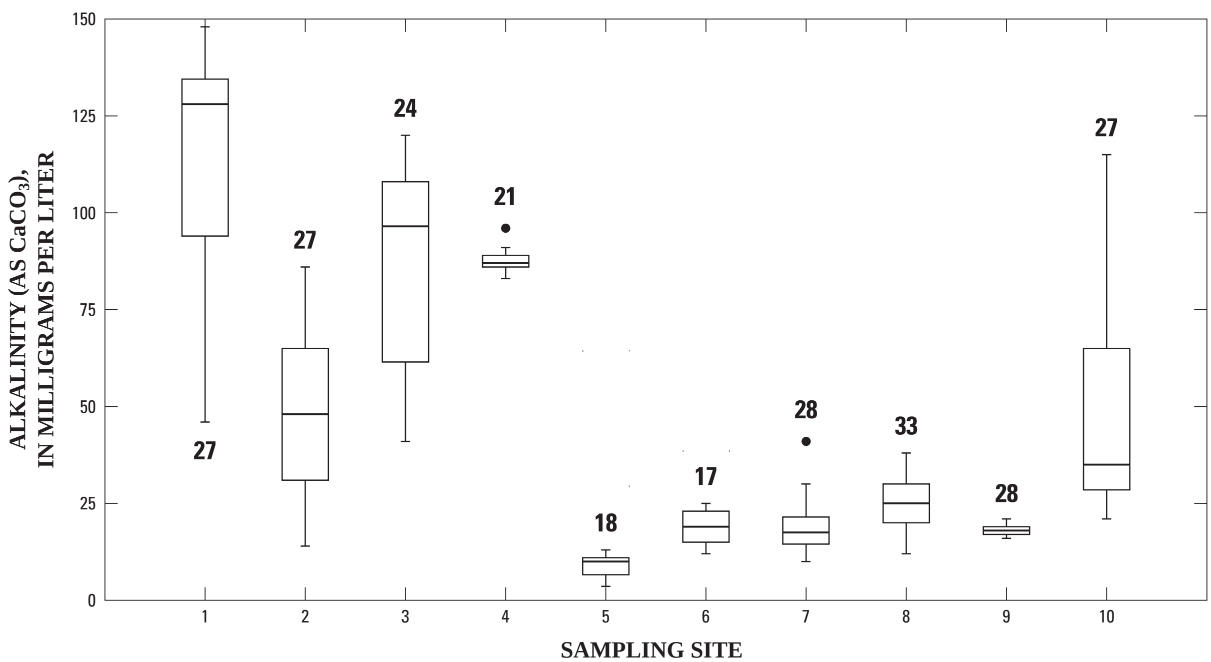


Figure 17. Distribution of alkalinity values for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001. (Site locations shown in figure 1 and described in table 1)

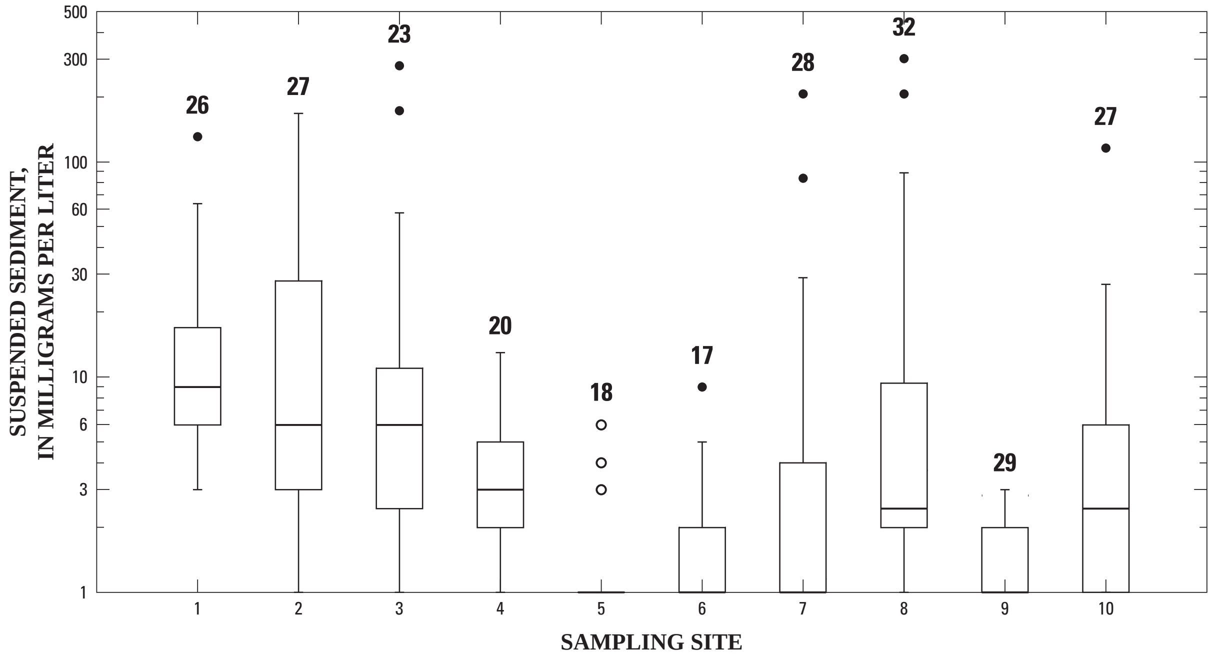


Figure 18. Distribution of suspended sediment concentrations for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001. (Site locations shown in figure 1 and described in table 1)

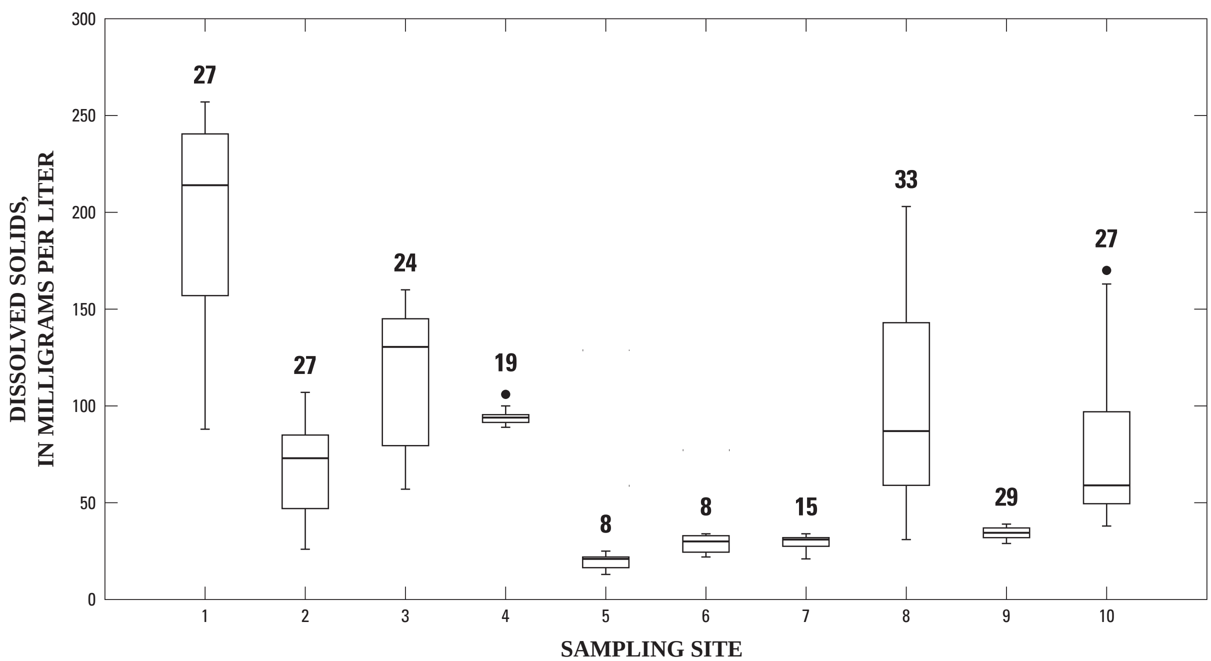


Figure 19. Distribution of dissolved solids concentrations for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001. (Site locations shown in figure 1 and described in table 1)

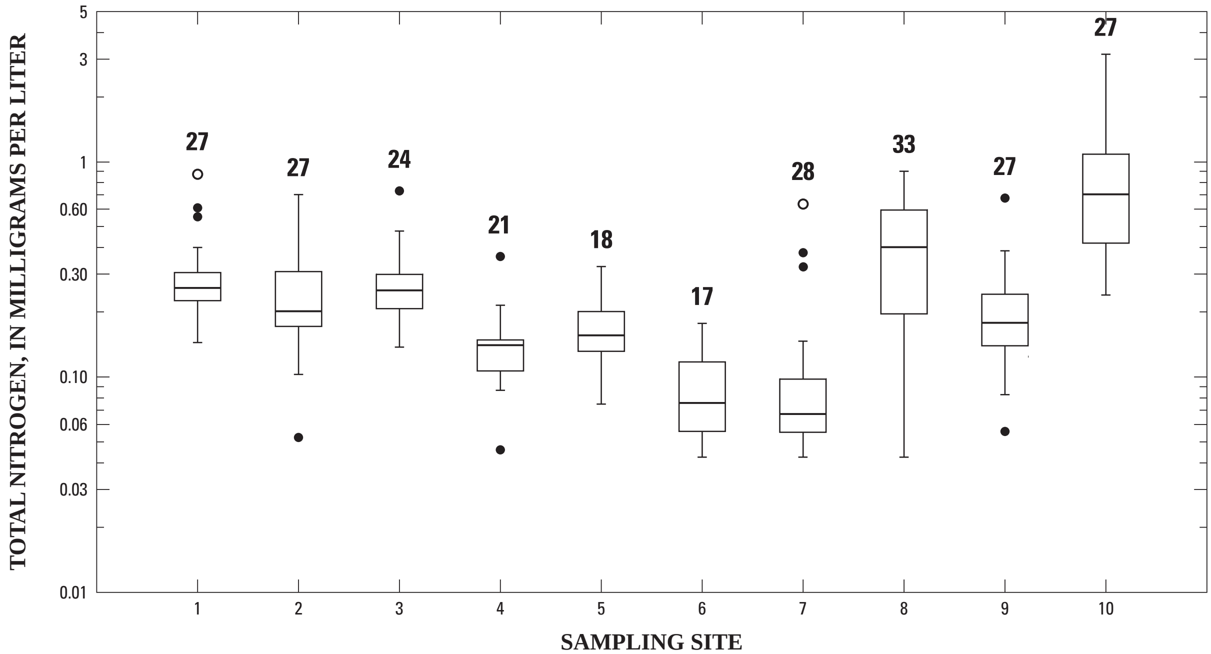


Figure 20. Distribution of total nitrogen concentrations for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001. (Site locations shown in figure 1 and described in table 1; censored values were set to one-half the reporting value, and "estimated" values were used directly)

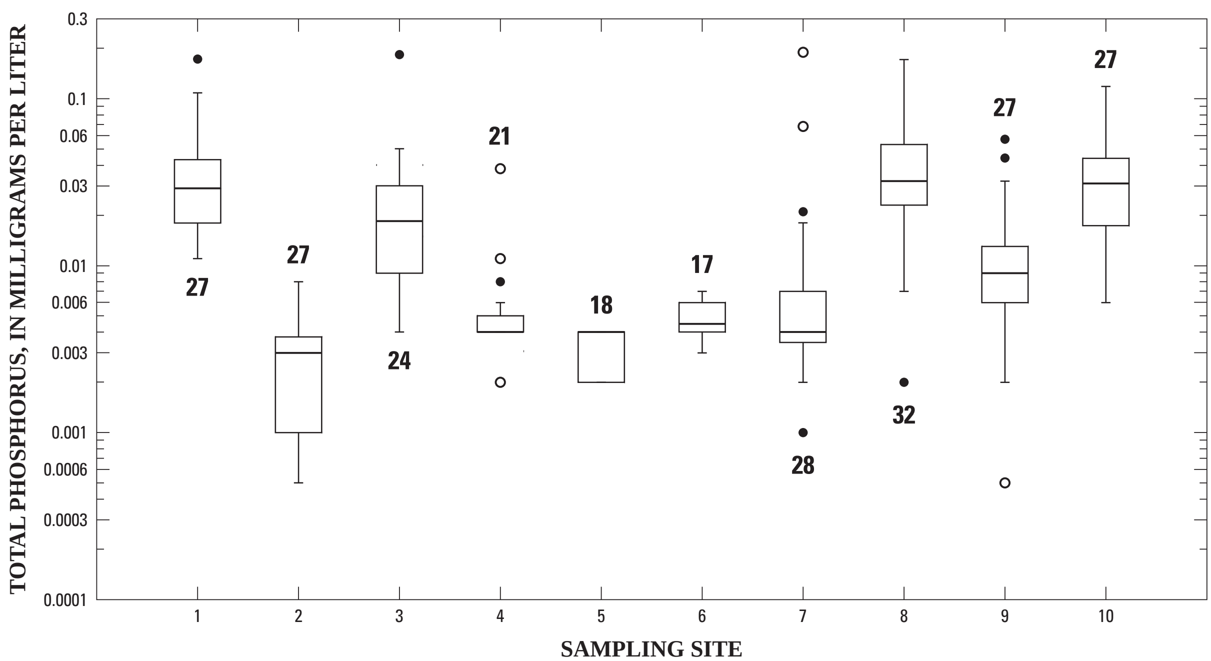


Figure 21. Distribution of total phosphorus concentrations for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001. (Site locations shown in figure 1 and described in table 1; censored values were set to one-half the reporting value, and "estimated" values were used directly)

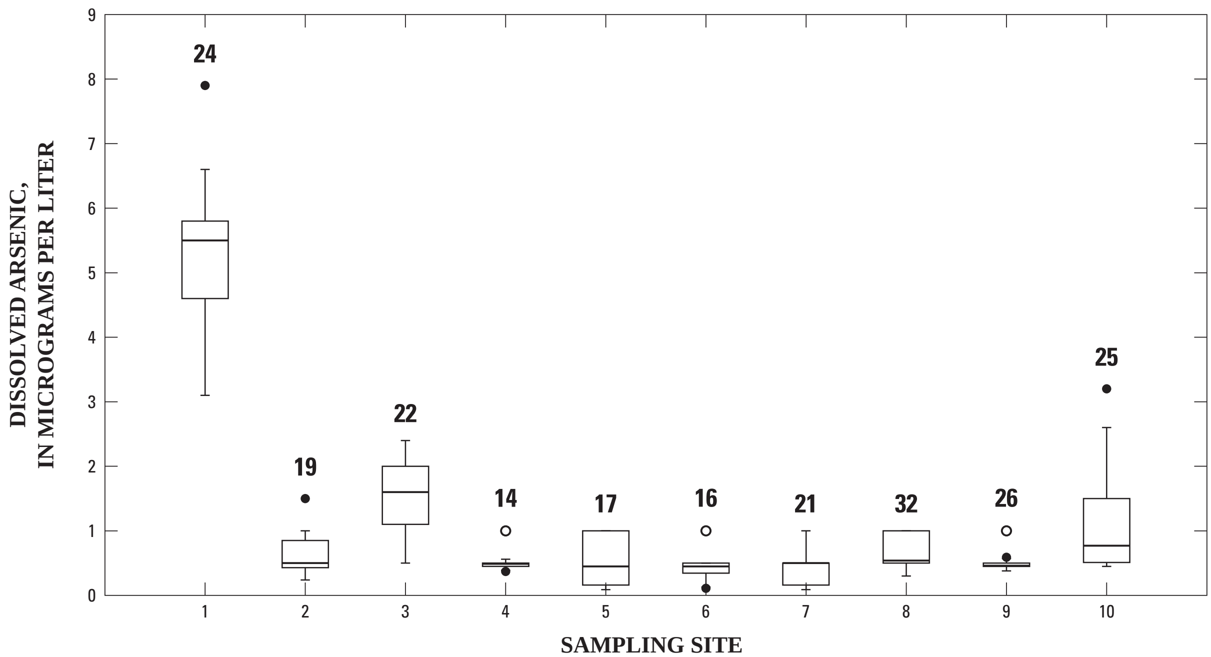


Figure 22. Distribution of dissolved arsenic concentrations for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001. (Site locations shown in figure 1 and described in table 1; censored values were set to one-half the reporting value, and "estimated" values were used directly)

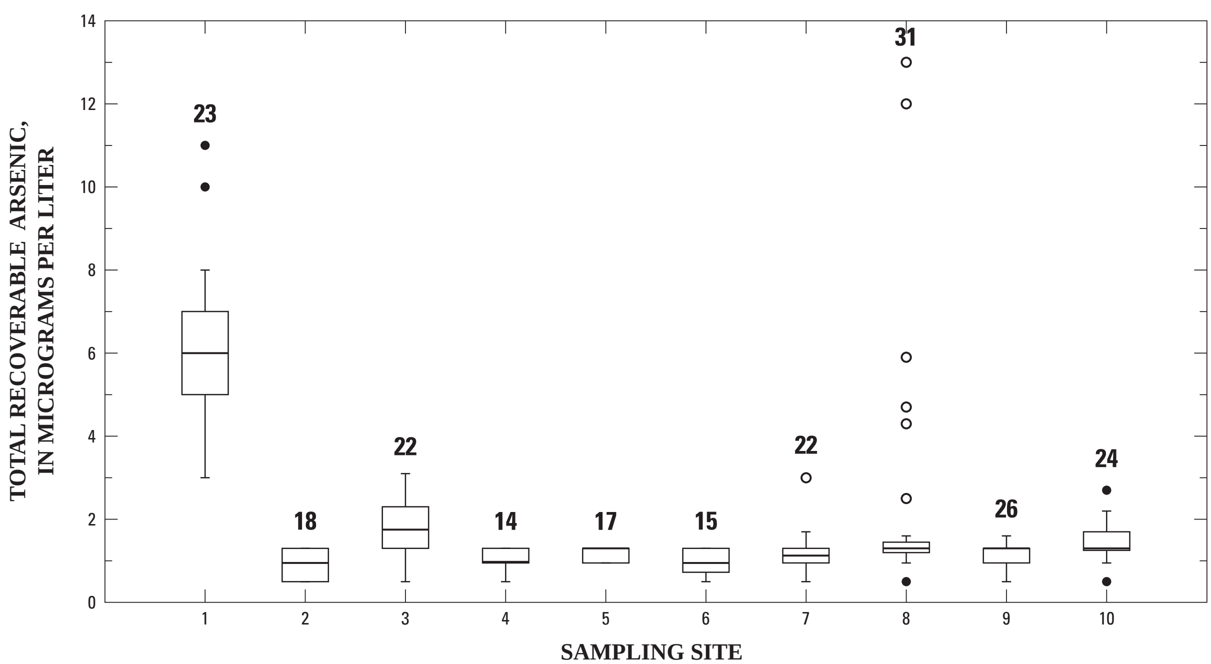


Figure 23. Distribution of total recoverable arsenic concentrations for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001. (Site locations shown in figure 1 and described in table 1; censored values were set to one-half the reporting value, and "estimated" values were used directly)

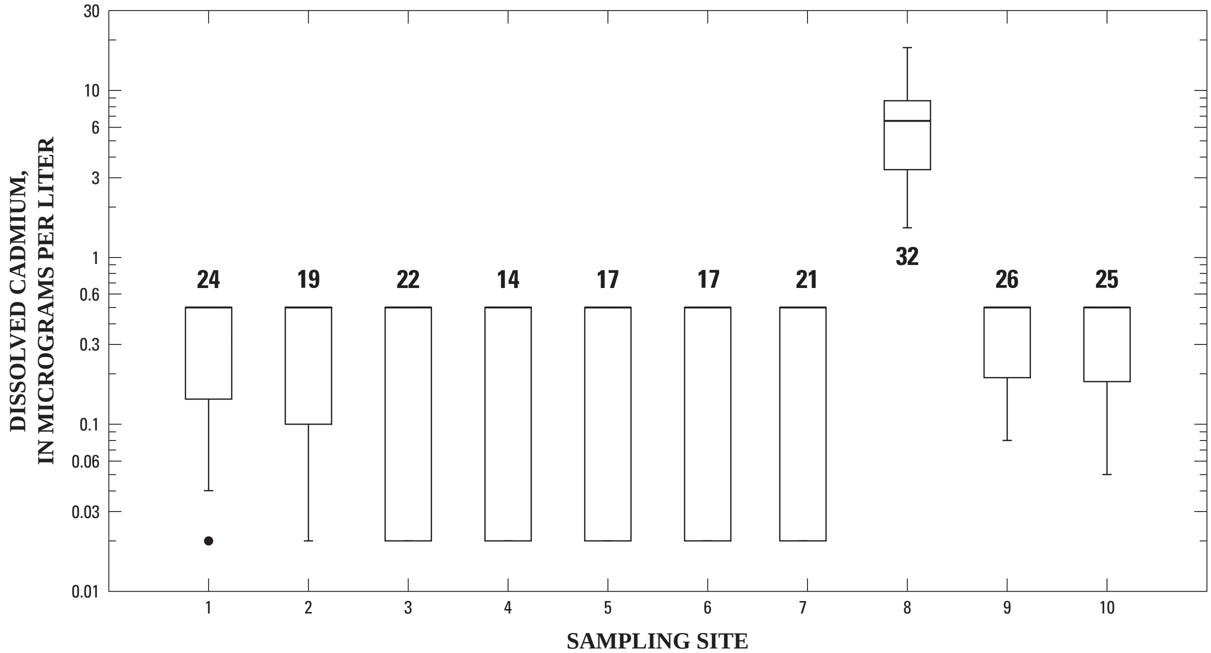


Figure 24. Distribution of dissolved cadmium concentrations for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001. (Site locations shown in figure 1 and described in table 1; censored values were set to one-half the reporting value, and "estimated" values were used directly)

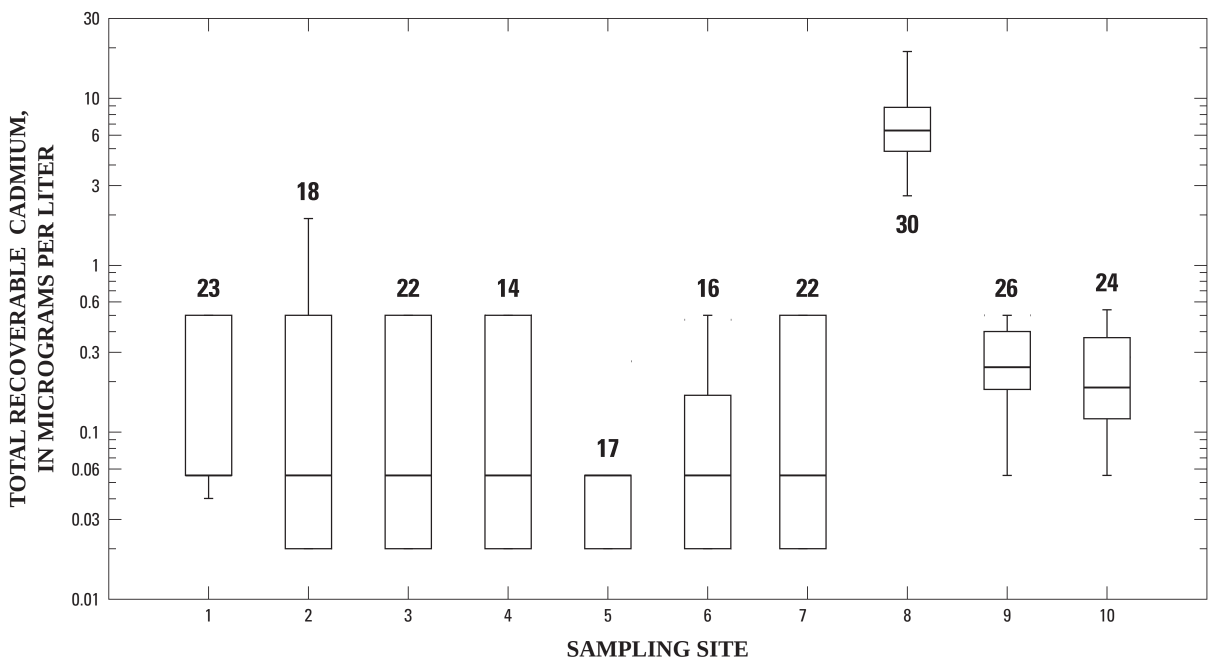


Figure 25. Distribution of total recoverable cadmium concentrations for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001. (Site locations shown in figure 1 and described in table 1; censored values were set to one-half the reporting value, and "estimated" values were used directly)

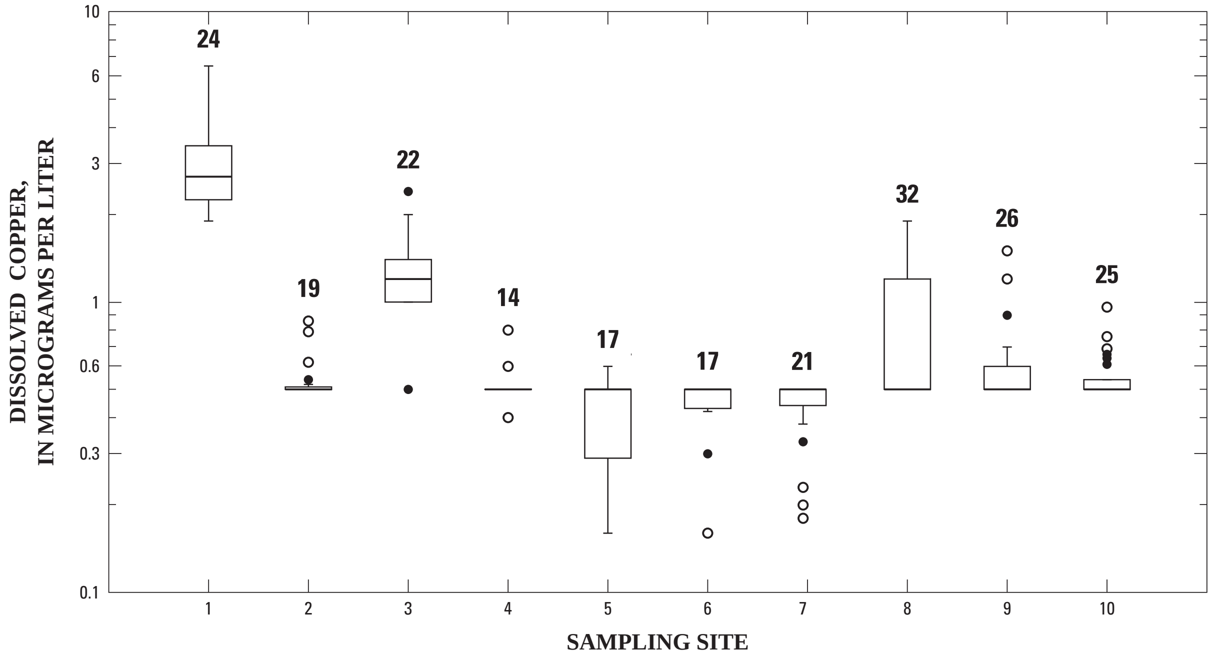


Figure 26. Distribution of dissolved copper concentrations for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001. (Site locations shown in figure 1 and described in table 1; censored values were set to one-half the reporting value, and "estimated" values were used directly)

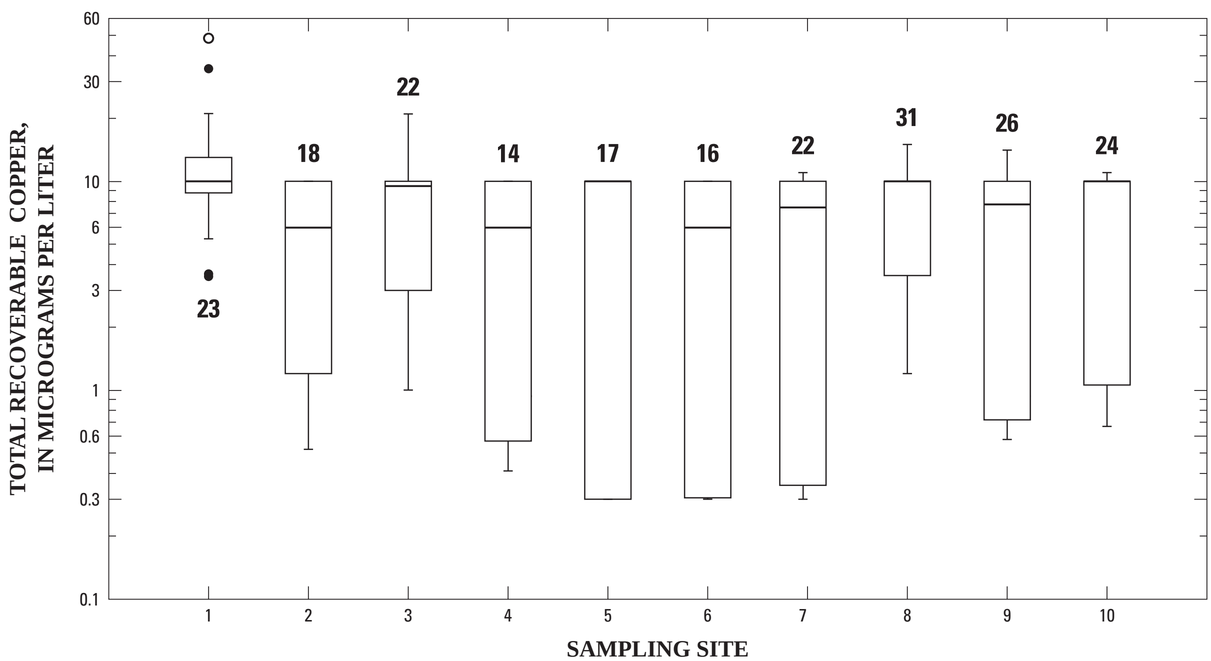


Figure 27. Distribution of total recoverable copper concentrations for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001. (Site locations shown in figure 1 and described in table 1; censored values were set to one-half the reporting value, and "estimated" values were used directly)

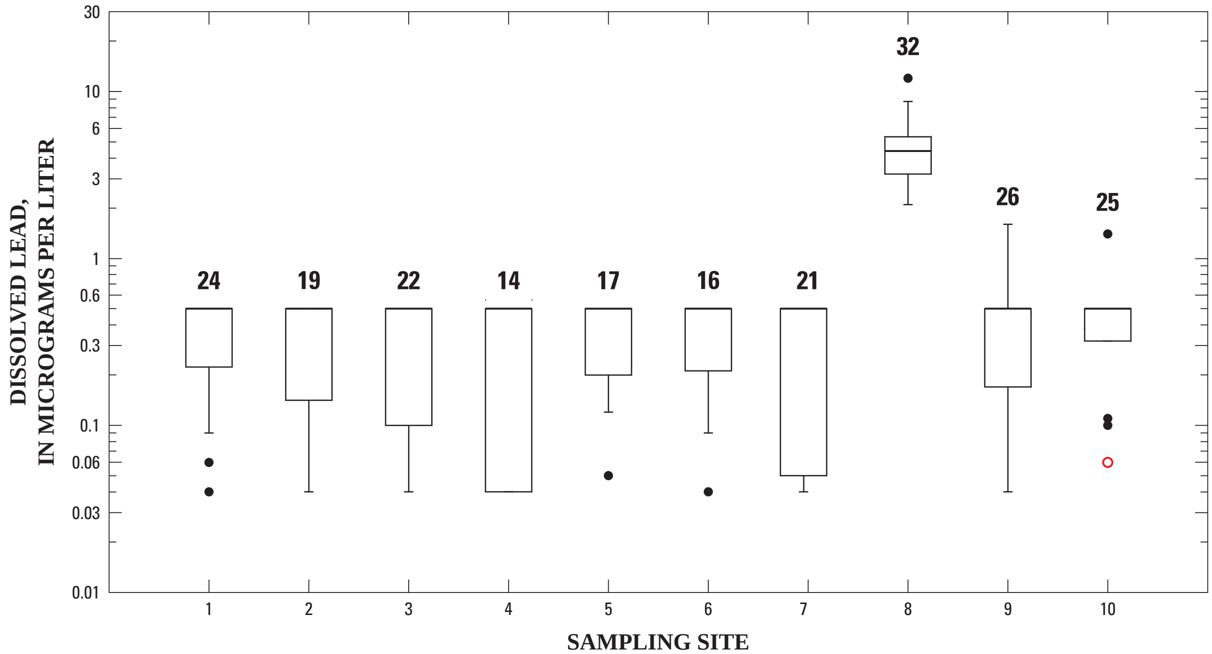


Figure 28. Distribution of dissolved lead concentrations for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001. (Site locations shown in figure 1 and described in table 1; censored values were set to one-half the reporting value, and "estimated" values were used directly)

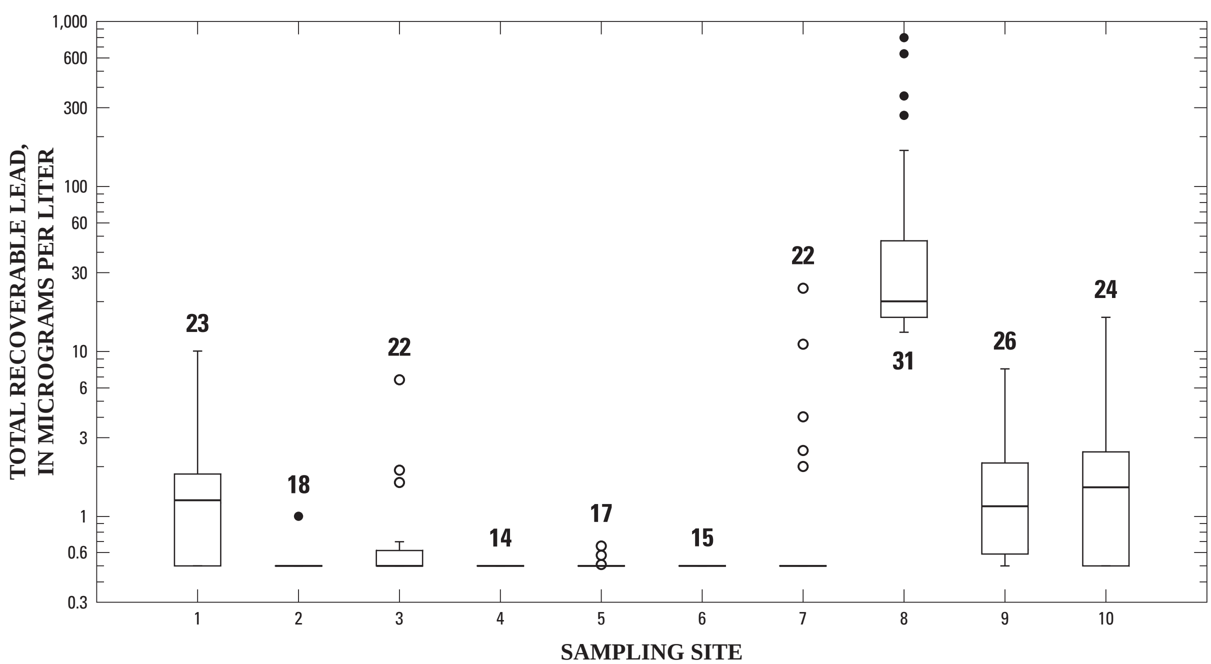


Figure 29. Distribution of total recoverable lead concentrations for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001. (Site locations shown in figure 1 and described in table 1; censored values were set to one-half the reporting value, and "estimated" values were used directly)

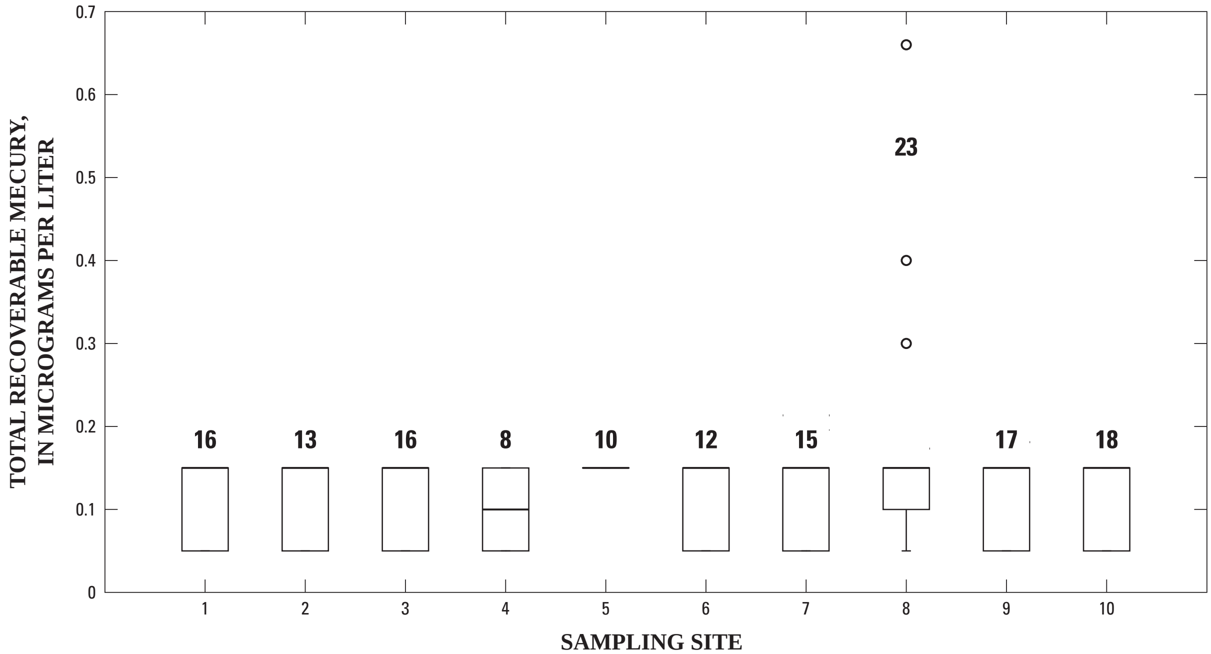


Figure 30. Distribution of total recoverable mercury concentrations for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001. (Site locations shown in figure 1 and described in table 1; censored values were set to one-half the reporting value, and "estimated" values were used directly)

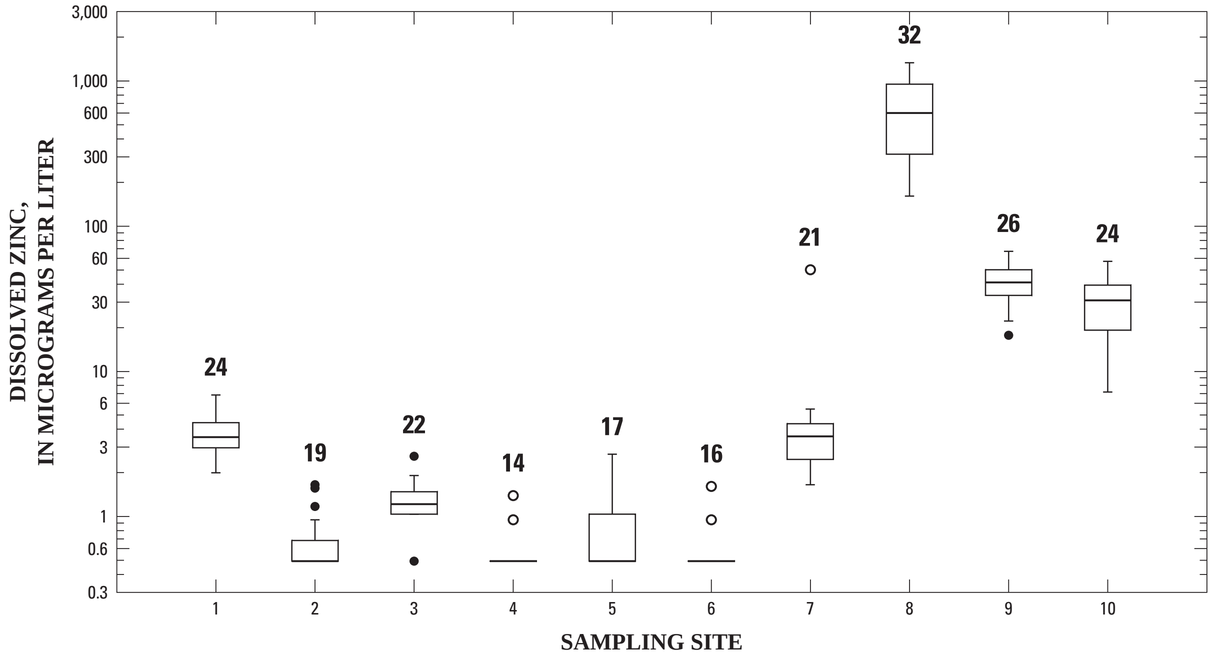


Figure 31. Distribution of dissolved zinc concentrations for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001. (Site locations shown in figure 1 and described in table 1; censored values were set to one-half the reporting value, and "estimated" values were used directly)

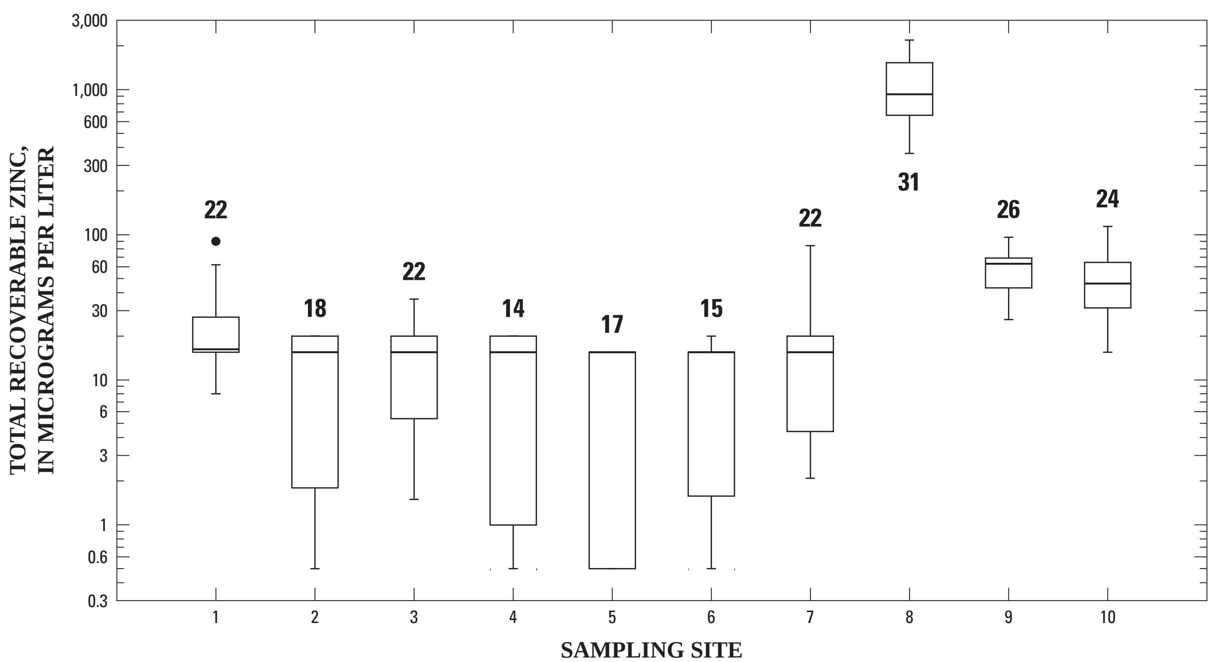


Figure 32. Distribution of total recoverable zinc concentrations for samples collected at surface-water-quality sampling sites in the Northern Rockies Intermontane Basins study area, water years 1999–2001. (Site locations shown in figure 1 and described in table 1; censored values were set to one-half the reporting value, and "estimated" values were used directly)

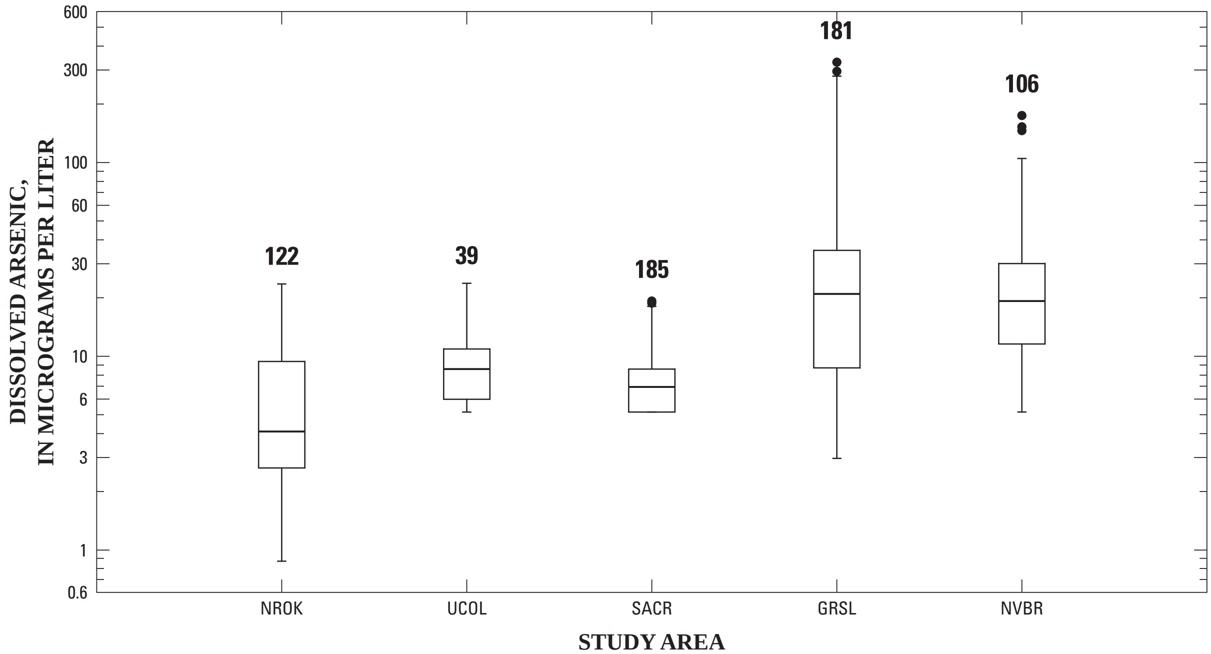


Figure 33. Distribution of dissolved arsenic concentrations for samples collected in surface water in National Water-Quality Assessment study areas in the Western United States affected by historical mining activities. (NROK, Northern Rockies Intermontane Basins; UCOL, Upper Colorado River; SACR, Sacramento River; GRSL, Great Salt Lake Basins; NVBR, Nevada Basin and Range; censored values were set to one-half the reporting value, and "estimated" values were used directly)

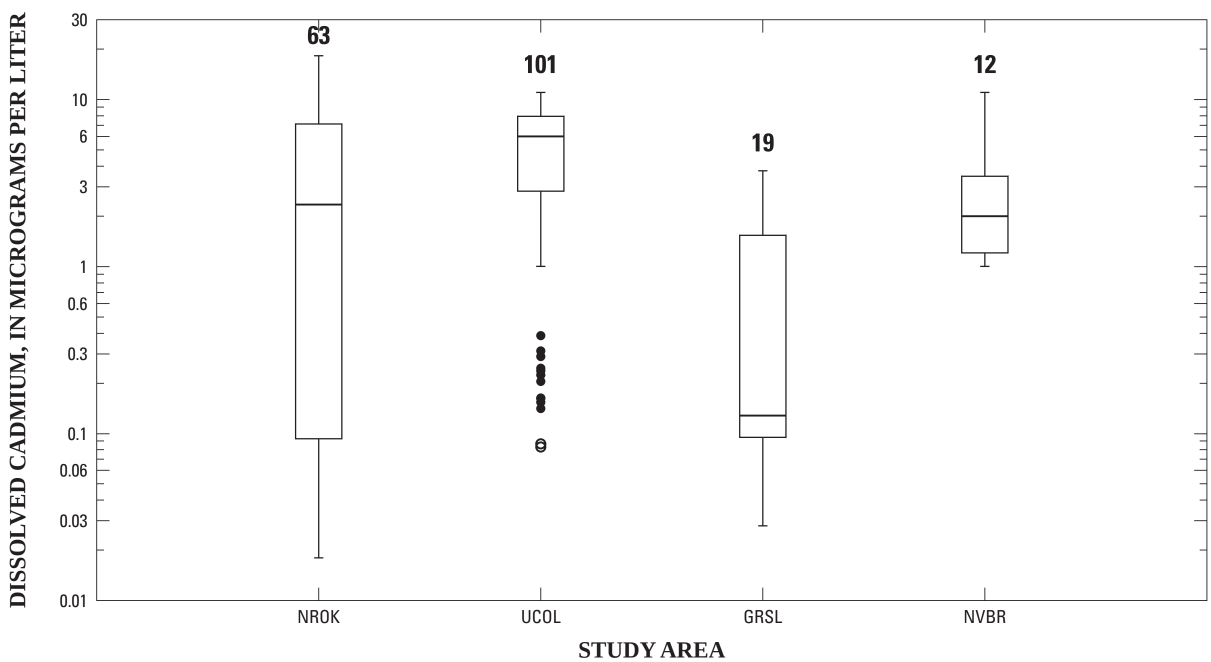


Figure 34. Distribution of dissolved cadmium concentrations for samples collected in surface water in National Water-Quality Assessment study areas in the Western United States affected by historical mining activities. (NROK, Northern Rockies Intermontane Basins; UCOL, Upper Colorado River; SACR, Sacramento River; GRSL, Great Salt Lake Basins; NVBR, Nevada Basin and Range; censored values were set to one-half the reporting value, and "estimated" values were used directly)

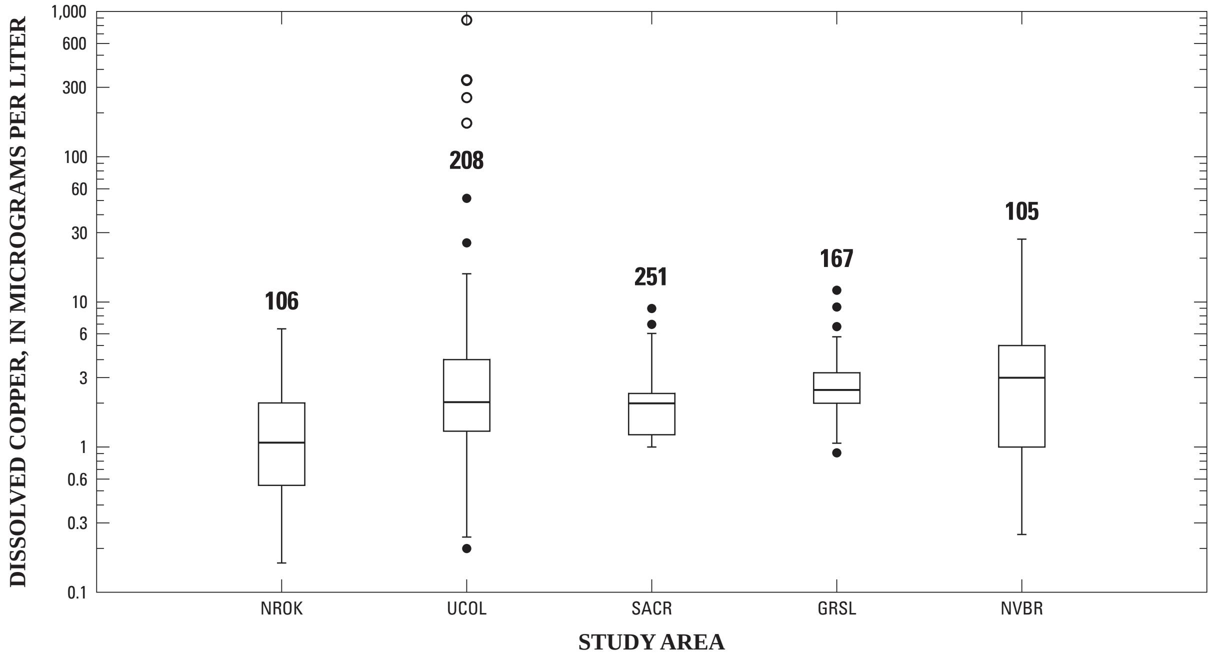


Figure 35. Distribution of dissolved copper concentrations for samples collected in surface water in National Water-Quality Assessment study areas in the Western United States affected by historical mining activities. (NROK, Northern Rockies Intermontane Basins; UCOL, Upper Colorado River; SACR, Sacramento River; GRSL, Great Salt Lake Basins; NVBR, Nevada Basin and Range; censored values were set to one-half the reporting value, and "estimated" values were used directly)

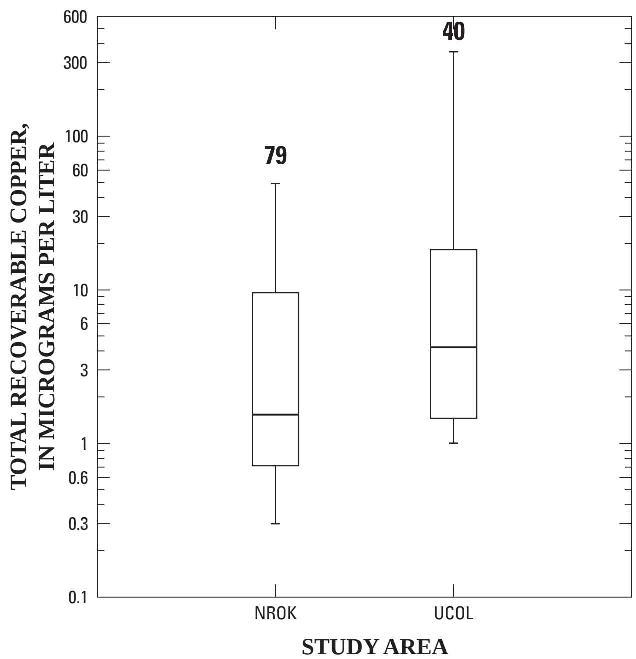


Figure 36. Distribution of total recoverable copper concentrations for samples collected in surface water in National Water-Quality Assessment study areas in the Western United States affected by historical mining activities. (NROK, Northern Rockies Intermontane Basins; UCOL, Upper Colorado River; censored values were set to one-half the reporting value, and "estimated" values were used directly)

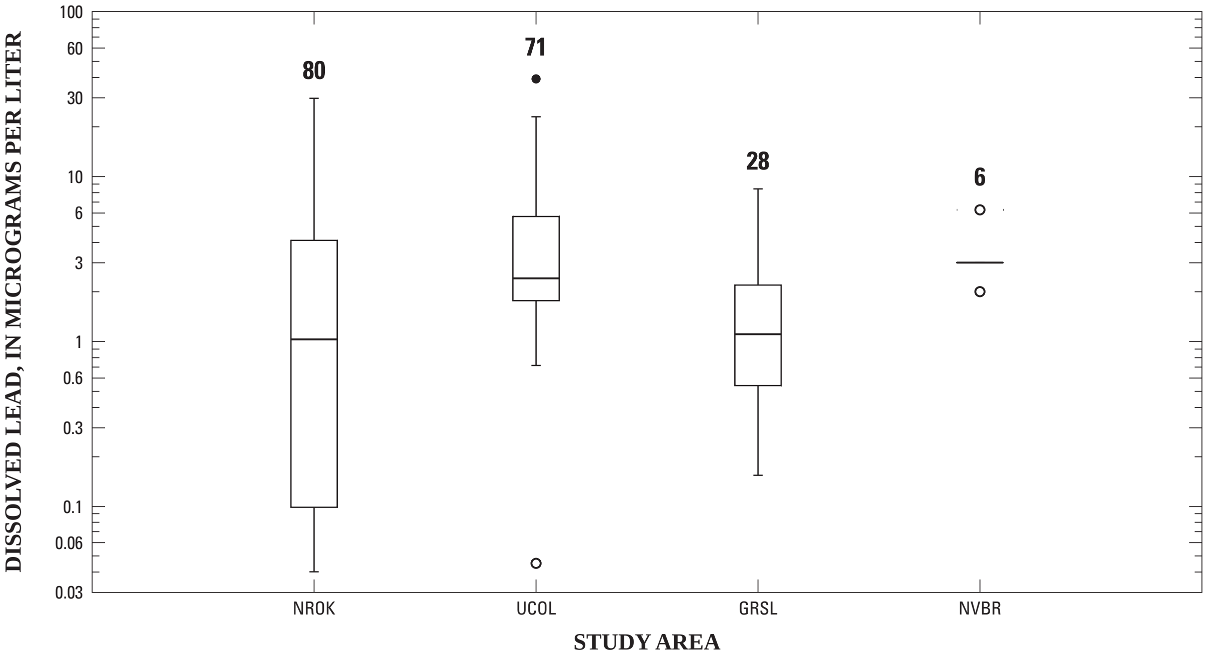


Figure 37. Distribution of dissolved lead concentrations for samples collected in surface water in National Water-Quality Assessment study areas in the Western United States affected by historical mining activities. (NROK, Northern Rockies Intermontane Basins; UCOL, Upper Colorado River; SACR, Sacramento River; GRSL, Great Salt Lake Basins; NVBR, Nevada Basin and Range; censored values were set to one-half the reporting value, and "estimated" values were used directly)

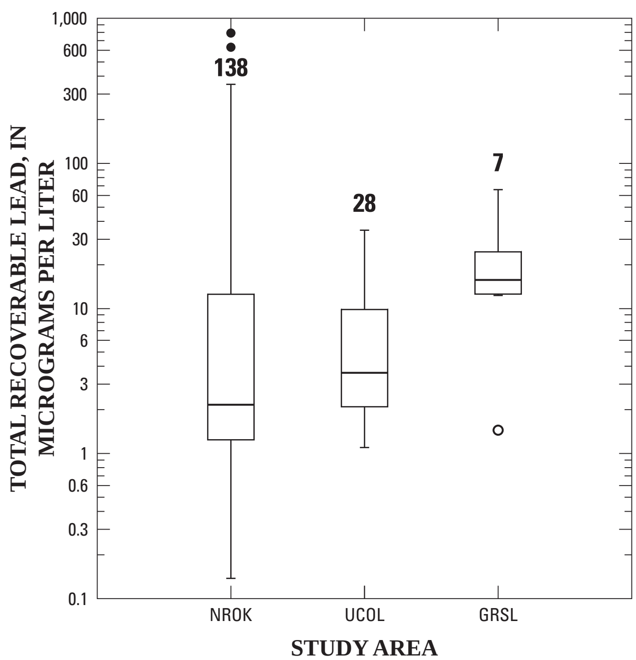


Figure 38. Distribution of total recoverable lead concentrations for samples collected in surface water in National Water-Quality Assessment study areas in the Western United States affected by historical mining activities. (NROK, Northern Rockies Intermontane Basins; UCOL, Upper Colorado River; SACR, Sacramento River; GRSL, Great Salt Lake Basins; censored values were set to one-half the reporting value, and "estimated" values were used directly)

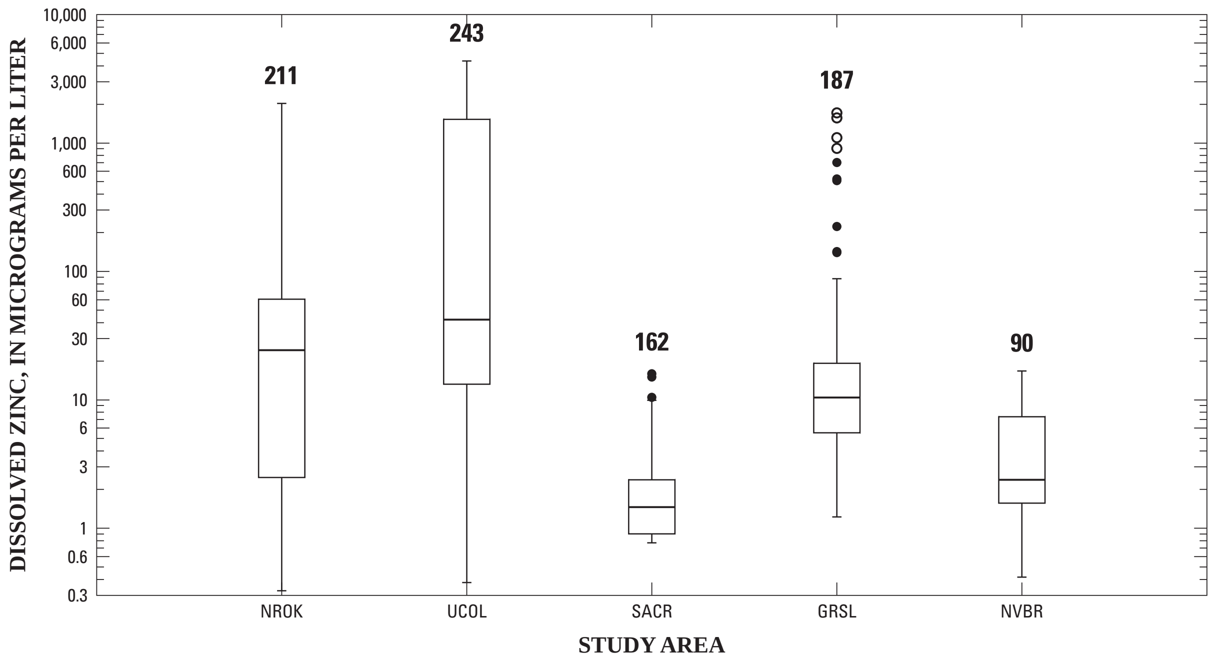


Figure 39. Distribution of dissolved zinc concentrations for samples collected in surface water in National Water-Quality Assessment study areas in the Western United States affected by historical mining activities. (NROK, Northern Rockies Intermontane Basins; UCOL, Upper Colorado River; SACR, Sacramento River; GRSL, Great Salt Lake Basins; NVBR, Nevada Basin and Range; censored values were set to one-half the reporting value, and "estimated" values were used directly)

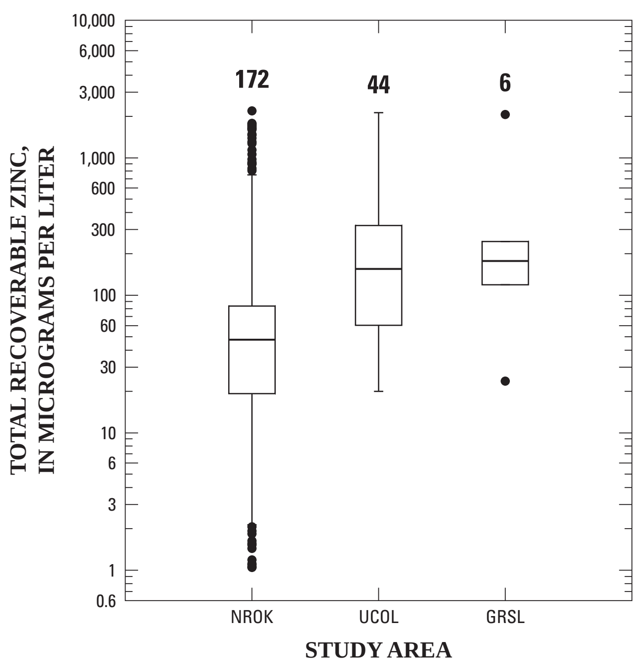


Figure 40. Distribution of total recoverable zinc concentrations for samples collected in surface water in National Water-Quality Assessment study areas in the Western United States affected by historical mining activities. (NROK, Northern Rockies Intermontane Basins; UCOL, Upper Colorado River; SACR, Sacramento River; GRSL, Great Salt Lake Basins; censored values were set to one-half the reporting value, and "estimated" values were used directly)

Michael A. Beckwith / Surface-Water-Quality Data Collected for the Northern Rockies Intermontane Basins NAWQA Program in the Clark Fork-Pend Oreille and Spokane River Basins, Montana, Idaho, and Washington, Water Years 1999–2001 / OFR 02–472