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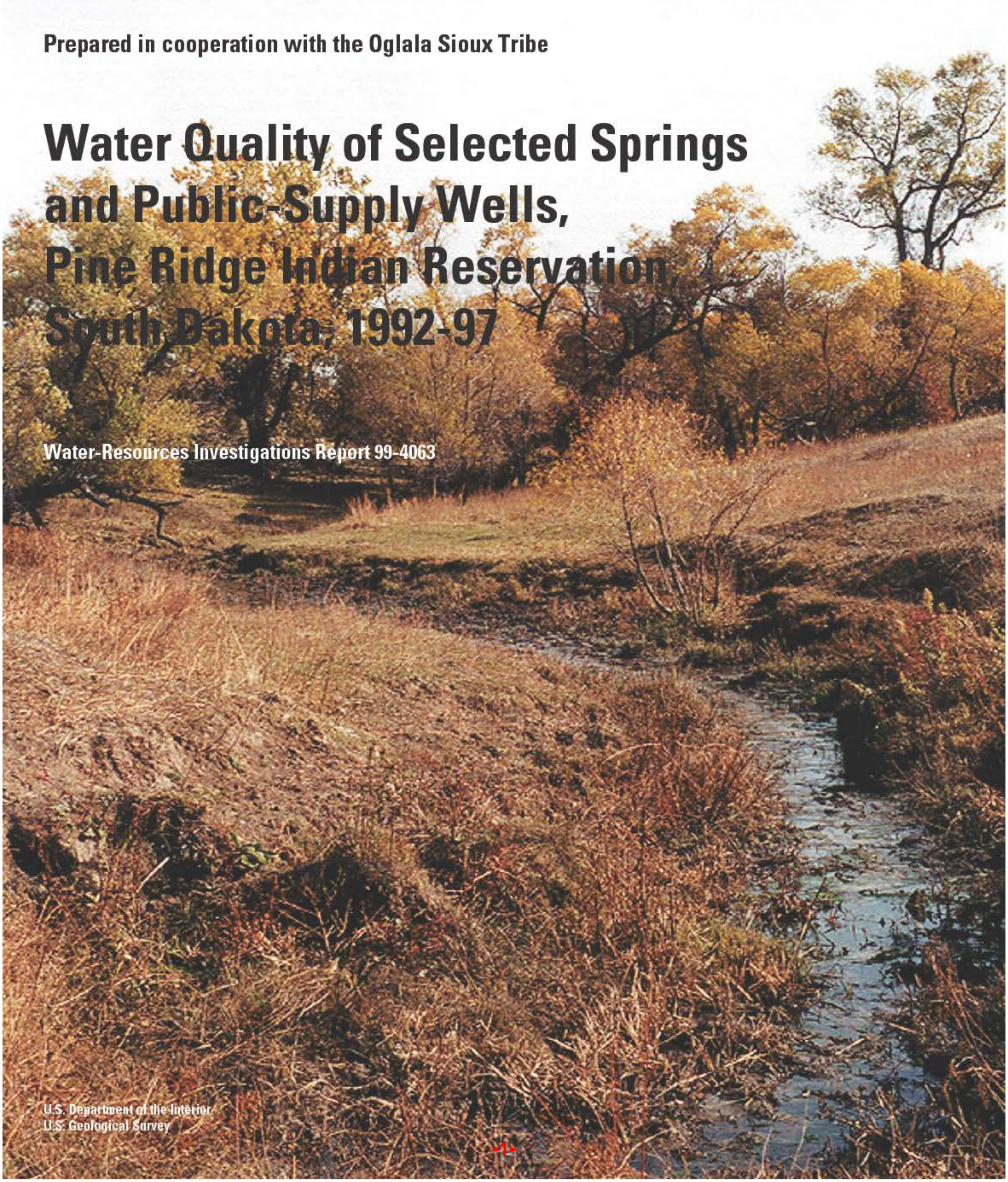
Prepared in cooperation with the Oglala Sioux Tribe

Water Quality of Selected Springs and Public-Supply Wells, Pine Ridge Indian Reservation, South Dakota, 1992-97

Water-Resources Investigations Report 99-4063



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U.S. Department of the Interior

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ABBREVIATED UNITS USED IN THIS REPORT AND VERTICAL DATUM

mi^2	square miles
ft	feet
mi	miles
in.	inches
ft^3/s	cubic feet per second
gal/min	gallons per minute
gal/d	gallons per day
gal/hr	gallons per hour
° F	degrees Fahrenheit
µg/L	micrograms per liter
mg/L	milligrams per liter
µS/cm	microsiemens per centimeter at 25 degrees Celsius
mL	milliliters
col/100 mL	colonies per 100 milliliters
pCi/L	picocuries per liter

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.

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ABSTRACT

This report presents results of a water-quality study for the Pine Ridge Indian Reservation, South Dakota. The study was a cooperative effort between the U.S. Geological Survey and the Water Resources Department of the Oglala Sioux Tribe.

Discharge and water-quality data were collected during 1992-97 for 14 contact springs located in the northwestern part of the Reservation. Data were collected to evaluate potential alternative sources of water supply for the village of Red Shirt, which currently obtains water of marginal quality from a well completed in the Inyan Kara aquifer. During 1995-97, water-quality data also were collected for 44 public-supply wells that serve about one-half of the Reservation's population. Quality-assurance sampling was used to evaluate the precision and accuracy of environmental samples.

Ten of the springs sampled contact the White River Group, and four contact the Pierre Shale. Springs contacting the White River Group range from calcium bicarbonate to sodium bicarbonate water types. Two springs contacting the Pierre Shale have water types similar to this; however, sulfate is the dominant anion for the other two springs. In general, springs contacting the White River Group are shown to have better potential as alternative sources of water supply for the village of Red Shirt than springs contacting the Pierre Shale.

Nine of the springs with better water quality were sampled repeatedly; however, only minor variability in water quality was identified. Six of these nine springs, of which five contact the White River Group, probably have the best potential for use as water supplies. Discharge from any of these six springs probably would provide adequate water supply for Red Shirt during most periods, based on a limited number of discharge measurements collected. Concentrations of lead exceeded the U.S. Environmental Protection Agency (USEPA) action level of 15 µg/L for three of these six springs. Five of these six springs also had arsenic concentrations that exceeded 10 µg/L, which could be problematic if the current maximum contaminant level (MCL) is lowered. Blending of water from one or more springs with water from the existing Inyan Kara well may be an option to address concerns regarding both quantity and quality of existing and potential sources.

All nine springs that were sampled for indicator bacteria had positive detections on one or more occasions during presumptive tests. Although USEPA standards for bacteria apply only to public-water supplies, local residents using spring water for domestic purposes need to be aware of the potential health risks associated with consuming untreated water.

One spring contacting the White River Group and two springs contacting the Pierre Shale exceeded 15 pCi/L for gross alpha; these values do not necessarily constitute exceedances of the MCL, which excludes radioactivity contributed by

uranium and radon. Additional sampling using different analysis techniques would be needed to conclusively determine if any samples exceeded this MCL. Nine springs were sampled for selected pesticides and tritium. The pesticides atrazine, carbaryl, and 2,4-D were not detected in any of the samples. The nine springs were analyzed for tritium in order to generally assess the age of the water and to determine if concentrations exceeded the MCL established for gross beta-particle activity. Tritium results indicated two springs are composed primarily of water recharged prior to atmospheric testing of nuclear bombs and two other springs have a relatively large percentage of test-era water. The remaining five springs had tritium values that indicated some percentage of test-era water; however, additional sampling would be needed to determine whether water is predominantly pre- or post-bomb age.

Of the 44 public-supply wells sampled, 42 are completed in the Arikaree aquifer, one is completed in an alluvial aquifer, and one is completed in the Inyan Kara aquifer. Water from the alluvial well is a sodium bicarbonate water type, water from Arikaree aquifer ranges from calcium bicarbonate to sodium bicarbonate types, and water from the Inyan Kara well is a calcium sulfate bicarbonate type. Of the 44 wells sampled, 28 (64 percent) tested positive for indicator bacteria in presumptive tests. Because these were single samples that generally were collected upstream from chemical treatment feeders, positive detections do not necessarily constitute exceedances of drinking-water standards.

A single sample from an Arikaree well exceeded the MCL for arsenic of 50 μg/L. Arsenic exceeded 10 μg/L for six additional Arikaree wells and for the alluvial well and the Inyan Kara well, which could be problematic if the current MCL is lowered. The alluvial well also exceeded the secondary maximum contaminant level (SMCL) for dissolved solids, which is nonenforceable, and the action level for lead. The Inyan Kara well exceeded the SMCL's for iron and for manganese and the MCL of 5 pCi/L for radium-226 and 228 combined. Several Arikaree wells exceeded SMCL's for either pH, sulfate, dissolved solids, iron, or manganese. One Arikaree well exceeded the MCL of 4.0 mg/L for fluoride and another exceeded the MCL of 10 mg/L for nitrite plus nitrate.

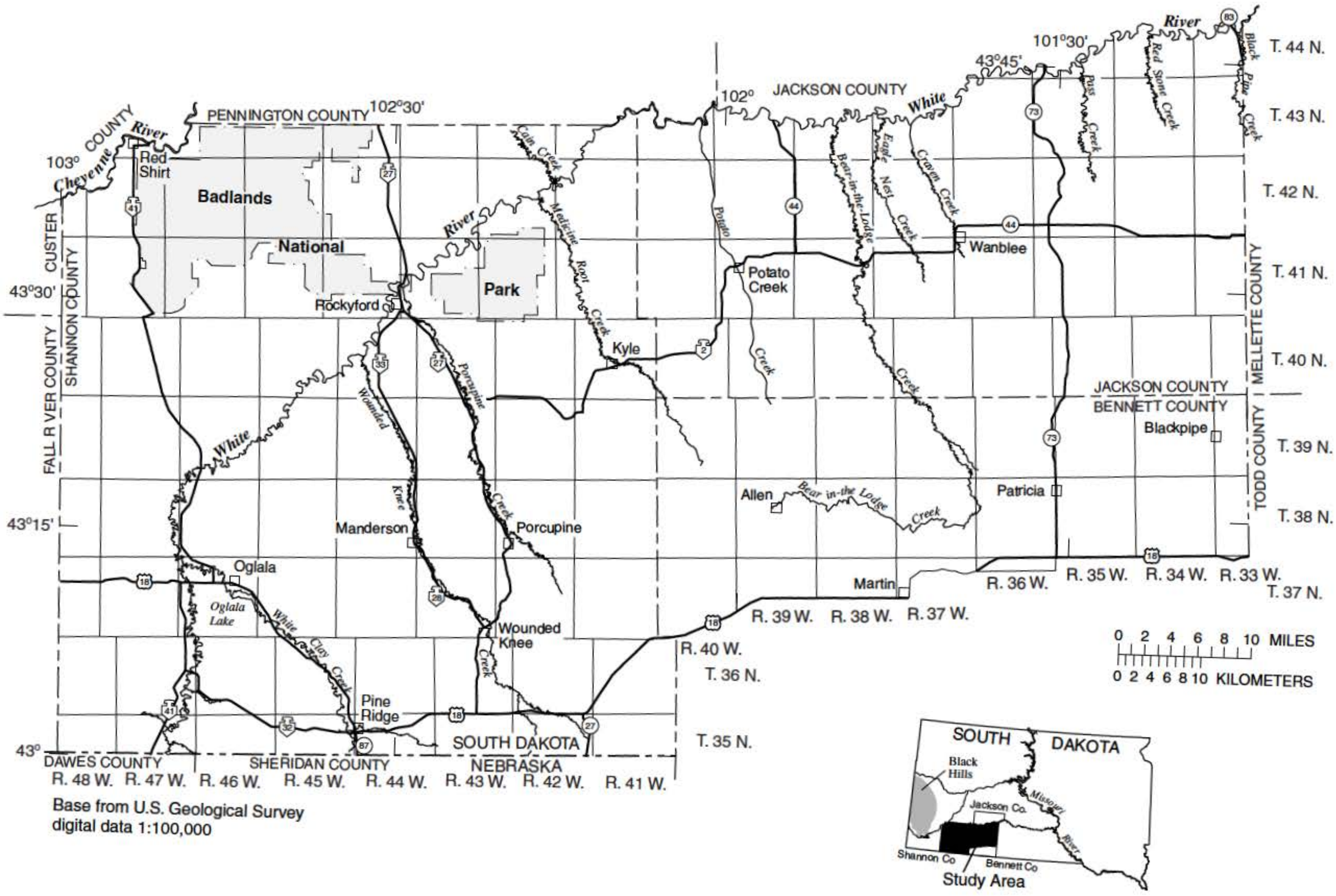
Ten Arikaree wells equalled or exceeded 15 pCi/L for gross alpha; however, these values do not necessarily constitute exceedances of the MCL, which excludes radioactivity contributed by uranium and radon. Additional sampling using different analysis techniques would be needed to conclusively determine if any samples exceeded this MCL.

Eight wells, all from the Arikaree aquifer, equalled or exceeded the proposed MCL of 20 μg/L for uranium and 33 wells (75 percent) equalled or exceeded one-half of the proposed MCL. Although this standard has only been proposed, additional information regarding the extent of elevated uranium concentrations in the Arikaree aquifer, and the geochemical processes involved, may be beneficial. It was determined from analyses of uranium isotope data for five wells that the source of elevated uranium concentrations is naturally occurring, rather than anthropogenic.

INTRODUCTION

The Pine Ridge Indian Reservation is located in south-central South Dakota. The village of Red Shirt is located in the northwestern part of Shannon County (fig. 1). The sole source of public water supply for the village is from a well drilled about 2,600-ft deep, completed in the Inyan Kara aquifer. Water from the well is geothermally heated, highly mineralized, and because it exceeds several U.S. Environmental Protection Agency (USEPA) standards, cannot be used for drinking purposes without costly pretreatment.

Throughout the rest of the Reservation, wells completed in the Arikaree aquifer are the primary source of public supply. Concentrations of several constituents such as bacteria, sulfate, nitrate, arsenic, and selenium have been reported to exceed USEPA drinking-water standards in various public-supply wells.



Base from U.S. Geological Survey digital data 1:100,000

Figure 1. Location of study area.

In 1992, the U.S. Geological Survey (USGS), in cooperation with the Oglala Sioux Tribe, initiated a study to assess water quality on the Reservation. The two specific objectives of the study were to (1) evaluate the quality and quantity of water produced by springs located in the northwestern part of Shannon County as sources of an alternative water supply for the village of Red Shirt; and (2) evaluate the water quality of public-supply wells located throughout the Reservation.

Purpose and Scope

The purpose of this report is to present the results of the study of selected springs and public-supply wells for the Pine Ridge Indian Reservation, South Dakota. Discharge and water-quality data for 14 springs located in the northwestern part of the Reservation and water-quality data for 44 public-supply wells are presented. Data for the springs were collected during 1992-97, and data for the wells were collected during 1995-97. Selected water-quality constituents include field parameters (specific conductance, pH, temperature, dissolved oxygen, acid neutralizing capacity, and bacterial concentration), common ions, nutrients, trace elements, radionuclides, and pesticides. Water-quality data are compared to standards and criteria for drinking water promulgated by the USEPA to determine if concentrations of any constituents were present at levels that could be harmful to humans.

Previous Investigations

Various studies describing the geology and the hydrology of the study area are available. Darton (1909) described the general surface geology, which was later published as part of a geologic map of South Dakota (Darton, 1951). Gries (1964) described the shallow ground-water resources, and Harksen and MacDonald (1969) used road logs to describe the surficial geology within the study area. Ellis and Adolphson (1971) provided an extensive description of the hydrogeology of the study area. They produced a map showing major geologic units and assessed the potential of these units as sources of water supply. Kolm and Case (1983) estimated various hydraulic properties of the High Plains aquifer, which includes the Ogallala and Arikaree aquifers, within the study area. Meyer (1984) summarized the water-quality data available in the U.S. Geological Survey National Water Data Storage and Retrieval System (WATSTORE). Heintzman (1988) completed a study that evaluated water quality for 39 wells distributed throughout the study area, and Sipe (1989) investigated the hydrogeology of part of the Arikaree aquifer near Pine Ridge. Greene and others (1991) performed aquifer tests and water-quality analyses on the Arikaree aquifer near Pine Ridge.

Description of Study Area

The study area (the Pine Ridge Indian Reservation) includes all of Shannon County, the portion of Jackson County south of the White River, and the portion of Bennett County north of U.S. Highway 18 (fig. 1). The topography of the study area is diverse; in the northwestern part there are numerous sod-covered tableland features that are remnants of alluvial deposits. The Badlands also are in this general area and are characterized by stark contrasts in topography, ranging from low hills to sharply rising pinnacles. Gently rolling plains are present in the southern and eastern parts of the study area, but the relief is steeper and more broken along the Cheyenne and White Rivers and their tributaries.

Land use is predominantly a mixture of cropland and grazing land, with the majority of grazing land consisting of subhumid and semi-arid grasses. Livestock production and dryland farming are the main agricultural enterprises on the Reservation. Livestock produced include cattle, horses, hogs, sheep, and chickens. The major crops include wheat, alfalfa, barley, corn, oats, rye, and sorghum (South Dakota Crop and Livestock Reporting Service, 1924-65).

Physiography and Climate

The study area is located within the Great Plains physiographic province (Fenneman, 1946). The climate, which is characteristic of the northern Great Plains, is semi-arid with cold winters and hot summers. Most of the precipitation falls during the growing season between April and September. Climatological data for Manderson (fig. 1) indicate that May typically is the wettest month with an average (1961-90) of 5.9 in. of precipitation, and December typically is the driest month with an average of only 0.2 in. of precipitation (U.S. Department of Commerce, 1995). The average annual precipitation is 16 in., and the average annual air temperature is about 48° F, with an average of 72° F for July and an average of 27° F for January.

Mean annual evaporation in southern South Dakota averages about 60 in. (Gutentag and others, 1984). High evaporative losses coupled with moderate annual precipitation result in only limited water available to recharge ground-water systems.

Geology

The relatively shallow (Cretaceous age and younger) geology of the study area is comprised of sedimentary rocks that have been divided into rock-stratigraphic units (table 1). These include, from oldest to youngest, the Inyan Kara Group, the Skull Creek Shale, the Dakota Formation, and the Graneros Shale, all of Early Cretaceous age; the Greenhorn Formation, the Carlile Shale, the Niobrara Formation, and the Pierre Shale, all of Late Cretaceous age; the White River Group of Oligocene age; the Arikaree Formation of Miocene age; the Ogallala Formation of Pliocene age; and various deposits of Quaternary age (Harksen and MacDonald, 1969; Ellis and Adolphson, 1971). Bedrock units within the study area are of Cretaceous age and older. Areal extents of units occurring at the land surface are shown in figure 2.

The Inyan Kara Group is composed of two formations. These formations are, from oldest to youngest, the Lakota Formation and the Fall River Formation.

Part of the Badlands National Park is located within the Reservation in northern Shannon County. Thick deposits of clays and sands were deposited in the Badlands area at the end of Eocene time (Gries, 1996). These sedimentary clays and sands comprise the White River Group. The White River Group has been divided into the older Chadron Formation, which forms conspicuous haystack-shaped features, and the younger Brule Formation, which forms the steep fluted cliffs and bluffs typical throughout much of the Badlands.

During Oligocene time, volcanic ash became a significant part of the accumulating sediments. The ash probably resulted from volcanic activity to the west that was transported by winds and incorporated into the upper Brule Formation. Volcanic ash continued to be deposited in the lower Arikaree Formation until the middle of Miocene time (Gries, 1996).

The Arikaree Formation has been divided into five geologic subdivisions by Ellis and Adolphson (1971). These units, from oldest to youngest, have been designated A through E. The Rockyford Ash Member of the Sharps Formation corresponds to unit A and an unnamed member of the Sharps Formation corresponds to unit B. The Monroe Creek Formation is equivalent to unit C and the Harrison Formation is equivalent to unit D. The Rosebud Formation corresponds to unit E of the Arikaree Formation (Harksen and MacDonald, 1969).

Hydrology

Ground water from wells and springs is the predominant source of domestic supply within the study area. Ground water usually can be obtained from most of the bedrock units shown in table 1, except for the White River Group, Pierre Shale, the Niobrara Formation, the Carlile Shale, the Greenhorn Formation, and the Graneros and Skull Creek Shales. The Ogallala aquifer (corresponds to the Ogallala Formation) is present only in small parts of the study area (fig. 2). The Arikaree aquifer (corresponds to the Arikaree Formation), which is the primary source of water supply in the study area, is much more extensive. Within the study area, the potentiometric surface of the Arikaree aquifer is highest in the southwest corner and the predominant direction of ground-water flow is to the northeast (Kolm and Case, 1983). Ground water in the Arikaree aquifer generally occurs under water-table conditions; however, in some locations confined conditions can occur (Greene and others, 1991). Depth to water ranged from 26 to 134 ft below land surface in wells sampled for this study. In the northwestern part of the study area, the Arikaree Formation has been eroded, and there is no continuous aquifer present. However, permeable beds overlying less permeable beds of the White River Group and the Pierre Shale in this area have created many isolated, shallow aquifers that are sufficient for domestic supply.

Outcrops of the Inyan Kara Group are exposed at higher elevations along the eastern slope of the Black Hills (west of study area; fig. 1, index map). These outcrops provide areas of recharge for the aquifer. The Inyan Kara aquifer (corresponds to the Inyan Kara Group) extends eastward from the Black Hills throughout most of South Dakota. Because a large portion of the aquifer recharge comes from higher elevations, the aquifer is under high artesian pressure and numerous flowing wells have been completed in the Inyan Kara aquifer.

Table 1. Generalized stratigraphic column showing selected geologic units and characteristics

[Modified from Ellis and Adolphson, 1971]

System	Series	Rock-stratigraphic unit	Sub-divisions	Thickness (feet)	Lithology	Hydrology
Quaternary	Holocene	Flood-plain alluvium		0-40	Light-brown to gray clay, silt, and fine sand; discontinuous sandy and clayey gravel beds in lower part.	Generally water bearing. Yields are adequate for domestic and stock needs, but differ because deposits are not uniform. Along some small tributaries deposits are thin, and wells commonly go dry in late summer or early fall. Water levels, especially along rivers, respond rapidly to changes in streamflow. Quality of the water is good where alluvium is underlain by Tertiary deposits and generally poor where underlain by Cretaceous-age deposits.
	Holocene and Pleistocene	Terrace alluvium		0-60	Light-brown clay, silt, and fine sand; thin discontinuous beds of medium to coarse gravel at or near the top. Clayey and sandy gravel common in the basal few feet, especially along the White River.	Water bearing where deposits extend below the water table of adjacent flood-plain alluvium, or where water table is perched. Yields and water quality similar to those of flood-plain alluvium.
		Windblown sand deposits		0-200	Brown, unconsolidated, very fine to medium grained, uniform, quartz sand; characterized by dune topography and blowouts.	Water table generally near the base of sand. Springs are common along the margins of the deposits. Yields commonly more than adequate for domestic and stock needs. Quality of water generally is good.
	Pleistocene	Old terrace deposits		0-80	Brown, silty clay, sand, and gravel. Commonly, the silty and sandy layers are partly cemented, and the gravel and sand beds are commonly interbedded with laminated silty clay.	Generally water bearing in the basal few feet. Springs and seeps common along river-side margins. Yields generally adequate for domestic and stock needs. Quality of water generally is good.
Tertiary	Pliocene	Ogallala Formation		0-200	Tan to olive, fine- to medium-grained sandstone with some silty clay. Upper unit of Ogallala Formation is also known as the Ash Hollow Formation and the lower unit as the Valentine Formation.	Upper unit relatively impermeable; water bearing only locally because of high topographic position. Lower unit generally water bearing where areally extensive. Springs and seeps common at contact with underlying Arikaree Formation. Yields of most wells adequate for domestic and stock needs. Quality of water generally is good.
	Miocene	Arikaree Formation	Unit E	0-235	Light-tan to brown, interbedded calcareous sand, silt, and clay; contains gray to pinkish-gray tabular concretions and small light-brown and greenish clay beds.	Lack of detailed subsurface information makes it impossible to determine the water-bearing properties of individual units. However, the Arikaree is the most common source of ground water on the Reservation. Yields usually adequate for domestic and stock needs. Springs and seeps occur at the contact between the Arikaree and the underlying White River Group.

Tertiary			Unit D	0-125	Gray, massive, poorly consolidated, fine to very fine sand; commonly contains layers of light-gray sandy marl, large pipey concretions, and small spherical concretions. Formation becomes silty toward the east; concretions in the lower part present only in discontinuous zones. Unit is difficult to differentiate from underlying units.	
			Unit C	0-90	Buff siltstone and very fine-grained sandstone; sandier toward east. Difficult to distinguish from overlying and underlying units.	
			Unit B	0-375	Pinkish-tan, poorly consolidated silt and very fine-grained sand; gray, small (2-4 in.) calcareous concretions are common. Lenses of limestone and channel sand and gravel occur locally throughout the unit in central and western parts of the Reservation.	
			Unit A	0-45	White, tan, buff, and reddish-brown silty volcanic ash; interbedded with thin layers of silt.	
	Oligocene	White River Group	Brule Formation	0-450	Yellow to brown, poorly consolidated siltstone and claystone with some beds of fine-grained sand.	Generally too impermeable to serve as a source of ground water. Quality of water generally is only fair.
			Chadron Formation	0-110	Pale, gray-green bentonite clay alternating with layers of greenish-gray siltstone.	Generally too impermeable to serve as a source of ground water. Quality of water generally is only fair.
Cretaceous	Upper Cretaceous	Pierre Shale		0-1,200	Dark-gray marine shale and mudstone with some layers of bentonite.	Not a source of ground water. Quality of water generally is poor.
		Niobrara Formation		0-325	Tan to gray, highly calcareous shale. Commonly described by drillers as “chalk.”	Not a source of ground water. Quality of water generally is poor.
		Carlile Shale		100-325	Dark-gray marine shale and mudstone. Middle part of the formation is sandy and contains thin limestone ledges locally.	Not a source of ground water.
		Greenhorn Formation		[1]70-207	Tan, bluish, white, or gray calcareous shale. Marine origin.	Water-bearing traits are largely unknown.
	Lower Cretaceous	Graneros Shale		[1]200-330	Dark-gray non-calcareous shale. Marine origin.	Nearly impermeable. Water-bearing traits are largely unknown.
		Dakota Formation (Dakota Sandstone)		[1]155-292	Interbedded tan to white sandstone and dark-colored shale. Sandstone is composed of loose to well-cemented, very fine to coarse quartz sand; cement most commonly is calcium carbonate. Marine origin.	Permeable sandstone beds yield moderate quantities of water under artesian pressure for stock and domestic wells. The water is highly mineralized and cannot be used for irrigation purposes.
		Skull Creek Shale		[1]109-284	Dark bluish-gray shale. Marine origin.	Relatively impermeable. Water-bearing traits are largely unknown.
		Inyan Kara Group (undifferentiated)		[1]241-357	White to light-gray or tan sandstone and siltstone; contains beds of gray to black and reddish to buff shale. The Inyan Kara Group is sometimes divided into the Fall River and Lakota Formations. Continental to marginal marine origin.	Permeable sandstone beds yield moderate quantities of water under artesian pressure for stock and domestic wells. The water is highly mineralized and cannot be used for irrigation purposes.

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[1] Based on interpretation and projection of data from electric logs and drillers’ logs.

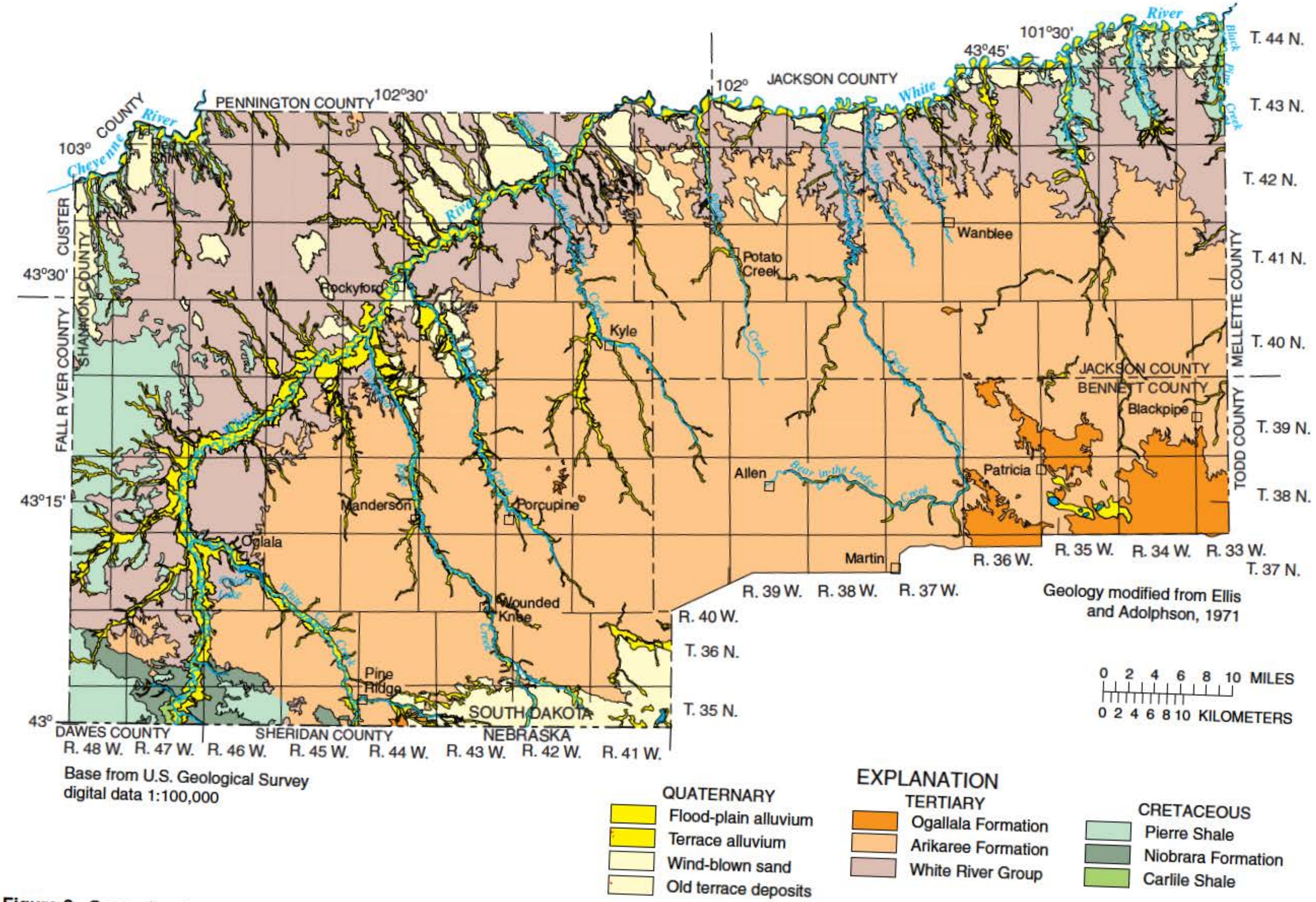

Figure 2. Generalized geology of the study area.

Springs with relatively steady flows are present in the northwestern part of the study area where terrace deposits overlie either the White River Group or the Pierre Shale. Some of the more productive springs have been developed to serve as sources for domestic supply or livestock watering.

The Cheyenne and White Rivers are the major rivers present within the study area (fig. 1). The headwaters of the Cheyenne River are in eastern Wyoming, from where the river flows southeast around the Black Hills and enters Angostura Reservoir in southwestern South Dakota. It then flows northeast forming the northwestern boundary of the Reservation, and continues flowing northeast to its confluence with the Missouri River.

The headwaters of the White River are in northwestern Nebraska, from where the river flows northeast and enters South Dakota about 15 mi southwest of Oglala. Upstream of Oglala, contributions from ground-water discharge maintain flow in the river. Downstream of Oglala, the White River flows through the Badlands and then continues to its confluence with the Missouri River. Because the Badlands contain highly erodible soils, they serve as a primary source of sediment load in the river. Most of the smaller tributaries to the White River flow from south to north and are intermittent, flowing mainly in response to precipitation. However, short reaches of Bear-in-the-Lodge, Porcupine, Wounded Knee, and White Clay Creeks sustain some flow throughout most of the year because either discharge from springs supplements runoff or their streambeds intercept the water table (Ellis and Adolphson, 1971).

Public Water-Supply Systems

Two Tribal departments are responsible for maintaining the Reservation's public water-supply systems: the Oglala Sioux Tribe Water and Sewer Department and the Oglala Sioux Rural Water Department. The Oglala Sioux Water and Sewer Department operates and maintains about 20 wells, 15 pump houses, and 14 mi of water mains that serve about 5,300 people in 12 communities (U.S. Public Health Service, 1996). The Oglala Sioux Rural Water Department operates and maintains about 19 wells, 11 pump houses, and 130 mi of water mains that serve about 4,000 people in five communities.

On October 24, 1988, Congress enacted Public Law 100-516, which authorized the construction of a rural water-supply and distribution system named Mni Wiconi that would pump water from the Missouri River through about 4,000 mi of pipeline to serve water-poor areas of southwestern South Dakota. The Reservation is included in the area to be served by Mni Wiconi. The project is expected to take 10 years to complete and cost about $260 million, making it the Nation's largest rural water-supply system. Water from some of the Tribe's existing public-supply wells and possibly from additional new public-supply wells also will be used to augment the supply.

WATER-QUALITY SAMPLING LOCATIONS AND METHODS

Samples were collected from 14 springs (table 2) located in northwestern Shannon County (fig. 3). Nine of these springs were sampled five times to evaluate temporal changes in water quality. Springs typically are found where the land surface has been deeply eroded and intercepts local water tables. Consequently, most springs are located on the flanks of tablelands and can be easily distinguished by abundant brush thickets or cedar groves in areas that would otherwise lack such vegetation. The largest yielding springs are located at the stratigraphic contact between deposits of Quaternary-age windblown sand or old terrace gravel and underlying relatively impermeable clays of the White River Group or the Pierre Shale. Springs were selected for sampling based on discharge and proximity to the village of Red Shirt.

Samples were collected from 44 public-supply wells (table 3). Forty-two of the 44 public-supply wells sampled for this study were completed in the Arikaree aquifer, one was completed in an alluvial aquifer, and one was completed in the Inyan Kara aquifer (fig. 3).

Location of Springs and Wells

Two methods are used to locate sampling sites that appear in the water-quality tables in this report. The first method is the station identification number. This unique number is based on the international system of latitude and longitude. The number is composed of 15 digits. The first six digits denote the degrees, minutes, and seconds of latitude north of the equator. The next seven digits denote the degrees, minutes and seconds of longitude west of the prime (Greenwich) meridian. The last two digits are used to distinguish between multiple sites located at the same latitude and longitude.

Table 2. Spring sites for which data are presented

[Site number refers to spring location in fig. 3]

Site number	Station identification number	Local number	Spring name	County	Sampling date or period	Number of samples	Confining unit
[1]S1	432750102484701	40N46W18BBAD	South Hubner	Shannon	09-29-92	1	White River Group
[1]S2	432853102365501	41N44W31CBCC	Old Road	Shannon	09-23-92 to 03-26-97	5	White River Group
[1]S3	433301102430501	41N45W 6DDCC	Red Shirt Table	Shannon	09-21-92	1	White River Group
S4	433105102391401	41N45W23BBCB	Cuny Cafe	Shannon	09-25-92 to 03-24-97	5	White River Group
S5	433052102372401	41N45W24ACCA	South Corral	Shannon	09-22-92 to 03-24-97	5	White River Group
[1]S6	433022102401001	41N45W27BBAA	Davey Cuny	Shannon	09-30-92 to 03-25-97	5	White River Group
S7	433252102484201	41N46W 9BBCA	Blackfeather	Shannon	10-01-92 to 03-26-97	5	White River Group
[1]S8	433226102441601	41N46W12DACD	Duhamill	Shannon	09-21-92 to 03-25-97	5	White River Group
[1]S9	433035102441701	41N46W24DCBA	Mill's East	Shannon	10-08-92 to 03-25-97	5	White River Group
[1]S10	433218102573801	41N47W 7DCBA	Rapp North	Shannon	11-04-92	1	Pierre Shale
S11	433113102530501	41N47W23BAAC	Slide	Shannon	09-18-92	1	Pierre Shale
S12	433822102164601	42N42W 2DACA	Heathershaw	Shannon	11-12-92 to 03-27-97	5	White River Group
S13	433852102524501	42N47W 2ACAA	Red Shirt Table N/E	Shannon	09-30-92	1	Pierre Shale
[1]S14	433524102585401	42N48W25ABCC	Knupe North	Shannon	11-05-92 to 03-26-97	5	Pierre Shale

[1] Indicates developed spring.

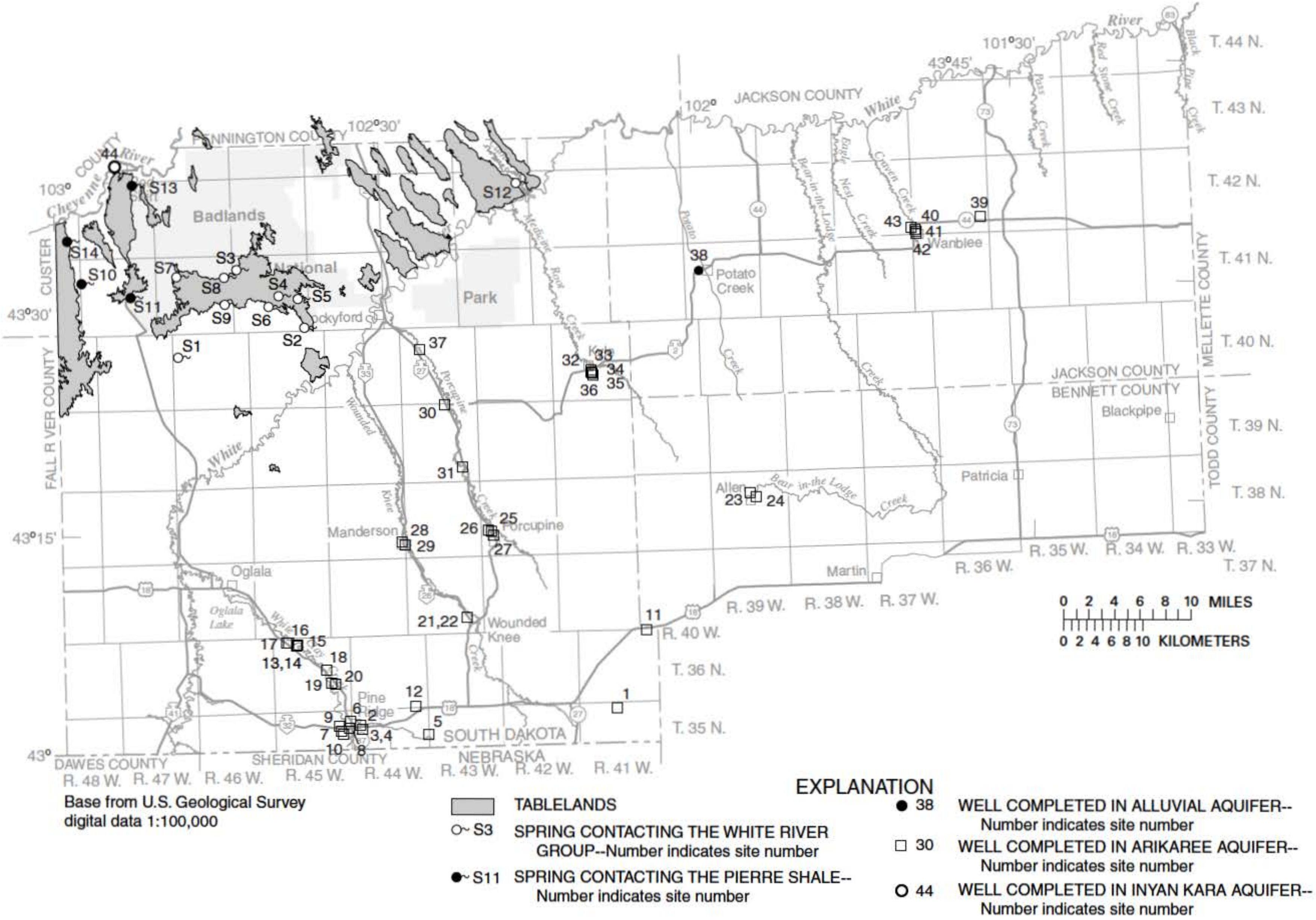

Figure 3. Location of springs and public-supply wells sampled for this study.

Table 3. Public-supply wells for which data are presented

[Site number refers to well location in fig. 3; ---, no data]

Site number	Station identification number	Local number	County	Date sampled	Depth of well (feet)	Aquifer
1	430223102084901	35N41W 4DA	Shannon	09-26-96	120	Arikaree
2	430140102324101	35N44W 7ACBB	Shannon	08-29-96	374	Arikaree
3	430125102324001	35N44W 7ACCD	Shannon	08-21-96	455	Arikaree
4	430125102324002	35N44W 7DBAB	Shannon	08-20-96	520	Arikaree
5	430056102261501	35N44W13AADB	Shannon	06-26-97	280	Arikaree
6	430157102333801	35N45W 1DCDA	Shannon	08-22-96	284	Arikaree
7	430122102342801	35N45W11DAAC	Shannon	07-08-97	168	Arikaree
8	430129102333101	35N45W12ACCA	Shannon	09-05-96	---	Arikaree
9	430141102343701	35N45W12BDDB	Shannon	12-07-95	340	Arikaree
10	430120102341601	35N45W12CCCA	Shannon	09-09-96	303	Arikaree
11	430738102055901	36N41W 1BBCB	Shannon	07-17-97	375	Arikaree
12	430247102273201	36N44W35DDCD	Shannon	07-23-97	---	Arikaree
13	430706102382802	36N45W 5DCAC	Shannon	09-19-96	---	Arikaree
14	430703102383101	36N45W 5DCCA	Shannon	09-25-96	---	Arikaree
15	430709102382801	36N45W 5DCCB	Shannon	09-18-96	320	Arikaree
16	430726102391202	36N45W 6DAA	Shannon	09-12-96	300	Arikaree
17	430742102394301	36N45W 6DAAC	Shannon	09-17-96	71	Arikaree
18	430531102354101	36N45W15DDAB	Shannon	07-08-97	130	Arikaree
19	430439102350701	36N45W23CDBD	Shannon	09-03-96	180	Arikaree
20	430439102350702	36N45W23DCBC	Shannon	09-03-96	100	Arikaree
21	430928102225102	37N43W26CADD	Shannon	11-30-95	187	Arikaree
22	430929102225301	37N43W26CDAA	Shannon	11-30-95	187	Arikaree
23	431703101560801	38N39W10CBCC	Bennett	11-08-95	205	Arikaree
24	431625101551201	38N39W15AACA	Bennett	11-08-95	---	Arikaree
25	431526102202601	38N42W30ABAC	Shannon	11-29-95	454	Arikaree
26	431442102201601	38N42W30ABBB	Shannon	09-24-96	300	Arikaree
27	431440102202801	38N42W30ADBD	Shannon	11-29-95	526	Arikaree
28	431405102282901	38N44W25DBDC	Shannon	12-06-95	---	Arikaree
29	431351102280601	38N44W25DDCD	Shannon	07-09-97	---	Arikaree
30	432336102240401	39N43W 3BBAA	Shannon	11-28-95	---	Arikaree
31	431907102223501	39N43W36BCCC	Shannon	11-28-95	180	Arikaree
32	432523102101801	40N41W21DADD	Shannon	06-30-97	---	Arikaree
33	432518102102801	40N41W21DDAC	Shannon	06-30-97	110	Arikaree
34	432538102102001	40N41W21DDDA	Shannon	11-09-95	---	Arikaree
35	432513102100501	40N41W22CCCB	Shannon	07-01-97	93	Arikaree
36	432507102100701	40N41W28AAAA	Shannon	07-01-97	121	Arikaree
37	432731102261101	40N43W 8CCAC	Shannon	12-05-95	60	Arikaree
38	433157101593001	41N39W17BADB	Jackson	10-19-95	68	Alluvium
39	433456101332001	42N36W25CACC	Jackson	07-22-97	---	Arikaree
40	433400101390001	42N36W31CBDB	Jackson	10-18-95	184	Arikaree
41	433357101392301	42N36W31CCAD	Jackson	07-16-97	124	Arikaree
42	433328101392801	42N36W31CCDA	Jackson	07-16-97	200	Arikaree
43	433422101390301	42N37W36ADDA	Jackson	10-18-95	106	Arikaree
44	433740102532001	43N47W27CDA	Shannon	06-25-97	2,640	Inyan Kara

The second method is the local number and is based on the Federal system of land subdivision (township, range, and section) (fig. 4). The first number of a site designation indicates the township and is followed by "N" or "S" (for north or south); the second number indicates the range and is followed by "E" or "W" (for east or west); the third number represents the section and it may be followed with up to four uppercase letters. An increasing number of letters following the section number indicates the degree of accuracy with which the site has been located. The first letter after the section number represents the 160-acre tract, the second the 40-acre tract, the third the 10-acre tract and the fourth the 2.5-acre tract in which the site is located. The letters A, B, C, and D are assigned in a counter-clockwise direction, beginning in the northeast corner of each tract. A number following the last uppercase letter is sometimes used to distinguish between multiple sites in the same tract. The well number 38N44W25DDCD, shown in figure 4, indicates the well is located in the SE1/4 of the SW1/4 of the SE1/4 of the SE1/4 of section 25 in township 38 north and range 44 west.

Sampling Methods

Water-quality samples were collected from springs and public-supply wells according to methods recommended by the USGS. Samples collected prior to 1994 generally followed methods presented in Wood (1976). Samples collected and processed during 1994 and thereafter generally followed methods described by Horowitz and others (1994). Field measurements of specific conductance, pH, temperature, dissolved oxygen, and acid neutralizing capacity were recorded at all sampling sites. The term acid neutralizing capacity (ANC) is applied to the acid neutralizing capacity of solutes plus particulates in a water sample, reported in equivalents, and normally titrated on an unfiltered sample. Samples were processed and preserved according to Horowitz and others (1994), then kept chilled until received at the laboratory.

Fourteen springs were sampled during 1992-97, of which eight were developed for domestic supply or stock watering, and six were undeveloped (table 2). Developed springs generally consist of a pipe pushed horizontally into a hillside until a flow of spring water is intercepted. Discharge is then routed to a house or to a tank for livestock. Spring discharge can be accurately determined by measuring the rate of water flowing from the pipe. Samples from developed springs were collected using a separate, precleaned 8-L churn splitter at each site. Prior to sampling, each churn splitter was cleaned and double bagged as needed to prevent contamination. Churn splitters were opened only for rinsing and sample collection, and were then covered to avoid contamination. Quality-assurance procedures used for sample collection and processing are described by Horowitz and others (1994). Powder-free vinyl gloves were worn throughout the sample collection and processing procedure to reduce the potential for sample contamination.

Discharge was measured from undeveloped springs with a portable flume. Grab samples were collected because limited width and depth made collection of integrated cross-sectional samples impractical. Aliquots of spring water were carefully collected in precleaned 8-L churn splitters and covered.

A flow-through chamber was used to obtain field measurements for wells so that contact with the atmosphere was limited. Samples were collected after a minimum of three casing volumes were evacuated from the well and after field measurements stabilized (Wood, 1976).

To reduce the potential for external contamination, most of the public-supply well samples were collected from sampling ports located upstream of any chemical treatment feeders. However, workable sampling ports were not available upstream of chemical feeders for sites 6, 11, and 12; thus, samples for these three sites were collected downstream of treatment. Tygon tubing was used to connect the flow-through chamber to the sampling ports. Sample bottles were filled from a valve located upstream from the flow-through chamber. The tygon tubing, flow-through chamber, and associated plumbing were field rinsed several times with deionized water between sampling sites.

Samples from springs and wells were analyzed for common ions, nutrients, trace elements, and radionuclides by the USGS National Water Quality Laboratory (NWQL) using analytical methods described by Fishman and Friedman (1989) and Fishman (1993). Pesticide samples were collected from nine springs and analyzed at the local USGS office laboratory by the enzyme-linked immunoassay method developed by Ohmicron Environmental Diagnostics, Newtown, Pennsylvania. Bacteria samples were processed in the field and analyzed at the local USGS office laboratory, generally following the procedures described by Britton and Greeson (1987) and by Myers and Sylvester (1997).

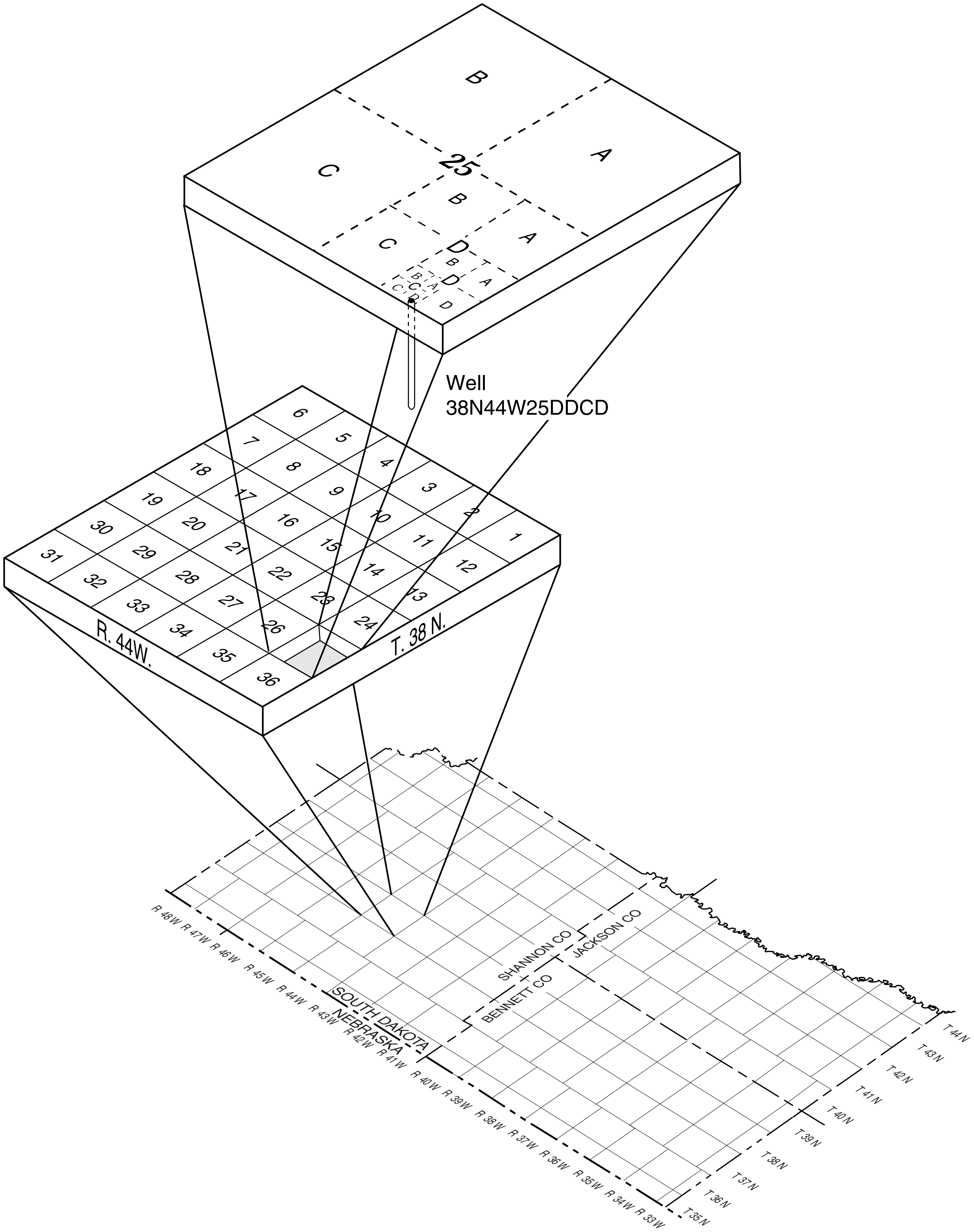

Figure 4. Site-location diagram. The local number consists of the township number, followed by "N," the range number followed by "W," and the section number followed by a maximum of four uppercase letters that indicate, respectively, the 160-, 40-, 10-, and 2 1/2-acre tract in which the well is located. These letters are assigned in a counterclockwise direction beginning with "A" in the northeast quarter. A serial number following the last letter is used to distinguish between wells in the same 2 1/2-acre tract.

To avoid any cross contamination between wells, raw water samples for the determination of indicator bacteria concentrations were collected directly into sterilized glass jars. The samples were kept on ice until they were processed, then placed in portable incubators and held at the required temperature for the specified time until the colonies were counted. Presumptive analysis was used as a screening method in order to generally assess the types of indicator bacteria present. Additional conformation procedures are usually required to quantify the presence of indicator bacteria for regulatory purposes. Kits for the presumptive analysis of fecal coliform and fecal streptococcus bacteria were obtained from the USGS Quality of Water Services Unit (QWSU) in Ocala, Florida. The bacteria kits that QWSU supply must pass quality-assurance tests performed by the NWQL (Horowitz and others, 1994). PourRite[1] ampules of M-ColiBlue24[1] agar broth were used for the presumptive analysis of total coliform and *E. coli* bacteria. This agar was chosen because it can be used to simultaneously analyze for total coliforms and *E. coli*. Total coliform colonies are determined by counting both blue and red colonies on each plate, while *E. coli* are determined by counting only blue colonies. All media were used prior to the expiration date.

Quality Assurance

Quality-assurance samples were used to evaluate the precision and accuracy of the analysis of environmental samples. The quality-assurance samples included blanks, duplicate field samples, and standard reference samples (SRS's) that were submitted as blind samples to the laboratory and analyzed concurrently with the environmental samples.

Blank Samples

Blank samples, consisting of equipment and field blanks, were collected and analyzed to identify the presence and magnitude of contamination that could potentially bias analytical results. Equipment blanks are samples of ultrapure deionized water that are certified trace-element free and processed through the sampling equipment used to collect water-quality samples. Equipment blanks are processed through the sampling equipment in a laboratory or some other controlled environment so that any contamination attributable to the equipment can be isolated and identified. Field blanks are samples of ultrapure deionized water that are processed through the sampling equipment at a sample-collection site and represent actual field conditions and are used to identify contamination attributable to the equipment or contamination introduced during sample collection and processing in the field.

One equipment blank and one field blank were collected during the sampling program, and the results are presented in table 4. Low-level analyses were performed on the equipment blank; thus, minimum reporting levels (MRL's) for many constituents were lower than for the field blank, which was analyzed at the same limits as environmental samples. In the equipment blank, silica and boron were present at detectable concentrations. Silica was reported at 0.3 mg/L and boron at 9.1 µg/L. Lot numbers provided by the manufacturers of the blank water, as well as the filters used to process the equipment blank, were checked and the statements of analyses indicated that silica was present at 0.04 mg/L in the water and at less than 0.02 mg/L in the filtrate from the capsule filters, which indicates that the source of silica detected in the equipment blank probably is due to contamination. Boron was present at 10 µg/L in the blank water, and at less than 2.0 µg/L in the filtrate from the capsule filters, indicating that source of boron detected in the equipment blank was from the blank water and possibly from the filter as well. The equipment blank was processed in the laboratory, and it is possible that the source of some of the silica and boron contamination could be contact with a glass beaker, considering that laboratory glass beakers often are made with borosilicate glass.

The results of the field-blank sample, collected after the equipment blank, show a silica value at the minimum reporting level of 0.01 mg/L and a boron value below the minimum reporting level of 10 µg/L. Field-blank-sample results indicate that external contamination did not substantially contribute to concentrations of silica and boron detected in the water-quality samples presented in this report. This conclusion also is supported by the water-quality data for silica and boron because the minimum value reported for all environmental samples collected was 8.2 mg/L for silica and 20 µg/L for boron.

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[1] M-ColiBlue24 and PourRite are trademarks of the Hach Company, Loveland, Colorado.

Table 4. Quality-assurance results of blank samples

[µS/cm, microsiemens per centimeter at 25° Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; --, no data; <, less than]

Constituent and reporting unit	Equipment blank 4-12-95	Field blank 4-24-95
Specific conductance, lab (µS/cm)	1.4	1.4
pH, lab (standard units)	--	7.2
Calcium, dissolved (mg/L as Ca)	0.01	<0.02
Magnesium, dissolved (mg/L as Mg)	0.01	<0.01
Sodium, dissolved (mg/L as Na)	<0.03	<0.2
Potassium, dissolved (mg/L as K)	--	<0.1
Sulfate, dissolved (mg/L as SO_4)	--	<0.1
Chloride, dissolved (mg/L as Cl)	--	<0.1
Fluoride, dissolved (mg/L as F)	--	<0.1
Silica, dissolved (mg/L as SiO_2)	0.3	0.01
Nitrogen, ammonia dissolved (mg/L)	--	<0.01
Nitrogen, ammonia + organic dissolved (mg/L as N)	--	<0.2
Nitrogen, nitrite dissolved (mg/L as N)	--	<0.01
Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)	--	<0.05
Phosphorus, dissolved (mg/L as P)	--	<0.01
Phosphorus ortho, dissolved (mg/L as P)	--	<0.01
Arsenic, dissolved (µg/L as As)	--	<1
Barium, dissolved (µg/L as Ba)	<0.2	<2
Beryllium, dissolved (µg/L as Be)	<0.2	<0.5
Boron, dissolved (µg/L as B)	9.1	<10
Cadmium, dissolved (µg/L as Cd)	<0.3	1
Cadmium, water unfiltered total (µg/L as Cd)	--	<1
Chromium, dissolved (µg/L as Cr)	<0.2	<5
Cobalt, dissolved (µg/L as Co)	<0.2	<3
Copper, dissolved (µg/L as Cu)	<0.2	<10
Iron, dissolved (µg/L as Fe)	<3	<3
Lead, dissolved (µg/L as Pb)	<0.3	<10
Lithium, dissolved (µg/L as Li)	--	<4
Manganese, dissolved (µg/L as Mn)	<0.1	1
Mercury, dissolved (µg/L as Hg)	--	<0.1
Molybdenum, dissolved (µg/L as Mo)	<0.2	<10
Nickel, dissolved (µg/L as Ni)	<0.5	10
Selenium, dissolved (µg/L as Se)	--	<1
Silver, dissolved (µg/L as Ag)	<0.2	<1
Thallium, dissolved (µg/L as Tl)	<0.1	<0.5
Strontium, dissolved (µg/L as Sr)	<0.1	<0.5
Vanadium, dissolved (µg/L as V)	--	<6
Zinc, dissolved (µg/L as Zn)	<0.5	<3

Three constituents (cadmium, manganese, and nickel) were present at detectable concentrations in the field blank. Cadmium and manganese were both present at 1.0 µg/L, and nickel was present at 10 µg/L. The corresponding minimum reporting levels for cadmium, manganese, and nickel were 1.0, 1.0, and 10 µg/L, respectively. Statements of analyses provided for the blank water, as well as filters used to process the field blank, indicated that they were not the source of the contamination. It is therefore possible that contamination could account for detectable concentrations of these three constituents, which were present at or near the minimum reporting level in the environmental samples.

The effectiveness of sterilization techniques used during collection and processing of bacterial samples was monitored by filtering an aliquot of sterile phosphate buffer as a blank between sampling sites. The filter was then placed on the respective agar media and incubated to determine if characteristic bacteria colonies developed. Bacteria colonies developed on one blank collected between spring sites; no bacteria colonies developed on blanks collected during the public-supply well sampling.

Duplicate Samples

Duplicate field samples consist of splits from the same sample aliquot that are collected in a manner such that the samples are assumed to be essentially identical in composition. These samples are used to estimate variability in the sample-collection and analysis process.

A data-quality objective for precision of duplicate field samples was established at a maximum relative standard deviation of 20 percent. The establishment of a data-quality objective provides a tool for assessing the reliability of sampling and analytical methods, as well as a method for identifying and qualifying questionable data. Comparisons of quality-assurance data to the data-quality objective are used to evaluate whether sampling and analytical methods have consistently produced data that are representative of existing environmental conditions.

The precision of the analytical results for a specific constituent can be determined by calculating a standard deviation from the differences of pairs of the duplicate measurements. The standard deviation is estimated by the following equation (Taylor, 1987):

$$S = \sqrt{\frac{\Sigma d^2}{2k}}$$

where:

S = standard deviation of the difference in concentration between duplicate analyses;

d = difference in concentration between each pair of duplicate analyses; and

k = number of pairs of duplicate analyses.

Precision also can be expressed as a relative standard deviation (RSD), in percent, for a specific constituent. The RSD is calculated from the standard deviation and the mean concentration of all duplicate analyses as given in the following equation (Taylor, 1987):

$$RSD = \frac{S}{\bar{x}} \times (100)$$

where:

RSD = relative standard deviation, in percent;

S = standard deviation; and

$\bar{x}$ = mean of all duplicate concentrations.

Chemical analyses of duplicate field samples for springs and public-supply wells (table 5) were combined to provide the paired sets of data used to calculate precision. Results of precision calculations are provided in table 6.

Many reported concentrations were less than the MRL. For these "censored" values, an estimated value of one-half the MRL was substituted into precision calculations.

Radionuclide analyses presented in table 5 include precision estimates for each analysis. The term 2 sigma refers to the 2 sigma precision estimate (2SPE), which is a measure of the uncertainty of the reported concentration. Generally, there is about 95 percent certainty that the true concentration for a sample is within the range of the reported value plus or minus 2SPE, with the lower part of that range bounded by zero.

The data-quality objective (maximum RSD) of 20 percent for the precision of field duplicates was exceeded for five of the constituents (beryllium, iron, molybdenum, zinc, and radium-226) in table 6. The high RSD for two constituents (beryllium and molybdenum) resulted from a single sample for each constituent for which a detectable concentration was reported (table 5). Similarly, reported values for zinc and radium-226 were near the MRL. Iron was the only constituent for which a particularly large discrepancy was identified; however, poor precision of this relatively low concentration for iron is of small consequence. Thus, although the data-quality objective was not met for all constituents, the problems are considered very minor.

Table 5. Chemical and radionuclide analyses of duplicate field samples for springs and public-supply wells

[µS/cm, microsiemens per centimeter at 25° Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; --, no data; <, less than]

Constituent and reporting unit	Site S9 (spring) 10-08-92		Site 7 (well) 07-28-97		Site 29 (well) 07-09-97	
	Sample	Duplicate	Sample	Duplicate	Sample	Duplicate
Specific conductance, lab (µS/cm)	511	511	542	542	661	658
pH, lab (standard units)	8.3	8.3	7.9	7.2	7.3	7.1
ANC, lab (mg/L as $CaCO_3$)	201	201	262	250	276	276
Calcium, dissolved (mg/L as Ca)	27	27	58	56	81	81
Magnesium, dissolved (mg/L as Mg)	3	3	7.9	7.7	8.7	8.6
Sodium, dissolved (mg/L as Na)	74	75	44	44	49	48
Potassium, dissolved (mg/L as K)	11	13	--	--	12	12
Sulfate, dissolved (mg/L as SO_4)	34	34	23	23	80	80
Chloride, dissolved (mg/L as Cl)	11	11	8.1	8.1	5.1	5.2
Fluoride, dissolved (mg/L as F)	0.3	0.3	0.3	0.3	0.3	0.3
Silica, dissolved (mg/L as SiO_2)	56	56	54	53	57	56
Solids, dissolved (mg/L)	357	347	374	371	480	481
Nitrogen, ammonia dissolved (mg/L)	--	--	0.2	0.2	<0.015	<0.015
Nitrogen ammonia + organic, dissolved (mg/L)	--	--	--	--	<0.2	<0.2
Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)	--	--	3	3	0.6	0.7
Phosphorus, dissolved (mg/L as P)	--	--	0.1	0.1	0.04	0.04
Arsenic, dissolved (µg/L as As)	10	10	11	15	4.7	4.8
Barium, dissolved (µg/L as Ba)	52	51	260	270	49	47
Beryllium, dissolved (µg/L as Be)	<0.5	<0.5	<0.5	1.4	<0.5	<0.5
Boron, dissolved (µg/L as B)	170	180	130	130	77	74
Cadmium, dissolved (µg/L as Cd)	<1	<1	<1	<1	<1	<1
Cadmium, water unfiltered total (µg/L as Cd)	<1	<1	--	--	<1	<1
Chromium, dissolved (µg/L as Cr)	<5	<5	<5	<5	<5	<5
Cobalt, dissolved (µg/L as Co)	<3	<3	<3	<3	<3	<3
Copper, dissolved (µg/L as Cu)	<10	<10	<10	<10	<10	<10
Iron, dissolved (µg/L as Fe)	3	4	33	11	<3	<3
Lead, dissolved (µg/L as Pb)	<10	<10	<10	<10	<10	<10
Lithium, dissolved (µg/L as Li)	36	37	18	24	45	44
Manganese, dissolved (µg/L as Mn)	<1	1	75	67	<1	<1

Table 5. Chemical and radionuclide analyses of duplicate field samples for springs and public-supply wells–Continued

[µS/cm, microsiemens per centimeter at 25° Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; --, no data; <, less than]

Constituent and reporting unit	Site S9 (spring) 10-08-92		Site 7 (well) 07-28-97		Site 29 (well) 07-09-97	
	Sample	Duplicate	Sample	Duplicate	Sample	Duplicate
Mercury, dissolved (µg/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Molybdenum, dissolved (µg/L)	<10	<10	<10	10	<10	<10
Nickel, dissolved (µg/L as Ni)	<10	<10	<10	<10	<10	<10
Selenium, dissolved (µg/L as Se)	11	10	3	4	2.1	1.8
Silver, dissolved (µg/L as Ag)	<1	<1	<1	<1	<1	<1
Strontium, dissolved (µg/L as Sr)	360	360	420	460	850	829
Thallium, dissolved (µg/L as Tl)	--	--	--	--	<0.5	<0.5
Vanadium, dissolved (µg/L as V)	9	9	10	12	<6	6.6
Zinc, dissolved (µg/L as Zn)	3	<3	<3	9	<3	5.1
Gross alpha, dissolved (µg/L as U)	13.5	13.9	12	15	--	--
Alpha count, 2 sigma precision estimate, dissolved (pCi/L as U)	2.8	3.1	5.3	6.3	--	--
Gross alpha radio, dissolved (pCi/L as Th-230)	9.2	9.9	8.3	11	18.8	16.5
Alpha count, 2 sigma precision estimate dissolved (pCi/L as Th-230)	1.9	2.0	3.7	4.4	5.7	5.3
Gross beta, dissolved (pCi/L as Cs-137)	8.8	8.9	24	21	21.2	21.3
Beta, 2 sigma precision estimate dissolved (pCi/L as Cs-137)	0.8	1.3	3.4	3.2	4.8	4.8
Gross beta, dissolved (pCi/L as Sr90/Y90)	--	--	18	16	--	--
Beta, 2 sigma precision estimate dissolved (pCi/L as Sr90/Y90)	--	--	2.6	2.4	--	--
Ra-226, dissolved (pCi/L)	--	--	0.1	0.2	0.03	0.03
Ra-226, dissolved 2 sigma precision estimate (pCi/L)	--	--	0.1	0.1	0.04	0.04
Uranium, dissolved (µg/L as U)	--	--	10	12	18.4	19.6
Uranium, dissolved 2 sigma precision estimate (µg/L)	--	--	3.0	3.5	5.2	5.5

Table 6. Precision of chemical analyses of duplicate field samples for springs and public-supply wells

[Units in micrograms per liter except where indicated. µS/cm, microsiemens per centimeter at 25° Celsius; mg/L, milligrams per liter; pCi/L, picocuries per liter]

Constituent and reporting unit	Minimum reporting level	Number of duplicate pairs	Standard deviation	Relative standard deviation (percent)
Specific conductance (µS/cm)	1	3	1.2	0.2
pH (standard units)	0.1	3	0.3	3.9
Acid neutralizing capacity (mg/L as $CaCO_3$)	1	3	4.9	2.0
Calcium, dissolved (mg/L)	0.1	3	0.8	1.5
Magnesium, dissolved (mg/L)	0.1	3	0.09	1.4
Sodium, dissolved (mg/L)	0.1	3	0.6	1.0
Potassium, dissolved (mg/L)	0.1	2	1.0	8.3
Sulfate, dissolved (mg/L)	0.1	3	0.0	0.0
Chloride, dissolved (mg/L)	0.1	3	0.04	0.5
Fluoride, dissolved (mg/L)	0.1	3	0.0	0.0
Silica, dissolved (mg/L)	0.1	3	0.6	1.1
Solids, dissolved (mg/L)	1	3	4.3	1.1
Nitrogen, ammonia, dissolved (mg/L)	0.02	2	0.0	0.0
Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)	0.005	2	0.05	2.7
Phosphorus, dissolved (mg/L)	0.001	2	0.0	0.0
Arsenic, dissolved	1	3	1.6	18
Barium, dissolved	1	3	4.2	3.4
Beryllium, dissolved	0.5	3	0.50	106
Boron, dissolved	10	3	4.3	3.4
Cadmium, water unfiltered total	1	2	0.0	0.0
Cadmium, dissolved	1	3	0.0	0.0
Chromium, dissolved	5	3	0.0	0.0
Cobalt, dissolved	3	3	0.0	0.0
Copper, dissolved	10	3	0.0	0.0
Iron, dissolved	3	3	9.0	100
Lead, dissolved	10	3	0.0	0.0
Lithium, dissolved	6	3	2.5	7.4
Manganese, dissolved	1	3	3.3	14
Mercury, dissolved	0.1	3	0.0	0.0
Molybdenum, dissolved	10	3	2.0	35
Nickel, dissolved	10	3	0.0	0.0
Selenium, dissolved	1	3	0.6	11
Silver, dissolved	1	3	0.0	0.0
Thallium, dissolved	0.5	1	0.0	0.0
Strontium, dissolved	1	3	18	3.4
Vanadium, dissolved	6	3	1.6	20
Zinc, dissolved	3	3	3.4	96
Gross alpha, dissolved, as uranium natural	3	2	1.5	11
Gross alpha radioactivity, dissolved, as Th-230, pCi/L	3	3	1.5	12
Gross beta, dissolved, pCi/L as Cs-137	4	3	1.2	6.9
Gross beta, dissolved, pCi/L as Sr/Y-90	4	1	1.4	8.3
Radium-226, dissolved, pCi/L	0.1	2	0.05	55
Uranium, natural, dissolved	1	2	1.2	7.8

Standard Reference Samples

Two standard reference samples (SRS's), which consisted of standard reference water provided by the NWQL, were submitted as quality-assurance samples. The SRS's are sample lots that are prepared by the NWQL as part of a USGS interlaboratory evaluation program (Farrar and Long, 1996) and are available for quality-assurance purposes. Analyses performed by numerous laboratories are used to determine the most probable value (MPV) for selected analytes in an SRS. The MPV represents the median (midpoint) value established for a constituent. An F-pseudosigma value, which is a measure of variability similar to a standard deviation, also is determined for each analyte from results reported by participating laboratories.

Two SRS's were prepared as quality-assurance samples by pouring directly into sample bottles that had been rinsed with SRS water. SRS M-116 (mainly for major constituents) was submitted on December 11, 1995, and SRS T-99 (mainly for trace constituents) was submitted on September 6, 1996. Analytical results are presented in table 7, along with a comparison to the MPV and an "acceptable" analytical range, which is the MPV plus or minus two times the F-pseudosigma value. The MPV's and F-pseudosigma values were provided by Keith R. Long and Jerry W. Farrar (U.S. Geological Survey, written commun., 1991). The MPV data, acceptable F-pseudosigma ranges, and results of SRS's submitted as blind samples to the NWQL are summarized in table 7.

The SRS M-116 was analyzed for seven constituents. The only constituent that exceeded the established acceptable range was sulfate. Because sulfate only narrowly exceeded the acceptable range, and because the analyses of sulfate in duplicate field samples were in perfect agreement, the exceedance was not considered to be a problem in the analysis of environmental samples.

The SRS T-99 was analyzed for 22 constituents with established MPV's and F-pseudosigma ranges. Seven constituents (cadmium, cobalt, copper, lead, molybdenum, silver, and zinc) had values that fell outside of their established acceptable ranges, indicating the analytical variability associated with these constituents. Chronic problems with NWQL analyses for a limited number of constituents, primarily in ranges near the MRL's, have been identified based largely on data collected by the NWQL Blind Sample Program. To address these problems, the NWQL raised the minimum reporting levels effective December 15, 1997, for six of the seven constituents, and for several others routinely analyzed by inductively coupled plasma-atomic emission spectroscopy (ICP-AES). (U.S. Geological Survey, National Water Quality Laboratory Technical Memorandum 98.05, dated Dec. 9, 1997). Had the newly established minimum reporting levels been in effect at the time SRS T-99 was analyzed, lead and molybdenum would have had acceptable F-pseudosigma ranges. Because the SRS data presented in this report for cadmium, cobalt, copper, lead, molybdenum, silver, and zinc failed to meet the required standards for precision, the data presented for environmental samples for these seven constituents should be used cautiously.

Summary of Quality-Assurance Data

The quality-assurance samples analyzed for this report included equipment blanks, field blanks, field-duplicate samples, and SRS's. Although a number of minor analytical problems were identified, none of the problems posed any real difficulty with respect to the interpretation of the environmental data sets. This is because most of the minor problems would be significant only if analyses for selected constituents were of particular importance, near the MRL's. If this were the case, low-level analytical methods would have been used.

The analysis of the equipment blank shows that silica and boron were both present at detectable concentrations but did not have an appreciable effect on the environmental samples. The analysis of the field blank shows that cadmium, manganese, and nickel were present at detectable concentrations. Therefore, detections of cadmium and manganese in the environmental samples at concentrations near the minimum reporting level could have resulted from sample contamination. Nickel was not detected in any of the environmental samples analyzed, and therefore was not affected.

Results from the analysis of field-duplicate samples show that precision data for beryllium, iron, molybdenum, zinc, and radium-226 fail to meet the established data-quality objectives. Because beryllium was only detected in a single environmental sample, its failure to meet the established data-quality objective did not negatively affect the beryllium data. The reason radium-226 failed to meet the established data-quality objective probably resulted from the generally low concentrations detected in the randomly selected field-duplicate samples.

Table 7. Quality-assurance results for standard reference samples M-116 and T-99 submitted during public-supply well sampling program

[Units in micrograms per liter except where indicated. SRS, standard reference sample; NWQL, USGS National Water Quality Laboratory; MPV, most probable value; µS/cm, microsiemens per centimeter at 25° Celsius; mg/L, milligrams per liter; --, no data; <, less than]

Constituent and reporting unit	SRS M-116				SRS T-99			
	MPV	Acceptable range[1]	NWQL reported value (4-1-96)	Within acceptable range?	MPV	Acceptable range[1]	NWQL reported value (10-29-96)	Within acceptable range?
Specific conductance (µS/cm)	1,477	1,373-1,581	1,460	Yes	--	--	--	--
pH (standard units)	2.7	2.5-2.9	2.7	Yes	--	--	--	--
Calcium (mg/L)	--	--	--	--	202	172-232	200	Yes
Magnesium (mg/L)	--	--	--	--	113	99-127	110	Yes
Sodium (mg/L)	--	--	--	--	323	289-357	310	Yes
Potassium (mg/L)	4.9	4.3-5.5	5.1	Yes	5.2	3.6-6.8	5.0	Yes
Sulfate (mg/L	97	85-109	110	No	--	--	--	--
Chloride (mg/L)	208	192-224	210	Yes	--	--	--	--
Fluoride (mg/L)	0.7	0.5-0.9	0.5	Yes	--	--	--	--
Silica (mg/L)	--	--	--	--	10.9	9.5-12.3	10	Yes
Arsenic	--	--	--	--	5.8	2-9.6	8.0	Yes
Barium	--	--	--	--	19.6	<2-40	23	Yes
Boron	136	88-184	130	Yes	495	455-535	498	Yes
Cadmium	--	--	--	--	4.7	1.7-7.7	15	No
Chromium	--	--	--	--	16.3	3.3-29.3	27	Yes
Cobalt	--	--	--	--	2.1	<3-4.1	12	No
Copper	--	--	--	--	27.9	18.7-37.1	40	No
Iron	--	--	--	--	137	79-195	130	Yes
Lead	--	--	--	--	4.7	<10-11.5	40	No
Lithium	--	--	--	--	176	134-218	170	Yes
Manganese	--	--	--	--	82	54-110	84	Yes
Molybdenum	--	--	--	--	13.1	8.3-17.9	40	No
Nickel	--	--	--	--	16.5	<10-50.1	40	Yes
Silver	--	--	--	--	3	<1-6	7	No
Strontium	--	--	--	--	3,900	3,500-4,300	3,900	Yes
Vanadium	--	--	--	--	11.8	<6-24	24	Yes
Zinc	--	--	--	--	36	21.4-50.6	120	No

[1] Acceptable range established as MPV plus or minus 2 times F-pseudosigma values.

The analysis of SRS's show that cadmium, cobalt, copper, lead, molybdenum, silver, and zinc exceeded the established acceptable ranges. Because copper was only detected in a single environmental sample, its failure to fall within the established acceptable range did not negatively affect the copper data.

The results of four meticulous quality-assurance methods applied to nearly 50 constituents analyzed for this study show that data reported for six (cadmium, cobalt, iron, manganese, silver and zinc) exceeded the established acceptable criteria and there is no clear explanation. Subsequently, even though most of these trace metal constituents appear at or near the minimum reporting level in the environmental samples analyzed, the results for these six constituents should be used cautiously. The quality-assurance methods used for this study also show that for most constituents of concern, specifically for most of those regulated by the Safe Drinking Water Act, the data are highly reliable.

WATER-QUALITY DATA AND ANALYSIS FOR SELECTED SPRINGS AND WELLS

Water-quality data were collected during 1992-97 for 14 springs and 44 public-supply wells. Analytical results of sampling for field parameters, common ions, nutrients, trace elements, radionuclides, and pesticides are discussed in the following sections.

Water-quality data also are compared to USEPA criteria and standards for drinking water (table 8). Two types of standards are typically used to assess the suitability of water for human consumption. A secondary maximum contaminant level (SMCL) represents a recommended level for a constituent and is considered to be a nonenforceable guideline that is usually related to the aesthetic quality of water. The second type of standard is the maximum contaminant level (MCL), which represents the maximum permissible level of a contaminant allowed in water that is delivered to any user of a public-supply system. MCL's are enforceable standards under the Safe Drinking Water Act.

The USGS typically analyzes ground-water samples for dissolved constituent concentrations, which means the water sample has been passed through a filter with an average mesh size of 0.45 microns. Drinking-water standards established by the USEPA are based on total constituent concentrations, which refer to the combined concentration of both dissolved and suspended phases of the water sample. Therefore, results reported by the USGS as dissolved constituent concentrations may be less than those obtained for similar samples analyzed for total constituent concentrations.

Springs

Fourteen springs were initially sampled in 1992, during the reconnaissance phase of the study. After the initial sampling, nine of these springs were sampled four more times between 1994 and 1997. Water-quality data for all spring samples are presented in table 13 in the Supplemental Data section at the end of this report. Median values for the nine springs that were sampled multiple times are presented in table 9.

Discharge measurements generally were made at the time that water-quality samples were collected from springs. Additional discharge measurements were made at six of the springs (S4-S9) to evaluate variability in spring discharge. Hydrographs are shown in figure 5 for all springs at which multiple discharge measurements were made. Most of the springs show very little variability in discharge. The largest variability in discharge was for Cuny Cafe Spring (S4), which ranged from about 0.05 to 0.39 ft^3/s (fig. 5).

Several long-time residents of the area have reported that even during periods of drought conditions, most of the more consistent springs have maintained enough flow for livestock watering. Severe drought conditions occurred during the late 1980's, a few years prior to initiation of the sampling for this study. None of the springs sampled were reported dry during the late 1980's; thus, it is likely that most of these springs maintained some flow during that period. It is not possible to make estimates of discharge during that period; however, flow for some of the springs may have been less than the minimum values shown in figure 5. All discharge measurements shown in figure 5 are rounded to the nearest 0.01 ft^3/s; thus, actual discharges for some of the measurements shown are somewhat less than 0.01 ft^3/s.

The village of Red Shirt includes 12 houses and a Shannon County School, with an estimated population of about 80 people while the school is in session (U.S. Public Health Service, 1996). Assuming an average use of 80 gal/d per person, a spring would need to supply about 6,400 gal/d to meet demand. A discharge of 0.01 ft^3/s is equal to about 4.5 gal/min or about 6,460 gal/d. Thus, a single spring discharging 0.01 ft^3/s might only minimally meet the present public water-supply needs of the village of Red Shirt during periods of average demand. Blending water from springs and the existing well completed in the Inyan Kara aquifer may be a possible alternative for meeting the public water-supply needs of the village of Red Shirt.

Table 8. Water-quality criteria, standards, or recommended limits for selected properties or constituents

[Modified from Howells, 1979. All concentrations are from U.S. Environmental Protection Agency (1996) unless noted. MCL, maximum contaminant level; SMCL, secondary maximum contaminant level; mL, milliliters; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; --, no limit established]

Constituent or property	Limit	Significance
Specific conductance	--	A measure of the ability of water to conduct an electrical current; varies with temperature. Magnitude depends on concentration, kind, and degree of ionization of dissolved constituents; can be used to determine the approximate concentration of dissolved solids. Values are reported in microsiemens per centimeter at 25° Celsius.
pH	6.5-8.5 units SMCL	A measure of the hydrogen ion concentration; pH of 7.0 indicates a neutral solution, pH values smaller than 7.0 indicate acidity, pH values larger than 7.0 indicate alkalinity. Water generally becomes more corrosive with decreasing pH; however, excessively alkaline water also may be corrosive.
Acid neutralizing capacity (ANC)	--	A measure of the capacity of unfiltered water to neutralize acid. In almost all natural waters ANC is produced by the dissolved carbon dioxide species, bicarbonate and carbonate. Typically expressed as mg/L $CaCO_3$.
E. coli bacteria	presence/absence MCL[1]	Indicator bacteria used to assess the quality of water. *E. coli* strictly inhabit the gastrointestinal tract of humans and warm-blooded animals. Its presence in water is direct evidence of fecal contamination and the possible presence of disease-causing organisms. Disease symptoms may include gastroenteritis, fever, and diarrhea.
Total coliform bacteria	presence/absence MCL[1]	Indicator bacteria used to assess the quality of water. They are not typically disease causing, but are correlated to the presence of several water-borne disease-causing organisms. May result from the intestinal tract of humans and warm-blooded animals or from other sources. The presence of indicator bacteria is used to assess the sanitary quality of water for consumption.
Fecal coliform bacteria	presence/absence MCL[1]	Indicator bacteria used to assess the quality of water. They are not typically disease causing, but are correlated to the presence of several waterborne disease-causing organisms. Generally found in the intestinal tract of humans and warm-blooded animals, presence in water indicates fecal pollution.
Fecal streptococci bacteria	--	Indicator bacteria used to assess the quality of water. They are not typically disease causing, but are correlated to the presence of several waterborne disease-causing organisms. Generally found in the intestinal tract of humans and warm-blooded animals, presence in water indicates fecal pollution.
Hardness (mg/L as $CaCO_3$)	--	Related to the soap-consuming characteristics of water; results in formation of scum when soap is added. May cause deposition of scale in boilers, water heaters, and pipes. Hardness contributed by calcium and magnesium, bicarbonate and carbonate mineral species in water is called carbonate hardness; hardness in excess of this concentration is called noncarbonate hardness. Water that has a hardness less than 61 mg/L is considered soft; 61-120 mg/L, moderately hard; 121-180 mg/L, hard; and more than 180 mg/L, very hard (Heath, 1983).
Calcium plus magnesium	--	Cause most of the hardness and scale-forming properties of water (see hardness).
Sodium plus potassium	--	Large concentrations may limit use of water for irrigation and industrial use and, in combination with chloride, give water a salty taste. Abnormally large concentrations may indicate natural brines, industrial brines, or sewage.
Sodium-adsorption ratio (SAR)		A ratio used to express the relative activity of sodium ions in exchange reactions with soil. Important in irrigation water; the greater the SAR, the less suitable the water for irrigation.
Bicarbonate	--	In combination with calcium and magnesium forms carbonate hardness.

Table 8. Water-quality criteria, standards, or recommended limits for selected properties or constituents–Continued

[Modified from Howells, 1979. All concentrations are from U.S. Environmental Protection Agency (1996) unless noted. MCL, maximum contaminant level; SMCL, secondary maximum contaminant level; mL, milliliters; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; --, no limit established]

Constituent or property	Limit	Significance
Sulfate	250 mg/L SMCL	Sulfates of calcium and magnesium form hard scale. Large concentrations of sulfate have a laxative effect on some people and, in combination with other ions, give water a bitter taste.
Chloride	250 mg/L SMCL	Large concentrations increase the corrosiveness of water and, in combination with sodium, give water a salty taste.
Fluoride	4.0 mg/L MCL 2.0 mg/L SMCL	Reduces incidence of tooth decay when optimum fluoride concentrations present in water consumed by children during the period of tooth calcification. Potential health effects of long-term exposure to elevated fluoride concentrations include dental and skeletal fluorosis (U.S. Environmental Protection Agency, 1994).
Silica (as SiO_2)	--	Forms hard scale in pipes and boilers and may form deposits on blades of steam turbines. Inhibits deterioration of zeolite-type water softeners.
Dissolved solids	500 mg/L SMCL	The total of all dissolved mineral constituents, usually expressed in milligrams per liter. The concentration of dissolved solids may affect the taste of water. Water that contains more than 1,000 mg/L is unsuitable for many industrial uses. Some dissolved mineral matter is desirable; otherwise the water would have no taste. The dissolved solids concentration commonly is called the water's salinity and is classified as follows: fresh, 0-1,000 mg/L; slightly saline, 1,000-3,000 mg/L; moderately saline, 3,000-10,000 mg/L; very saline, 10,000-35,000 mg/L; and briny, more than 35,000 mg/L (Heath, 1983).
Nitrite (mg/L as N)	1.0 mg/L MCL	An acute health concern at certain levels of exposure. Nitrite may originate in water from fertilizers and is found in sewage and wastes from humans and farm animals. Concentrations greater than 1.0 mg/L, as nitrogen, may be injurious when used in feeding infants.
Nitrite plus nitrate (mg/L as N)	10 mg/L MCL	Concentrations greater than local background levels may indicate pollution by feedlot runoff, sewage, or fertilizers. Concentrations greater than 10 mg/L, as nitrogen, may be injurious when used in feeding infants.
Phosphorus, orthophosphate	--	Dense agal blooms or rapid plant growth can occur in waters rich in phosphorus. A limiting nutrient for eutrophication because it is typically in shortest supply. Sources are human and animal wastes and fertilizers.
Arsenic	[2]50 µg/L MCL	No known necessary role in human or animal diet, but is toxic. A cumulative poison that is slowly excreted. Can cause nasal ulcers; damage to the kidneys, liver, and intestinal walls; and death. Recently suspected to be a carcinogen (U.S. Environmental Protection Agency, written commun., 1998).
Barium	2,000 µg/L MCL	Toxic; used in rat poison. In moderate to large concentrations can cause death; smaller concentrations cause damage to the heart, blood vessels, and nerves.
Beryllium	4 µg/L MCL	Toxic, suspected human carcinogen and poison. Potential human health effects include eye, lung, liver, spleen, and heart damage.
Boron	--	Essential to plant growth, but may be toxic to crops when present in excessive concentrations in irrigation water. Sensitive plants show damage when irrigation water contains more than 670 µg/L and even tolerant plants may be damaged when boron exceeds 2,000 µg/L. The recommended limit is 750 µg/L for long-term irrigation on sensitive crops (U.S. Environmental Protection Agency, 1986).
Cadmium	5 µg/L MCL	A cumulative poison; very toxic. Not known to be either biologically essential or beneficial. Believed to promote renal arterial hypertension. Elevated concentrations may cause liver and kidney damage, or even anemia, retarded growth, and death.
Chromium	100 µg/L MCL	No known necessary role in human or animal diet. In the hexavalent form is toxic, leading to intestinal damage and to nephritis.

Table 8. Water-quality criteria, standards, or recommended limits for selected properties or constituents–Continued

[Modified from Howells, 1979. All concentrations are from U.S. Environmental Protection Agency (1996) unless noted. MCL, maximum contaminant level; SMCL, secondary maximum contaminant level; mL, milliliters; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; --, no limit established]

Constituent or property	Limit	Significance
Cobalt	--	Importance to human nutrition is not known but the element is essential in plant and animal nutrition. Concentrations of cobalt in the Earth's crust are generally very low. Uncontaminated natural water should generally contain no more than a few micrograms per liter of cobalt (Hem, 1989, p. 139).
Copper	1,300 µg/L (action level)	Essential to metabolism; copper deficiency in infants and young animals results in nutritional anemia. Large concentrations of copper are toxic and may cause liver damage. Moderate levels of copper (near the action level) can cause gastro-intestinal distress. If more than 10 percent of samples at the tap of a public water system exceed 15 µg/L, the USEPA requires treatment to control corrosion of plumbing materials in the system (U.S. Environmental Protection Agency, 1991).
Iron	300 µg/L SMCL	Forms rust-colored sediment; stains laundry, utensils, and fixtures reddish brown. Objectionable for food and beverage processing. Can promote growth of certain kinds of bacteria that clog pipes and well openings.
Lead	15 µg/L (action level)	A cumulative poison, toxic in small concentrations. Can cause lethargy, loss of appetite, constipation, anemia, abdominal pain, gradual paralysis in the muscles, and death. If more than 10 percent of samples of a public supply exceed 15 µg/L, the USEPA recommends treatment to remove lead and monitoring of the water supply for lead content (U.S. Environmental Protection Agency, 1991).
Lithium	--	Reported as probably beneficial in small concentrations (250-1,250 µg/L). Reportedly may help strengthen the cell wall and improve resistance to genetic damage and to disease. Lithium salts are used to treat certain types of psychosis.
Manganese	50 µg/L SMCL	Causes gray or black stains on porcelain, enamel, and fabrics. Can promote growth of certain kinds of bacteria that clog pipes and wells.
Mercury	2 µg/L MCL	No known essential or beneficial role in human or animal nutrition. Liquid metallic mercury and elemental mercury dissolved in water are comparatively nontoxic, but some mercury compounds, such as mercuric chloride and alkyl mercury, are very toxic. Elemental mercury is readily alkylated, particularly to methyl mercury, and concentrated by biological activity. Potential health effects of exposure to some mercury compounds in water include severe kidney and nervous system disorders (U.S. Environmental Protection Agency, 1994).
Molybdenum	--	In minute concentrations, appears to be an essential nutrient for both plants and animals, but in large concentrations may be toxic.
Nickel	--	Very toxic to some plants and animals. Toxicity for humans is believed to be minimal.
Selenium	50 µg/L MCL	Essential to human and animal nutrition in minute concentrations, but even a moderate excess may be harmful or potentially toxic if ingested for a long time (Callahan and others, 1979). Potential human health effects of exposure to elevated selenium concentrations include liver damage (U.S. Environmental Protection Agency, 1994).
Silver	100 µg/L SMCL	Causes permanent bluish darkening of the eyes and skin (argyria). Where found in water is almost always from pollution or by intentional addition. Silver salts are used in some countries to sterilize water supplies. Toxic in large concentrations.
Strontium	--	Importance in human and animal nutrition is not known, but believed to be essential. Toxicity believed minimal—no more than that of calcium.
Thallium	2 µg/L MCL	Toxic; used as rat and insect poison. Potential human health effects of exposure to thallium include eye, central nervous system, liver, and kidney damage. Oral ingestion may be fatal.

Table 8. Water-quality criteria, standards, or recommended limits for selected properties or constituents–Continued

[Modified from Howells, 1979. All concentrations are from U.S. Environmental Protection Agency (1996) unless noted. MCL, maximum contaminant level; SMCL, secondary maximum contaminant level; mL, milliliters; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; --, no limit established]

Constituent or property	Limit	Significance
Vanadium	--	Not known to be essential to human or animal nutrition, but believed to be beneficial in trace concentrations. May be an essential trace element for all green plants. Large concentrations may be toxic.
Zinc	5,000 µg/L SMCL	Essential and beneficial in metabolism; its deficiency in young children or animals will retard growth and may decrease general body resistance to disease. Seems to have no ill effects even in fairly large concentrations (20,000-40,000 mg/L), but can impart a metallic taste or milky appearance to water. Zinc in drinking water commonly is derived from galvanized coatings of piping.
Gross alpha-particle activity	15 pCi/L MCL	The measure of alpha-particle radiation present in a sample. A limit is placed on gross alpha-particle activity because it is impractical at the present time to identify all alpha-particle-emitting radionuclides due to analytical costs. Gross alpha-particle activity is a radiological hazard. The 15 pCi/L standard also includes radium-226, a known carcinogen, but excludes any uranium or radon that may be present in the sample.
Radium-226 & 228 combined	5 pCi/L MCL	Radium locates primarily in bone, however, inhalation or ingestion may result in lung cancer. Radium-226 is a highly radioactive alkaline-earth metal that omits alpha-particle radiation. It is the longest lived of the four naturally occurring isotopes of radium and is a disintegration product of uranium-238. Concentrations of radium in most natural waters are usually less than 1.0 pCi/L (Hem, 1985, p. 149).
Strontium-90	Gross beta-particle activity, man-made (4 millirem/yr) MCL	Strontium-90 is one of 12 unstable isotopes of strontium known to exist. It is a product of nuclear fallout and is known to cause adverse human health affects. Strontium-90 is a bone seeker and a relatively long-lived beta emitter with a half-life of 28 years. The USEPA has calculated that an average annual concentration of 8 pCi/L will produce a total body or organ dose of 4 millirem/yr (U.S. Environmental Protection Agency, 1997).
Thorium-230	Gross alpha-particle activity, 15 pCi/L MCL	Thorium-230 is a product of natural radioactive decay when uranium-234 emits alpha-particle radiation. Thorium-230 also is a radiological hazard because it is part of the uranium-238 decay series and emits alpha-particle radiation through its own natural decay to become radium-226. The half-life of thorium-230 is about 80,000 years.
Tritium (^3H)	Gross beta-particle activity, man-made (4 millirem/yr) MCL	Tritium occurs naturally in the atmosphere but is present largely as a result of testing thermonuclear bombs between 1952-69. It can be incorporated into water molecules that reach the Earth's surface as precipitation. Tritium emits low energy beta particles and is relatively short-lived with a half-life of about 12.3 years. The USEPA has calculated that a concentration of 20,000 pCi/L will produce a total body or organ dose of 4 millirem/yr (U.S. Environmental Protection Agency, 1997).
Uranium	20 µg/L proposed MCL	Uranium is a chemical and a radiological hazard and carcinogen. It omits alpha-particle radiation through natural decay. It is a hard, heavy, malleable metal that can be present in several oxidation states. Generally, the more oxidized states are more soluble. Uranium-238 and uranium-235, which occur naturally, account for most of the radioactivity in water. Uranium concentrations range between 0.1 and 10 µg/L in most natural waters.

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[1] USEPA's policy (U.S. Environmental Protection Agency, 1997, p. 360-361) is that a single positive sample is not an exceedance of the MCL but dictates further monitoring for conformation. Successive positive results may constitute an exceedance of the MCL.

[2] While the drinking water MCL currently remains at 50 µg/L, USEPA is reviewing the standard to have a new MCL set by January 2001; public water suppliers should be concerned about any source-water concentration exceeding 10 µg/L (U.S. Environmental Protection Agency, written commun., 1998).

Table 9. Statistical summary of chemical analyses of spring-water samples collected September 1992 through March 1997

[Site number refers to spring location in fig. 3. Data reported in micrograms per liter except where indicated. ft^3/s, cubic feet per second; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25° Celsius; pCi/L, picocuries per liter; <, less than minimum reporting level]

Property or dissolved constituent	Median values for selected springs sampled multiple times								
	Site numbers								
	S2	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S12**	**S14**
Discharge (ft^3/s)	0.01	0.19	0.07	0.02	0.12	0.03	0.02	0.07	0.01
Specific conductance, field (µS/cm)	494	504	370	520	542	621	512	431	534
pH, field (standard units)	7.5	7.9	8.1	7.8	8.2	7.7	8.3	8.4	8.1
Oxygen, dissolved (mg/L)	5.7	7.8	8.1	8.3	7.6	8.4	9.2	7.5	9.9
Acid neutralizing capacity, field, as $CaCO_3$ (mg/L)	223	249	176	219	278	214	214	217	231
Hardness, total as $CaCO_3$ (mg/L)	120	185	165	110	180	87	82	135	195
Solids, residue at 180° C	327	325	249	335	378	423	335	282	324
Solids, sum of constituents	325	330	252	347	390	419	364	300	321
Calcium (mg/L)	45	60	54	34	59	28	27	46	58
Magnesium (mg/L)	2.3	8.1	7.2	5.9	7.5	4.0	3.0	5.2	11
Sodium (mg/L)	61	36	9.5	64	48	96	73	34	37
Potassium (mg/L)	6.6	9.9	6.4	11	13	11	13	11	6.0
Bicarbonate, HCO_3 (mg/L)	273	321	214	268	339	243	254	277	279
Sulfate (mg/L)	18	7.4	7.6	31	23	66	35	10	45
Chloride (mg/L)	1.7	3.5	0.9	9.7	14	24	11	2.0	5.4
Fluoride (mg/L)	0.2	0.3	0.3	0.3	0.3	0.2	0.3	0.3	0.4
Silica (mg/L)	41	47	49	51	54	59	57	46	18
Nitrite (mg/L as N)	<0.01	<0.01	0.02	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
Nitrogen, nitrite plus nitrate (mg/L as N)	5.0	0.09	2.4	2.4	2.8	4.0	4.0	1.2	<0.05
Phosphorus, orthophosphate (mg/L)	0.07	<0.01	0.02	0.04	0.04	0.01	<0.01	0.03	<0.01
Arsenic	4.0	8.0	8.5	16	14	17	9.0	6.0	<1.0
Barium	150	260	270	70	210	84	46	175	150
Beryllium	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Boron	80	75	30	145	130	220	175	55	60
Cadmium	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chromium	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Cobalt	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Copper	<10	<10	<10	<10	<10	<10	<10	<10	<10

Table 9. Statistical summary of chemical analyses of spring-water samples collected September 1992 through March 1997–Continued

[Site number refers to spring location in fig. 3. Data reported in micrograms per liter except where indicated. ft^3/s, cubic feet per second; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25° Celsius; pCi/L, picocuries per liter; <, less than minimum reporting level]

Property or dissolved constituent	Median values for selected springs sampled multiple times								
	Site numbers								
	S2	S4	S5	S6	S7	S8	S9	S12	S14
Iron	[1]3.2	104	60	<3.0	28	<3.0	<3.0	15	22
Lead	<10	<10	<10	<10	<10	<10	<10	<10	<10
Lithium	27	22	14	25	27	48	36	26	28
Manganese	[1]1.2	21	16	<1.0	59	<1.0	<1.0	5.0	3.0
Mercury	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Molybdenum	<10	<10	<10	<10	<10	15	<10	<10	<10
Nickel	<10	<10	<10	<10	<10	<10	<10	<10	<10
Selenium	2.0	<1.0	1.0	11	3.5	26	10	6.0	3.0
Silver	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Strontium	180	445	340	315	435	310	360	500	480
Thallium	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Vanadium	<6.0	<6.0	7.5	11	8.0	7.0	9.0	6.0	<6.0
Zinc	[1]4.0	<3.0	<3.0	[1]3.2	<3.0	11.2	<3.0	<3.0	<3.0
Gross alpha as uranium natural	7.8	6.4	5.1	11.5	12	22	15.5	8.0	11.2
Gross alpha (pCi/L) as Th-230	5.7	4.4	3.8	8.1	8.5	17	10.1	5.9	8.1
Gross beta (pCi/L) as Cs-137	9.5	10.2	4.1	12	18	15.5	13.4	15.7	11
Radium-226 (pCi/L)	0.2	<0.1	<0.1	0.1	<0.1	0.1	<0.1	0.2	0.2
Uranium	7.1	3.3	2.1	11.0	10	13	9.6	7.2	7.0
Tritium (pCi/L)	100	32	110	9.3	28	2.9	18	25	40

[1] The data set contained reported concentrations for some determinations that were less than the MRL. For these "censored" values, an estimated value of one-half the MRL was substituted to calculate the median.

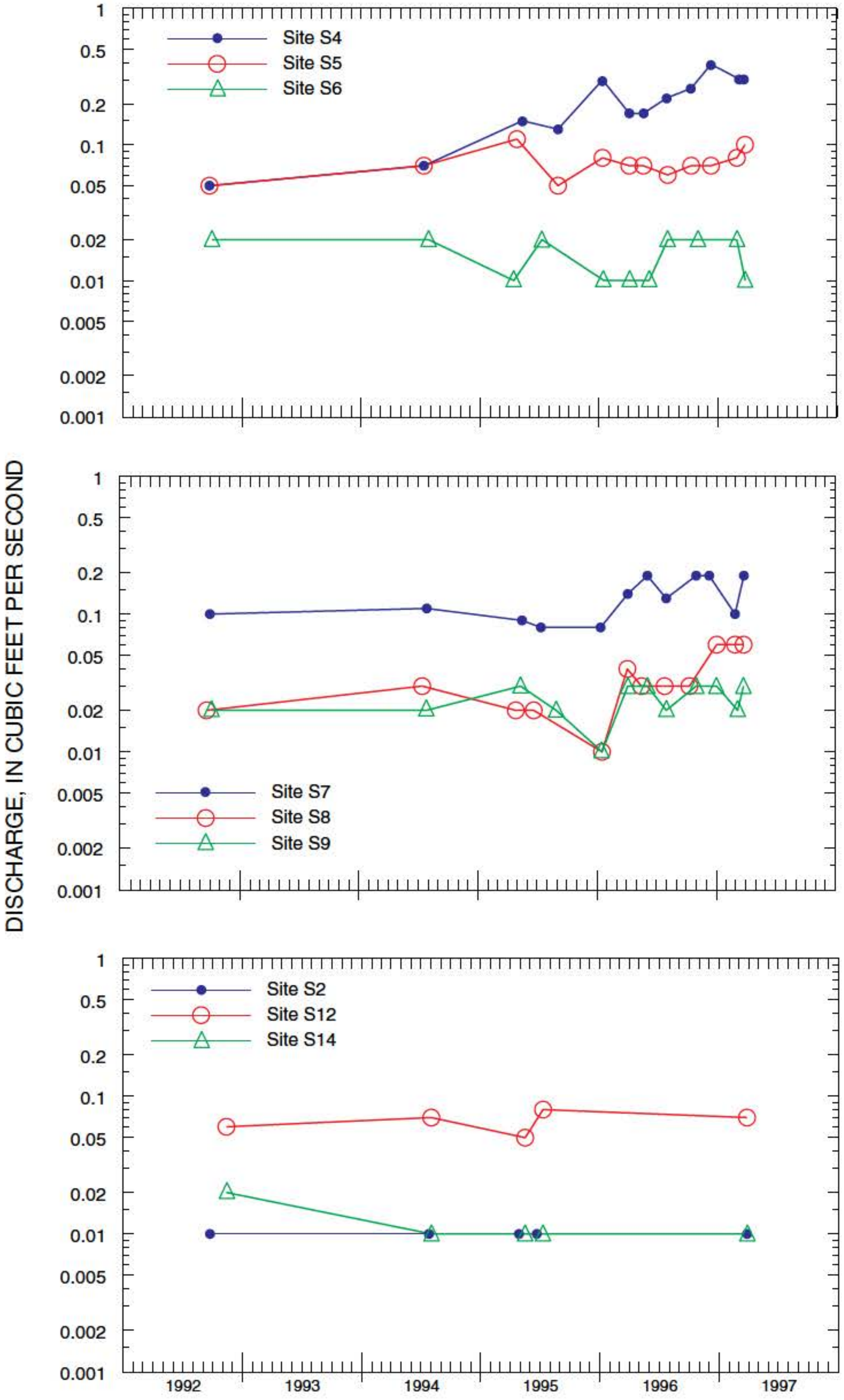


Figure 5. Hydrographs for selected springs (site number and spring location shown in fig. 3).

Concentrations of most constituents for most of the nine springs with multiple samples have relatively small variability (table 13). Concentrations of some trace elements have somewhat larger variability than concentrations of common ions for some springs. Concentrations of many dissolved constituents frequently are inversely related to discharge in surface streams and rivers (Hem, 1985). Variability in discharge for the springs with multiple samples was shown to be relatively small (fig. 5), and no relations between discharge and constituent concentrations were apparent.

Ten of the springs sampled contact the White River Group and four contact the Pierre Shale (table 2). Major-ion data for all samples collected from all 14 springs are presented graphically on trilinear diagrams (fig. 6) using a method developed by Piper (1944). Concentrations of the major dissolved ionic constituents are determined in milliquivalents per liter and expressed as percentages of the total anions and cations present in the water sample. This allows for further classification into different water types based on the relative proportion of anions and cations present. For example, the springs contacting the White River Group range from calcium bicarbonate to sodium bicarbonate water types. Two of the springs (S11 and S14) contacting the Pierre Shale have similar water types; however, sulfate is the dominant anion for springs S10 and S13. Once a water has been classified as a particular water type, it can be used to associate different water sources with a particular water type. Additional information on how trilinear diagrams can be used to classify water into different types can be found in Freeze and Cherry (1979, p. 245-247) and in Back (1966).

Water-quality criteria, standards, and recommended limits for community drinking water, promulgated by the USEPA, are presented in table 8. The analytical results for the spring water samples (table 13) were compared to the standards in table 8 to determine if concentrations of any constituents were present at levels that could be harmful to humans. Water-quality constituents that equalled or exceeded the USEPA drinking-water standards in at least one sample from the springs are summarized in table 10.

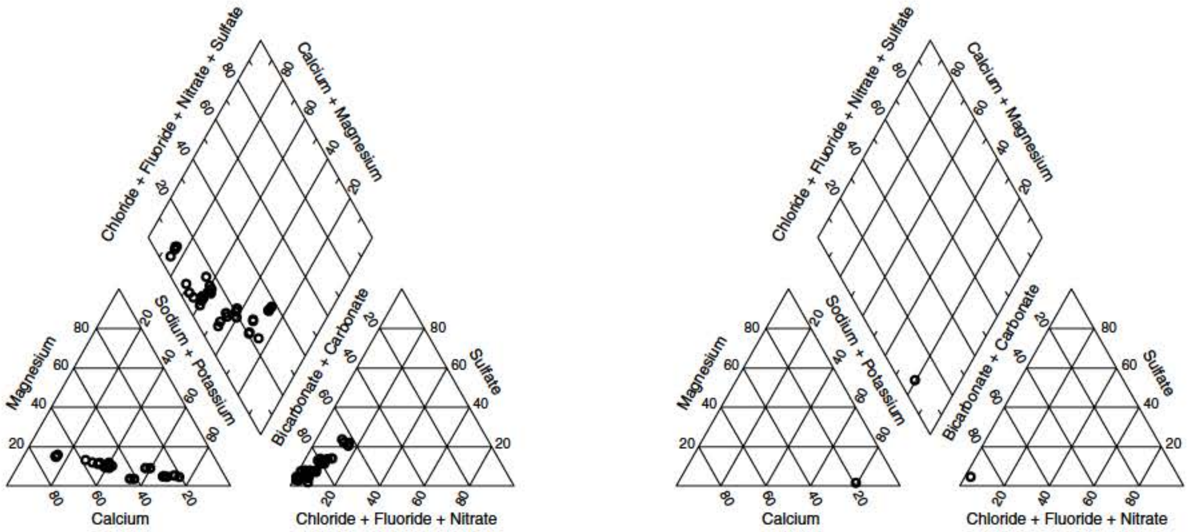
Two springs contacting the White River Group and one spring contacting the Pierre Shale exceeded the upper recommended level of pH 8.5 established by the USEPA (table 10). Recommended levels, or SMCL's, are nonenforceable guidelines that typically are related to aesthetic qualities such as taste, odor, or color.

Five springs (sites S1, S3, S10, S11, and S13) were not sampled for indicator bacteria; however, water from the remaining nine springs produced positive results for presumptive tests for the presence of *E. coli*, total coliform, fecal coliform, and fecal streptococci bacteria one or more times (tables 10 and 13). Whereas these fecal-indicator bacteria typically are not disease causing, they indicate the possible presence of pathogenic organisms. Furthermore, the presence of *E. coli* in water is direct evidence of fecal contamination from warm-blooded animals (Dufour, 1977).

A likely source of bacteria is livestock and other animals that may water at the springs. Although the USEPA standards apply only to public suppliers, local residents should be aware of the potential health risks of bacterial contamination associated with the consumption of water from springs and other untreated sources.

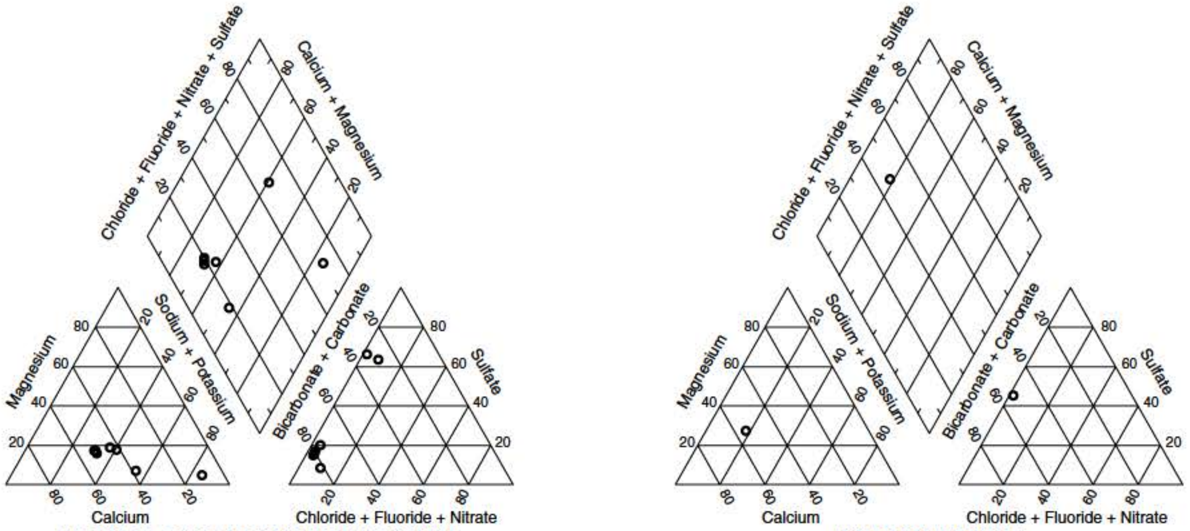
No springs contacting the White River Group equalled or exceeded the SMCL of 250 mg/L established for sulfate (table 10); however, two springs contacting the Pierre Shale had dissolved sulfate values that exceeded the SMCL. No springs contacting the White River Group equalled or exceeded the MCL of 4.0 mg/L established for fluoride; however, one spring contacting the Pierre Shale exceeded the MCL. One spring contacting the White River Group exceeded the SMCL of 500 mg/L for dissolved solids; however, two springs contacting the Pierre Shale had values that exceeded the SMCL. No springs exceeded the MCL of 50 µg/L for arsenic; however, dissolved arsenic exceeded 10 µg/L for seven of the springs contacting the White River Group. The MCL for arsenic may be changed to 10 µg/L (table 8), following a review by USEPA (U.S. Environmental Protection Agency, written commun., 1998). No springs contacting the White River Group equalled or exceeded the SMCL of 300 µg/L for iron; however, two springs contacting the Pierre Shale exceeded the SMCL for iron.

Three springs contacting the White River Group and one spring contacting the Pierre Shale exceeded the action level of 15 µg/L for lead. Two springs contacting the Pierre Shale had censored values of less than 30 µg/L for lead (S10 and S13). Both samples contacting the Pierre Shale had high values for specific conductance that required a three-fold dilution of the sample prior to analysis. This caused the reporting level for lead to be changed from 10 to 30 µg/L (the reporting level multiplied times the dilution factor). It is therefore not possible to ascertain if these samples exceeded the 15 µg/L action level established for lead. Although the precision data for lead showed no problems for field duplicate samples, the analysis of the SRS's submitted to the NWQL did indicate unacceptable analytical variability. Lead concentrations reported for all environmental samples should therefore be interpreted cautiously.



SPRINGS CONTACTING WHITE RIVER GROUP

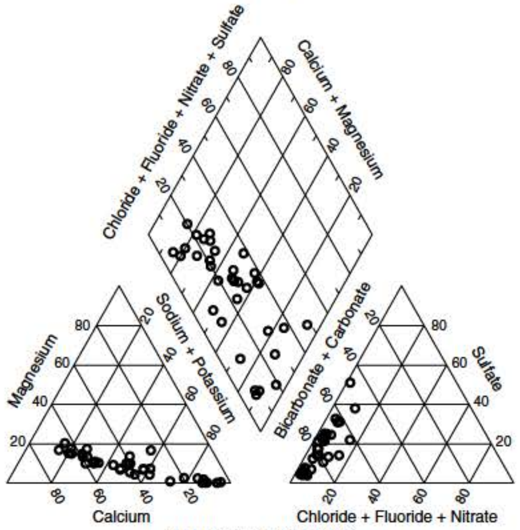
ALLUVIAL WELL



SPRINGS CONTACTING PIERRE SHALE

INYAN KARA WELL

NOTE: Concentrations expressed as percentages of total anions and cations present in the water sample.



ARIKAREE WELLS

Figure 6. Trilinear diagrams showing proportional concentrations of major ions in ground-water samples from selected springs and wells.

Table 10. Comparison of water-quality data for selected springs to U.S. Environmental Protection Agency drinking-water standards

[Site number refers to spring location in fig. 3; SMCL, secondary maximum contaminant level; MCL, maximum contaminant level]

Site number	Spring name	Confining unit	Constituents of concern[1]	Type of standard equalled or exceeded[1]
S1	South Hubner	White River Group	Solids Arsenic	SMCL ([2])
S2	Old Road	White River Group	Bacteria	Presence[3]
S3	Red Shirt Table	White River Group	Arsenic	([2])
S4	Cuny Cafe	White River Group	pH Bacteria Arsenic Lead	SMCL Presence[3] ([2]) Action level
S5	South Corral	White River Group	Bacteria Lead	Presence[3] Action level
S6	Davey Cuny	White River Group	Arsenic Bacteria	([2]) Presence[3]
S7	Blackfeather	White River Group	Arsenic Bacteria	([2]) Presence[3]
S8	Duhamill	White River Group	Arsenic Bacteria	([2]) Presence[3]
S9	Mill’s East	White River Group	Arsenic Bacteria Lead	([2]) Presence[3] Action level
S10	Rapp North	Pierre Shale	Sulfate Fluoride Solids Iron	SMCL MCL SMCL SMCL
S11	Slide	Pierre Shale	Iron	SMCL
S12	Heathershaw	White River Group	pH Bacteria	SMCL Presence[3]
S13	Red Shirt Table N/E	Pierre Shale	Sulfate Solids	SMCL SMCL
S14	Knupe North	Pierre Shale	pH Bacteria Lead	SMCL Presence[3] Action level

[1] USEPA standards apply to total constituents; however, analyses performed were for dissolved constituents.

[2] Current MCL of 50 µg/L not exceeded; however, USEPA is reviewing the standard to have a new MCL set by January 2001; public water suppliers should be concerned about any source-water concentrations exceeding 10 µg/L (U.S. Environmental Protection Agency, written commun., 1998).

[3] USEPA’s policy (U.S. Environmental Protection Agency, 1997, p. 360-361) is that a single positive sample is not an exceedance of the MCL but dictates further monitoring for conformation. Successive positive results may constitute an exceedance of the MCL.

One spring contacting the White River Group and two springs contacting the Pierre Shale exceeded 15 pCi/L for gross alpha. Because the USEPA standard for gross alpha includes radium-226 but excludes any uranium or radon present in a sample, it is not possible to conclusively determine if any of these samples exceed the MCL. This is because the units used to present results for gross alpha and uranium were different. Therefore, additional samples could be collected at sites where gross alpha equalled or exceeded 15 pCi/L. The new samples could be analyzed for gross alpha, ^{234}U, ^{235}U, ^{238}U, and radon in picocuries per liter so that the radioactivity contributed by uranium and radon can be subtracted. The resulting "adjusted" gross alpha values could then be appropriately compared to the MCL.

Nine springs were analyzed for tritium to generally assess the age of the water and to determine if concentrations exceeded the MCL established for gross beta-particle activity. Results of tritium analyses are presented in table 11. Although tritium occurs naturally, large amounts of manmade tritium were introduced into the atmosphere during the era of large-scale testing of thermonuclear bombs between 1952 and 1969 (Freeze and Cherry, 1979). Payne (1972) estimated that prior to atmospheric testing in 1952, the natural content of precipitation was in the range of 5 to 20 TU [one TU (tritium unit) = one tritium atom per 1,018 hydrogen atoms]. Between 1953 and 1962, monthly tritium values in precipitation at Ottawa, Canada, generally increased. During 1963, monthly tritium values in precipitation peaked at about 1,400 TU. Since 1963, monthly tritium values in precipitation generally have decreased (Freeze and Cherry, 1979). Because the half-life of tritium is 12.3 years, ground water that was recharged prior to 1953 would have tritium concentrations about 2 to 4 TU, or less. Ground water that contains tritium at concentrations greater than about 30 TU probably has a relatively large percentage of water that was recharged during the bomb-testing era. Ground water that contains intermediate concentrations of tritium probably result from bomb-testing era water mixed with pre- or post-bomb water.

The USGS reports tritium values in picocuries per liter, which can be converted to tritium units by dividing picocuries per liter by 3.24. Tritium values for the nine springs ranged from 0.9 to 33.9 TU. Two springs (S6 and S8) had values less than 4 TU and probably are composed primarily of pre-bomb water indicating a relatively long travel time from areas of recharge to areas of discharge. Two springs (S2 and S5) had values greater than 30 TU and probably consist of a relatively large percentage of test-era water. The remaining five springs (S4, S7, S9, S12, and S14) had values that ranged from 5.5 to 12 TU and probably have some test-era water. Additional study would be required to determine if the tritium values for these five springs fall on the increasing or decreasing side of the 1963 tritium peak.

Table 11. Tritium and pesticide analyses for selected springs

[Site number refers to spring location in fig. 3. Data reported in micrograms per liter except as indicated; pCi/L, picocuries per liter; <, less than]

Site number	Date sampled	Tritium total (pCi/L) (07000)	Tritium 2 sigma water, whole, total (pCi/L) (75985)	Tritium total (tritium units[1])	Atrazine	Carbaryl	2,4-D
S2	3-26-97	100	5.8	30.9	<0.1	<0.4	<1.0
S4	3-24-97	32	3.2	9.9	<0.1	<0.4	<1.0
S5	3-24-97	110	9.6	33.9	<0.1	<0.4	<1.0
S6	3-25-97	9.3	1.0	2.9	<0.1	<0.4	<1.0
S7	3-26-97	28	1.9	8.6	<0.1	<0.4	<1.0
S8	3-25-97	2.9	1.0	.9	<0.1	<0.4	<1.0
S9	3-25-97	18	1.3	5.5	<0.1	<0.4	<1.0
S12	3-27-97	25	2.6	8.6	<0.1	<0.4	<1.0
S14	3-26-97	40	2.6	12.3	<0.1	<0.4	<1.0

[1] pCi/L divided by 3.24 equals tritium units.

Pesticide samples were collected from nine springs and analyzed at the local USGS office laboratory by the enzyme-linked immunoassay method (table 11). Analysis of atrazine, carbaryl, and 2,4-D (the most commonly used pesticides in the area) were all below minimum reporting levels of 0.1, 0.4, and 1.0 µg/L, respectively.

In general, springs contacting the White River Group are shown to have better potential as alternative sources of water supply for the village of Red Shirt than springs contacting the Pierre Shale. All of the springs sampled that contact the Pierre Shale exceeded SMCL's for one or more constituents. In addition, discharge from most of the springs contacting the Pierre Shale, considered individually, probably would not provide an adequate supply of water.

Nine of the springs with better water quality were sampled repeatedly, of which six (sites S4-S9) were subsequently selected for additional discharge measurements. These six springs, of which five contact the White River Group, probably have the best potential for use as water supplies. Discharge from any of these six springs probably would supply adequate yield for Red Shirt during most periods, based on the limited number of discharge measurements. Concentrations of lead exceeded the USEPA action level of 15 µg/L for three of these six springs; however, results may be unreliable because of analytical uncertainty. Additional sampling using low-level analysis could accurately quantify lead concentrations in these springs. Five of these six springs also had arsenic concentrations that exceeded 10 µg/L, which could be problematic if the current MCL is lowered (U.S. Environmental Protection Agency, written commun., 1998).

Blending of water from one or more springs with water from the existing well completed in the Inyan Kara aquifer may be an option for providing additional water supply for Red Shirt. Blending could be used to address concerns regarding both quantity and quality of existing and potential sources.

Public-Supply Wells

Forty-four public-supply wells were sampled during 1995-97. Water-quality data are presented in table 14 in the Supplemental Data section. Forty-two of the wells sampled were completed in the Arikaree aquifer, one was completed in an alluvial aquifer, and one was completed in the Inyan Kara aquifer (table 3). Water from the alluvial well is a sodium bicarbonate water type, and water from the Inyan Kara well is a calcium sulfate bicarbonate water type (fig. 6). Water from the Arikaree aquifer ranges from calcium bicarbonate to sodium bicarbonate water types. Water-quality constituents that equalled or exceeded USEPA drinking-water standards for selected public-supply wells are summarized in table 12.

Positive detections for indicator bacteria were common, with samples from the alluvial well, Inyan Kara well, and 26 of the Arikaree wells testing positive. In all, 28 of 44 (64 percent) of the wells sampled tested positive for the presence of bacteria. Of the 44 wells sampled, 13 (29 percent) tested positive for *E. coli* bacteria, 27 (61 percent) tested positive for total coliform bacteria, 9 (20 percent) tested positive for fecal coliform bacteria, and 12 (27 percent) tested positive for fecal streptococci bacteria.

Most of the bacteria samples, with the exception of sites 6, 11, and 12, were collected from sampling ports located upstream of chemical treatment feeders, as described in the section titled "Sampling Methods." Thus, bacterial detections do not necessarily constitute exceedances of drinking-water standards, which apply to successive positive detections using colony confirmation methods for treated water (table 8). However, 16 percent of the wells sampled (sites 1, 13, 14, 15, 17, 39, and 42) simultaneously tested positive for total coliform, fecal coliform, and fecal streptococci bacteria. Even though this study used only presumptive tests to determine bacterial concentration, the fact that some wells tested positive for several different types of indicator bacteria may be viewed as strong evidence of fecal contamination in water samples collected from those wells. Occurrences of bacteria in well water can be transient, with bacterial detections occurring sporadically. Additional information regarding results of samples of treated water from selected public-supply wells that have been collected and analyzed for bacteria and other constituents are available from the U.S. Public Health Service (1996).

It is not possible to determine the sources of the indicator bacteria from the reconnaissance-level sampling that was performed. Many possible bacterial sources exist, including introduction of bacteria into well casings by insects or rodents; water moving downward along the borehole annulus outside the casing; and water moving through the aquifer media to the well. Widespread bacterial contamination could occur from leaking sewage lagoons or surface streams that have numerous potential bacterial sources. Additional studies would be necessary to evaluate potential sources of bacteria to individual wells.

Table 12. Comparison of water-quality data for selected public-supply wells to U.S. Environmental Protection Agency drinking-water standards

[Site number refers to well location in fig. 3; SMCL, secondary maximum contaminant level; MCL, maximum contaminant level; --, none of the constituents analyzed equalled or exceeded standards]

Site number	Community or facility served/well identifier	Aquifer	Constituents of concern[1]	Type of standard equalled or exceeded[1]
1	Wakpamni	Arikaree	Bacteria Arsenic	Presence[2] ([3])
2	Pine Ridge/Pine Ridge Water and Sewer	Arikaree	--	--
3	Pine Ridge/New Hospital No.1	Arikaree	Nitrite plus nitrate Bacteria	MCL Presence[2]
4	Pine Ridge/New Hospital No.2	Arikaree	--	--
5	Wolf Creek	Arikaree	Bacteria	Presence[2]
6	Pine Ridge/Old Hospital No.6	Arikaree	--	--
7	Pine Ridge/ No.12	Arikaree	Solids	SMCL
8	Pine Ridge/Baker’s Hill	Arikaree	Bacteria	Presence[2]
9	Pine Ridge/ PWS-7	Arikaree	pH	SMCL
10	Pine Ridge/OCS Campus	Arikaree	Sulfate Bacteria Uranium Solids	SMCL Presence[2] Proposed MCL SMCL
11	Batesland	Arikaree	Bacteria	Presence[2]
12	Wolf Creek School	Arikaree	Bacteria	Presence[2]
13	Oglala/PWS-2C	Arikaree	Bacteria	Presence[2]
14	Oglala/PWS-2D	Arikaree	Bacteria Arsenic	Presence[2] ([3])
15	Oglala/PWS-5	Arikaree	Bacteria Arsenic	Presence[2] ([3])
16	Oglala/PWS-4	Arikaree	Bacteria	Presence[2]
17	Oglala/PWS-7C	Arikaree	Bacteria	Presence[2]
18	Calico	Arikaree	Bacteria	Presence[2]
19	Red Cloud School/ Main	Arikaree	Arsenic	([3])
20	Red Cloud School/ North East	Arikaree	--	--
21	Wounded Knee Housing Authority/No.2	Arikaree	--	--
22	Wounded Knee Housing Authority/No.1	Arikaree	Bacteria	Presence[2]
23	American Horse School	Arikaree	--	--
24	Allen Housing Authority	Arikaree	--	--
25	Porcupine School	Arikaree	Bacteria	([4])
26	Our Lady of Lourdes School	Arikaree	Bacteria Uranium	Presence[2] Proposed MCL
27	Porcupine	Arikaree	Fluoride Uranium	MCL Proposed MCL
28	Manderson Housing Authority	Arikaree	Bacteria Uranium	Presence[2] Proposed MCL
29	Wounded Knee School	Arikaree	--	--

Table 12. Comparison of water-quality data for selected public-supply wells to U.S. Environmental Protection Agency drinking-water standards–Continued

[Site number refers to well location in fig. 3; SMCL, secondary maximum contaminant level; MCL, maximum contaminant level; --, none of the constituents analyzed equalled or exceeded standards]

Site number	Community or facility served/well identifier	Aquifer	Constituents of concern[1]	Type of standard equalled or exceeded[1]
30	Sharp's Housing Authority	Arikaree	Arsenic Solids Uranium	([3]) SMCL Proposed MCL
31	Evergreen Housing Authority	Arikaree	Bacteria Uranium	Presence[2] Proposed MCL
32	Kyle/No.5	Arikaree	Bacteria	Presence[2]
33	Kyle/No.2	Arikaree	Bacteria	Presence[2]
34	Kyle/BIA No. 1	Arikaree	--	--
35	Kyle/No.1	Arikaree	Bacteria	Presence[2]
36	Kyle/No.3	Arikaree	Bacteria	Presence[2]
37	Rockyford School/Jim Hart	Arikaree	Bacteria Solids Arsenic Uranium	Presence[2] SMCL MCL Proposed MCL
38	Potato Creek Housing Authority	Alluvium	Bacteria Solids Arsenic Lead	Presence[2] SMCL ([3]) Action level
39	Wanblee East Housing Authority	Arikaree	Bacteria Arsenic	Presence[2] ([3])
40	Wanblee Housing Authority	Arikaree	Uranium	Proposed MCL
41	Wanblee North Housing Authority	Arikaree	Bacteria	Presence[2]
42	Wanblee West Housing Authority	Arikaree	Bacteria	Presence[2]
43	Crazy Horse School	Arikaree	--	--
44	Red Shirt	Inyan Kara	Bacteria Arsenic Iron Manganese Ra-226	Presence[2] ([3]) SMCL SMCL MCL

[1] USEPA standards apply to total constituents; however, analyses performed were for dissolved constituents.

[2] USEPA's policy (U.S. Environmental Protection Agency, 1997, p. 360-361) is that a single positive sample is not an exceedance of the MCL but dictates further monitoring for conformation. Successive positive results may constitute an exceedance of the MCL.

[3] Current MCL of 50 µg/L not exceeded; however, USEPA is reviewing the standard to have a new MCL set by January 2001; public water suppliers should be concerned about any source-water concentrations exceeding 10 µg/L (U.S. Environmental Protection Agency, written commun., 1998).

[4] Only fecal streptococcus bacteria were detected, and they are not regulated under USEPA's total coliform rule.

Other investigators have reported similar problems with respect to bacterial contamination. Heintzman (1988) sampled 39 wells in the Arikaree aquifer on the western part of the Reservation, with 51 percent of the wells sampled testing positive for either fecal coliform or fecal streptococcus bacteria. Whereas Heintzman's (1988) results showed higher percentages of detections for fecal coliform and fecal streptococcus bacteria than this study, he sampled only private wells that typically were shallow. Heintzman (1988) suggested on-site wastewater disposal systems such as septic tanks or pit privies as likely sources of bacteria for the shallow wells considered.

Only one well exceeded the MCL for arsenic of 50 µg/L. This was site number 37, which is completed in the Arikaree aquifer. Six additional wells in the Arikaree aquifer, as well as the alluvial well (site number 38) and the Inyan Kara well (site number 44), had dissolved arsenic concentrations that equalled or exceeded 10 µg/L. The MCL for arsenic may be changed to 10 µg/L, following a review by USEPA (U.S. Environmental Protection Agency, written commun., 1998).

The sample collected from the alluvial well also exceeded the SMCL of 500 mg/L for dissolved solids and the action level of 15 µg/L for lead. Although concentrations of lead in blanks and duplicate samples showed no contamination, SRS's submitted to the NWQL indicated unacceptable levels of analytical variability for lead. Therefore, lead values presented in this report for all environmental samples should be interpreted cautiously.

The sample collected from the Inyan Kara well exceeded the SMCL of 300 µg/L for iron and the SMCL of 50 µg/L for manganese. Although all 44 wells were analyzed for radium-226, only water from the Inyan Kara aquifer exceeded the MCL of 5 pCi/L for radium-226 and 228 combined.

One sample collected from an Arikaree well exceeded the SMCL for pH of 8.5. One sample exceeded the SMCL of 250 mg/L for sulfate, four samples exceeded the SMCL of 500 mg/L for dissolved solids, one sample exceeded the MCL of 4.0 mg/L for fluoride, and one sample exceeded the action level of 15 µg/L for lead.

One sample collected from an Arikaree well equalled the MCL of 10 mg/L for dissolved NO_2 (nitrite) plus NO_3 (nitrate). Nitrate values for all samples from the Arikaree aquifer ranged from 0.3 to 10.0 mg/L and had a median value of 1.3 mg/L. Mueller and Helsel (1996) compiled nitrate values from 1,100 public-supply wells located throughout the country and determined the median value was less than 0.2 mg/L (42 of the 44 public-supply wells sampled for this study exceeded this value). They also determined that natural concentrations of nitrate in ground water generally are less than 2 mg/L (7 of the 44 public-supply wells sampled exceeded this value). Concentrations of dissolved NO_2 plus NO_3 above 2 mg/L may indicate that the ground water has been affected by sources of contamination such as feedlot runoff, sewage, or fertilizers. More information would be needed to determine if nitrate concentrations above 2 mg/L found in some of the public-supply wells on the Reservation are natural or result from anthropogenic sources.

Carter (1997) reported similar nitrate concentrations in 14 domestic and 18 observation wells completed in the Arikaree aquifer located on the Rosebud Indian Reservation, which is east of the study area. Concentrations of dissolved NO_2 plus NO_3 ranged from <0.005 to 4.0 mg/L with a median value of 1.1 mg/L.

Ten of the 44 (23 percent) samples equalled or exceeded 15 pCi/L for gross-alpha radioactivity. Sites exceeding 15 pCi/L could be resampled and analyzed for gross alpha, ^{234}U, ^{235}U, ^{238}U, and radon in picocuries per liter, so that the radioactivity contributed by uranium and radon can be subtracted. The "adjusted" gross alpha values could then be compared to the MCL. Of the 44 wells sampled, 8 (18 percent) equalled or exceeded the proposed MCL of 20 µg/L for uranium, and 33 (75 percent) equalled or exceeded one-half of the proposed MCL.

Reasons for the elevated concentrations of dissolved uranium in the Arikaree aquifer are not completely understood. Dunham (1961) investigated the occurrence of uranium contained in Cretaceous shales in an area extending from northern Nebraska into southern Shannon County in South Dakota. Dunham (1961) hypothesized that downward-moving water may have leached uranium from volcanic ash deposited during Miocene and Oligocene time. Additional studies would be needed to better understand the geochemical processes responsible for elevated uranium concentrations.

Five samples collected for dissolved uranium also were analyzed for the isotopes of uranium (^{234}U, ^{235}U, and ^{238}U). The uranium isotope data for sites 27, 28, 30, 31, and 37 are presented in table 14 in the Supplemental Data section. The composition of natural uranium is about 99.3 percent ^{238}U and 0.7 percent ^{235}U (Magill and others, 1995). Weapons grade uranium is enriched with ^{235}U until its composition is about 93.5 percent ^{235}U and 6.5 percent ^{238}U. If the uranium present in water samples collected from the five wells was from a nuclear weapon, elevated ^{235}U values would have been detected, considering that the half-life of ^{235}U is 7.04 x 10^8 years. However, analyses of uranium isotopes indicate a natural distribution of ^{234}U, ^{235}U, and ^{238}U, with ^{235}U present only at background levels, suggesting that the uranium source is natural.

A method that compares the activity ratio between ^{235}U and ^{238}U also was used to determine the source of uranium detected in water samples collected from the five wells. The activity ratio between ^{235}U/^{238}U has been determined to be about 0.046 in naturally occurring uranium (Tom Kraemer, U.S. Geological Survey, written commun., 1998). Dividing the ^{235}U concentrations obtained for the five water samples by their corresponding ^{238}U concentrations should result in a value less than about 0.046 if the uranium detected is naturally occurring. The ^{235}U/^{238}U ratios were less than 0.046 for sites 27, 28, 30, and 31; however, the ratio is slightly larger than 0.046 for site 37. Considering the variability (2 sigma values) associated with the ^{235}U and ^{238}U values (table 14), the ratio for site 37 might also be less than 0.046. Thus, it is concluded that the uranium source is naturally occurring for all of the samples.

SUMMARY AND CONCLUSIONS

Discharge and water-quality data were collected during 1992-97 for 14 contact springs located in the northwestern part of the Reservation. Data were collected to evaluate potential alternative sources of water supply for the village of Red Shirt, which currently obtains water of marginal quality from a well completed in the Inyan Kara aquifer. During 1995-97, water-quality data also were collected for 44 public-supply wells that currently serve as the primary source of water for about one-half of the Reservation's population. Quality-assurance sampling was used to evaluate the precision and accuracy of environmental samples.

Ten of the springs sampled contact the White River Group, and four contact the Pierre Shale. Springs contacting the White River Group range from calcium bicarbonate to sodium bicarbonate water types. Two springs contacting the Pierre Shale have water types similar to this; however, sulfate is the dominant anion for the other two springs.

In general, springs contacting the White River Group are shown to have better potential as alternative sources of water supply for the village of Red Shirt than springs contacting the Pierre Shale. All of the springs sampled that contact the Pierre Shale exceeded SMCL's for one or more constituents. In addition, discharge from most of these springs probably would not provide an adequate supply of water.

Nine of the springs with better water quality were sampled repeatedly; however, only minor variability in water quality was identified. Six of these nine springs were subsequently selected for additional discharge measurements. These six springs, of which five contact the White River Group, probably have the best potential for use as water supplies. Discharge from any of these six springs probably would supply adequate discharge for Red Shirt during most periods, based on the limited number of discharge measurements. Concentrations of lead exceeded the USEPA action level of 15 µg/L for three of these six springs; however, results may be unreliable because of analytical uncertainty. Additional sampling using low-level analysis would be required to accurately quantify lead concentrations in these springs. Five of these six springs also had arsenic concentrations that exceeded 10 µg/L, which could be problematic if the current MCL is lowered. Blending of water from one or more springs with water from the existing Inyan Kara well may be an option for providing additional water supply for Red Shirt. Blending could be used to address concerns regarding both quantity and quality of existing and potential sources.

The nine springs with multiple samples included analyses for various indicator bacteria; the other five springs were not sampled for the presence of bacteria. All nine springs that were sampled for bacteria had positive detections for presumptive tests on one or more occasions. Although USEPA standards for bacteria apply only to public-water supplies, local residents using spring water for domestic purposes should be aware of the potential health risks associated with consuming untreated water.

One spring contacting the White River Group and two springs contacting the Pierre Shale exceeded 15 pCi/L for gross alpha. Because the USEPA standard for gross alpha includes radium-226 but excludes any uranium or radon present in a sample, it is not possible to conclusively determine if any of these samples exceed the MCL. This is because different units are used to present results for gross alpha and uranium in this report. Thus, for samples where gross alpha exceeds 15 pCi/L, accurate comparison to the MCL would require additional sampling with analyses for ^{234}U, ^{235}U, ^{238}U, and radon in picocuries per liter. Then, radioactivity contributed by uranium and radon could be subtracted.

Nine springs were sampled for selected pesticides and tritium. The pesticides atrazine, carbaryl, and 2,4-D were not detected in any of the samples. Tritium results for two springs showed that they were probably composed primarily of water recharged prior to atmospheric testing of nuclear bombs. Results for two other springs indicated a relatively large percentage of test-era water. The remaining five springs had tritium values that indicated some percentage of test-era water; however, additional sampling would be needed to determine whether water is predominantly pre- or post-bomb age.

During 1995-97, water-quality data were collected for 44 public-supply wells in the study area. Forty-two of these wells were completed in the Arikaree aquifer, one was completed in an alluvial aquifer, and one was completed in the Inyan Kara aquifer. Water from the alluvial aquifer is a sodium bicarbonate water type, water from Arikaree aquifer ranges from calcium bicarbonate to sodium bicarbonate types, and water from the Inyan Kara aquifer is a calcium sulfate bicarbonate type.

Of the 44 wells sampled, 28 (64 percent) tested positive for indicator bacteria during presumptive tests. Because these were single samples that generally were collected upstream from chemical treatment feeders, positive detections do not necessarily constitute exceedances of drinking-water standards. However, 16 percent of the wells sampled (sites 1, 13, 14, 15, 17, 39, and 42) simultaneously tested positive for total coliform, fecal coliform, and fecal streptococci bacteria, which provides strong evidence of fecal contamination at these sites even though only presumptive tests were used for this study.

A single sample from an Arikaree well exceeded the MCL for arsenic of 50 μg/L. Arsenic exceeded 10 μg/L for six additional Arikaree wells and for the alluvial well and the Inyan Kara well, which could be problematic if the current MCL is lowered. The alluvial well also exceeded the SMCL for dissolved solids and the action level for lead. The Inyan Kara well exceeded the SMCL's for iron and for manganese and the MCL of 5 pCi/L for radium-226 and 228 combined. Several Arikaree wells exceeded SMCL's for either pH, sulfate, dissolved solids, iron, or manganese.

One Arikaree well exceeded the MCL of 4.0 mg/L for fluoride and another exceeded the MCL of 10 mg/L for nitrite plus nitrate. Seven of the wells sampled exceeded natural concentrations for nitrate (generally less than 2 mg/L) for ground water, which sometimes is used as an indicator of possible contamination from various sources. More information would be needed to determine sources of nitrate in the Arikaree aquifer.

Ten Arikaree wells equalled or exceeded 15 pCi/L for gross alpha; however, these values do not necessarily constitute exceedances of the MCL, which excludes radioactivity contributed by uranium and radon, as discussed above. Additional sampling would be needed to conclusively determine if samples exceeded the MCL.

Eight of the wells (18 percent), all from the Arikaree aquifer, equalled or exceeded the proposed MCL of 20 μg/L for uranium. In all, 33 wells (75 percent) equalled or exceeded one-half of the proposed MCL. Although the standard for uranium has only been proposed, additional information regarding the extent of elevated uranium concentrations in the Arikaree aquifer, and the geochemical processes involved, may be beneficial. It was determined from analyses of uranium isotope data for five wells that the source of elevated uranium concentrations is naturally occurring, rather than anthropogenic.

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SUPPLEMENTAL DATA

Table 13. Spring water-quality data

[US/CM, microsiemens per centimeter at 25°Celsius; DEG C, degrees Celsius; mm, millimeters; mg/L, milligrams per liter; UG/L, micrograms per liter; COL/100 ML, colonies per 100 milliliters; AC-FT, acre-feet; PCI/L, picocuries per liter; K, non-ideal colony count; <, less than; >, greater than; --, no data. The term non-ideal colony count is used when all filters analyzed for a sample failed to produce colony counts in the established ideal range]

SITE NUMBER	DATE	DISCHARGE, INST. CUBIC FEET PER SECOND (00061)	SPECIFIC CONDUCTANCE (US/CM) (00095)	PH WATER WHOLE FIELD (STANDARD UNITS) (00400)	TEMPERATURE AIR (DEG C) (00020)	TEMPERATURE WATER (DEG C) (00010)	BAROMETRIC PRESSURE (MM OF HG) (00025)	OXYGEN, DISSOLVED (MG/L) (00300)	OXYGEN, DISSOLVED (PERCENT SATURATION) (00301)	HARDNESS TOTAL (MG/L AS CACO3) (00900)
S1	09-29-92	.001	819	8.1	19.0	18.0	688	6.0	70	18
S2	09-23-92	.01	497	7.5	22.0	18.5	685	4.0	47	120
	07-26-94	.01	494	7.1	23.0	16.5	--	5.8	68	120
	04-27-95	.01	493	7.6	9.0	10.0	--	6.4	--	110
	06-21-95	.01	494	7.3	28.0	15.0	--	5.7	--	120
	03-26-97	.01	489	7.8	--	10.0	--	--	--	--
S3	09-21-92	.003	678	8.4	24.0	19.0	680	7.9	105	95
S4	09-25-92	.05	504	7.8	17.0	15.0	673	6.5	76	180
	07-13-94	.07	477	7.9	18.5	18.5	--	9.0	--	180
	05-11-95	.16	486	8.3	16.0	14.0	668	10.0	111	190
	08-28-95	.13	608	7.9	24.0	19.5	--	6.7	--	190
	01-12-96	.30	--	--	--	--	--	--	--	--
	04-03-96	.17	--	--	--	--	--	--	--	--
	05-16-96	.17	--	--	--	--	--	--	--	--
	07-26-96	.22	--	--	--	--	--	--	--	--
	10-10-96	.26	--	--	--	--	--	--	--	--
	12-10-96	.39	--	--	--	--	--	--	--	--
	03-07-97	.30	--	--	--	--	--	--	--	--
	03-24-97	.30	540	8.6	--	6.0	--	--	--	--
S5	09-22-92	.05	370	8.1	23.5	15.0	686	8.3	109	180
	07-12-94	.07	377	8.0	26.0	17.0	--	7.9	96	160
	04-24-95	.10	360	8.4	15.0	11.0	628	9.8	108	170
	08-28-95	.05	390	7.8	25.0	19.5	--	7.6	--	160
	01-12-96	.08	--	--	--	--	--	--	--	--
	04-03-96	.07	--	--	--	--	--	--	--	--
	05-16-96	.07	--	--	--	--	--	--	--	--
	07-30-96	.06	--	--	--	--	--	--	--	--
	10-10-96	.07	--	--	--	--	--	--	--	--
	12-10-96	.07	--	--	--	--	--	--	--	--
	02-27-97	.08	--	--	--	--	--	--	--	--
	03-24-97	.10	330	8.1	--	9.5	--	--	--	--
S6	09-30-92	.02	520	7.9	15.0	14.5	686	8.0	86	110
	07-27-94	.02	521	7.8	20.0	13.0	--	9.0	98	120
	04-14-95	.01	519	7.8	15.0	11.5	688	8.6	87	110
	07-10-95	.02	582	7.8	28.0	13.5	--	7.4	--	110
	01-16-96	.01	--	--	--	--	--	--	--	--
	04-04-96	.01	--	--	--	--	--	--	--	--
	06-03-96	.01	--	--	--	--	--	--	--	--
	07-30-96	.02	--	--	--	--	--	--	--	--
	10-31-96	.02	--	--	--	--	--	--	--	--
	02-27-97	.02	--	--	--	--	--	--	--	--
	03-25-97	.01	509	7.9	--	12.0	--	--	--	--
S7	10-01-92	.09	559	8.1	28.0	19.0	679	8.3	100	180
	07-28-94	.10	542	7.9	30.0	20.0	--	6.7	--	180
	05-16-95	.09	592	8.2	20.0	14.5	685	8.9	97	190
	07-13-95	.08	510	8.3	31.0	20.0	--	7.0	--	170
	01-12-96	.08	--	--	--	--	--	--	--	--
	04-04-96	.14	--	--	--	--	--	--	--	--
	06-03-96	.19	--	--	--	--	--	--	--	--
	07-31-96	.13	--	--	--	--	--	--	--	--
	10-31-96	.19	--	--	--	--	--	--	--	--
	12-10-96	.19	--	--	--	--	--	--	--	--
	02-27-97	.10	--	--	--	--	--	--	--	--
	03-26-97	.19	514	8.3	--	9.5	--	--	--	--
S8	09-21-92	.02	615	7.9	21.0	14.5	680	8.1	102	87
	07-14-94	.03	623	7.5	26.0	14.0	664	8.9	99	87
	04-27-95	.02	626	7.7	20.0	11.0	--	8.7	--	84
	06-21-95	.02	620	7.6	26.0	13.5	--	8.2	--	87
	01-16-96	.01	--	--	--	--	--	--	--	--
	04-03-96	.04	--	--	--	--	--	--	--	--
	05-16-96	.03	--	--	--	--	--	--	--	--
	07-26-96	.03	--	--	--	--	--	--	--	--
	10-10-96	.03	--	--	--	--	--	--	--	--
	01-02-97	.06	--	--	--	--	--	--	--	--
	02-27-97	.06	--	--	--	--	--	--	--	--
	03-25-97	.06	621	8.3	--	10.5	--	--	--	--
S9	10-08-92	.01	511	8.4	6.0	10.0	681	10.0	99	80
	07-27-94	.02	512	8.2	23.0	18.0	--	9.7	--	86
	05-12-95	.03	500	8.3	--	11.0	686	8.7	88	80
	08-29-95	.02	550	8.3	24.0	15.0	--	8.8	--	84
	01-16-96	.01	--	--	--	--	--	--	--	--
	04-04-96	.03	--	--	--	--	--	--	--	--
	06-03-96	.03	--	--	--	--	--	--	--	--
	07-31-96	.02	--	--	--	--	--	--	--	--
	10-31-96	.03	--	--	--	--	--	--	--	--
	01-02-97	.03	--	--	--	--	--	--	--	--
	03-07-97	.02	--	--	--	--	--	--	--	--
	03-25-97	.03	521	8.4	--	11.5	--	--	--	--
S10	11-04-92	.01	2680	6.8	--	12.5	687	.1	10	1000
S11	09-18-92	.004	518	7.3	18.0	14.5	685	.1	11	120
S12	11-12-92	.06	423	8.4	12.0	10.0	673	8.2	82	130
	08-02-94	.07	422	8.3	27.0	17.5	674	8.6	101	130
	05-17-95	.05	431	8.6	15.0	14.0	--	6.2	65	140
	07-11-95	.08	445	8.4	28.0	17.0	--	6.8	--	150
	03-27-97	.07	433	8.4	--	--	--	--	--	--
S13	09-30-92	.004	3440	8.6	28.0	22.0	685	--	--	290
S14	11-05-92	.02	534	8.0	3.5	8.0	685	8.4	79	200
	08-03-94	.01	537	7.6	27.0	19.5	678	7.7	95	200
	05-16-95	.01	449	8.7	21.0	22.5	685	12.1	155	150
	07-12-95	.01	535	8.1	31.0	19.0	--	7.5	--	190
	03-26-97	.01	528	8.2	--	15.5	--	--	--	--

Table 13. Spring water-quality data—Continued

SITE NUMBER	DATE	ANC[1] UNFLTRD TIT 4.5 LAB (MG/L AS CACO3) (90410)	ANC[1] WATER UNFLTRD IT FIELD MG/L AS CACO3 (00419)	E. COLI WATER WHOLE TOTAL (COL / 100 ML) (31633)	COLI- FORM, TOTAL, (COLS. PER 100 ML) (31503)	COLI- FORM, FECAL, 0.7 UM-MF (COLS./ 100 ML) (31625)	STREP- TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML) (31673)	CALCIUM DIS- SOLVED (MG/L AS CA) (00915)	MAGNE- SIUM, DIS- SOLVED (MG/L AS MG) (00925)	SODIUM, DIS- SOLVED (MG/L AS NA) (00930)	SODIUM PERCENT (00932)
S1	09-29-92	423	438	--	--	--	--	6.4	.40	190	92
S2	09-23-92	226	245	--	--	--	--	45	2.3	61	50
	07-26-94	223	223	<5	>1600	<2	68	45	2.3	60	50
	04-27-95	224	224	<4	K7	<4	<4	42	2.2	61	52
	06-21-95	225	216	K2	K4	K2	K14	45	2.3	61	50
	03-26-97	--	--	--	--	--	--	--	--	--	--
S3	09-21-92	281	316	--	--	--	--	31	4.2	120	70
S4	09-25-92	269	236	--	--	--	--	60	7.7	39	30
	07-13-94	252	249	<2	>130	K360	390	58	7.6	34	28
	05-11-95	256	250	110	250	210	K25	62	8.6	30	24
	08-28-95	332	278	K1600	K2050	550	970	61	9.1	49	34
	01-12-96	--	--	--	--	--	--	--	--	--	--
	04-03-96	--	--	--	--	--	--	--	--	--	--
	05-16-96	--	--	--	--	--	--	--	--	--	--
	07-26-96	--	--	--	--	--	--	--	--	--	--
	10-10-96	--	--	--	--	--	--	--	--	--	--
	12-10-96	--	--	--	--	--	--	--	--	--	--
	03-07-97	--	--	--	--	--	--	--	--	--	--
	03-24-97	--	--	--	--	--	--	--	--	--	--
S5	09-22-92	181	192	--	--	--	--	58	7.4	10	11
	07-12-94	184	180	50	132	E270	>2000	54	7.1	9.4	11
	04-24-95	174	164	--	--	--	--	54	7.5	9.6	11
	08-28-95	180	172	K1600	K2800	K1200	K2200	54	7.0	9.1	10
	01-12-96	--	--	--	--	--	--	--	--	--	--
	04-03-96	--	--	--	--	--	--	--	--	--	--
	05-16-96	--	--	--	--	--	--	--	--	--	--
	07-30-96	--	--	--	--	--	--	--	--	--	--
	10-10-96	--	--	--	--	--	--	--	--	--	--
	12-10-96	--	--	--	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--	--	--	--
	03-24-97	--	--	--	--	--	--	--	--	--	--
S6	09-30-92	220	229	--	--	--	--	33	5.9	66	54
	07-27-94	221	204	<2	>88	110	>4200	36	6.0	65	52
	04-14-95	218	230	<4	>12	K4	K4	35	5.9	64	53
	07-10-95	217	210	<1	45	<1	<1	34	5.8	62	52
	01-16-96	--	--	--	--	--	--	--	--	--	--
	04-04-96	--	--	--	--	--	--	--	--	--	--
	06-03-96	--	--	--	--	--	--	--	--	--	--
	07-03-96	--	--	--	--	--	--	--	--	--	--
	10-31-96	--	--	--	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--	--	--	--
	03-25-97	--	--	--	--	--	--	--	--	--	--
S7	10-01-92	265	254	--	--	--	--	60	7.8	49	35
	07-28-94	262	287	>8000	>16000	>6000	>10000	58	7.9	44	33
	05-16-95	272	288	K16	33	K25	170	63	7.2	53	36
	07-13-95	251	270	2100	13900	8800	4600	55	7.1	48	36
	01-12-96	--	--	--	--	--	--	--	--	--	--
	04-04-96	--	--	--	--	--	--	--	--	--	--
	06-03-96	--	--	--	--	--	--	--	--	--	--
	07-31-96	--	--	--	--	--	--	--	--	--	--
	10-31-96	--	--	--	--	--	--	--	--	--	--
	12-10-96	--	--	--	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--	--	--	--
	03-26-97	--	--	--	--	--	--	--	--	--	--
S8	09-21-92	199	203	--	--	--	--	28	4.0	98	68
	07-14-94	197	198	K2	K4	K2	<10	28	4.0	96	68
	04-27-95	198	200	230	>230	<4	<4	27	4.0	96	68
	06-21-95	197	198	92	312	70	70	28	4.0	97	68
	01-16-96	--	--	--	--	--	--	--	--	--	--
	04-03-96	--	--	--	--	--	--	--	--	--	--
	05-16-96	--	--	--	--	--	--	--	--	--	--
	07-26-96	--	--	--	--	--	--	--	--	--	--
	10-10-96	--	--	--	--	--	--	--	--	--	--
	01-02-97	--	--	--	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--	--	--	--
	03-25-97	--	--	--	--	--	--	--	--	--	--
S9	10-08-92	201	216	--	--	--	--	27	3.0	75	63
	07-27-94	196	204	<2	>60	44	420	29	3.1	73	61
	05-12-95	208	224	K2	62	44	420	27	2.9	74	63
	08-29-95	197	212	K8700	K8726	230	K46	28	3.2	73	61
	01-16-96	--	--	--	--	--	--	--	--	--	--
	04-04-96	--	--	--	--	--	--	--	--	--	--
	06-03-96	--	--	--	--	--	--	--	--	--	--
	07-31-96	--	--	--	--	--	--	--	--	--	--
	10-31-96	--	--	--	--	--	--	--	--	--	--
	01-02-97	--	--	--	--	--	--	--	--	--	--
	03-07-97	--	--	--	--	--	--	--	--	--	--
	03-25-97	--	--	--	--	--	--	--	--	--	--
S10	11-04-92	509	538	--	--	--	--	280	72	300	39
S11	09-18-92	232	236	--	--	--	--	42	4.7	63	50
S12	11-12-92	203	230	--	--	--	--	43	5.0	33	34
	08-02-94	209	205	920	1330	700	4900	45	5.1	33	33
	05-17-95	214	368	K800	K2400	K1200	K2200	47	5.3	36	34
	07-11-95	235	200	50	10850	210	690	51	5.8	38	33
	03-27-97	--	--	--	--	--	--	--	--	--	--
S13	09-30-92	561	534	--	--	--	--	76	23	750	84
S14	11-05-92	237	239	--	--	--	--	59	12	38	29
	08-03-94	239	224	<100	>400	<50	610	59	12	37	28
	05-16-95	178	182	200	520	300	120	42	11	37	34
	07-12-95	237	244	90	1790	100	690	58	11	39	30
	03-26-97	--	--	--	--	--	--	--	--	--	--

Table 13. Spring water-quality data—Continued

SITE NUMBER	DATE	SODIUM AD-SORP-TION RATIO (00931)	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)	ANC[1] BICAR-BONATE IT FIELD MG/L AS HCO3 (00450)	ANC[1] CAR-BONATE IT FIELD MG/L AS CO3 (00447)	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)	FLUO-RIDE, DIS-SOLVED (MG/L AS F) (00950)	SILICA, DIS-SOLVED (MG/L AS SIO2) (00955)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L) (70300)
S1	09-29-92	20	14	534	0	27	10	.50	68	579	574
S2	09-23-92	2	6.5	299	0	18	1.5	.20	41	323	336
	07-26-94	2	7.1	270	0	19	1.8	.30	41	314	318
	04-27-95	2	6.3	273	0	18	1.7	.30	38	327	310
	06-21-95	2	6.7	263	0	17	2.0	.20	41	327	340
	03-26-97	--	--	--	0	--	--	--	--	--	--
S3	09-21-92	5	15	321	34	49	25	.20	55	492	457
S4	09-25-92	1	11	337	0	7.8	3.4	.30	51	347	340
	07-13-94	1	8.3	303	0	7.8	1.7	.30	46	314	310
	05-11-95	.9	8.8	305	0	7.0	3.7	.40	35	307	310
	08-28-95	2	15	339	0	5.7	14	.40	49	372	384
	01-12-96	--	--	--	--	--	--	--	--	--	--
	04-03-96	--	--	--	--	--	--	--	--	--	--
	05-16-96	--	--	--	--	--	--	--	--	--	--
	07-26-96	--	--	--	--	--	--	--	--	--	--
	10-10-96	--	--	--	--	--	--	--	--	--	--
	12-10-96	--	--	--	--	--	--	--	--	--	--
	03-07-97	--	--	--	--	--	--	--	--	--	--
	03-24-97	--	--	--	0	--	--	--	--	--	--
S5	09-22-92	.3	6.6	235	0	8.5	.50	.10	50	257	255
	07-12-94	.3	6.4	219	0	7.8	1.0	.30	49	253	256
	04-24-95	.3	6.5	200	0	7.4	1.2	.30	47	245	242
	08-28-95	.3	6.1	210	0	7.5	.90	.40	51	251	244
	01-12-96	--	--	--	--	--	--	--	--	--	--
	04-03-96	--	--	--	--	--	--	--	--	--	--
	05-16-96	--	--	--	--	--	--	--	--	--	--
	07-30-96	--	--	--	--	--	--	--	--	--	--
	10-10-96	--	--	--	--	--	--	--	--	--	--
	12-10-96	--	--	--	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--	--	--	--
	03-24-97	--	--	--	0	--	--	--	--	--	--
S6	09-30-92	3	11	280	0	34	11	.30	50	349	321
	07-27-94	3	11	250	0	33	9.4	.30	51	345	348
	04-14-95	3	11	280	0	30	10	.30	51	357	338
	07-10-95	3	11	256	0	30	9.0	.30	51	340	333
	01-16-96	--	--	--	--	--	--	--	--	--	--
	04-04-96	--	--	--	--	--	--	--	--	--	--
	06-03-96	--	--	--	--	--	--	--	--	--	--
	07-03-96	--	--	--	--	--	--	--	--	--	--
	10-31-96	--	--	--	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--	--	--	--
	03-25-97	--	--	--	0	--	--	--	--	--	--
S7	10-01-92	2	13	310	0	23	10	.30	54	370	378
	07-28-94	1	16	350	0	23	8.1	.30	54	398	374
	05-16-95	2	13	351	0	24	11	.30	50	404	394
	07-13-95	2	13	329	0	21	7.0	.30	56	383	379
	01-12-96	--	--	--	--	--	--	--	--	--	--
	04-04-96	--	--	--	--	--	--	--	--	--	--
	06-03-96	--	--	--	--	--	--	--	--	--	--
	07-31-96	--	--	--	--	--	--	--	--	--	--
	10-31-96	--	--	--	--	--	--	--	--	--	--
	12-10-96	--	--	--	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--	--	--	--
	03-26-97	--	--	--	0	--	--	--	--	--	--
S8	09-21-92	5	10	247	0	65	28	.20	59	414	412
	07-14-94	4	11	241	0	69	24	.30	59	411	434
	04-27-95	5	11	244	0	67	24	.30	59	427	416
	06-21-95	5	11	242	0	61	24	.20	61	424	430
	01-16-96	--	--	--	--	--	--	--	--	--	--
	04-03-96	--	--	--	--	--	--	--	--	--	--
	05-16-96	--	--	--	--	--	--	--	--	--	--
	07-26-96	--	--	--	--	--	--	--	--	--	--
	10-10-96	--	--	--	--	--	--	--	--	--	--
	01-02-97	--	--	--	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--	--	--	--
	03-25-97	--	--	--	0	--	--	--	--	--	--
S9	10-08-92	4	13	246	0	34	11	.30	56	341	347
	07-27-94	3	14	250	0	37	12	.20	57	367	362
	05-12-95	4	13	273	0	29	9.1	.30	57	361	348
	08-29-95	3	13	259	2	39	13	.30	57	374	370
	01-16-96	--	--	--	--	--	--	--	--	--	--
	04-04-96	--	--	--	--	--	--	--	--	--	--
	06-03-96	--	--	--	--	--	--	--	--	--	--
	07-31-96	--	--	--	--	--	--	--	--	--	--
	10-31-96	--	--	--	--	--	--	--	--	--	--
	01-02-97	--	--	--	--	--	--	--	--	--	--
	03-07-97	--	--	--	--	--	--	--	--	--	--
	03-25-97	--	--	--	0	--	--	--	--	--	--
S10	11-04-92	4	22	661	0	1000	10	4.8	13	2030	2210
S11	09-18-92	2	9.7	287	0	23	19	.20	58	362	353
S12	11-12-92	1	11	305	15	11	2.1	.30	47	318	280
	08-02-94	1	11	250	0	11	1.9	.20	45	282	284
	05-17-95	1	11	449	0	9.4	2.4	.30	46	384	278
	07-11-95	1	11	195	2	10	1.8	.40	48	268	314
	03-27-97	--	--	--	0	--	--	--	--	--	--
S13	09-30-92	19	21	574	38	1200	110	1.4	8.2	2510	2600
S14	11-05-92	1	6.1	288	0	45	5.7	.40	19	328	332
	08-03-94	1	6.0	270	0	45	5.2	.40	17	315	326
	05-16-95	1	6.3	205	8	45	5.5	.40	14	271	262
	07-12-95	1	5.5	298	0	43	5.0	.80	19	329	323
	03-26-97	--	--	--	0	--	--	--	--	--	--

Table 13. Spring water-quality data—Continued

SITE NUMBER	DATE	SOLIDS, DIS-SOLVED (TONS PER AC-FT) (70303)	SOLIDS, DIS-SOLVED (TONS PER DAY) (70302)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N) (00608)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS NH4) (71846)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N) (00613)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N) (00631)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N) (00618)	PHOS-PHORUS DIS-SOLVED (MG/L AS P) (00666)	PHOS-PHORUS ORTHO, DIS-SOLVED (MG/L AS P) (00671)
S1	09-29-92	.78	--	--	--	--	--	--	--	--
S2	09-23-92	.46	.01	--	--	--	--	--	--	--
	07-26-94	.43	.01	.010	.01	--	.960	--	.075	--
	04-27-95	.42	.01	<.015	--	<.010	5.00	--	.040	.070
	06-21-95	.46	.01	.020	.03	<.010	5.00	--	.080	.070
	03-26-97	--	--	--	--	--	--	--	--	--
S3	09-21-92	.62	.00	--	--	--	--	--	--	--
S4	09-25-92	.46	.05	--	--	--	--	--	--	--
	07-13-94	.42	.06	.010	.01	--	.031	--	.012	--
	05-11-95	.42	.13	<.015	--	<.010	.090	--	<.010	<.010
	08-28-95	.52	.13	.040	.05	<.010	.270	--	.010	.010
	01-12-96	--	--	--	--	--	--	--	--	--
	04-03-96	--	--	--	--	--	--	--	--	--
	05-16-96	--	--	--	--	--	--	--	--	--
	07-26-96	--	--	--	--	--	--	--	--	--
	10-10-96	--	--	--	--	--	--	--	--	--
	12-10-96	--	--	--	--	--	--	--	--	--
	03-07-97	--	--	--	--	--	--	--	--	--
	03-24-97	--	--	--	--	--	--	--	--	--
S5	09-22-92	.35	.03	--	--	--	--	--	--	--
	07-12-94	.35	.05	.010	.01	--	2.10	--	.029	--
	04-24-95	.33	.07	<.015	--	.020	2.70	2.68	.020	.020
	08-28-95	.33	.03	.050	.06	.030	2.40	2.37	.020	.020
	01-12-96	--	--	--	--	--	--	--	--	--
	04-03-96	--	--	--	--	--	--	--	--	--
	05-16-96	--	--	--	--	--	--	--	--	--
	07-30-96	--	--	--	--	--	--	--	--	--
	10-10-96	--	--	--	--	--	--	--	--	--
	12-10-96	--	--	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--	--	--
	03-24-97	--	--	--	--	--	--	--	--	--
S6	09-30-92	.44	.02	--	--	--	--	--	--	--
	07-27-94	.47	.02	.020	.03	--	2.10	--	.029	--
	04-14-95	.46	.01	.020	.03	.010	2.50	2.49	.040	.050
	07-10-95	.45	.02	<.015	--	<.010	2.40	--	.030	.040
	01-16-96	--	--	--	--	--	--	--	--	--
	04-04-96	--	--	--	--	--	--	--	--	--
	06-03-96	--	--	--	--	--	--	--	--	--
	07-03-96	--	--	--	--	--	--	--	--	--
	10-31-96	--	--	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--	--	--
	03-25-97	--	--	--	--	--	--	--	--	--
S7	10-01-92	.51	.09	--	--	--	--	--	--	--
	07-28-94	.51	.10	.230	.30	--	3.00	--	.090	--
	05-16-95	.54	.10	.020	.03	.010	1.90	1.89	.020	.020
	07-13-95	.52	.08	.100	.13	.030	2.80	2.77	.060	.070
	01-12-96	--	--	--	--	--	--	--	--	--
	04-04-96	--	--	--	--	--	--	--	--	--
	06-03-96	--	--	--	--	--	--	--	--	--
	07-31-96	--	--	--	--	--	--	--	--	--
	10-31-96	--	--	--	--	--	--	--	--	--
	12-10-96	--	--	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--	--	--
	03-26-97	--	--	--	--	--	--	--	--	--
S8	09-21-92	.56	.02	--	--	--	--	--	--	--
	07-14-94	.59	.04	<.010	--	--	<.050	--	.011	--
	04-27-95	.57	.02	<.015	--	<.010	4.00	--	<.010	.010
	06-21-95	.58	.02	.020	.03	<.010	4.10	--	.020	.010
	01-16-96	--	--	--	--	--	--	--	--	--
	04-03-96	--	--	--	--	--	--	--	--	--
	05-16-96	--	--	--	--	--	--	--	--	--
	07-26-96	--	--	--	--	--	--	--	--	--
	10-10-96	--	--	--	--	--	--	--	--	--
	01-02-97	--	--	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--	--	--
	03-25-97	--	--	--	--	--	--	--	--	--
S9	10-08-92	.47	.01	--	--	--	--	--	--	--
	07-27-94	.49	.02	.030	.04	--	4.20	--	.007	--
	05-12-95	.47	.03	<.015	--	.010	3.20	3.19	<.010	.010
	08-29-95	.50	.02	.030	.04	<.010	4.00	--	<.010	<.010
	01-16-96	--	--	--	--	--	--	--	--	--
	04-04-96	--	--	--	--	--	--	--	--	--
	06-03-96	--	--	--	--	--	--	--	--	--
	07-31-96	--	--	--	--	--	--	--	--	--
	10-31-96	--	--	--	--	--	--	--	--	--
	01-02-97	--	--	--	--	--	--	--	--	--
	03-07-97	--	--	--	--	--	--	--	--	--
	03-25-97	--	--	--	--	--	--	--	--	--
S10	11-04-92	3.01	.06	--	--	--	--	--	--	--
S11	09-18-92	.48	--	--	--	--	--	--	--	--
S12	11-12-92	.38	.05	--	--	--	--	--	--	--
	08-02-94	.39	.05	.030	.04	--	1.30	--	.039	--
	05-17-95	.38	.04	.020	.03	<.010	1.20	--	.030	.040
	07-11-95	.43	.07	.050	.06	<.010	.740	--	.030	.030
	03-27-97	--	--	--	--	--	--	--	--	--
S13	09-30-92	3.54	--	--	--	--	--	--	--	--
S14	11-05-92	.45	.02	--	--	--	--	--	--	--
	08-03-94	.44	.01	.030	.04	--	.013	--	.015	--
	05-16-95	.36	.01	<.015	--	<.010	<.050	--	.030	<.010
	07-12-95	.44	.01	<.015	--	<.010	<.050	--	<.010	<.010
	03-26-97	--	--	--	--	--	--	--	--	--

Table 13. Spring water-quality data—Continued

SITE NUMBER	DATE	ARSENIC DIS- SOLVED (UG/L AS AS) (01000)	BARIUM, DIS- SOLVED (UG/L AS BA) (01005)	BERYL- LIUM, DIS- SOLVED (UG/L AS BE) (01010)	BORON, DIS- SOLVED (UG/L AS B) (01020)	CADMIUM WATER UNFLTRD TOTAL (UG/L AS CD) (01027)	CADMIUM DIS- SOLVED (UG/L AS CD) (01025)	CHRO- MIUM, DIS- SOLVED (UG/L AS CR) (01030)	COBALT, DIS- SOLVED (UG/L AS CO) (01035)	COPPER, DIS- SOLVED (UG/L AS CU) (01040)
S1	09-29-92	13	17	<.50	240	<1	<1.0	<5.0	<3.0	<10
S2	09-23-92	5	140	<.50	80	<1	<1.0	<5.0	<3.0	<10
	07-26-94	4	150	<.50	80	--	<1.0	<5.0	<3.0	<10
	04-27-95	4	150	<.50	80	<1	1.0	<5.0	<3.0	<10
	06-21-95	5	150	<.50	70	<1	<1.0	<5.0	<3.0	<10
	03-26-97	--	--	--	--	--	--	--	--	--
S3	09-21-92	15	52	<.50	240	<1	<1.0	<5.0	<3.0	<10
S4	09-25-92	8	240	<.50	80	<1	<1.0	<5.0	<3.0	<10
	07-13-94	9	250	<.50	70	--	<1.0	<5.0	<3.0	<10
	05-11-95	8	270	<.50	70	<1	2.0	<5.0	<3.0	<10
	08-28-95	13	310	<.50	100	<1	<1.0	<5.0	<3.0	<10
	01-12-96	--	--	--	--	--	--	--	--	--
	04-03-96	--	--	--	--	--	--	--	--	--
	05-16-96	--	--	--	--	--	--	--	--	--
	07-26-96	--	--	--	--	--	--	--	--	--
	10-10-96	--	--	--	--	--	--	--	--	--
	12-10-96	--	--	--	--	--	--	--	--	--
	03-07-97	--	--	--	--	--	--	--	--	--
	03-24-97	--	--	--	--	--	--	--	--	--
S5	09-22-92	8	260	<.50	30	<1	<1.0	<5.0	<3.0	<10
	07-12-94	7	280	<.50	30	--	<1.0	<5.0	<3.0	<10
	04-24-95	9	260	<.50	20	<1	2.0	<5.0	<3.0	<10
	08-28-95	9	300	<.50	40	<1	<1.0	<5.0	4.0	<10
	01-12-96	--	--	--	--	--	--	--	--	--
	04-03-96	--	--	--	--	--	--	--	--	--
	05-16-96	--	--	--	--	--	--	--	--	--
	07-30-96	--	--	--	--	--	--	--	--	--
	10-10-96	--	--	--	--	--	--	--	--	--
	12-10-96	--	--	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--	--	--
	03-24-97	--	--	--	--	--	--	--	--	--
S6	09-30-92	16	69	<.50	140	<1	<1.0	<5.0	<3.0	<10
	07-27-94	11	71	<.50	150	--	<1.0	<5.0	<3.0	<10
	04-14-95	16	73	<.50	140	<1	<1.0	<5.0	<3.0	<10
	07-10-95	16	70	<.50	150	<1	<1.0	<5.0	<3.0	<10
	01-16-96	--	--	--	--	--	--	--	--	--
	04-04-96	--	--	--	--	--	--	--	--	--
	06-03-96	--	--	--	--	--	--	--	--	--
	07-03-96	--	--	--	--	--	--	--	--	--
	10-31-96	--	--	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--	--	--
	03-25-97	--	--	--	--	--	--	--	--	--
S7	10-01-92	14	210	<.50	150	<1	<1.0	<5.0	<3.0	<10
	07-28-94	11	260	<.50	130	--	<1.0	<5.0	<3.0	<10
	05-16-95	15	210	<.50	130	<1	<1.0	<5.0	<3.0	<10
	07-13-95	14	210	<.50	130	<1	<1.0	<5.0	4.0	<10
	01-12-96	--	--	--	--	--	--	--	--	--
	04-04-96	--	--	--	--	--	--	--	--	--
	06-03-96	--	--	--	--	--	--	--	--	--
	07-31-96	--	--	--	--	--	--	--	--	--
	10-31-96	--	--	--	--	--	--	--	--	--
	12-10-96	--	--	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--	--	--
	03-26-97	--	--	--	--	--	--	--	--	--
S8	09-21-92	17	84	<.50	220	<1	<1.0	<5.0	<3.0	<10
	07-14-94	19	82	<.50	230	--	<1.0	<5.0	<3.0	<10
	04-27-95	17	86	<.50	220	<1	1.0	<5.0	<3.0	<10
	06-21-95	17	85	<.50	210	<1	<1.0	<5.0	<3.0	<10
	01-16-96	--	--	--	--	--	--	--	--	--
	04-03-96	--	--	--	--	--	--	--	--	--
	05-16-96	--	--	--	--	--	--	--	--	--
	07-26-96	--	--	--	--	--	--	--	--	--
	10-10-96	--	--	--	--	--	--	--	--	--
	01-02-97	--	--	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--	--	--
	03-25-97	--	--	--	--	--	--	--	--	--
S9	10-08-92	10	52	<.50	170	<1	<1.0	<5.0	<3.0	<10
	07-27-94	8	47	<.50	170	--	<1.0	<5.0	<3.0	<10
	05-12-95	9	45	<.50	180	<1	2.0	<5.0	<3.0	<10
	08-29-95	12	44	<.50	180	<1	<1.0	<5.0	<3.0	<10
	01-16-96	--	--	--	--	--	--	--	--	--
	04-04-96	--	--	--	--	--	--	--	--	--
	06-03-96	--	--	--	--	--	--	--	--	--
	07-31-96	--	--	--	--	--	--	--	--	--
	10-31-96	--	--	--	--	--	--	--	--	--
	01-02-97	--	--	--	--	--	--	--	--	--
	03-07-97	--	--	--	--	--	--	--	--	--
	03-25-97	--	--	--	--	--	--	--	--	--
S10	11-04-92	<1	22	<1.5	470	<1	<3.0	<15	<9.0	<30
S11	09-18-92	5	210	<.50	170	<1	<1.0	<5.0	<3.0	<10
S12	11-12-92	6	170	<.50	50	<1	2.0	<5.0	<3.0	<10
	08-02-94	5	170	<.50	50	<1	<1.0	<5.0	<3.0	<10
	05-17-95	7	180	<.50	60	<1	<1.0	<5.0	<3.0	<10
	07-11-95	6	200	<.50	60	<1	<1.0	<5.0	<3.0	<10
	03-27-97	--	--	--	--	--	--	--	--	--
S13	09-30-92	1	18	<1.5	2800	<1	<3.0	<15	<9.0	<30
S14	11-05-92	1	160	<.50	60	<1	<1.0	<5.0	<3.0	<10
	08-03-94	<1	150	<.50	50	<1	<1.0	<5.0	<3.0	<10
	05-16-95	<1	100	<.50	60	<1	<1.0	<5.0	<3.0	<10
	07-12-95	<1	150	<.50	80	<1	<1.0	<5.0	<3.0	<10
	03-26-97	--	--	--	--	--	--	--	--	--

Table 13. Spring water-quality data—Continued

SITE NUMBER	DATE	IRON, DISSOLVED (UG/L AS FE) (01046)	LEAD, DISSOLVED (UG/L AS PB) (01049)	LITHIUM DISSOLVED (UG/L AS LI) (01130)	MANGANESE, DISSOLVED (UG/L AS MN) (01056)	MERCURY DISSOLVED (UG/L AS HG) (71890)	MOLYBDENUM, DISSOLVED (UG/L AS MO) (01060)	NICKEL, DISSOLVED (UG/L AS NI) (01065)	SELENIUM, DISSOLVED (UG/L AS SE) (01145)	SILVER, DISSOLVED (UG/L AS AG) (01075)
S1	09-29-92	23	<10	64	<1.0	<.1	<10	<10	4	<1.0
S2	09-23-92	5.0	10	27	2.0	<.1	<10	<10	3	<1.0
	07-26-94	<3.0	10	23	<1.0	<.1	<10	<10	2	<1.0
	04-27-95	<3.0	<10	28	<1.0	<.1	<10	<10	2	2.0
	06-21-95	5.0	<10	31	1.0	<.1	<10	<10	3	<1.0
	03-26-97	--	--	--	--	--	--	--	--	--
S3	09-21-92	270	<10	57	30	<.1	<10	<10	32	<1.0
S4	09-25-92	47	<10	25	27	<.1	<10	<10	<1	<1.0
	07-13-94	89	<10	19	10	<.1	<10	<10	<1	<1.0
	05-11-95	160	30	18	39	<.1	<10	<10	1	1.0
	08-28-95	120	<10	26	16	<.1	10	<10	<1	<1.0
	01-12-96	--	--	--	--	--	--	--	--	--
	04-03-96	--	--	--	--	--	--	--	--	--
	05-16-96	--	--	--	--	--	--	--	--	--
	07-26-96	--	--	--	--	--	--	--	--	--
	10-10-96	--	--	--	--	--	--	--	--	--
	12-10-96	--	--	--	--	--	--	--	--	--
	03-07-97	--	--	--	--	--	--	--	--	--
	03-24-97	--	--	--	--	--	--	--	--	--
S5	09-22-92	38	<10	12	7.0	<.1	<10	<10	2	<1.0
	07-12-94	19	<10	17	4.0	<.1	<10	<10	1	<1.0
	04-24-95	100	30	16	25	<.1	<10	<10	2	<1.0
	08-28-95	83	<10	6	34	<.1	20	<10	<2	1.0
	01-12-96	--	--	--	--	--	--	--	--	--
	04-03-96	--	--	--	--	--	--	--	--	--
	05-16-96	--	--	--	--	--	--	--	--	--
	07-30-96	--	--	--	--	--	--	--	--	--
	10-10-96	--	--	--	--	--	--	--	--	--
	12-10-96	--	--	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--	--	--
	03-24-97	--	--	--	--	--	--	--	--	--
S6	09-30-92	<3.0	<10	26	<1.0	<.1	<10	<10	12	<1.0
	07-27-94	8.0	<10	27	<1.0	<.1	<10	<10	12	<1.0
	04-14-95	<3.0	<10	24	<1.0	<.1	<10	<10	10	<1.0
	07-10-95	<3.0	<10	25	<1.0	<.1	<10	<10	4	<1.0
	01-16-96	--	--	--	--	--	--	--	--	--
	04-04-96	--	--	--	--	--	--	--	--	--
	06-03-96	--	--	--	--	--	--	--	--	--
	07-03-96	--	--	--	--	--	--	--	--	--
	10-31-96	--	--	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--	--	--
	03-25-97	--	--	--	--	--	--	--	--	--
S7	10-01-92	37	<10	27	44	<.1	<10	<10	3	<1.0
	07-28-94	33	<10	18	75	<.1	<10	<10	3	<1.0
	05-16-95	23	10	36	16	<.1	<10	<10	5	<1.0
	07-13-95	22	10	27	78	<.1	<10	<10	4	<1.0
	01-12-96	--	--	--	--	--	--	--	--	--
	04-04-96	--	--	--	--	--	--	--	--	--
	06-03-96	--	--	--	--	--	--	--	--	--
	07-31-96	--	--	--	--	--	--	--	--	--
	10-31-96	--	--	--	--	--	--	--	--	--
	12-10-96	--	--	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--	--	--
	03-26-97	--	--	--	--	--	--	--	--	--
S8	09-21-92	5.0	<10	49	<1.0	<.1	<10	<10	26	<1.0
	07-14-94	<3.0	<10	47	<1.0	<.1	10	<10	24	<1.0
	04-27-95	<3.0	<10	51	<1.0	<.1	20	<10	27	<1.0
	06-21-95	<3.0	<10	37	1.0	<.1	20	<10	27	<1.0
	01-16-96	--	--	--	--	--	--	--	--	--
	04-03-96	--	--	--	--	--	--	--	--	--
	05-16-96	--	--	--	--	--	--	--	--	--
	07-26-96	--	--	--	--	--	--	--	--	--
	10-10-96	--	--	--	--	--	--	--	--	--
	01-02-97	--	--	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--	--	--
	03-25-97	--	--	--	--	--	--	--	--	--
S9	10-08-92	3.0	<10	37	<1.0	<.1	<10	<10	10	<1.0
	07-27-94	3.0	<10	30	<1.0	<.1	<10	<10	10	<1.0
	05-12-95	<3.0	30	38	<1.0	<.1	<10	<10	6	<1.0
	08-29-95	<3.0	<10	36	2.0	<.1	<10	<10	10	<1.0
	01-16-96	--	--	--	--	--	--	--	--	--
	04-04-96	--	--	--	--	--	--	--	--	--
	06-03-96	--	--	--	--	--	--	--	--	--
	07-31-96	--	--	--	--	--	--	--	--	--
	10-31-96	--	--	--	--	--	--	--	--	--
	01-02-97	--	--	--	--	--	--	--	--	--
	03-07-97	--	--	--	--	--	--	--	--	--
	03-25-97	--	--	--	--	--	--	--	--	--
S10	11-04-92	390	<30	370	440	<.1	<30	<30	<1	<3.0
S11	09-18-92	310	<10	28	190	<.1	<10	<10	5	<1.0
S12	11-12-92	11	10	26	3.0	<.1	<10	<10	6	<1.0
	08-02-94	5.0	<10	30	3.0	<.1	<10	<10	6	<1.0
	05-17-95	20	<10	27	7.0	<.1	<10	<10	6	2.0
	07-11-95	21	<10	24	11	<.1	<10	<10	6	<1.0
	03-27-97	--	--	--	--	--	--	--	--	--
S13	09-30-92	110	<30	250	3.0	.1	<30	<30	<1	<3.0
S14	11-05-92	36	<10	28	78	<.1	<10	<10	4	<1.0
	08-03-94	7.0	10	28	1.0	<.1	<10	<10	3	<1.0
	05-16-95	52	20	28	4.0	<.1	<10	<10	5	<1.0
	07-12-95	9.0	<10	24	3.0	<.1	<10	<10	2	<1.0
	03-26-97	--	--	--	--	--	--	--	--	--

Table 13. Spring water-quality data—Continued

SITE NUMBER	DATE	THALLIUM, DISSOLVED (UG/L AS TL) (01057)	STRONTIUM, DISSOLVED (UG/L AS SR) (01080)	VANADIUM, DISSOLVED (UG/L AS V) (01085)	ZINC, DISSOLVED (UG/L AS ZN) (01090)	GROSS ALPHA RADIO. WATER DISS AS TH-230 (PCI/L) (04126)	ALPHA COUNT, 2 SIGMA WAT DIS AS TH-230 (PCI/L) (75987)	GROSS ALPHA, DISSOLVED (UG/L AS U-NAT) (80030)	ALPHA, COUNT, 2 SIGMA WAT DIS AS NAT U (UG/L) (75986)	GROSS BETA, DISSOLVED (PCI/L AS CS-137) (03515)
S1	09-29-92	--	130	14	<3.0	2.6	5.2	38	7.9	18
S2	09-23-92	--	180	<6	3.0	6.2	1.4	8.4	1.8	9.0
	07-26-94	--	170	<6	<3.0	5.2	2.9	7.3	4.0	10
	04-27-95	<.50	180	7	6.0	--	--	--	--	--
	06-21-95	<.50	180	<6	<3.0	--	--	--	--	--
	03-26-97	--	--	--	--	--	--	--	--	--
S3	09-21-92	--	270	11	6.0	3.4	1.1	5.1	1.6	9.6
S4	09-25-92	--	450	<6	4.0	5.9	1.4	8.6	1.7	9.4
	07-13-94	--	420	<6	<3.0	3.0	2.0	4.2	2.7	11
	05-11-95	<.50	440	<6	<3.0	--	--	--	--	--
	08-28-95	<.50	470	<6	<3.0	--	--	--	--	--
	01-12-96	--	--	--	--	--	--	--	--	--
	04-03-96	--	--	--	--	--	--	--	--	--
	05-16-96	--	--	--	--	--	--	--	--	--
	07-26-96	--	--	--	--	--	--	--	--	--
	10-10-96	--	--	--	--	--	--	--	--	--
	12-10-96	--	--	--	--	--	--	--	--	--
	03-07-97	--	--	--	--	--	--	--	--	--
	03-24-97	--	--	--	--	--	--	--	--	--
S5	09-22-92	--	350	8	4.0	6.0	1.7	7.8	2.2	.7
	07-12-94	--	350	7	<3.0	1.7	1.5	2.4	2.1	7.5
	04-24-95	<.50	330	9	5.0	--	--	--	--	--
	08-28-95	<.50	330	<6	<3.0	--	--	--	--	--
	01-12-96	--	--	--	--	--	--	--	--	--
	04-03-96	--	--	--	--	--	--	--	--	--
	05-16-96	--	--	--	--	--	--	--	--	--
	07-30-96	--	--	--	--	--	--	--	--	--
	10-10-96	--	--	--	--	--	--	--	--	--
	12-10-96	--	--	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--	--	--
	03-24-97	--	--	--	--	--	--	--	--	--
S6	09-30-92	--	320	11	11	8.1	1.6	12	2.2	11
	07-27-94	--	310	9	<3.0	8.2	3.8	11	5.2	14
	04-14-95	<.50	320	11	<3.0	--	--	--	--	--
	07-10-95	<.50	310	12	5.0	--	--	--	--	--
	01-16-96	--	--	--	--	--	--	--	--	--
	04-04-96	--	--	--	--	--	--	--	--	--
	06-03-96	--	--	--	--	--	--	--	--	--
	07-03-96	--	--	--	--	--	--	--	--	--
	10-31-96	--	--	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--	--	--
	03-25-97	--	--	--	--	--	--	--	--	--
S7	10-01-92	--	450	<6	4.0	8.8	2.3	13	3.4	12
	07-28-94	--	420	10	<3.0	8.3	3.7	12	5.3	24
	05-16-95	<.50	480	8	<3.0	--	--	--	--	--
	07-13-95	<.50	410	8	5.0	--	--	--	--	--
	01-12-96	--	--	--	--	--	--	--	--	--
	04-04-96	--	--	--	--	--	--	--	--	--
	06-03-96	--	--	--	--	--	--	--	--	--
	07-31-96	--	--	--	--	--	--	--	--	--
	10-31-96	--	--	--	--	--	--	--	--	--
	12-10-96	--	--	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--	--	--
	03-26-97	--	--	--	--	--	--	--	--	--
S8	09-21-92	--	320	7	11	16	2.8	22	4.0	14
	07-14-94	--	290	6	<3.0	18	6.1	23	8.0	17
	04-27-95	<.50	320	9	17	--	--	--	--	--
	06-21-95	<.50	300	7	<3.0	--	--	--	--	--
	01-16-96	--	--	--	--	--	--	--	--	--
	04-03-96	--	--	--	--	--	--	--	--	--
	05-16-96	--	--	--	--	--	--	--	--	--
	07-26-96	--	--	--	--	--	--	--	--	--
	10-10-96	--	--	--	--	--	--	--	--	--
	01-02-97	--	--	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--	--	--
	03-25-97	--	--	--	--	--	--	--	--	--
S9	10-08-92	--	360	9	<3.0	9.2	1.9	13	2.8	8.8
	07-27-94	--	360	7	<3.0	11	4.4	18	6.8	18
	05-12-95	<.50	350	9	<3.0	--	--	--	--	--
	08-29-95	<.50	370	9	5.0	--	--	--	--	--
	01-16-96	--	--	--	--	--	--	--	--	--
	04-04-96	--	--	--	--	--	--	--	--	--
	06-03-96	--	--	--	--	--	--	--	--	--
	07-31-96	--	--	--	--	--	--	--	--	--
	10-31-96	--	--	--	--	--	--	--	--	--
	01-02-97	--	--	--	--	--	--	--	--	--
	03-07-97	--	--	--	--	--	--	--	--	--
	03-25-97	--	--	--	--	--	--	--	--	--
S10	11-04-92	--	3700	<18	16	22	9.8	29	13	22
S11	09-18-92	--	260	<6	48	18	3.4	27	5.0	17
S12	11-12-92	--	500	7	<3.0	5.1	2.5	6.9	3.4	16
	08-02-94	--	480	6	<3.0	6.8	2.9	9.1	4.0	15
	05-17-95	<.50	500	6	<3.0	--	--	--	--	--
	07-11-95	<.50	520	<6	<3.0	--	--	--	--	--
	03-27-97	--	--	--	--	--	--	--	--	--
S13	09-30-92	--	1300	<18	<9.0	5.5	2.1	7.9	3.0	6.6
S14	11-05-92	--	500	<6	6.0	9.7	3.9	14	5.5	12
	08-03-94	--	480	<6	<3.0	6.5	3.2	8.4	4.1	10
	05-16-95	<.50	430	<6	4.0	--	--	--	--	--
	07-12-95	<.50	480	<6	<3.0	--	--	--	--	--
	03-26-97	--	--	--	--	--	--	--	--	--

Table 13. Spring water-quality data—Continued

SITE NUMBER	DATE	BETA, 2 SIGMA WATER, DISS, AS CS-137 (PCI/L) (75989)	GROSS BETA, DIS- SOLVED (PCI/L AS SR/ Y-90) (80050)	BETA, 2 SIGMA WATER, DISS, AS SR90 /Y90 (PCI/L) (75988)	RA-226, DIS- SOLVED, PLAN- CHET COUNT (PCI/L) (09510)	RA-226 2 SIGMA WATER, DISS, (PCI/L) (76001)	URANIUM NATURAL DIS- SOLVED (UG/L AS U) (22703)	URANIUM NATURAL 2 SIGMA WATER, DISS, (UG/L) (75990)
S1	09-29-92	1.6	--	--	--	--	--	--
S2	09-23-92	.90	--	--	--	--	--	--
	07-26-94	1.9	7.5	1.4	.2	.151	7.1	2.2
	04-27-95	--	--	--	--	--	--	--
	06-21-95	--	--	--	--	--	--	--
	03-26-97	--	--	--	--	--	--	--
S3	09-21-92	1.2	--	--	--	--	--	--
S4	09-25-92	.80	--	--	--	--	--	--
	07-13-94	2.0	8.4	1.5	<.1	.115	3.3	1.1
	05-11-95	--	--	--	--	--	--	--
	08-28-95	--	--	--	--	--	--	--
	01-12-96	--	--	--	--	--	--	--
	04-03-96	--	--	--	--	--	--	--
	05-16-96	--	--	--	--	--	--	--
	07-26-96	--	--	--	--	--	--	--
	10-10-96	--	--	--	--	--	--	--
	12-10-96	--	--	--	--	--	--	--
	03-07-97	--	--	--	--	--	--	--
	03-24-97	--	--	--	--	--	--	--
S5	09-22-92	1.4	--	--	--	--	--	--
	07-12-94	1.5	5.7	1.1	<.1	.134	2.1	0.7
	04-24-95	--	--	--	--	--	--	--
	08-28-95	--	--	--	--	--	--	--
	01-12-96	--	--	--	--	--	--	--
	04-03-96	--	--	--	--	--	--	--
	05-16-96	--	--	--	--	--	--	--
	07-30-96	--	--	--	--	--	--	--
	10-10-96	--	--	--	--	--	--	--
	12-10-96	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--
	03-24-97	--	--	--	--	--	--	--
S6	09-30-92	1.1	--	--	--	--	--	--
	07-27-94	2.4	11	1.8	.1	.125	11	3.2
	04-14-95	--	--	--	--	--	--	--
	07-10-95	--	--	--	--	--	--	--
	01-16-96	--	--	--	--	--	--	--
	04-04-96	--	--	--	--	--	--	--
	06-03-96	--	--	--	--	--	--	--
	07-03-96	--	--	--	--	--	--	--
	10-31-96	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--
	03-25-97	--	--	--	--	--	--	--
S7	10-01-92	1.0	--	--	--	--	--	--
	07-28-94	3.5	18	2.6	.1	.129	10	3.0
	05-16-95	--	--	--	--	--	--	--
	07-13-95	--	--	--	--	--	--	--
	01-12-96	--	--	--	--	--	--	--
	04-04-96	--	--	--	--	--	--	--
	06-03-96	--	--	--	--	--	--	--
	07-31-96	--	--	--	--	--	--	--
	10-31-96	--	--	--	--	--	--	--
	12-10-96	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--
	03-26-97	--	--	--	--	--	--	--
S8	09-21-92	1.3	--	--	--	--	--	--
	07-14-94	2.8	13	2.0	.1	.125	13	3.7
	04-27-95	--	--	--	--	--	--	--
	06-21-95	--	--	--	--	--	--	--
	01-16-96	--	--	--	--	--	--	--
	04-03-96	--	--	--	--	--	--	--
	05-16-96	--	--	--	--	--	--	--
	07-26-96	--	--	--	--	--	--	--
	10-10-96	--	--	--	--	--	--	--
	01-02-97	--	--	--	--	--	--	--
	02-27-97	--	--	--	--	--	--	--
	03-25-97	--	--	--	--	--	--	--
S9	10-08-92	.80	--	--	--	--	--	--
	07-27-94	2.7	14	2.0	<.1	.130	9.6	2.8
	05-12-95	--	--	--	--	--	--	--
	08-29-95	--	--	--	--	--	--	--
	01-16-96	--	--	--	--	--	--	--
	04-04-96	--	--	--	--	--	--	--
	06-03-96	--	--	--	--	--	--	--
	07-31-96	--	--	--	--	--	--	--
	10-31-96	--	--	--	--	--	--	--
	01-02-97	--	--	--	--	--	--	--
	03-07-97	--	--	--	--	--	--	--
	03-25-97	--	--	--	--	--	--	--
S10	11-04-92	9.8	--	--	--	--	--	--
S11	09-18-92	1.4	--	--	--	--	--	--
S12	11-12-92	2.6	--	--	--	--	--	--
	08-02-94	2.3	11	1.7	.2	.146	7.2	2.2
	05-17-95	--	--	--	--	--	--	--
	07-11-95	--	--	--	--	--	--	--
	03-27-97	--	--	--	--	--	--	--
S13	09-30-92	.70	--	--	--	--	--	--
S14	11-05-92	2.2	--	--	--	--	--	--
	08-03-94	1.9	7.7	1.4	.2	.167	7.0	2.1
	05-16-95	--	--	--	--	--	--	--
	07-12-95	--	--	--	--	--	--	--
	03-26-97	--	--	--	--	--	--	--

[1] The term acid neutralizing capacity (ANC) is applied to the acid-neutralizing capacity of solutes plus particulates in a water sample, reported in equivalents, and normally titrated on an unfiltered sample.

Table 14. Public-supply well water-quality data

[G/M, gallons per minute; US/CM, microsiemens per centimeter at 25°Celsius; DEG C, degrees Celsius; mm, millimeters; mg/L, milligrams per liter; UG/L, micrograms per liter; COL/100 ML, colonies per 100 milliliters; AC-FT, acre-feet; PCI/L, picocuries per liter; K, non-ideal colony count; <, less than; --, no data]

SITE NUMBER	DATE	FLOW RATE (G/M) (00059)	DEPTH OF WELL, TOTAL (FEET) (72008)	SPECIFIC CONDUCTANCE (US/CM) (00095)	PH WATER WHOLE FIELD (STANDARD UNITS) (00400)	TEMPERATURE AIR (DEG C) (00020)	TEMPERATURE WATER (DEG C) (00010)	BAROMETRIC PRESSURE (MM OF HG) (00025)	OXYGEN, DISSOLVED (MG/L) (00300)
1	09-26-96	--	120.00	439	7.9	10.0	16.0	677	1.3
2	08-29-96	--	374.00	432	7.4	24.0	16.0	688	3.4
3	08-21-96	--	455.00	404	7.6	27.0	18.0	681	4.8
4	08-20-96	--	520.00	399	7.6	28.0	18.5	683	4.8
5	06-26-97	30.0	280.00	295	7.5	26.0	13.0	677	7.6
6	08-22-96	--	284.00	515	7.2	26.0	16.0	689	2.4
7	07-08-97	130	168.00	726	7.2	28.0	15.0	684	4.2
8	09-05-96	46.0	--	499	7.5	29.0	17.0	678	5.0
9	12-07-95	--	340.00	568	8.8	4.0	10.0	682	4.1
10	09-09-96	60.0	303.00	1070	7.0	24.0	17.5	684	.9
11	07-17-97	--	375.00	410	7.6	--	15.0	673	7.7
12	07-23-97	--	--	351	7.2	30.0	16.0	675	5.3
13	09-19-96	--	--	646	7.3	10.0	13.0	686	1.4
14	09-25-96	--	--	643	7.3	8.0	11.0	683	1.5
15	09-18-96	--	320.00	642	7.3	14.0	11.5	687	1.3
16	09-12-96	--	300.00	626	7.4	22.0	15.0	693	4.6
17	09-17-96	--	71.00	556	7.5	19.0	12.5	685	4.2
18	07-08-97	30.0	130.00	540	7.2	--	12.0	685	4.8
19	09-03-96	55.0	180.00	559	7.2	24.0	13.0	683	2.6
20	09-03-96	55.0	100.00	488	7.4	25.0	13.5	683	4.4
21	11-30-95	--	187.00	404	7.3	18.0	14.0	675	6.9
22	11-30-95	--	187.00	405	7.6	19.0	15.0	674	6.7
23	11-08-95	--	205.00	359	7.6	--	--	678	7.7
24	11-08-95	--	--	337	7.6	--	--	678	8.5
25	11-29-95	20.0	454.00	504	7.3	14.0	12.0	683	5.4
26	09-24-96	--	300.00	561	8.2	11.0	17.0	686	5.9
27	11-29-95	--	526.00	708	8.3	15.0	20.5	682	3.3
28	12-06-95	--	--	643	7.1	2.0	12.5	692	3.9
29	07-09-97	26.0	--	675	7.1	30.0	12.0	686	1.2
30	11-28-95	--	--	981	7.6	--	12.5	686	5.6
31	11-28-95	--	180.00	459	7.5	3.0	12.5	684	7.3
32	06-30-97	80.0	--	638	7.2	--	11.0	686	3.6
33	06-30-97	--	110.00	515	7.5	--	12.0	686	7.5
34	11-09-95	--	--	642	7.4	16.0	12.5	678	3.4
35	07-01-97	65.0	93.00	600	7.3	--	11.0	--	5.5
36	07-01-97	100	121.00	552	7.4	--	12.0	682	6.6
37	12-05-95	--	60.00	1100	7.7	--	11.0	677	6.8
38	10-19-95	20.0	68.10	882	7.6	--	12.0	685	3.5
39	07-22-97	55.0	--	506	7.9	31.0	12.5	693	8.9
40	10-18-95	70.0	184.00	486	8.3	--	13.5	675	5.6
41	07-16-97	100	124.00	487	7.7	37.0	13.0	694	7.2
42	07-22-97	44.0	200.00	461	7.9	30.0	13.5	688	7.1
43	10-18-95	25.0	106.00	498	7.9	--	14.0	677	5.4
44	06-25-97	18.6	2640.00	667	7.0	22.0	44.0	700	.1

Table 14. Public-supply well water-quality data—Continued

SITE NUMBER	DATE	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION) (00301)	HARD-NESS TOTAL (MG/L AS CACO3) (00900)	HARD-NESS NONCARB DISSOLV FLD. AS CACO3 (MG/L) (00904)	ANC[1] UNFLTRD TIT 4.5 LAB (MG/L AS CACO3) (90410)	ANC[1] WATER UNFLTRD IT FIELD MG/L AS CACO3 (00419)	E. COLI WATER WHOLE TOTAL (COL / 100 ML) (31633)	COLI-FORM, TOTAL, (COLS. PER 100 ML) (31503)	COLI-FORM, FECAL, 0.7 UM-MF (COLS./ 100 ML) (31625)	STREP-TOCOCCI FECAL, KF AGAR (COLS. PER 100 ML) (31673)
1	09-26-96	15	97	--	176	177	<1	58	K2	K2
2	08-29-96	40	150	--	188	182	<1	<1	<1	<1
3	08-21-96	58	110	--	155	152	<1	K3	<1	<1
4	08-20-96	58	99	--	157	152	<1	<1	<1	<1
5	06-26-97	82	120	--	137	134	K27	K27	<1	<1
6	08-22-96	28	210	--	234	219	<1	<1	<1	<1
7	07-08-97	47	160	--	210	211	<1	<1	<1	<1
8	09-05-96	59	110	--	188	179	<1	K8	<1	<1
9	12-07-95	41	110	--	194	204	<1	<1	<1	<1
10	09-09-96	11	410	--	292	282	<1	73	<1	<1
11	07-17-97	86	150	--	165	166	<1	K16	<1	<1
12	07-23-97	61	150	3	146	148	K2	K9	<1	<1
13	09-19-96	15	170	--	258	253	<1	K6	K17	K1000
14	09-25-96	15	170	--	258	261	<1	64	K6	K900
15	09-18-96	14	170	--	258	255	<1	400	39	21
16	09-12-96	49	120	--	205	200	55	96	890	<1
17	09-17-96	45	130	--	204	200	<1	K16	24	K2
18	07-08-97	50	210	3	204	203	<1	K4	<1	<1
19	09-03-96	29	210	--	222	214	<1	<1	<1	<1
20	09-03-96	49	180	--	197	197	<1	<1	<1	<1
21	11-30-95	76	130	--	170	165	<1	<1	<1	<1
22	11-30-95	75	120	--	172	164	K10	K10	<1	<1
23	11-08-95	83	140	--	172	174	<1	<1	<1	<1
24	11-08-95	90	140	--	165	164	<1	<1	<1	<1
25	11-29-95	55	190	--	227	228	K2	K2	<1	<1
26	09-24-96	69	47	--	186	185	<1	<1	<1	240
27	11-29-95	41	20	--	192	186	<1	<1	<1	<1
28	12-06-95	31	170	--	243	238	K3	K3	<1	<1
29	07-09-97	12	240	--	276	272	<1	<1	<1	<1
30	11-28-95	59	67	--	389	390	<1	<1	<1	<1
31	11-28-95	77	130	--	226	226	K6	K6	<1	<1
32	06-30-97	36	150	--	311	301	<1	K11	<1	K7
33	06-30-97	78	86	--	224	248	<1	K2	<1	<1
34	11-09-95	36	140	--	307	316	<1	<1	<1	<1
35	07-01-97	--	140	--	289	297	K2	K12	<1	K2
36	07-01-97	69	92	--	252	254	K3	K3	K4	<1
37	12-05-95	69	27	--	486	500	K8	K8	<1	<1
38	10-19-95	36	95	--	450	460	<1	K3	<1	<1
39	07-22-97	92	58	--	187	192	K1000	K1000	K4	71
40	10-18-95	61	28	--	241	245	<1	<1	<1	<1
41	07-16-97	75	34	--	244	242	25	53	<1	K4
42	07-22-97	76	27	--	228	227	220	220	K2	K9
43	10-18-95	60	72	--	247	235	<1	<1	<1	<1
44	06-25-97	2	280	89	187	189	<1	270	<1	K36

Table 14. Public-supply well water-quality data—Continued

SITE NUMBER	DATE	CALCIUM DISSOLVED (MG/L AS CA) (00915)	MAGNESIUM, DISSOLVED (MG/L AS MG) (00925)	SODIUM, DISSOLVED (MG/L AS NA) (00930)	SODIUM PERCENT (00932)	SODIUM ADSORPTION RATIO (00931)	POTASSIUM, DISSOLVED (MG/L AS K) (00935)	ANC[1] BICARBONATE IT FIELD MG/L AS HCO3 (00450)	ANC[1] CARBONATE IT FIELD MG/L AS CO3 (00447)	SULFATE DISSOLVED (MG/L AS SO4) (00945)
1	09-26-96	24	8.8	51	51	2	9.5	216	0	47
2	08-29-96	49	5.9	26	25	.9	15	222	0	38
3	08-21-96	37	3.3	35	38	1	15	185	0	51
4	08-20-96	35	2.7	39	41	2	18	185	0	51
5	06-26-97	39	5.5	10	15	.4	6.3	164	0	10
6	08-22-96	67	9.5	19	16	.6	12	226	0	39
7	07-08-97	56	5.3	82	49	3	22	258	0	150
8	09-05-96	37	4.2	58	49	2	18	218	0	60
9	12-07-95	38	2.8	69	54	3	17	195	3	77
10	09-09-96	140	14	69	26	1	21	344	0	290
11	07-17-97	49	7.4	18	19	.6	11	202	0	27
12	07-23-97	49	7.2	8.0	10	.3	7.1	181	0	19
13	09-19-96	54	8.1	70	45	2	13	309	0	76
14	09-25-96	56	8.2	68	44	2	13	318	0	77
15	09-18-96	53	7.9	69	45	2	13	311	0	76
16	09-12-96	39	5.3	78	56	3	11	244	0	93
17	09-17-96	44	5.4	74	52	3	13	243	0	95
18	07-08-97	69	8.0	29	22	.9	11	240	0	67
19	09-03-96	68	9.3	29	22	.9	12	261	0	68
20	09-03-96	57	7.9	27	24	.9	11	240	0	54
21	11-30-95	44	5.0	29	31	1	8.0	201	0	27
22	11-30-95	39	4.5	35	37	1	8.9	200	0	28
23	11-08-95	44	7.5	12	15	.4	7.1	212	0	11
24	11-08-95	43	8.2	7.9	10	.3	7.3	200	0	7.3
25	11-29-95	58	11	29	24	.9	6.3	278	0	32
26	09-24-96	16	1.7	110	80	7	9.4	226	0	92
27	11-29-95	8.0	.090	140	90	14	12	227	0	130
28	12-06-95	59	5.8	62	42	2	14	290	0	80
29	07-09-97	81	8.6	48	29	1	12	342	0	80
30	11-28-95	23	2.2	200	85	11	10	476	0	110
31	11-28-95	37	7.9	50	45	2	6.1	276	0	14
32	06-30-97	55	3.5	73	48	3	15	367	0	30
33	06-30-97	33	.88	71	60	3	13	302	0	33
34	11-09-95	52	3.3	72	49	3	15	385	0	26
35	07-01-97	53	2.8	71	49	3	15	362	0	30
36	07-01-97	35	.94	78	60	4	15	310	0	34
37	12-05-95	9.6	.72	250	93	21	11	610	0	84
38	10-19-95	35	1.8	160	76	7	14	561	0	22
39	07-22-97	21	1.6	91	75	5	6.7	--	0	35
40	10-18-95	11	.11	100	85	8	8.0	299	0	10
41	07-16-97	13	.12	102	83	8	8.8	296	0	14
42	07-22-97	11	.10	101	86	8	7.5	277	0	11
43	10-18-95	28	.49	83	68	4	8.8	287	0	9.0
44	06-25-97	74	22	23	15	.6	8.4	--	0	160

Table 14. Public-supply well water-quality data—Continued

SITE NUMBER	DATE	CHLORIDE, DIS-SOLVED (MG/L AS CL) (00940)	FLUORIDE, DIS-SOLVED (MG/L AS F) (00950)	SILICA, DIS-SOLVED (MG/L AS SIO2) (00955)	SOLIDS, SUM OF CONSTITUENTS, DIS-SOLVED (MG/L) (70301)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L) (70300)	SOLIDS, DIS-SOLVED (TONS PER AC-FT) (70303)	NITROGEN, AMMONIA DIS-SOLVED (MG/L AS N) (00608)	NITROGEN, AMMONIA DIS-SOLVED (MG/L AS NH4) (71846)	NITROGEN, NO2+NO3 DIS-SOLVED (MG/L AS N) (00631)
1	09-26-96	1.3	.60	71	322	314	.43	<.015	--	.420
2	08-29-96	3.7	.20	69	320	322	.44	<.015	--	.790
3	08-21-96	1.8	.30	70	349	322	.44	.020	.03	10.0
4	08-20-96	1.9	.30	71	314	338	.46	.020	.03	.850
5	06-26-97	1.7	.43	60	222	231	.31	<.015	--	1.65
6	08-22-96	5.4	.20	64	330	380	.52	<.020	--	.530
7	07-08-97	6.9	.18	73	525	552	.75	<.015	--	1.35
8	09-05-96	7.7	.30	73	372	372	.51	<.015	--	1.30
9	12-07-95	6.3	1.6	73	388	428	.58	<.015	--	.920
10	09-09-96	5.7	.20	74	786	798	1.09	<.015	--	.300
11	07-17-97	9.4	.43	65	298	317	.43	<.015	--	2.42
12	07-23-97	8.1	.22	60	255	274	.37	<.015	--	1.63
13	09-19-96	6.1	.50	55	440	436	.59	<.015	--	1.00
14	09-25-96	5.8	.50	55	446	468	.64	.020	.03	1.10
15	09-18-96	5.9	.50	55	438	420	.57	<.015	--	1.00
16	09-12-96	5.9	.50	56	421	427	.58	<.015	--	2.60
17	09-17-96	6.5	.40	59	432	436	.59	<.015	--	3.30
18	07-08-97	5.0	.33	58	374	396	.54	<.015	--	1.78
19	09-03-96	5.4	.30	58	383	400	.54	<.015	--	.970
20	09-03-96	4.3	.30	60	348	360	.49	<.015	--	1.80
21	11-30-95	4.9	.40	67	291	270	.37	<.015	--	1.40
22	11-30-95	3.9	.40	68	292	282	.38	<.015	--	1.20
23	11-08-95	1.7	.40	60	252	236	.32	<.015	--	.720
24	11-08-95	1.3	.30	58	235	222	.30	<.015	--	.530
25	11-29-95	4.9	.40	58	342	336	.46	<.015	--	.960
26	09-24-96	5.4	.40	60	411	438	.60	<.015	--	1.10
27	11-29-95	4.8	9.1	57	481	474	.64	<.015	--	1.80
28	12-06-95	4.8	.30	63	440	438	.60	<.015	--	1.70
29	07-09-97	5.2	.31	57	465	481	.65	<.015	--	.656
30	11-28-95	12	.50	52	652	612	.83	<.015	--	1.70
31	11-28-95	4.4	.40	58	318	260	.35	<.015	--	.800
32	06-30-97	5.9	.31	49	415	440	.60	<.015	--	.419
33	06-30-97	5.5	.27	53	366	370	.50	<.015	--	1.67
34	11-09-95	6.0	.30	48	414	400	.54	<.015	--	.410
35	07-01-97	6.2	.30	51	410	420	.57	<.015	--	.660
36	07-01-97	6.0	.26	53	380	402	.55	<.015	--	1.01
37	12-05-95	13	.90	48	730	738	1.00	<.015	--	2.60
38	10-19-95	8.3	.40	41	559	560	.76	<.015	--	.065
39	07-22-97	21	.44	59	359	390	.53	<.015	--	2.61
40	10-18-95	3.3	.20	57	343	332	.45	<.015	--	1.30
41	07-16-97	4.8	.19	54	354	376	.51	<.015	--	2.70
42	07-22-97	4.6	.23	57	336	353	.48	<.015	--	1.83
43	10-18-95	5.3	.90	52	336	344	.47	<.015	--	1.60
44	06-25-97	2.5	.77	22	424	455	.62	.060	.08	.006

Table 14. Public-supply well water-quality data—Continued

SITE NUMBER	DATE	PHOSPHORUS DISSOLVED (MG/L AS P) (00666)	ARSENIC DISSOLVED (UG/L AS AS) (01000)	BARIUM, DISSOLVED (UG/L AS BA) (01005)	BERYLLIUM, DISSOLVED (UG/L AS BE) (01010)	BORON, DISSOLVED (UG/L AS B) (01020)	CADMIUM WATER UNFLTRD TOTAL (UG/L AS CD) (01027)	CADMIUM DISSOLVED (UG/L AS CD) (01025)	CHROMIUM, DISSOLVED (UG/L AS CR) (01030)	COBALT, DISSOLVED (UG/L AS CO) (01035)
1	09-26-96	.007	11	61	<.50	107	<1	<1.0	<5.0	<3.0
2	08-29-96	.006	3	69	<.50	57	<1	<1.0	8.0	<3.0
3	08-21-96	.007	4	63	<.50	65	<1	<1.0	5.0	<3.0
4	08-20-96	.004	4	60	1.0	65	<1	<1.0	6.0	<3.0
5	06-26-97	.007	5	143	<.50	36	<1	<1.0	<5.0	<3.0
6	08-22-96	.009	3	71	<.50	55	<1	<1.0	<5.0	<3.0
7	07-08-97	.007	4	22	<.50	158	<1	<1.0	<5.0	<3.0
8	09-05-96	.006	4	60	<.50	70	<1	<1.0	<5.0	<3.0
9	12-07-95	.011	8	28	<.50	80	<1	<1.0	<5.0	<3.0
10	09-09-96	.012	3	32	<.50	176	<1	<1.0	<5.0	<3.0
11	07-17-97	.002	6	83	<.50	53	<1	<1.0	<5.0	<3.0
12	07-23-97	.003	4	102	<.50	33	<1	<1.0	<5.0	<3.0
13	09-19-96	.074	7	64	<.50	94	<1	<1.0	5.0	<3.0
14	09-25-96	.077	11	65	<.50	93	<1	1.0	<5.0	<3.0
15	09-18-96	.070	11	65	<.50	91	<1	<1.0	<5.0	<3.0
16	09-12-96	.052	7	56	<.50	88	<1	<1.0	<5.0	<3.0
17	09-17-96	.026	7	66	<.50	87	<1	<1.0	<5.0	<3.0
18	07-08-97	.041	5	79	<.50	62	<1	<1.0	<5.0	<3.0
19	09-03-96	.052	10	87	<.50	66	<1	<1.0	<5.0	<3.0
20	09-03-96	.036	6	79	<.50	64	<1	<1.0	7.0	<3.0
21	11-30-95	.006	6	67	<.50	60	<1	<1.0	<5.0	<3.0
22	11-30-95	.001	6	68	<.50	70	<1	<1.0	<5.0	<3.0
23	11-08-95	.004	8	140	<.50	40	<1	<1.0	<5.0	<3.0
24	11-08-95	.005	8	130	<.50	50	<1	<1.0	<5.0	<3.0
25	11-29-95	.022	5	180	<.50	60	<1	<1.0	<5.0	<3.0
26	09-24-96	.015	8	46	<.50	169	<1	<1.0	<5.0	<3.0
27	11-29-95	.008	9	18	<.50	260	<1	<1.0	<5.0	<3.0
28	12-06-95	.022	3	35	<.50	70	<1	<1.0	<5.0	<3.0
29	07-09-97	.040	5	47	<.50	74	<1	<1.0	<5.0	<3.0
30	11-28-95	.033	21	41	<.50	300	<1	<1.0	<5.0	<3.0
31	11-28-95	.017	6	39	<.50	90	<1	<1.0	<5.0	<3.0
32	06-30-97	.027	7	79	<.50	102	<1	<1.0	<5.0	<3.0
33	06-30-97	.008	6	68	<.50	117	<1	<1.0	<5.0	<3.0
34	11-09-95	.030	6	79	<.50	100	<1	<1.0	<5.0	<3.0
35	07-01-97	.032	6	90	<.50	105	<1	<1.0	<5.0	<3.0
36	07-01-97	.008	7	61	<.50	122	<1	<1.0	<5.0	<3.0
37	12-05-95	.022	77	22	<.50	500	<1	<1.0	<5.0	<3.0
38	10-19-95	.074	13	120	<.50	250	<1	<1.0	<5.0	<3.0
39	07-22-97	.010	14	27	<.50	147	<1	<1.0	<5.0	<3.0
40	10-18-95	.009	5	10	<.50	110	<1	<1.0	<5.0	<3.0
41	07-16-97	.006	4	15	<.50	103	<1	1.5	<5.0	<3.0
42	07-22-97	.008	4	9.8	<.50	113	<1	<1.0	<5.0	<3.0
43	10-18-95	.029	6	26	<.50	90	<1	<1.0	<5.0	<3.0
44	06-25-97	.001	14	51	<.50	43	<1	<1.0	<5.0	20

Table 14. Public-supply well water-quality data—Continued

SITE NUMBER	DATE	COPPER, DIS-SOLVED (UG/L AS CU) (01040)	IRON, DIS-SOLVED (UG/L AS FE) (01046)	LEAD, DIS-SOLVED (UG/L AS PB) (01049)	LITHIUM DIS-SOLVED (UG/L AS LI) (01130)	MANGA-NESE, DIS-SOLVED (UG/L AS MN) (01056)	MERCURY DIS-SOLVED (UG/L AS HG) (71890)	MOLYB-DENUM, DIS-SOLVED (UG/L AS MO) (01060)	NICKEL, DIS-SOLVED (UG/L AS NI) (01065)	SELE-NIUM, DIS-SOLVED (UG/L AS SE) (01145)
1	09-26-96	<10	4.0	<10	24	<1.0	<.1	10	<10	5
2	08-29-96	<10	7.0	<10	29	<1.0	<.1	<10	<10	3
3	08-21-96	<10	<3.0	<10	32	<1.0	<.1	<10	<10	2
4	08-20-96	<10	3.0	<10	34	<1.0	<.1	<10	<10	2
5	06-26-97	<10	<3.0	<10	13	<1.0	<.1	<10	<10	<1
6	08-22-96	<10	<3.0	10	23	<1.0	<.1	10	<10	3
7	07-08-97	<10	8.1	<10	52	1.0	<.1	<10	<10	6
8	09-05-96	<10	<3.0	<10	46	<1.0	<.1	<10	<10	3
9	12-07-95	<10	<3.0	<10	38	<1.0	.2	<10	<10	3
10	09-09-96	<10	11	10	62	2.0	<.1	20	<10	16
11	07-17-97	<10	<3.0	<10	18	<1.0	<.1	<10	<10	<1
12	07-23-97	<10	<3.0	<10	13	<1.0	<.1	<10	<10	4
13	09-19-96	<10	<3.0	<10	42	3.0	<.1	10	<10	5
14	09-25-96	<10	<3.0	<10	42	4.0	<.1	<10	<10	7
15	09-18-96	<10	<3.0	<10	44	4.0	<.1	<10	<10	5
16	09-12-96	<10	<3.0	<10	39	<1.0	<.1	<10	<10	8
17	09-17-96	<10	<3.0	<10	41	<1.0	<.1	<10	<10	7
18	07-08-97	<10	<3.0	<10	35	1.5	<.1	<10	<10	3
19	09-03-96	<10	3.0	<10	31	<1.0	<.1	<10	<10	4
20	09-03-96	<10	<3.0	10	30	<1.0	<.1	<10	<10	3
21	11-30-95	<10	<3.0	<10	30	<1.0	<.1	<10	<10	2
22	11-30-95	<10	<3.0	<10	31	<1.0	<.1	<10	<10	2
23	11-08-95	<10	<3.0	<10	12	<1.0	<.1	<10	<10	<1
24	11-08-95	<10	<3.0	<10	10	<1.0	<.1	<10	<10	<1
25	11-29-95	<10	<3.0	<10	23	<1.0	<.1	<10	<10	2
26	09-24-96	<10	5.0	<10	43	<1.0	<.1	<10	<10	5
27	11-29-95	<10	3.0	<10	61	<1.0	<.1	10	<10	3
28	12-06-95	<10	<3.0	<10	48	<1.0	<.1	<10	<10	4
29	07-09-97	<10	<3.0	<10	44	<1.0	<.1	<10	<10	2
30	11-28-95	<10	<3.0	<10	50	<1.0	<.1	<10	<10	10
31	11-28-95	<10	4.0	<10	21	<1.0	<.1	<10	<10	2
32	06-30-97	<10	7.9	<10	31	<1.0	<.1	<10	<10	1
33	06-30-97	<10	<3.0	<10	28	<1.0	<.1	<10	<10	3
34	11-09-95	30	26	<10	29	<1.0	<.1	<10	<10	1
35	07-01-97	<10	<3.0	12	30	<1.0	<.1	14	<10	1
36	07-01-97	<10	13	<10	30	<1.0	<.1	<10	<10	3
37	12-05-95	<10	<3.0	<10	51	<1.0	<.1	20	<10	11
38	10-19-95	<10	<3.0	20	59	8.0	<.1	20	<10	<1
39	07-22-97	<10	<3.0	<10	50	1.3	<.1	<10	<10	9
40	10-18-95	<10	<3.0	<10	45	<1.0	<.1	<10	<10	3
41	07-16-97	<10	<3.0	<10	48	<1.0	<.1	<10	<10	2
42	07-22-97	<10	<3.0	<10	47	<1.0	<.1	<10	<10	3
43	10-18-95	<10	20	10	40	<1.0	<.1	<10	<10	2
44	06-25-97	<10	2600	<10	53	84	<.1	12	<10	<1

Table 14. Public-supply well water-quality data—Continued

SITE NUMBER	DATE	SILVER, DIS-SOLVED (UG/L AS AG) (01075)	THAL-LIUM, DIS-SOLVED (UG/L AS TL) (01057)	STRON-TIUM, DIS-SOLVED (UG/L AS SR) (01080)	VANA-DIUM, DIS-SOLVED (UG/L AS V) (01085)	ZINC, DIS-SOLVED (UG/L AS ZN) (01090)	GROSS ALPHA RADIO. WATER DISS AS TH-230 (PCI/L) (04126)	ALPHA COUNT, 2 SIGMA WAT DIS AS TH-230 (PCI/L) (75987)	GROSS ALPHA, DIS-SOLVED (UG/L AS U-NAT) (80030)	ALPHA, COUNT, 2 SIGMA WAT DIS AS NAT U (UG/L) (75986)
1	09-26-96	<1.0	<.50	470	7	22	3.5	2.8	--	--
2	08-29-96	<1.0	<.50	540	<6	8.0	6.6	3.1	--	--
3	08-21-96	<1.0	<.50	470	8	7.0	3.9	2.5	--	--
4	08-20-96	<1.0	<.50	420	<6	13	6.3	3.0	--	--
5	06-26-97	<1.0	<.50	314	6	3.1	<3.0	2.2	--	--
6	08-22-96	<1.0	<.50	610	<6	8.0	6.0	3.2	--	--
7	07-08-97	<1.0	<.50	452	<6	28	22	5.8	--	--
8	09-05-96	1.0	<.50	390	<6	22	6.5	3.1	--	--
9	12-07-95	6.0	<.50	360	10	<3.0	6.9	3.2	9.5	4.5
10	09-09-96	<1.0	<.50	1100	<6	12	35	9.8	--	--
11	07-17-97	<1.0	<.50	404	9	72	6.1	3.2	--	--
12	07-23-97	<1.0	<.50	326	<6	161	3.3	2.5	--	--
13	09-19-96	<1.0	<.50	520	16	<3.0	6.6	3.6	--	--
14	09-25-96	<1.0	<.50	520	7	6.0	11	4.4	--	--
15	09-18-96	<1.0	<.50	530	7	<3.0	5.6	3.4	--	--
16	09-12-96	<1.0	<.50	390	13	15	9.0	3.9	--	--
17	09-17-96	<1.0	<.50	510	14	9.0	8.5	3.8	--	--
18	07-08-97	<1.0	<.50	675	<6	<3.0	13	4.4	--	--
19	09-03-96	<1.0	<.50	630	12	13	7.0	3.4	--	--
20	09-03-96	<1.0	<.50	580	9	16	12	4.3	--	--
21	11-30-95	<1.0	<.50	640	6	<3.0	7.3	2.8	9.9	3.8
22	11-30-95	<1.0	<.50	570	7	4.0	9.1	3.3	12	4.3
23	11-08-95	<1.0	<.50	350	10	26	6.2	2.3	9.8	3.4
24	11-08-95	<1.0	<.50	310	14	<3.0	6.0	2.1	7.8	2.7
25	11-29-95	<1.0	<.50	700	<6	<3.0	4.6	2.2	6.4	3.0
26	09-24-96	<1.0	<.50	280	8	30	15	4.4	--	--
27	11-29-95	<1.0	<.50	74	<6	9.0	15	5.1	21	7.4
28	12-06-95	<1.0	<.50	800	<6	4.0	26	6.5	37	9.2
29	07-09-97	<1.0	<.50	829	<7	<5.1	19	5.7	--	--
30	11-28-95	<1.0	<.50	240	230	<3.0	30	9.6	41	14
31	11-28-95	<1.0	<.50	420	19	<3.0	12	3.7	19	5.8
32	06-30-97	<1.0	<.50	483	<6	<3.0	13	4.9	--	--
33	06-30-97	<1.0	<.50	311	<6	<3.0	10	4.0	--	--
34	11-09-95	<1.0	<.50	490	<6	3.0	10	4.1	14	5.6
35	07-01-97	<1.0	<.50	486	<6	<3.0	16	5.1	--	--
36	07-01-97	<1.0	<.50	341	<6	<3.0	8.4	3.7	--	--
37	12-05-95	<1.0	<.50	100	110	12	34	10	45	14
38	10-19-95	<1.0	<.50	230	<6	10	6.1	3.6	8.4	5.0
39	07-22-97	<1.0	<.50	114	12	63	8.9	3.7	--	--
40	10-18-95	<1.0	<.50	65	7	12	13	3.7	18	5.3
41	07-16-97	<1.0	<.50	72	<6	3.4	16	4.6	--	--
42	07-22-97	<1.0	<.50	60	6	4.5	11	4.0	--	--
43	10-18-95	<1.0	<.50	120	10	130	8.8	3.4	12	4.8
44	06-25-97	<1.0	<.50	1280	<6	<3.0	8.4	3.8	--	--

Table 14. Public-supply well water-quality data—Continued

SITE NUMBER	DATE	GROSS BETA, DIS- SOLVED (PCI/L AS CS-137) (03515)	BETA, 2 SIGMA WATER, DISS, AS CS-137 (PCI/L) (75989)	GROSS BETA, DIS- SOLVED (PCI/L AS SR/ Y-90) (80050)	BETA, 2 SIGMA WATER, DISS, AS SR90 /Y90 (PCI/L (75988)	RA-226, DIS- SOLVED, PLAN- CHET COUNT (PCI/L) (09510)	RA-226 2 SIGMA WATER, DISS, (PCI/L) (76001)	U-238 WATER, DISS, (PCI/L) (22603)	U-238 2 SIGMA WATER DISS, (PCI/L) (75991)
1	09-26-96	21	5.9	--	--	<.1	--	--	--
2	08-29-96	28	6.8	--	--	<.1	--	--	--
3	08-21-96	26	6.2	--	--	<.1	--	--	--
4	08-20-96	25	6.0	--	--	<.1	--	--	--
5	06-26-97	9.6	4.1	--	--	<.1	--	--	--
6	08-22-96	24	6.8	--	--	<.1	--	--	--
7	07-08-97	32	5.2	--	--	<.1	--	--	--
8	09-05-96	31	7.7	--	--	<.1	--	--	--
9	12-07-95	23	3.3	18	2.5	<.1	--	--	--
10	09-09-96	51	13	--	--	<.1	--	--	--
11	07-17-97	15	4.3	--	--	<.1	--	--	--
12	07-23-97	9.2	4.1	--	--	<.1	--	--	--
13	09-19-96	31	8.4	--	--	<.1	--	--	--
14	09-25-96	36	10	--	--	<.1	--	--	--
15	09-18-96	29	7.9	--	--	<.1	--	--	--
16	09-12-96	32	8.8	--	--	<.1	--	--	--
17	09-17-96	21	6.8	--	--	<.1	--	--	--
18	07-08-97	16	4.5	--	--	<.1	--	--	--
19	09-03-96	24	6.5	--	--	<.1	--	--	--
20	09-03-96	24	6.2	--	--	<.1	--	--	--
21	11-30-95	9.4	2.1	7.2	1.2	<.1	--	--	--
22	11-30-95	11	2.4	8.4	1.3	<.1	--	--	--
23	11-08-95	8.9	2.1	6.8	1.2	<.1	--	--	--
24	11-08-95	9.5	2.1	7.2	1.2	<.1	--	--	--
25	11-29-95	12	2.5	8.5	2.7	<.1	--	--	--
26	09-24-96	22	5.6	--	--	<.1	--	--	--
27	11-29-95	21	3.1	16	2.4	<.1	--	7.5	.83
28	12-06-95	28	3.9	21	2.9	<.1	--	9.1	1.3
29	07-09-97	21	4.8	--	--	<.1	--	--	--
30	11-28-95	21	3.6	16	2.8	<.1	--	7.4	.82
31	11-28-95	13	2.9	9.8	3.0	<.1	--	5.9	.65
32	06-30-97	24	4.9	--	--	<.1	--	--	--
33	06-30-97	20	4.6	--	--	<.1	--	--	--
34	11-09-95	21	3.2	16	2.4	<.1	--	--	--
35	07-01-97	23	4.8	--	--	<.1	--	--	--
36	07-01-97	21	4.7	--	--	<.1	--	--	--
37	12-05-95	23	4.0	18	3.0	<.1	--	15	1.8
38	10-19-95	18	3.3	14	2.5	<.1	--	--	--
39	07-22-97	15	4.4	--	--	<.1	--	--	--
40	10-18-95	13	3.2	10	2.0	<.1	--	--	--
41	07-16-97	21	4.6	--	--	<.1	--	--	--
42	07-22-97	14	4.3	--	--	<.1	--	--	--
43	10-18-95	16	3.6	12	3.5	<.1	--	--	--
44	06-25-97	9.1	4.2	--	--	11	2.21	--	--

Table 14. Public-supply well water-quality data—Continued

SITE NUMBER	DATE	U-234 WATER DISS, (PCI/L) (22610)	U-234 2 SIGMA WATER DISS, (PCI/L) (75992)	U-235 WATER DISS, (PCI/L) (22620)	U-235 2 SIGMA WATER DISS, (PCI/L) (75994)	URANIUM NATURAL DIS-SOLVED (UG/L AS U) (22703)	URANIUM NATURAL 2 SIGMA WATER, DISS, (UG/L) (75990)
1	09-26-96	--	--	--	--	6.7	2.1
2	08-29-96	--	--	--	--	18	5.3
3	08-21-96	--	--	--	--	9.6	2.8
4	08-20-96	--	--	--	--	10	3.1
5	06-26-97	--	--	--	--	3.4	1.1
6	08-22-96	--	--	--	--	12	3.6
7	07-08-97	--	--	--	--	16	4.4
8	09-05-96	--	--	--	--	6.8	2.0
9	12-07-95	--	--	--	--	18	5.3
10	09-09-96	--	--	--	--	59	18
11	07-17-97	--	--	--	--	6.0	1.8
12	07-23-97	--	--	--	--	5.3	1.6
13	09-19-96	--	--	--	--	13	3.9
14	09-25-96	--	--	--	--	11	3.3
15	09-18-96	--	--	--	--	16	4.6
16	09-12-96	--	--	--	--	11	3.1
17	09-17-96	--	--	--	--	15	4.4
18	07-08-97	--	--	--	--	15	4.2
19	09-03-96	--	--	--	--	13	3.7
20	09-03-96	--	--	--	--	15	4.3
21	11-30-95	--	--	--	--	9.4	2.8
22	11-30-95	--	--	--	--	6.7	2.0
23	11-08-95	--	--	--	--	6.1	1.8
24	11-08-95	--	--	--	--	7.1	2.2
25	11-29-95	--	--	--	--	11	3.3
26	09-24-96	--	--	--	--	31	9.1
27	01-29-95	14	1.5	.3	.07	22	6.4
28	12-06-95	18	2.2	.2	.14	28	8.1
29	07-09-97	--	--	--	--	18	5.2
30	11-28-95	16	1.7	.3	.06	24	6.8
31	11-28-95	11	1.1	.2	.05	20	5.9
32	06-30-97	--	--	--	--	13	3.8
33	06-30-97	--	--	--	--	12	3.3
34	11-09-95	--	--	--	--	16	4.8
35	07-01-97	--	--	--	--	10	3.0
36	07-01-97	--	--	--	--	11	3.1
37	12-05-95	27	3.1	.9	.23	57	16
38	10-19-95	--	--	--	--	11	3.1
39	07-22-97	--	--	--	--	11	3.3
40	10-18-95	--	--	--	--	20	6.1
41	07-16-97	--	--	--	--	14	4.0
42	07-22-97	--	--	--	--	12	3.4
43	10-18-95	--	--	--	--	13	3.8
44	06-25-97	--	--	--	--	<1.0	.3

[1] The term acid neutralizing capacity (ANC) is applied to the acid-neutralizing capacity of solutes plus particulates in a water sample, reported in equivalents, and normally titrated on an unfiltered sample.