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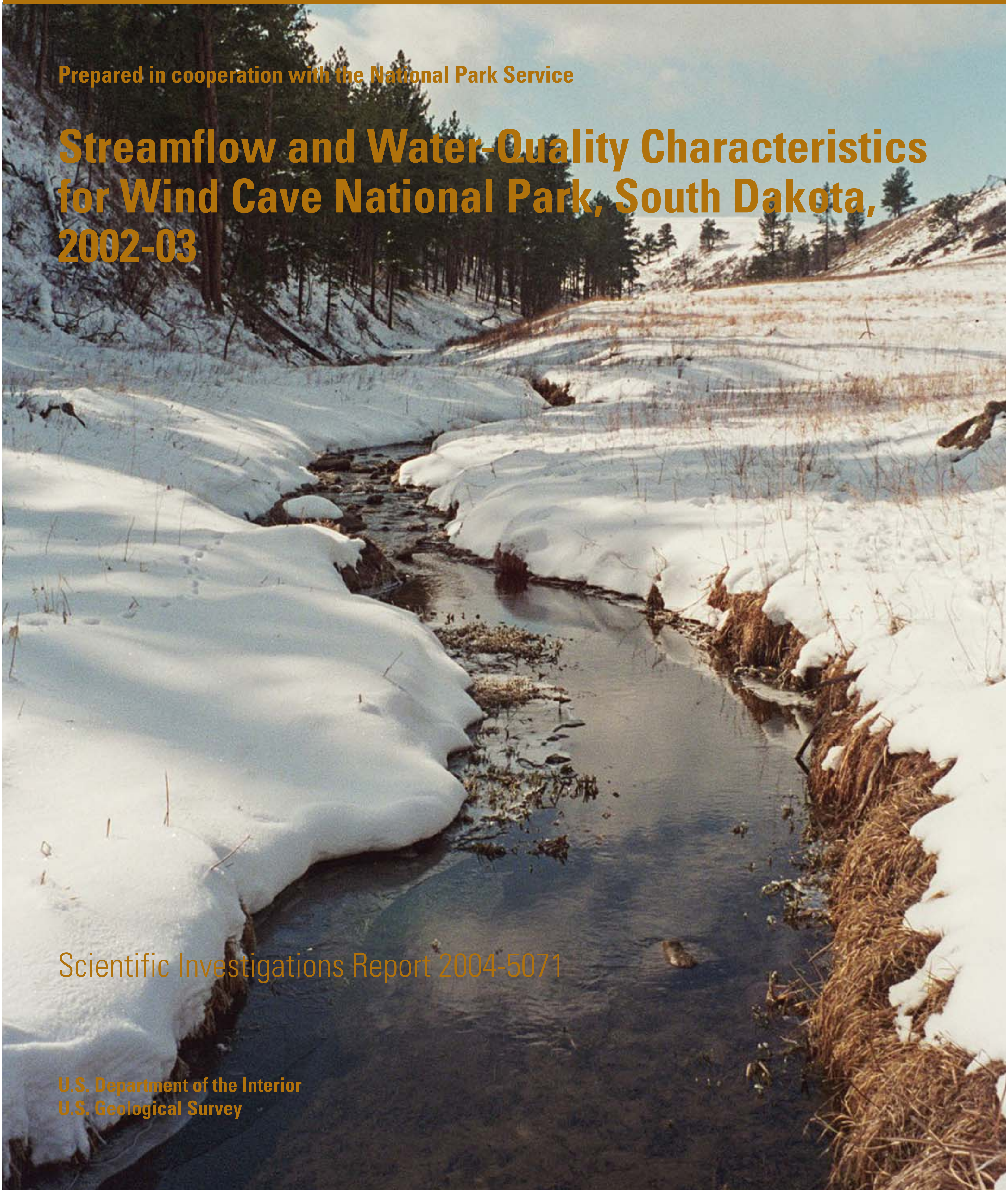
Streamflow and Water-Quality Characteristics for Wind Cave National Park, South Dakota, 2002-03



Scientific Investigations Report 2004-5071

U.S. Department of the Interior
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Highland Creek, Wind Cave National Park

Photograph courtesy of Wind Cave National Park

Bison, Wind Cave National Park

Photograph courtesy of Wind Cave National Park

Snow covered meadow, Wind Cave National Park

Photograph by Allen J. Heakin

Winter view of the sourthern Black Hills, Wind Cave National Park

Photograph by Allen J. Heakin

Front cover photograph is Beaver Creek below the confluence of Cold Spring Creek in Wind Cave National Park.

Photograph by Allen J. Heakin.

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Conversion Factors and Datum

Multiply	By	To obtain
acre	4,047	square meter
acre	0.4047	hectare
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
inch (in.)	2.54	centimeter
inch (in.)	25.4	millimeter
mile (mi)	1.609	kilometer
square foot (ft^2)	0.09290	square meter

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

°F = (1.8 x °C) + 32

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

°C = (°F - 32) / 1.8

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as mass (milligrams) of solute per unit volume (liter) of water. Micrograms per liter is a unit expressing the concentration of chemical constituents in solution as mass (micrograms) of solute per unit volume (liter) of water. Micrograms per liter are equivalent to milligrams per liter divided by 1,000.

Water year is the 12-month period, October 1 through September 30, and is designated by the calendar year in which it ends. Thus, the water year ending September 30, 2003, is called the "2003 water year."

Other Abbreviations, Symbols, and Acronyms Used:

mg/L	milligrams per liter
µg/L	micrograms per liter
µm	micron
µS/cm	microsiemens per centimeter
<	less than
BMIs	Benthic Macroinvertebrates
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
CCA	Chromated Copper Arsenate
CERCLIS	Comprehensive Environmental Response, Compensation, Liability Information System
DENR	South Dakota Department of Environment and Natural Resources
ELISA	Enzyme-Linked Immunosorbent Assay
EPT	Ephemeroptera, Plecoptera, Tricoptera
E&E	Ecology and Environment, Inc.
GC/MS	Gas Chromatography/Mass Spectrometry
MCL	Maximum Contaminant Level
MDL	Method Detection Limit
MRL	Minimum Reporting Level
NIWQP	National Irrigation Water Quality Program
NPS	National Park Service
NWQL	U.S. Geological Survey National Water Quality Laboratory
PAH	Polycyclic Aromatic Hydrocarbons
PCP	Pentachlorophenol
SMCL	Secondary Maximum Contaminant Level
TPH	Total Petroleum Hydrocarbons
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

Streamflow and Water-Quality Characteristics for Wind Cave National Park, South Dakota, 2002-03

By Allen J. Heakin

Abstract

A 2-year study of streamflow and water-quality characteristics in Wind Cave National Park was performed by the U.S. Geological Survey in cooperation with the National Park Service. During this study, streamflow and water-quality data were collected for three of the park's perennial streams (Cold Spring, Beaver, and Highland Creeks) from January 2002 through November 2003. The potential influence of parking lot runoff on cave drip within Wind Cave also was investigated by collecting and analyzing several time-dependent samples from a drainage culvert downstream from the parking lot and from Upper Minnehaha Falls inside the cave following a series of simulated runoff events. The primary focus of the report is on data collected during the 2-year study from January 2002 to November 2003; however, data collected previously also are summarized.

Losing reaches occur on both Beaver and Highland Creeks as these streams flow across outcrops of bedrock aquifers within the park. No streamflow losses occur along Cold Spring Creek because its confluence with Beaver Creek is located upstream from the outcrop of the Madison aquifer, where most streamflow losses occur.

Physical properties, major ions, trace elements, nutrients, bacteria, benthic macroinvertebrates, organic (wastewater) compounds, bottom sediment, and suspended sediment are summarized for samples collected from 2 sites on Cold Spring Creek, 2 sites on Beaver Creek, and 1 site on Highland Creek. None of the constituent concentrations for any of the samples collected during 2002-03 exceeded any of the U.S. Environmental Protection Agency drinking-water standards, with the exception of the Secondary Maximum Contaminant Level for pH, which was exceeded in numerous samples from Beaver Creek and Highland Creek. Additionally, the pH values in several of these same samples also exceeded beneficial-use criteria for coldwater permanent fisheries and coldwater marginal fisheries. Water temperature exceeded the coldwater permanent fisheries criterion in numerous samples from all three streams. Two samples from Highland Creek also exceeded the coldwater marginal fisheries criterion for water temperature.

Mean concentrations of ammonia, orthophosphate, and phosphorous were higher for the upstream site on Beaver Creek than for other water-quality sampling sites. Concentrations of *E. coli*, fecal coliform, and total coliform bacteria also were higher at the upstream site on Beaver Creek than for any other site.

Samples for the analysis of benthic macroinvertebrates were collected from one site on each of the three streams during July 2002 and May 2003. The benthic macroinvertebrate data showed that Beaver Creek had lower species diversity and a higher percentage of tolerant species than the other two streams during 2002, but just the opposite was found during 2003. However, examination of the complete data set indicates that the quality of water at the upstream site was generally poorer than the quality of water at the downstream site. Furthermore, the quality of water at the upstream site on Beaver Creek is somewhat degraded when compared to the quality of water from Highland and Cold Spring Creeks, indicating that anthropogenic activities outside the park probably are affecting the quality of water in Beaver Creek.

Samples for the analysis of wastewater compounds were collected at least twice from four of the five water-quality sampling sites. Bromoform, phenol, caffeine, and cholesterol were detected in samples from Cold Spring Creek, but only phenol was detected at concentrations greater than the minimum reporting level. Concentrations of several wastewater compounds were estimated in samples collected from sites on Beaver Creek, including phenol, para-cresol, and para-nonylphenol-total. Phenol was detected at both sites on Beaver Creek at concentrations greater than the minimum reporting level. Bromoform; para-cresol; ethanol,2-butoxy-phosphate; and cholesterol were detected at Highland Creek; however, none of these concentrations were greater than the minimum reporting level.

The geochemical composition of bottom sediments was analyzed in one composite sample from each of the three streams. Arsenic concentrations of 9.5 micrograms per gram in the sample from Cold Spring Creek and of 9.4 micrograms per gram in the sample from Beaver Creek exceeded the U.S. Environmental Protection Agency's threshold effects guidelines for sediment, the NOAA effects range low value, and the

National Irrigation Water Quality Program level of concern. The bottom-sediment sample from Highland Creek had the lowest percentage of organic, organic plus inorganic, and inorganic carbon of any site sampled during this study.

Samples for the analysis of suspended-sediment concentration were collected from each of the five water-quality sampling sites. Of the five sampling sites, mean concentrations of suspended sediment were highest in samples from the upstream site on Cold Spring Creek.

Analyses of water samples collected from the parking lot at the drainage culvert on September 4, 2002, following a simulated runoff event showed that toluene, benzene, meta- and para-xylene, chloroform, methyl isobutyl ketone, and acetone were present in the runoff. Analysis of a background sample collected from Upper Minnehaha Falls prior to the initiation of the simulated runoff event showed that only very low levels of toluene were present and at concentrations less than the minimum reporting level. Traces of acetone, total benzene, ethyl benzene, meta- and para-xylene, ortho-xylene, and styrene were present in the sequential cave-drip samples collected following the simulated runoff event, but at much lower levels than reported by a previous study.

Introduction

Wind Cave National Park is located in the Black Hills of southwestern South Dakota (fig. 1) and was established in 1903 as our Nation's seventh national park. The park currently (2004) encompasses 28,295 acres of rolling grasslands, pine forests, hills, and ravines on the southeastern flanks of the Black Hills. This area can be characterized as an ecologically significant zone of transition between the Black Hills and the prairie.

Wind Cave National Park is home to a diverse wildlife population that includes bison, pronghorn antelope, elk, mule and white-tailed deer, coyotes, porcupine, and prairie dogs. Various birds of prey such as hawks and eagles also inhabit the park. The only threatened or endangered species known to visit the park is the threatened bald eagle. Although the park's original purpose was to protect the cave and its resources, reestablishing native wildlife within the park quickly became another important goal.

Wind Cave is one of the world's oldest caves and the best example of an exhumed and modified paleocave (Palmer, 2000). It is recognized by cave experts throughout the world for its extensive deposits of calcite boxwork and uncommon formations of helictite brushes. The cave is the most complex example of a network maze cave known and was formed within mixing zones at multiple levels by water originating from multiple sources (Palmer, 2000). Wind Cave also is one of the world's largest caves and currently has over 110 mi of explored and/or mapped passageways. Although the focus of enabling legislation was on establishing Wind Cave National Park for the protection of its cave resources, the legislation was later revised to include the protection of surface and subsurface resources, which includes the quality of infiltrating water (National Park Service, 1994). Parts of Wind Cave are located below the existing water table, and at times some cave passages can be inundated with ground water. Numerous "lakes" and "pools" of varying size have been discovered in Wind Cave at depths approaching 430 ft below land surface (figs. 2 and 3). The cave's environment is nearly pristine, with the greatest threat to the subterranean ecosystem being the introduction of contaminants from the surface.

Much of the recharge to the Madison aquifer comes from streamflow losses as streams cross the outcrop areas of the karstic Madison Limestone, the geologic unit in which Wind Cave is located. Water flowing across outcrop areas enters the cave through fractures in the limestone. Water movement through karst features is dynamic, with potential for rapid changes in ground-water levels during recharge events. Large transmissivities related to secondary porosity cause the cave to be extremely vulnerable to contamination from the surface. Dye tests conducted in 1987 showed a hydrologic connection between Beaver Creek and subsurface water. Dye poured into Beaver Creek within the park boundaries was detected in the park's public-supply well within 2 months. Age dating indicated that the well water was less than 2 years old (Alexander and others, 1989). Therefore, a decline in the quality of surface-water resources could affect the quality of the park's subsurface resources.

Reductions in the volume or quality of surface water, related to anthropogenic activities upstream from the park's boundaries, have the potential to affect the management of fisheries and alter the composition and diversity of both the aquatic vertebrate and macroinvertebrate communities within Wind Cave National Park. Land use is changing just outside of the park boundary as development takes place. Land development coupled with other ongoing activities nearby such as agriculture, logging, and mining have potential to increase stream sediment and affect water chemistry and nutrient loads.

The U.S. Geological Survey (USGS) and National Park Service (NPS) initiated a cooperative study of streamflow and water-quality characteristics in Wind Cave National Park in 2002. During this 2-year study, streamflow and water-quality data were collected for three of the park's perennial streams (Cold Spring, Beaver, and Highland Creeks) from January 2002 through November 2003. These data were collected to characterize streamflow loss zones and to provide baseline water-quality data that will help park management determine if changing land-use practices outside the park are affecting Wind Cave's water resources. The potential influence of parking lot runoff on the quality of infiltrating water also was investigated. Several time-dependent samples were collected from a drainage culvert downstream from the parking lot and from Upper Minnehaha Falls inside the cave following a series of simulated runoff events conducted on June 19, August 12, and September 4, 2002.

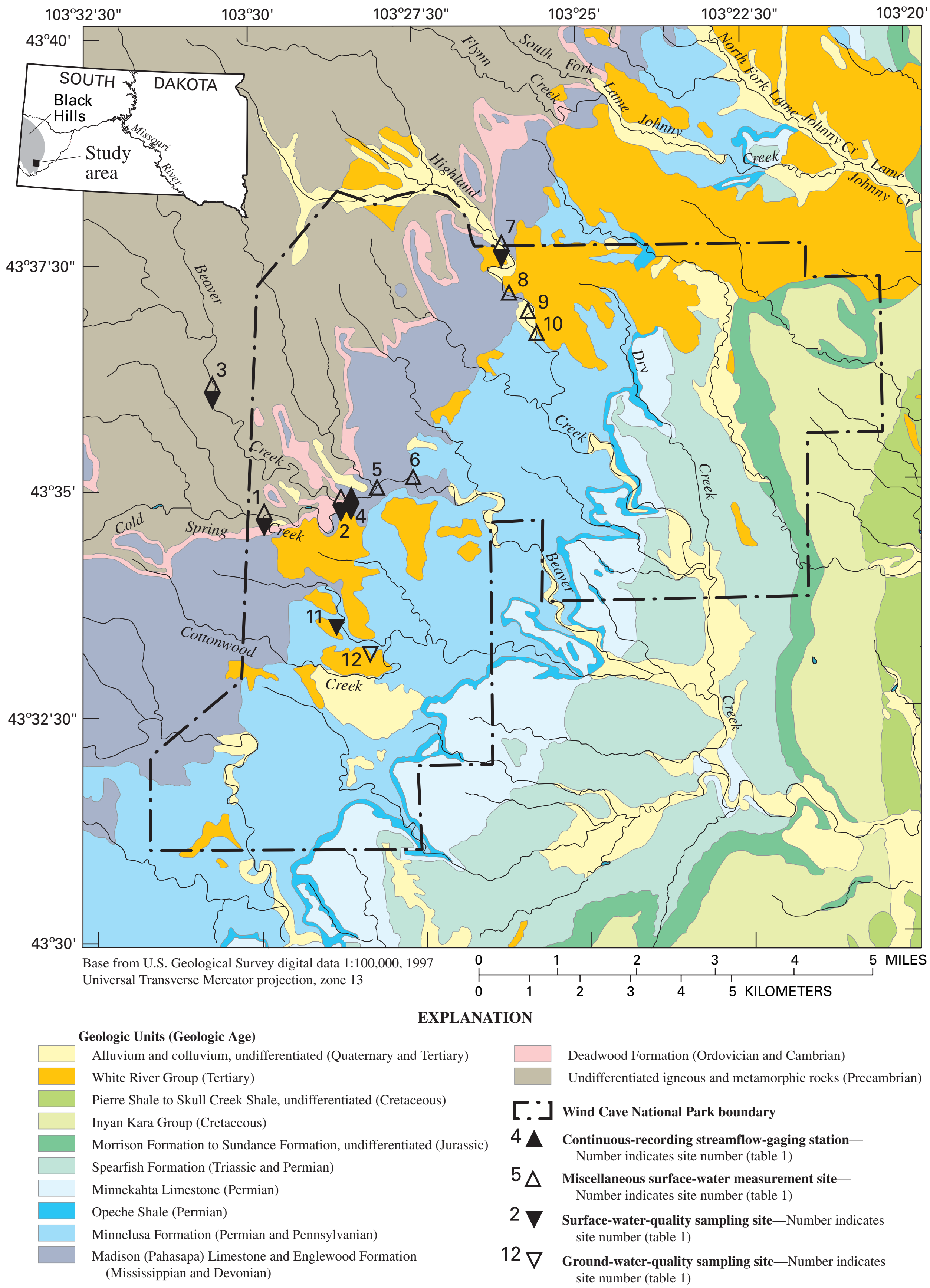
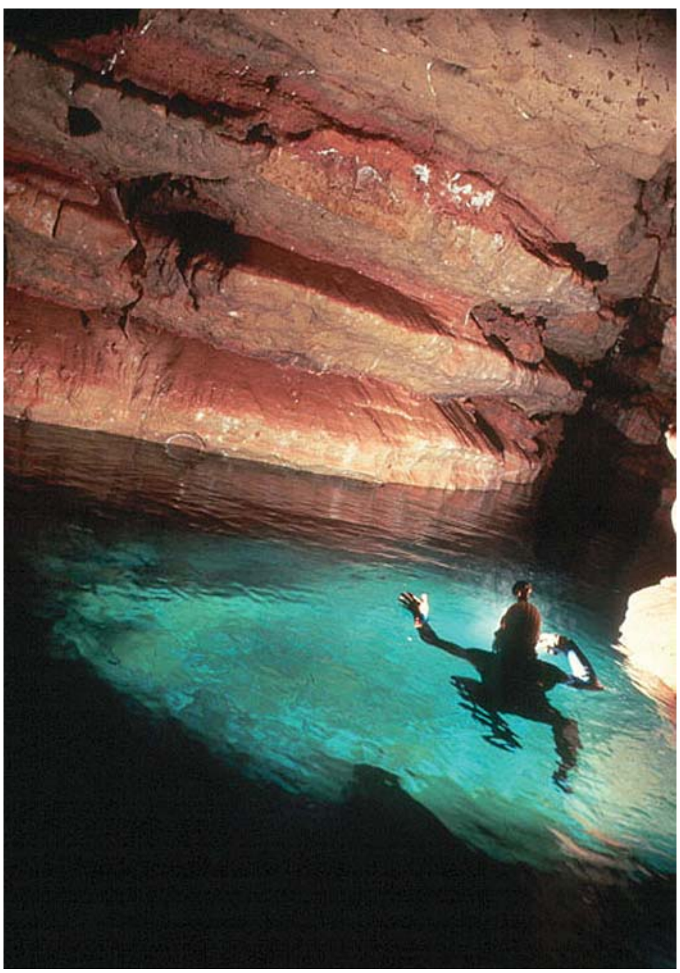


Figure 1. Location of study area and sampling sites. Distribution of geologic units also is shown (modified from Strobel and others, 1999).

Photograph courtesy of Wind Cave National Park

Figure 2. One of several underground lakes within Wind Cave that formed within solution openings in the Madison Limestone.



Photograph courtesy of Wind Cave National Park

Figure 3. A diver exploring an underground lake within Wind Cave.

Purpose and Scope

The primary purpose of this report is to describe streamflow and water-quality characteristics for Wind Cave National Park. The focus of the report is on data collected during the 2-year study from January 2002 to November 2003; however, data collected previously also are summarized. This report also describes the water-quality results of the simulated runoff events conducted in 2002.

Specifically, this report summarizes streamflow data collected for Cold Spring, Beaver, and Highland Creeks, and includes characterization of loss zones within these reaches. Water-quality data summarized for these streams include physical properties, major ions, trace elements, nutrients, bacteria, benthic macroinvertebrates, organic (wastewater) compounds, bottom sediment, and suspended sediment. Water-quality data summarized in samples from the drainage culvert and cave drip primarily include volatile organic compounds. Major-ion, trace-element, and nutrient concentrations also are summarized for one cave-drip sample.

Acknowledgments

The author is grateful to several individuals from the Wind Cave National Park staff who provided assistance with the study. Specifically, Dan Roddy helped with the study design and report review; Barbara Muenchau helped with obtaining scientific collection permits, streamflow measurements, and sample collection activities; Marc Ohms helped with water-quality sampling and provided a compilation of existing water-quality data for the park; and Rod Horrocks suggested the parking lot runoff investigation and also helped with report review.

Previous Investigations

The ground-water resources within Wind Cave National Park were described by Gries (1959) and by Alexander and others (1989), and explorations and surveys of the cave were documented by Nepstead and Pisarowicz (1988). An airflow study by Conn (1966) predicted that perhaps as little as 5 percent of Wind Cave had been explored, whereas a geographic information system approach recently predicted that between 9 and 40 percent of the passages had been explored (Horrocks and Szukalski, 2002).

In 1998, the NPS produced a summary of water-quality data collected for the park (National Park Service, 1998). The document presented results of chemical analysis for many of the park's water resources and included data for springs, cave-drip water, wells, and creeks. The 1998 report summarized water-quality data from six U.S. Environmental Protection Agency (USEPA) national databases. The USGS has collected daily streamflow data on Beaver Creek at a continuous streamflow-gaging station (site 4 in fig. 1) since water year 1991 (U.S. Geological Survey, 1992-2004). In addition to the 13 years of streamflow data collected on Beaver Creek, some basic field water-quality data also are available for the site (Driscoll and Bradford, 1994).

Alexander and others (1989) described the hydrology of Wind Cave and conducted a study of the quality of water infiltrating into the cave. They concluded that: (1) the elevated levels of sodium, chlorides, and/or nitrates detected in cave-drip water appeared to be effective indicators of surface, anthropogenic contamination; (2) there was evidence that low levels of hydrocarbon contamination reached at least one of the drip sites in the cave; and (3) runoff from the visitor's parking lot was directly reaching the underlying cave within a few days and the contamination from a single event persisted for months to years.

The conclusions from the Alexander (1989) study prompted a follow-up study by Venezky (1994). Venezky conducted simulated runoff studies by applying known quantities of water to a portion of the visitor's parking lot, then collected samples of cave drip at known intervals from several sites within the cave. During one simulation, Venezky (1994) reported that approximately 15 milligrams per liter (mg/L) of total hydrocarbon was washed from the north parking lot, and about 8 mg/L was washed from the south parking lot. Furthermore, samples collected inside the cave from Upper Minnehaha Falls following a rainfall event showed that concentrations of total hydrocarbon in cave-drip water increased from about 0.05 to 0.56 mg/L in less than 20 hours. This study also provided some water-quality data for Cold Spring, Beaver, and Highland Creeks and for various springs located outside the park.

Description of the Study Area

The study area includes all of Wind Cave National Park and is located along the southeastern flanks of the Black Hills in southwestern South Dakota (fig. 1). Altitudes within Wind Cave National Park range from about 3,560 ft above NGVD 29 in the southeast corner to about 5,010 ft above NGVD 29 in the northwest corner.

The climate of the area is continental, with generally low precipitation amounts, hot summers, cold winters, and extreme variations in both precipitation and temperatures (Johnson, 1933). Climatic conditions in the Black Hills area are influenced by orographic effects, with generally lower temperatures and higher precipitation at the higher altitudes. At Hot Springs (elevation of 3,560 ft above NGVD 29), which is located about 10 mi south of Wind Cave National Park, the mean annual temperature is about 49°F, and mean annual precipitation is about 21 in. (U.S. Department of Commerce, 1999).

Hydrology within the Black Hills area is greatly influenced by geology (Driscoll and Carter, 2001), which is highly complex. The Black Hills were formed about 60 to 65 million years ago during the Laramide orogeny (Feldman and Heimlich, 1980) and encompass an area that is nearly 125 mi long from north to south and 60 mi wide from east to west. The oldest rocks in the study area are the igneous and metamorphic rocks of Precambrian age (fig. 1), which are exposed in the "crystalline core" of the central Black Hills. A sequence of younger sedimentary rocks is exposed around the periphery of the Black Hills area and includes outcrops of the Cambrian- and Ordovician-age Deadwood Formation, the Mississippian-age Madison Limestone (also locally known as the Pahasapa Limestone), the Pennsylvanian- and Permian-age Minnelusa Formation, and the Permian-age Minnekahta Limestone (fig. 1). This layered sequence has been erosionally removed from the crystalline core area. The bedrock sedimentary formations typically dip away from the uplifted Black Hills at angles that can approach or exceed 15 to 20 degrees near the outcrops (Carter and others, 2002).

The headwater areas for Cold Spring, Beaver, and Highland Creeks are dominated by outcrops of Precambrian igneous and metamorphic rocks and are within the "crystalline core" hydrogeologic setting identified by Driscoll and Carter (2001). Streamflow characteristics for the crystalline core setting are typified by relatively small base flow and strong correlations between annual streamflow and precipitation. Small outcrop areas of the Madison Limestone also are present in the headwater area for Cold Spring Creek, and some base flow is provided from springs discharging from the Madison Limestone.

Most of the streams in the Black Hills area lose all or part of their flow as they cross the outcrop of the Madison Limestone (Rahn and Gries, 1973; Hortness and Driscoll, 1998). Large streamflow losses also occur in many locations within the outcrop of the Minnelusa Formation, and small losses probably also occur within the outcrop of the Minnekahta Limestone (Hortness and Driscoll, 1998). The confluence of Cold Spring Creek with Beaver Creek is just upstream from the outcrop of the Madison Limestone, so no loss zones are present along Cold Spring Creek. Hortness and Driscoll (1998) estimated maximum streamflow losses of 5 ft^3/s from Beaver Creek and of 10 ft^3/s or more from Highland Creek. Losses to unsaturated alluvial deposits located adjacent to stream channels also can occur.

The Precambrian basement rocks generally have low permeability and form the lower confining unit for the series of aquifers in sedimentary rocks in the Black Hills area. Driscoll and others (2002) assumed negligible regional ground-water outflow for Precambrian rocks; however, localized aquifers within Precambrian rocks occur in many locations in the crystalline core of the Black Hills, where enhanced secondary permeability results from weathering and fracturing. Ground-water discharge from Precambrian rocks provides base flow for streams in the study area, especially at higher altitudes where moisture surpluses result from increased precipitation and reduced evapotranspiration. Base flow can diminish very quickly during particularly dry periods.

Within the Paleozoic rock interval, aquifers in the Deadwood Formation, Madison Limestone, Minnelusa Formation, and Minnekahta Limestone are used extensively and are considered to be major aquifers in the Black Hills area. These aquifers receive recharge from infiltration of precipitation on outcrops, and the Madison and Minnelusa aquifers also receive substantial recharge from streamflow losses. These aquifers are collectively confined by the underlying Precambrian rocks and the overlying Spearfish Formation, where present (fig. 1). Individually, these aquifers are separated by minor confining units or by relatively impermeable layers within the individual units. In general, ground-water flow in these aquifers is radially outward from the crystalline core of the Black Hills.

Data-Collection Sites and Methods

Streamflow and/or water-quality data were collected at 12 sites in the study area (fig. 1; table 1). Sites 1-10 were used to characterize streamflow and/or water quality for Cold Spring, Beaver, and Highland Creeks. Water-quality samples were collected from 2 sites on Cold Spring Creek, 2 sites on Beaver Creek, and 1 site on Highland Creek to provide baseline water-quality data. Streamflow measurements were made at all of the water-quality sampling sites along these streams. Additional streamflow measurement sites along Beaver and Highland Creeks were used to determine streamflow losses. Continuous-record streamflow data have been collected at Beaver Creek near Pringle (site 4, station 06402430) since water year 1991 (U.S. Geological Survey, 1992-2004).

Water-quality samples were collected from sites 11 and 12 to investigate the potential influence of parking lot runoff on water infiltrating into the cave. The drainage culvert (site 11) is just downstream from the parking lot, and Upper Minnehaha Falls (site 12) is a site where cave drip occurs within Wind Cave.

Methods for Determining Streamflow Losses

Many streamflow measurements were made as part of seepage runs that began with measurement at the most upstream site and progressed to the most downstream site along each stream. During these seepage runs, streamflow measurements along each stream were made on the same day, when possible, to determine streamflow losses. However, some measurements were lagged by a day and are excluded from loss determinations.

Methods used to characterize streamflow conditions followed standard USGS protocols described by Rantz and others (1982). The accuracy of streamflow measurements are assumed to be ±5 percent. Streamflow losses were calculated by subtracting downstream flow from upstream flow. Thus, a positive residual represents a net gain, and a negative residual represents a net loss through a given reach. Analyses are arranged by stream reach, from upstream to downstream.

Sampling and Analytical Methods

Water samples for determination of instream characteristics for Cold Spring, Beaver, and Highland Creeks were collected from the center of the stream using grab procedures. Field measurements were made onsite using USGS standard methods as described in the U.S. Geological Survey National Field Manual (1997-2004). Field measurements included streamflow, dissolved oxygen, pH, specific conductance, and water temperature.

Table 1. Water-quality sampling and streamflow measurement site information.

Site number (fig. 1)	Station number	Site name	Site type
1	433444103295200	Cold Spring Creek 0.1 mile from the park boundary on Hwy 385	Water quality and streamflow
2	433451103284000	Cold Spring Creek 200 feet above confluence of Beaver Creek	Water quality and streamflow
3	433608103303600	Beaver Creek ¼ mile south of Corey Ranch site A	Water quality and streamflow
4	06402430	Beaver Creek near Pringle site B	Water quality and streamflow
5	433459103280800	Beaver Creek site C	Streamflow
6	433506103273500	Beaver Creek site D	Streamflow
7	433745103261900	Highland Creek above Madison outcrop near Pringle site A	Water quality and streamflow
8	433706103260400	Highland Creek site B	Streamflow
9	433654103254800	Highland Creek site C	Streamflow
10	433639103254000	Highland Creek site D	Streamflow
11	433328103284700	Drainage culvert (south end of visitor's parking lot)	Surface water (runoff)
12	433310103281701	Upper Minnehaha Falls	Ground water (cave drip)

Major ions, nutrients, trace elements, and organic (wastewater) compounds were analyzed by the USGS National Water Quality Laboratory (NWQL) in Denver, Colorado. References for analytical procedures used by NWQL can be found on the World Wide Web at URL http://nwql.usgs.gov/Public/ref_list.html (accessed February 6, 2004) and in Brown and others (1999) for the wastewater analyses. Major-ion and trace-element concentrations for this study generally are reported as "dissolved" concentrations, which means that the water samples were passed through 0.45-micron (µm) pore-size filters at the time of collection, thereby excluding the particulate phase from the analysis.

Results for organic wastewater compounds are reported in relation to the method reporting level (MRL) or method detection limit (MDL) (Childress and others, 1999). Estimated values can be reported that are less than the MRL (the smallest concentration of a substance that can be reliably measured by using a given analytical method) but greater than the MDL (the minimum concentration of a substance that can be measured and reported with a 99-percent confidence that the analyte concentration is greater than zero).

Grab samples for bacteria analyses were collected from the middle of the stream using pre-sterilized containers provided by the analyzing laboratory, and were immediately chilled following collection. The samples were analyzed for *E. coli*, fecal coliform, and total coliform bacteria within 12 hours of sample collection by Energy Laboratories in Rapid City, South Dakota. Energy laboratories has received USEPA certification for biological analysis and used method 9223B outlined in the 19th edition of Standard Methods for the Examination of Water and Wastewater (Eaton and others, 1995).

Samples for the analysis of benthic macroinvertebrates (BMIs) were collected using protocols developed by Barbour and others (1999), Klemm and others (1990), and Plafkin and others (1989) for USEPA's Environmental Monitoring and Assessment Program (EMAP), and by Cuffney and others (1993) for the National Water Quality Assessment (NAWQA) program. Taxonomic identifications were provided by the NWQL's Biological Group using methods outlined by Moulton and others (2000).

Composite bed sediment samples were collected from selected depositional zones along the streams using guidelines of Edwards and Glysson (1988) and Ward and Harr (1990). The samples were thoroughly mixed then wet sieved through a 62-µm mesh screen, and the fraction less than 62 µm was submitted to the Branch of Geochemistry Laboratory of the USGS, Geologic Discipline, Lakewood, Colorado, for analysis. The samples were analyzed using procedures described in Arbogast (1990).

Water samples were processed and analyzed for suspended sediments by the USGS Iowa District Sediment Laboratory. Analytical and quality-assurance procedures are described by Guy (1969) and Matthes and others (1991).

Several time-dependent samples were collected from a drainage culvert (site 11) downstream from the parking lot and from Upper Minnehaha Falls (site 12) inside the cave following a series of simulated runoff events conducted on June 19, August 12, and September 4, 2002. Samples were collected from the drainage culvert at 10-minute intervals following the simulated event until flow at the culvert ceased. Cave-drip samples were collected from Upper Minnehaha Falls at 1-hour time increments beginning at selected times following the simulated runoff event, based on previous dye studies done by Alexander and others (1989). The cave-drip samples were collected by NPS personnel using pre-cleaned bottles provided by the laboratory.

Source water samples and samples collected from the drainage culvert (site 11) following the June 19 and August 12, 2002, simulated runoff events were analyzed for the petroleum hydrocarbons of total benzene, toluene, ethylbenzene, and xylenes (BTEX) using the Enzyme-Linked Immunosorbent Assay (ELISA) technique at the USGS South Dakota District laboratory. The ELISA technique has an MDL of 20 micrograms per liter (µg/L). Samples collected from the drainage culvert following the September 4, 2002, simulated runoff event were analyzed for hydrocarbon compounds at the NWQL using gas chromatography/mass spectrometry (GC/MS) methods (Connor and others, 1997). All samples collected from Upper Minnehaha Falls (site 12) were analyzed for hydrocarbon compounds at the NWQL using GC/MS methods. One sample from site 12 also was analyzed at the NWQL for major-ion, nutrient, and trace-element concentrations.

Quality Assurance

Quality-assurance samples were used to evaluate the precision and accuracy of the analysis of environmental samples collected for this study. The quality-assurance samples consisted of replicate field samples, blanks, and spiked samples.

Two replicate samples were collected during the study and analyzed for major ions, nutrients, and trace elements. The quality-assurance and quality-control data for the replicate samples are presented in table 9 in the Supplemental Information section at the end of this report. Differences between environmental samples and replicate samples were determined to be negligible, which indicates that there were no problems with sample processing, preservation, or analysis techniques.

Quality-assurance procedures for the analysis of wastewater compounds followed guidelines developed by the NWQL. Basically, two types of quality-assurance samples were analyzed—blanks and spiked samples. Blanks are aliquots of ultrapure deionized water certified to be analyte free that are inserted along with environmental samples submitted for analysis in order to evaluate how the analytical instrumentation is operating and to determine if any contamination during field or laboratory processing or the analytical process could be affecting the results. Spikes are aliquots of ultrapure deionized water that have been fortified with a solution containing known concentrations of specific analytes. The NWQL establishes acceptable percent recovery ranges for specific analytes (table 10 in the Supplemental Information section) based upon evaluation of numerous spiked samples. Data for environmental samples that have associated percent recoveries for spiked samples that are outside the established ranges should be used with caution.

Blank samples were submitted between March 4, 2002, and May 13, 2003, and analyzed for wastewater compounds along with environmental samples. The results of the blank analysis (table 10) indicated “estimated” values for a few wastewater compounds; although the estimated concentrations were greater than the MDL for the analytical method employed, all estimated concentrations were less than the MRL.

Five blank samples were spiked by the NWQL and were analyzed along with environmental samples submitted on May 12, 2003, from Highland Creek. The results for the spiked sample (table 10) showed that a few compounds were outside of the established percent recovery ranges. However, the environmental samples analyzed in conjunction with the spiked samples had reported values that were all less than the MRL for these constituents.

Quality-assurance samples collected during the investigation of potential influence of parking lot runoff on cave drip water within Wind Cave consisted of two trip blanks. The blank samples were composed of organic-free water that accompanied the runoff samples during shipment to the laboratory on June 19 and September 4, 2002. The trip blanks were analyzed for volatile organic compounds. The results (table 9) indicate that all constituent concentrations were less than the respective MRLs. The only compound detected in the blank samples was toluene, which was detected in the September 4, 2002, sample at an estimated concentration of 0.01 μg/L, which is less than the MRL of 0.05 μg/L for that compound.

Streamflow

For the past several years, most of western South Dakota has experienced persistent drought conditions. Hydrologic conditions for water year 2002 (October 2001 through September 2002) and 2003 were much different than the wetter conditions experienced in the mid-to-late 1990s, with subsequent precipitation and streamflow levels generally well below normal. Throughout the duration of the study described in this report, precipitation amounts generally were 2 to 4 in. below average in much of western South Dakota. The U.S. Drought Monitor map produced by the National Oceanographic and Atmospheric Administration (2003) indicated that the study area ranked in the moderate to severe drought category. Consequently, most perennial streams probably would be expected to experience reduced streamflow as a result of extended periods of moderate to severe drought conditions.

Streamflow data collected during water years 1992-2003 for Beaver Creek near Pringle (station 06402430, table 1, site 4), the only continuous streamflow-gaging station within the study area, are represented graphically in figure 4. Data from water year 1991 are not included because records for that year were incomplete. The annual mean streamflow at site 4 was 3.18 ft^3/s for water years 1992 to 2003 (Burr and others, 2004). However, annual mean streamflow for the site was about 0.8 ft^3/s in water year 2003 (fig. 4A), and only water year 1992 had a lower recorded annual mean flow value indicating the intensity of the drought situation during the study period. The highest monthly mean streamflow at site 4 generally occurs during May and June (fig. 4B), when the effects of snowmelt and spring rains combine to augment surface runoff. Inflows from springs coupled with summer storms generally maintain streamflow through the summer months until storm frequency declines in late summer or early fall. The duration curve shown in fig. 4C indicates that daily mean flows at site 4 exceed 1.65 ft^3/s about 50 percent of the time. Between water years 1992 and 2003, the minimum daily mean flow fluctuated between 0.06 and 0.9 ft^3/s (fig. 4D). During the same period, the maximum peak flow recorded was 90 ft^3/s on June 10, 1995.

Streamflow measurements were made at selected sites on Cold Spring, Beaver, and Highland Creeks during January, March, May, July, September, October, and November 2002 and during January, March, May, July, September, and October 2003. Hydrographs depicting streamflow are presented in figure 5. Streamflow measurement sites are shown in figure 1 and presented in table 1. The uppermost measurement site on a creek is the lowest number, and downstream sites continue in ascending numerical order.

During 2002, Cold Spring Creek showed only minor variability in streamflow between site 1 and the downstream site 2 (table 2). The seven streamflow measurements made during 2002 indicate that the reach between the two sites generally lost a small amount of streamflow, most likely through a combination of plant uptake, evaporation, or seepage to the alluvium. However, at the time of the May measurement, the downstream site had slightly higher streamflow (0.41 ft^3/s) than the upstream site (0.34 ft^3/s).

During 2003, site 2 was discontinued as a water-quality sampling site and accordingly, streamflow was only measured at the site during January, March, and May. The March streamflow measurement showed that the reach between site 1 and the downstream site 2 lost flow.

For Beaver Creek, the uppermost site (site 3), generally had less flow than the next downstream site (site 4) located at the USGS streamflow-gaging station 06402430. This is because the uppermost site is above the confluence of Cold Spring Creek, whereas site 4 is below the confluence and includes contributions from Cold Spring Creek. Streamflow measurements began in May 2002 for the two downstream sites (sites 5 and 6) because those sites were frozen during the previous visits in January and March and again in November. Streamflow increased at sites 3 and 4 between January and May, then decreased at all four sites on Beaver Creek between May and September. Measurements between September and October at the downstream sites showed a slight increase in streamflow, which was probably due to vegetative die off that resulted from reduced water uptake by plants and as a result of cooler temperatures. During late fall and winter of 2003, no streamflow

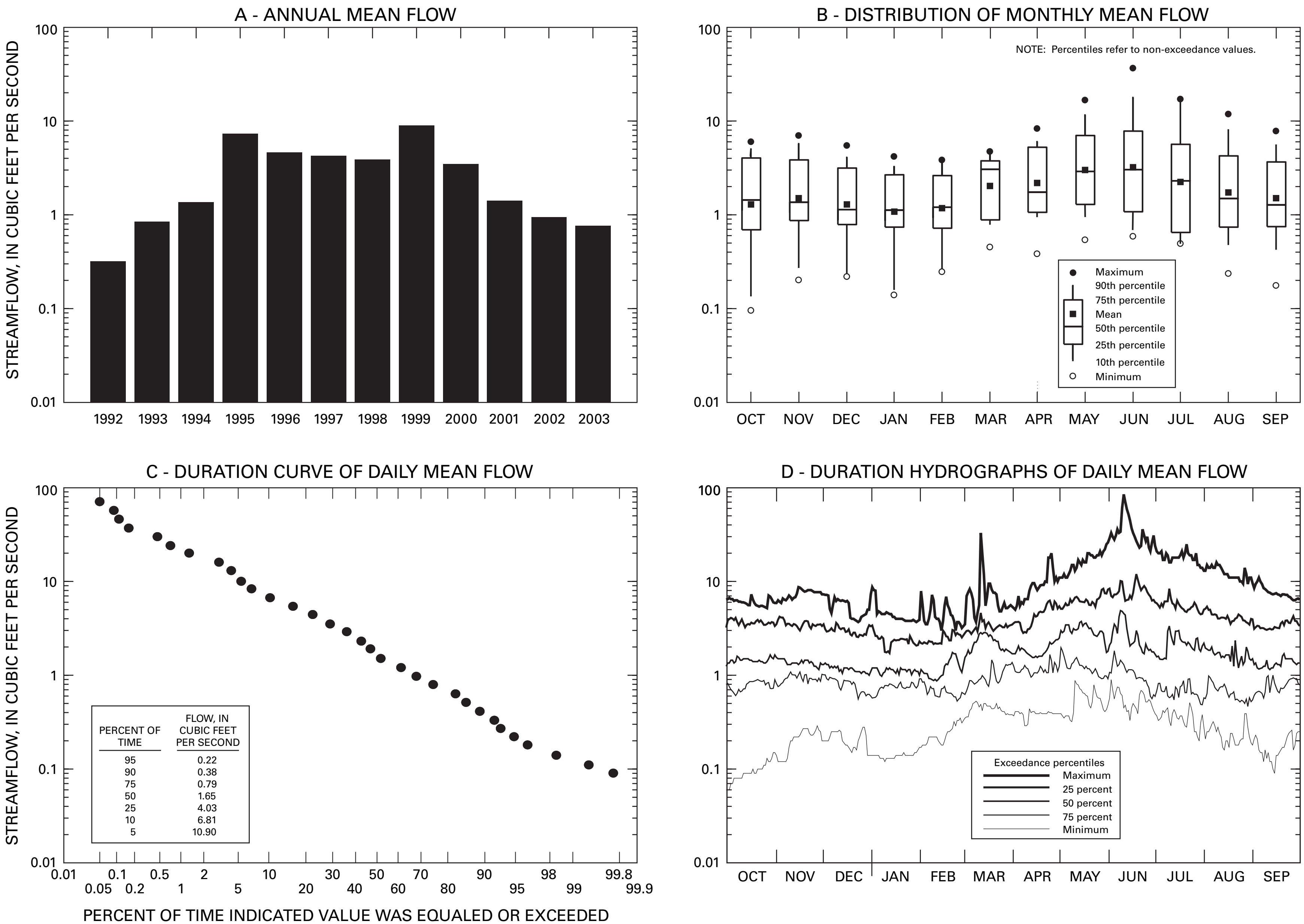


Figure 4. Variations in annual, monthly, and daily mean streamflow for station 06402430, Beaver Creek near Pringle (site 4), water years 1992-2003.

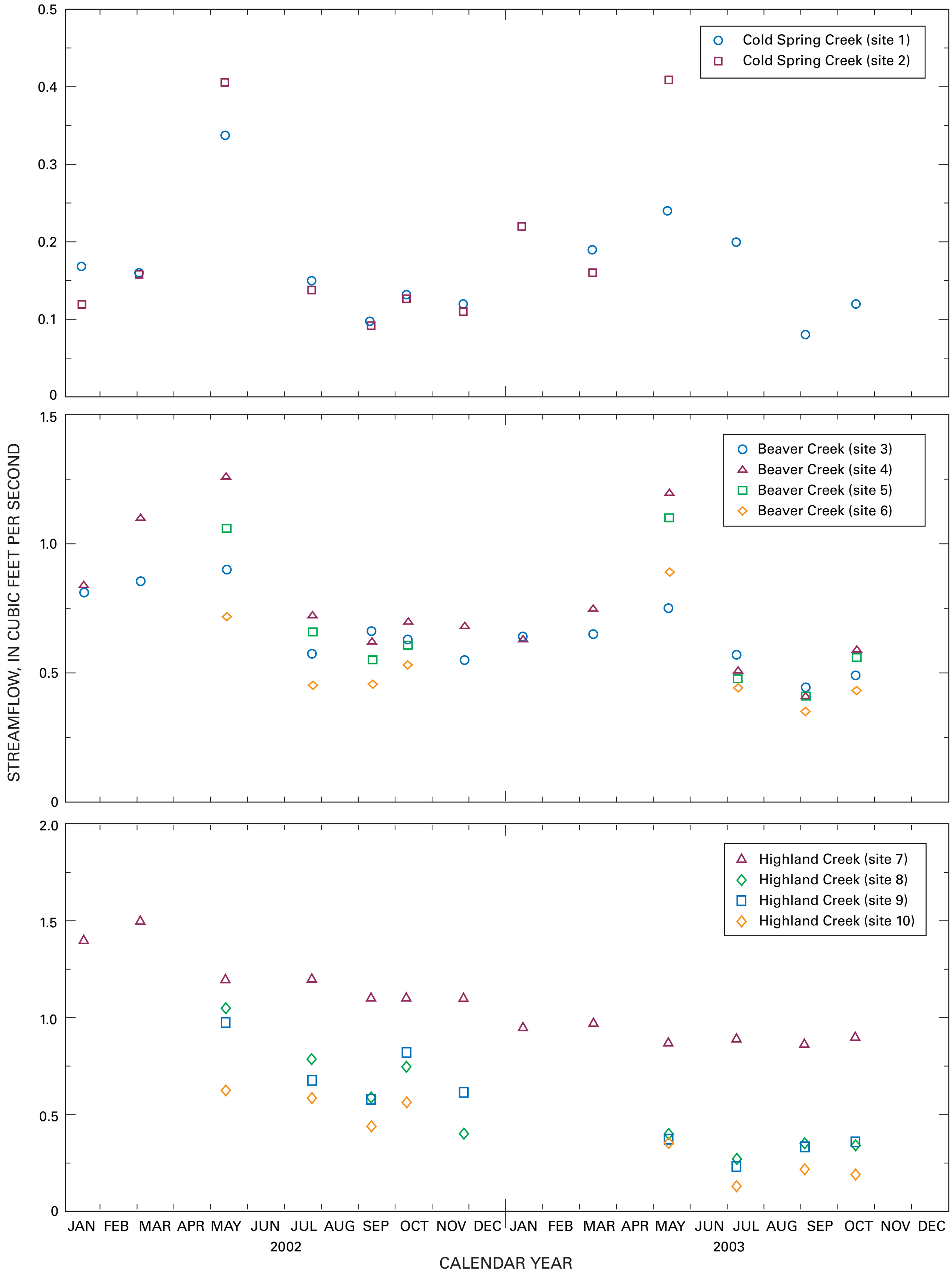


Figure 5. Streamflow measurements for Cold Spring, Beaver, and Highland Creeks.

Table 2. Streamflow data collected during the study.

[Values are in cubic feet per second; --, no data]

Date	Cold Spring Creek		Beaver Creek						Highland Creek						
	Site 1	Site 2	Site 3	Site 4	Site 5	Gain(+)/ loss(-) (from 4 to 5)	Site 6	Gain(+)/ loss(-) (from 5 to 6)	Site 7	Site 8	Gain(+)/ loss(-) (from 7 to 8)	Site 9	Gain(+)/ loss(-) (from 8 to 9)	Site 10	Gain(+)/ loss(-) (from 9 to 10)
01-16-02	0.17	0.12	0.81	0.84	--	--	--	--	1.4	--	--	--	--	--	--
03-04-02	.16	.16	.85	1.10	--	--	--	--	1.5	--	--	--	--	--	--
05-13-02	--	--	--	--	--	--	--	--	1.2	1.05	-0.15	0.98	-0.07	0.62	-0.36
05-14-02	.34	.41	.90	1.26	1.06	-0.2	0.72	-0.34	--	--	--	--	--	--	--
06-13-02	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
07-23-02	--	--	.57	--	--	--	--	--	1.07	.78	-.29	.68	-.10	.58	-.10
07-24-02	.15	.14	--	.72	.66	-.06	.45	-.21	--	--	--	--	--	--	--
09-10-02	.10	--	.66	--	--	--	--	--	1.1	.59	-.51	.57	-.02	.44	-.13
09-11-02	--	.09	--	.62	.55	-.07	.46	-.09	--	--	--	--	--	--	--
10-09-02	--	--	--	--	--	--	--	--	1.14	.75	-.39	.82	+.07	.56	-.26
10-10-02	.13	.13	.63	.70	.61	-.09	.53	-.08	--	--	--	--	--	--	--
11-25-02	--	--	--	--	--	--	--	--	1.05	.40	-.65	.61	+.21	--	--
11-26-02	.12	.11	.55	.68	--	--	--	--	--	--	--	--	--	--	--
01-13-03	--	.22	.64	.63	--	--	--	--	.95	--	--	--	--	--	--
03-12-03	.19	.16	.65	.75	--	--	--	--	.97	--	--	--	--	--	--
05-13-03	.24	--	.75	--	--	--	--	--	.87	.40	-.47	.37	-.03	.35	-.02
05-14-03	--	.41	--	1.18	1.11	-.07	.89	-.22	--	--	--	--	--	--	--
07-08-03	.20	--	.57	--	--	--	--	--	.89	.27	-.62	.23	-.04	.13	-.10
07-09-03	--	--	--	.51	.48	-.03	.44	-.04	--	--	--	--	--	--	--
09-02-03	--	--	--	--	--	--	--	--	.86	.35	-.51	.33	-.02	.22	-.11
09-03-03	.08	--	.44	.41	.41	0	.35	-.06	--	--	--	--	--	--	--
10-14-03	--	--	.49	--	--		--		.90	.34	-.56	.36	+.02	.19	-.17
10-15-03	.12	--	--	.59	.56	-.03	.43	-.13	--	--	--	--	--	--	--
Mean	--	--	--	--	--	-.07	--	-.14	--	--	-.46	--	0.00	--	-.15

measurements could be made at the two lower sites (5 and 6) on Beaver Creek because they were once again frozen. However, streamflow increased at sites 3 and 4 between January and May. Between May and September, all sites experienced decreased streamflow.

Streamflow measurements for Highland Creek for 2002 did not begin until May for three of the sites because they were frozen during the previous visits in January and March. Streamflow at the uppermost site (site 7 in fig. 5) decreased between January and May, remained fairly constant between May and July, decreased in September, and then increased slightly in October. Streamflow between May and September decreased at sites 8, 9, and 10. Streamflow increased slightly at all sites on Highland Creek between September and October probably as a result of reduced water requirements by vegetation and lower daily temperatures that decreased evapotranspiration.

No streamflow measurements were made at sites 8, 9, or 10 on Highland Creek during January and March 2003 because during that period, the stream was frozen at those locations. Streamflow at site 7 showed a gradual decline between January and May. Between May and October no significant changes in streamflow were observed.

Hydrographs constructed from data collected during the study for Cold Spring and Beaver Creeks show a similar seasonal pattern in streamflow fluctuations. Typically, spring months show peak flows followed by gradual declines through summer into early fall as shown by the 12 years of data presented in figure 4B. In contrast, the hydrograph for Highland Creek shows a relatively steady decline in streamflow at all sites with only slight seasonal fluctuation (fig. 5).

Net gains or losses in streamflow were calculated between selected sites (table 2). This table also allows for the identification of where the greatest streamflow losses or gains occurred between consecutive measurement sites on stream reaches. For example, very little change in streamflow was observed between sites 1 and 2 on Cold Spring Creek. This is because the confluence of Cold Spring Creek with Beaver Creek is just upstream from the outcrop of the Madison Limestone; therefore, no loss zones are present along Cold Spring Creek.

Beaver Creek generally gained flow between sites 3 and 4 largely as a result of inflows from Cold Spring Creek above site 4, but lost streamflow between sites 4 and 5 with a mean loss of 0.07 ft^3/s. The most substantial losses on Beaver Creek generally occurred between sites 5 and 6 with a mean loss of 0.14 ft^3/s. Streamflow losses between sites 4 and 6 probably are a result of recharge to the Madison Limestone.

The most substantial losses on Highland Creek generally occurred between sites 7 and 8 with a mean loss of 0.46 ft^3/s. Most of these losses probably can be attributed to a combination of alluvial recharge and losses to the underlying bedrock aquifer. There were no overall net losses or gains in streamflow between sites 8 and 9; however, some relatively large losses were observed between sites 9 and 10 with an average loss of 0.15 ft^3/s in that stream reach that are likely the result of alluvial recharge and losses to the underlying bedrock aquifer.

For all measurements made during the study period, Beaver Creek lost all of its flow to the Madison Limestone within the park at an area called Beaver Creek Cave (just downstream from site 6 in fig. 1). Similarly, flow on Highland Creek ceased just downstream from site 10. Low-flow conditions during the study period precluded characterization of streamflow-loss conditions for both Beaver Creek and Highland Creek.

Water Quality

Water-quality characteristics are summarized in this section of the report. Instream characteristics are summarized for Cold Spring, Beaver, and Highland Creeks with an emphasis on data collected from January 2002 to November 2003. Water-quality data from previous investigations reported in the NPS Natural Resources Technical Report (National Park Service, 1998) also are summarized. Water-quality characteristics of runoff from the parking lot also are summarized from analytical results of samples collected from the drainage culvert and cave drip following simulated runoff events.

Analytical results obtained for some of the constituents collected during this study are compared to standards established by the USEPA and the State of South Dakota, as part of the Clean Water Act of 1977 (table 3). The Clean Water Act requires States to classify streams with regard to beneficial use and to establish water-quality criteria that define acceptable properties or constituent concentrations to meet those uses (South Dakota Department of Environment and Natural Resources, 2002). The beneficial-use criteria have been established to protect human health and ensure that a stream can support the criteria established for its designated beneficial use. Aquatic-life criteria are established to provide protection to biota from either acute or chronic toxicity. Acute toxicity refers to the ability of a substance to cause adverse effects or death resulting from a single short-term exposure. Chronic toxicity refers to the ability of a substance to cause adverse effects as a result of long-term exposure.

Water-quality criteria, standards, and recommended limits for drinking-water and aquatic-life criteria promulgated by the USEPA also are presented in table 3. Comparisons are made for constituents that have an assigned standard. Two types of standards are typically used to assess the suitability of water for human consumption. The Maximum Contaminant Level (MCL) represents the maximum permissible level of a contaminant allowed in water delivered to any user of a public-supply system. MCLs are enforceable standards under the Safe Drinking Water Act. The 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.

Table 3. Water-quality standards for selected physical properties and constituents.

[All constituents in milligrams per liter unless otherwise noted. MCL, Maximum Contaminant Level; SMCL, Secondary Maximum Contaminant Level; µS/cm, microsiemens per centimeter at 25°C; µg/L, micrograms per liter; mL, milliliters; °F, degrees Fahrenheit; °C, degrees Celsius; ≥, greater than or equal to; --, no data available]

Property or constituent	U.S. Environmental Protection Agency drinking-water standards		Beneficial-use criteria						Aquatic-life criteria for fisheries (acute/chronic toxicity) (µg/L)[2]
	Drinking water MCL[1]	Drinking water SMCL[1]	Domestic water supply (mean/daily maximum)[2]	Coldwater permanent fisheries[2]	Coldwater marginal fisheries[2]	Immersion waters[2]	Limited contact waters[2]	Wildlife propagation and stock-watering waters[2]	
Specific conductance (µS/cm)	--	--	--	--	--	--	--	[3]4,000/7,000	--
pH (standard units)	--	6.5-8.5	6.5-9.0	6.6-8.6	6.5-8.8	--	--	6.0-9.5	--
Temperature (°F) (maximum)	--	--	--	65 (18.3°C)	75 (24°C)	--	--	--	--
Dissolved oxygen (minimum)	--	--	--	≥6.0 ≥7 during spawning	≥5.0	≥5.0	≥5.0	--	--
Total alkalinity (as $CaCO_3$)	--	--	--	--	--	--	--	[3]750/1,313	--
Total dissolved solids	--	500	[3]1,000/1,750	--	--	--	--	[3]2,500/4,375	--
Total suspended solids	--	--	--	[3]30/53	[3]90/158	--	--	--	--
Chloride	--	250	[3]250/438	[3]100/175	--	--	--	--	--
Coliform, total (per 100 mL)	--	--	5,000 (mean) 20,000 (single sample)	--	--	--	--	--	--
Coliform, fecal (per 100 mL) May 1-Sept. 30	--	--	--	--	--	200 (mean) 400 (single sample)	1,000 (mean) 2,000 (single sample)	--	--
Fluoride	4.0	2.0	4.0	--	--	--	--	--	--
Sulfate	500	250	[3]500/875	--	--	--	--	--	--
Nitrate (as N)	10	--	10	--	--	--	--	[3]50/88	--
Nitrite	1	--	1	--	--	--	--	--	--
Nitrate plus nitrite	10	--	10	--	--	--	--	--	--
Un-ionized ammonia (as N)	--	--	--	0.02	0.02	--	--	--	--
Cyanide (free)	0.2	--	0.2	220	220	--	--	--	22/5.2

Table 3. Water-quality standards for selected physical properties and constituents.—Continued

[All constituents in milligrams per liter unless otherwise noted. MCL, Maximum Contaminant Level; SMCL, Secondary Maximum Contaminant Level; µS/cm, microsiemens per centimeter at 25°C; µg/L, micrograms per liter; mL, milliliters; °F, degrees Fahrenheit; °C, degrees Celsius; ≥, greater than or equal to; --, no data available]

Property or constituent	U.S. Environmental Protection Agency drinking-water standards		Beneficial-use criteria						Aquatic-life criteria for fisheries (acute/chronic toxicity) (µg/L)[2]
	Drinking water MCL[1]	Drinking water SMCL[1]	Domestic water supply (mean/daily maximum)[2]	Coldwater permanent fisheries[2]	Coldwater marginal fisheries[2]	Immersion waters[2]	Limited contact waters[2]	Wildlife propagation and stock-watering waters[2]	
Dissolved antimony	0.006	--	0.006	--	--	--	--	--	--
Dissolved arsenic	0.05	--	0.05	0.00014	0.00014	--	--	--	360/190 ([4]340/[4]150)
Dissolved barium	2.0	--	2.0	--	--	--	--	--	--
Dissolved cadmium	0.005	--	0.005	--	--	--	--	--	[5]3.7/[5]1.0 ([4]4.3/[4]2.2)
Dissolved chromium	0.1	--	0.1	--	--	--	--	--	--
Dissolved copper	--	1.0	1.3	--	--	--	--	--	[5]17/[5]11 ([4]13/[4]9)
Dissolved iron	--	0.3	--	--	--	--	--	--	--
Dissolved lead	--	--	--	--	--	--	--	--	[5]65/[5]2.5
Dissolved manganese	--	0.05	--	--	--	--	--	--	--
Dissolved mercury	0.002	--	0.002	0.00015	0.00015	--	--	--	2.1/[6]0.012 ([4]1.4/[4]0.77)
Dissolved selenium	0.05	--	0.05	--	--	--	--	--	20/5 (--/[4]5)
Dissolved zinc	--	5	--	--	--	---	--	--	[5]110/[5]100 ([4]120/[4]120)

[1]U.S. Environmental Protection Agency, 1996, 1998b, 1998c.

[2]South Dakota Department of Environment and Natural Resources (2002) unless indicated otherwise.

[3]30-day average/daily maximum.

[4]U.S. Environmental Protection Agency, 1998a.

[5]Hardness-dependent criteria; value given is an example based on hardness of 100 mg/L as $CaCO_3$.

[6]Chronic criteria based on total recoverable concentration.

Instream Water Quality

Instream water-quality data that are summarized for Cold Spring, Beaver, and Highland Creeks include physical properties, major ions, trace elements, nutrients, bacteria, benthic macroinvertebrates, organic (wastewater) compounds, bottom sediment, and suspended sediment. Water-quality samples were collected during 2002-03 from 2 sites on Cold Spring Creek, 2 sites on Beaver Creek, and 1 site on Highland Creek to provide baseline water-quality data. The analytical results for the samples collected at the five sampling sites during 2002-03 are provided in table 16 (available on CD-ROM at the back of this report).

Summary statistics for major-ion, nutrient, and trace-element concentrations are provided in table 11 in the Supplemental Information section for samples collected at water-quality sampling sites during 2002-03, and data from previous studies are presented for comparison. Summary statistics were not calculated for bacteria, benthic macroinvertebrates, wastewater compounds, or bottom sediment geochemistry; however, the analytical results for these constituents are provided in various tables in the Supplemental Information section.

Physical Properties and Major Ions

Physical properties and major-ion concentrations were measured in samples collected from the five water-quality sampling sites. In addition, selected physical property measurements were collected at the streamflow sites on Beaver and Highland Creeks during flow measurements. The physical property data for the streamflow sites are presented in table 16 and are included in the following discussions, but are not included in the summary statistics (table 11).

Mean streamflow values were much lower at Cold Spring Creek (sites 1 and 2) than for other water-quality sampling sites, and the mean values for specific conductance were highest at Cold Spring Creek (table 11). Mean concentrations for dissolved calcium, magnesium, potassium, sodium, chloride, fluoride, and sulfate were lower for Highland Creek than for those determined for Cold Spring and Beaver Creeks during this study.

None of the physical properties or major-ion concentrations exceeded any of the USEPA drinking-water standards, with the exception of pH. The pH values for several samples from Beaver Creek (sites 5 and 6) and Highland Creek (sites 7, 9, and 10) exceeded the SMCL of 8.5 (table 16). Additionally, several of these same samples also exceeded beneficial-use criteria for coldwater permanent fisheries and coldwater marginal fisheries of 8.6 and 8.8, respectively. Water temperature exceeded the coldwater permanent fisheries criterion of 18.3°C in 1 sample from Cold Spring Creek (site 1), 3 samples from Beaver Creek (2 from site 5 and 1 from site 6), and 11 samples from Highland Creek (2 from site 8, 5 from site 9, and 4 from site 10). Two samples from Highland Creek also exceeded the coldwater marginal fisheries criterion of 24°C (one sample each at sites 9 and 10). Almost all of the samples that exceeded the temperature criteria were collected during July, indicating that temperature may stress fish during unusually warm summer periods with lower flows. Furthermore, NPS personnel documented a fish kill along portions of Highland Creek during July 2001, but a cause has not been identified (Dan Roddy, National Park Service, oral commun., 2004).

Major-ion data for Cold Spring, Beaver, and Highland Creeks are presented graphically on trilinear diagrams (fig. 6) using a method developed by Piper (1944). Concentrations of the major dissolved ionic constituents are determined as milliequivalents 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. Classification of water into different water types can be useful to determine if streams have different or similar water sources. The water type of all three streams is a calcium magnesium bicarbonate type.

Slight decreases in mean values for pH, specific conductance, water temperature, and calcium were observed at the downstream site (site 2) for Cold Spring Creek compared to the upstream site (site 1). Slight increases were observed in mean values for turbidity, magnesium, sodium, silica, and sulfate between the upstream and downstream sites (table 11). Several small springs enter Cold Spring Creek between site 1 and site 2, and it is possible that spring water could account for some of the observed differences in water chemistry.

There was no substantial difference observed during the 2002-03 study for specific conductance between sites 3 and 4 on Beaver Creek. The mean value for specific conductance for Beaver Creek was slightly higher at the downstream site (site 4) than at the upstream site (site 3) (table 11). Specific conductance data are available for Beaver Creek site 4 for water years 1991-2003, and a plot showing the relation between streamflow and specific conductance for this site is shown in figure 7. For most streams in the Black Hills area with headwaters in the crystalline core area, such as Beaver Creek, specific conductance generally decreases as flow increases due to dilution (Williamson and Carter, 2001). However, this relation is not evident in data collected from Beaver Creek, which shows that specific conductance does not vary with streamflow (fig. 7). Streams with influences from headwater springs in the Black Hills area generally show little variability in specific conductance in relation to streamflow (Williamson and Carter, 2001). The lack of variability in specific conductance at Beaver Creek site 4 is likely due to influences from headwater springs because there are several headwater springs that provide base flow to Cold Spring Creek (which discharges to Beaver Creek upstream from site 4) and to Beaver Creek upstream from site 4. Furthermore, the trilinear diagrams for sites 3 and 4 on Beaver Creek (fig. 6) are very similar to those presented for headwater springs in the Black Hills (Williamson and Carter, 2001).

Because water-quality sampling occurred during low streamflow conditions during this study, it was not possible to determine how concentrations of major ions might change under higher streamflow conditions. However, based on specific conductance values presented in figure 7 for site 4 on Beaver Creek, there appears to be a good indication that there

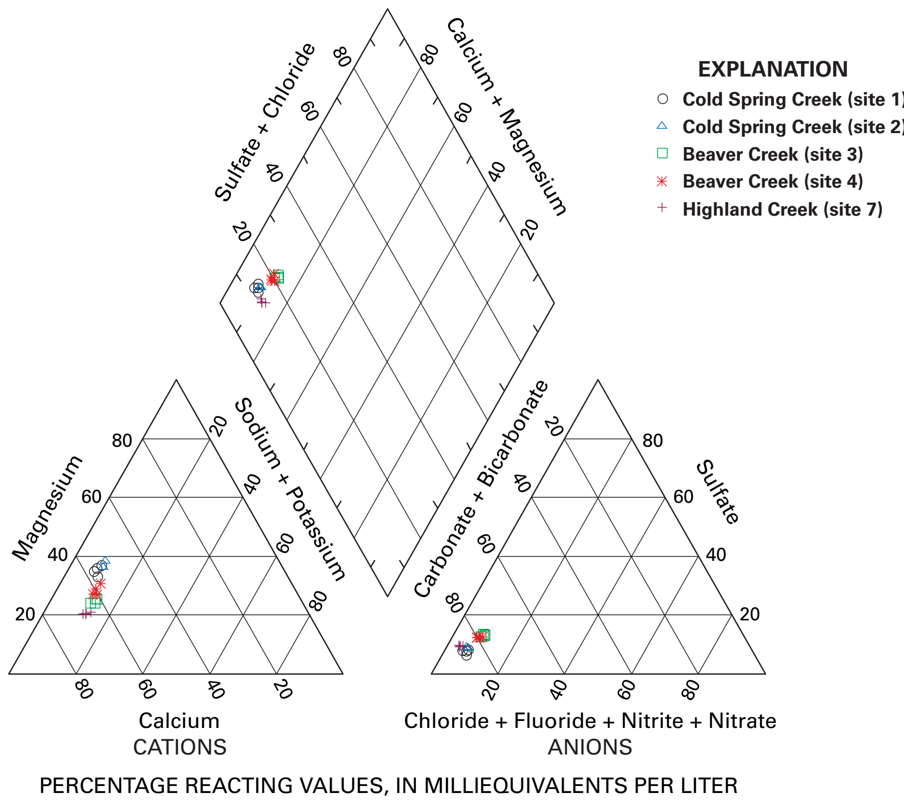


Figure 6. Trilinear diagram showing percentage of major ions for water-quality-sampling sites.

could be only slight variability in major-ion concentrations in Beaver Creek with increasing streamflow. However, additional data collected during higher streamflow conditions would be required in order to confirm this observation.

Differences in water-quality data were observed between samples collected from Beaver Creek and those collected from Cold Spring and Highland Creeks. Mean turbidity values for Beaver Creek were higher for the upstream site than for the downstream site, and mean turbidity values at the upper site generally were much higher than those determined for sites on the other two streams. Mean dissolved-oxygen concentrations were lower at site 3 than at sites 1, 2, 4, or 7. Mean water temperature was slightly lower at the upper Beaver Creek site than for sites 1, 2, 4, or 7. Mean values for most major ions tended to decrease from the upstream site to the downstream site on Beaver Creek. Mean concentrations of chloride and sulfate were higher at site 3 compared to the other water-quality sampling sites.

Only minor variability was observed in the concentrations of most major ions over time on Highland Creek (site 7), with the exception of dissolved calcium, potassium, and sodium concentrations reported for samples collected on September 10, 2002. Values for these three major ions were slightly higher than concentrations reported from the three other samples collected at this site during the study. Small variations in concentrations of these three major ions reported for samples collected on September 10, 2002, probably are a result of diminished streamflow measured at the sampling site on that date.

Nutrients

None of the nutrient concentrations from the streams sampled exceeded any of the USEPA drinking-water standards. Increases in mean values were observed for concentrations of nitrite plus nitrate on Cold Spring Creek between the upstream and downstream sites. Several small springs enter Cold Spring Creek between site 1 and site 2, and it is possible that spring water could account for some of the observed differences in water chemistry. Higher mean values for some constituents at the upstream site could be partially a result of water entering Cold Spring Creek from a septic system located just upstream from site 1 (outside the park boundary) or from a combination of several other potential sources.

Mean concentrations of ammonia, orthophosphate, and phosphorous were higher at site 3 on Beaver Creek than at other water-quality sampling sites, indicating a general decline in water quality at this site when compared to others monitored during this study. Mean values for nutrient concentrations decreased from the upstream site to the downstream site on Beaver Creek. The lower constituent concentrations at the downstream site probably result from dilution by inflows of Cold Spring Creek.

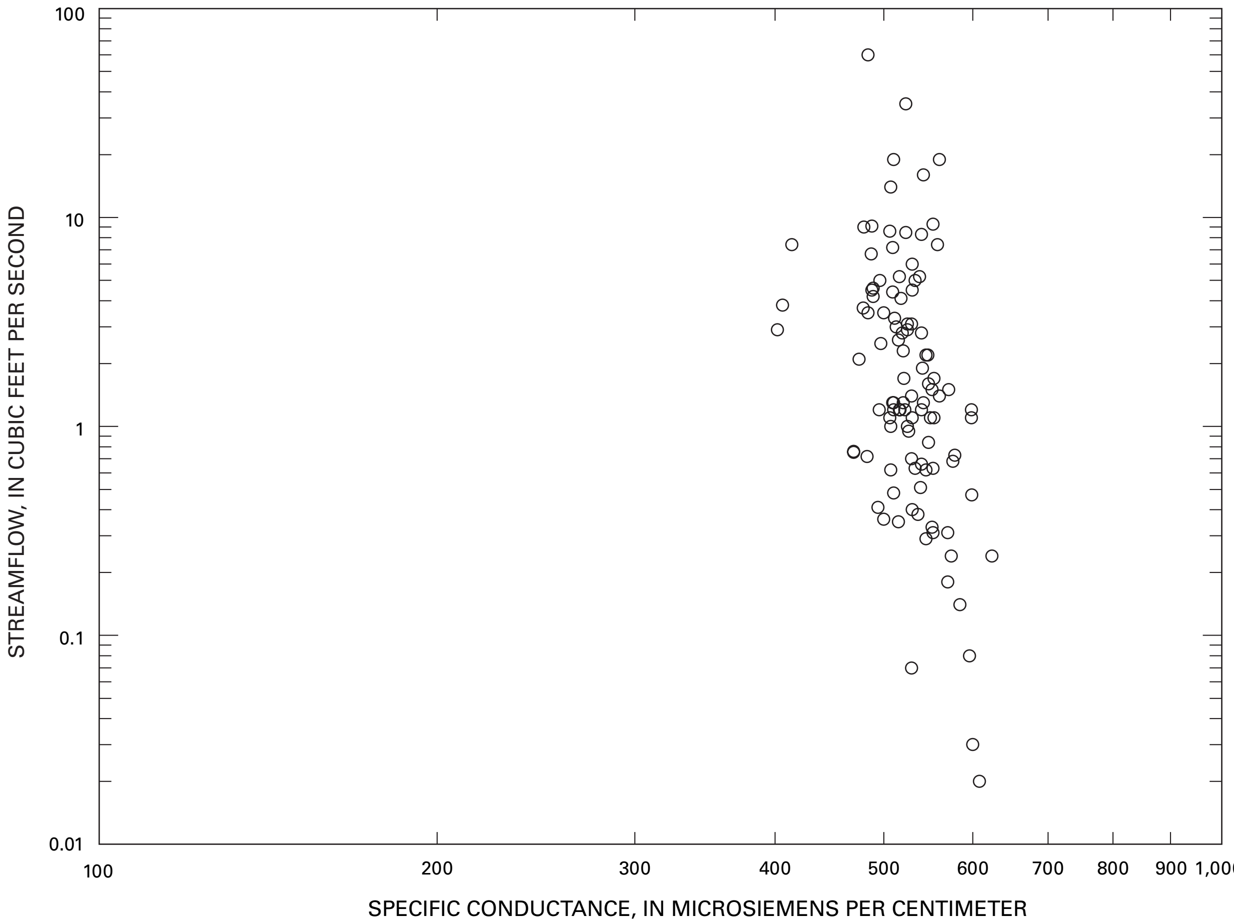


Figure 7. Relation between streamflow and specific conductance for Beaver Creek near Pringle (06402430) (site 4), water years 1991–2003.

Mean concentrations for most of the nutrients analyzed at Highland Creek during this study were similar to those determined for sites on Cold Spring and Beaver Creeks. However, site 7 had the highest mean concentration for dissolved nitrite plus nitrate of the five water-quality sampling sites.

Bacteria and Benthic Macroinvertebrates

Samples collected from the five water-quality sampling sites in 2002-03 were analyzed for *E. coli*, fecal coliform, and total coliform bacteria. Results of the bacteria analyses are presented in table 4.

In samples collected at Cold Spring Creek, *E. coli* bacteria only were detected in one sample, which was collected on March 4, 2002. The maximum concentration of fecal coliform bacteria in samples from Cold Spring Creek was 70 colony-forming units per 100 milliliters (CFU/100 mL) at site 1, and the maximum concentration of total coliform bacteria was 1,100 colonies per 100 milliliters (col/100 mL) at site 1. Concentrations of fecal and total coliform bacteria generally were higher at the upstream site (site 1) than at the downstream site (site 2).

Concentrations of *E. coli*, fecal coliform, and total coliform bacteria were highest at site 3 on Beaver Creek than for any other site (table 4). The maximum bacteria concentrations for Beaver Creek were 130 col/100 mL (site 3) for *E. coli*, 220 CFU/100 mL for fecal coliform, and 2,600 col/100 mL for total coliform. However, all values were below beneficial-use criteria established for bacteria in surface waters of South Dakota (table 3). Concentrations of these bacteria generally decreased from the upstream site (site 3) to the downstream site on Beaver Creek (site 4).

Bacterial concentrations determined for site 7 on Highland Creek generally were low with the exception of samples collected during July 2002 and 2003 (table 4). *E coli* bacteria were detected in two samples from Highland Creek with a maximum concentration of 42 col/100 mL. The maximum concentration of fecal coliform bacteria was 100 CFU/100 mL, and the maximum concentration of total coliform bacteria was 400 col/100 mL. Concentrations of bacterial colonies generally were lower in water samples collected from this site than in samples collected from other sites during this study.

Table 4. Results of bacteriological analysis for Cold Spring, Beaver, and Highland Creeks during 2002-03.

[col/100 mL, colonies per 100 milliliters; CFU/100 mL, colony-forming units per 100 milliliters; <, less than; NA, not analyzed]

Site name (number refers to fig. 1)	Date	Bacteria, *E-coli* (col/100 mL)	Bacteria, fecal coliform (CFU/100 mL)	Bacteria, total coliform (col/100 mL)
Cold Spring Creek 0.1 mile from the park boundary on Hwy 385 (site 1)	03-04-02	<2	<2	<2
	05-13-02	<2	2	110
	07-25-02	<2	70	NA
	09-11-02	<2	46	NA
	02-05-03	<2	NA	<2
	03-12-03	<2	NA	5
	05-13-03	<2	<2	10
	07-09-03	<2	NA	1,100
Cold Spring Creek 200 feet above confluence of Beaver Creek (site 2)	03-04-02	2	2	3
	05-14-02	<2	2	<2
	07-24-02	<2	10	NA
	09-11-02	<2	42	NA
	02-05-03	<2	NA	<2
	05-14-03	<2	<2	<2
Beaver Creek ¼ mile south of Corey Ranch (site 3)	03-04-02	7	32	44
	05-13-02	130	130	1,600
	07-23-02	5	220	NA
	09-10-02	<2	150	NA
	02-05-03	<2	NA	10
	03-12-03	<2	NA	77
	05-13-03	2	<2	24
	07-09-03	100	NA	2,600
Beaver Creek near Pringle (USGS gaging station 06402430) (site 4)	03-04-02	2	5	33
	05-14-02	<2	<2	<2
	07-24-02	<2	110	NA
	09-11-02	<2	56	NA
	02-05-03	<2	NA	5
	03-12-03	<2	NA	32
	05-14-03	<2	<2	2
	07-09-03	<2	NA	1,600
Highland Creek above Madison outcrop near Pringle (site 7)	03-04-02	2	3	2
	05-13-02	<2	2	70
	07-23-02	<2	100	NA
	09-10-02	<2	28	NA
	02-05-03	<2	NA	4
	03-12-03	<2	NA	12
	05-13-03	<2	<2	14
	07-09-03	42	NA	400

Samples for the analysis of benthic macroinvertebrates (BMIs) were collected from Cold Spring Creek site 2, Beaver Creek site 4, and Highland Creek site 7 during July 2002 and May 2003. Aquatic macroinvertebrate data are presented in table 12 in the Supplemental Information section.

The abundance of taxa, reported in number of organisms per 0.9 square meter, represents a measure of prevalence. At site 2 on Cold Spring Creek, the Ephemeroptera (Mayfly) *Tricorythodes* was the most prevalent taxan in 2002, and the Dipteran (true fly) *Chaetocladius* was the most prevalent taxan in 2003.

At site 4 on Beaver Creek, the Ephemeroptera (Mayfly) *Tricorythodes* was the most prevalent taxan in 2002, and the Coleoptera (beetle) *Optioservus divergens* (LeConte) was the most prevalent taxan in 2003. A species of Caddis fly *Mayatrichia ayama* previously unreported in the published literature for South Dakota was identified in samples collected from site 4 in 2002 (Dave Ruiter, written commun., Mar. 26, 2003). Attempts to confirm the presence of *Mayatrichia ayama* at the site in 2003 were unsuccessful. However, this taxan was confirmed to be present in samples collected from the Little White River, located in south-central South Dakota, in 2003 as part of an unrelated study.

Results of the 2002 sampling showed that the Ephemeroptera (Mayfly) *Baetidae* was the predominant taxan at site 7 on Highland Creek. During 2003, the Coleoptera (beetle) *Optioservus* sp.was most predominant taxan. Two new species of Caddis fly *Ceratopsyche cf. slossonae* (Banks) and *Brachycentrus occidentalis* (Banks) were identified from samples collected at Highland Creek in 2002 that had not previously been reported in South Dakota. Attempts to confirm the presence of these two macroinvertebrates at the site were unsuccessful in 2003.

A number of methods exist that use BMI data to determine or rank the relative amount of environmental stress present in the sampled reach of a stream at the time of sampling (Rosenberg and Resh, 2001). Two of these methods were used to generally assess stream conditions for this study; a brief description of two methods used follows.

The first method used (table 5) compares the total number of pollution-sensitive BMIs present from the Orders Ephemeroptera (May flies), Plecoptera (Stone flies), and Trichoptera (Caddis flies) (EPT) to the total number of more tolerant macroinvertebrates from the Family Chironomidae. The rationale for this method is that compared with a stream that is not environmentally stressed, a stream that is stressed will reflect an imbalance favoring the more tolerant organisms. However, this method is susceptible to errors from several habitat-specific conditions such as substrate size, water temperature, and seasonality that can greatly influence the relative abundance of these organisms present in the stream. The mesh size of the net used to collect the Chironomidae also is critical because the larger the mesh, the fewer Chironomidae collected.

Furthermore, information presented for BMIs are limited to the duration of this study only, and sampling was restricted to a single reach on each stream in an attempt to provide some basic background information. Therefore, the BMI data presented should be viewed cautiously and used in combination with the other traditional water chemistry, nutrient, and physical characteristics measurements provided in order to obtain a more integrated and accurate assessment of stream water quality. Multiple sampling sites on these streams visited over a period of several years would probably be required to provide enough information to definitively assess stream health based on BMI data.

These comparisons show that for all three sites sampled during July 2002 a substantially higher percentage of EPT taxa were present than Chironomidae. Actually, the inequality favors the less tolerant EPT taxa and would indicate that on a relative basis, the reach on Cold Spring Creek ranked slightly higher than Highland Creek (94.5 and 94.0 percent, respectively), and the reach on Beaver Creek ranked lowest (73 percent) with respect to the number of EPT taxa. However, all streams would be rated as having low environmental stress in their respective reaches at the time of sampling due to the high percentage of EPT taxa present.

Table 5. General assessment of relative stream reach health using comparison of percent EPT to percent Chironomidae.

[EPT, Ephemeroptera, Plecoptera, Trichoptera]

Number and percent of taxa present	Cold Spring Creek (site 2)		Beaver Creek (site 4)		Highland Creek (site 7)	
Date sampled	7/2002	5/2003	7/2002	5/2003	7/2002	5/2003
Number of EPT taxa	3,878	708	1,387	1,382	5,004	885
Number of Chironomidae	224	3,367	509	732	322	301
Percent Chironomidae	5.5	79.0	27.0	47.1	6.0	66.0
Percent EPT	94.5	21.0	73.0	52.9	94.0	34.0

Data from May 2003 show a different result because the reach on Beaver Creek ranked highest with respect to the number of EPT taxa (52.9 percent), followed by the reach on Highland Creek (34 percent), and the reach on Cold Spring Creek ranked lowest (21 percent). It seems likely that these differences can be attributed in part to the timing of the sample collection.

The second method used (table 6) compares the total number of organisms collected from the non-Dipteran taxa to the total number of organisms from all taxa collected from the entire stream reach sampled (percent non-Dipterans). The rationale for this approach assumes that a higher percentage of the less tolerant non-Dipteran groups than the more tolerant Dipteran groups indicates lower environmental stress. This method also is influenced by the same variables described previously for the first method.

Results from this comparison show that for July 2002, the reach on Cold Spring Creek ranked highest in percentage of non-Dipterans (91.5 percent) followed by Highland Creek (79.0 percent) and Beaver Creek (78.4 percent). All the 2002 sites showed a high percentage of non-Dipteran taxa present indicating low estimated levels of environmental stress at the time of sampling. The ranking from this comparison agreed with the ranking obtained by the percentage EPT method for data collected in July 2002.

Data from May 2003 show a different result than the data collected in 2002 because the reach on Beaver Creek ranked highest using the percentage non-Dipteran method (84.9 percent), followed by the reach on Highland Creek (69.4 percent). The reach on Cold Spring Creek ranked lowest with 27.5 percent non-Dipteran taxa present. These results indicate that the estimated level of environmental stress was higher at the time of sampling in the reach on Cold Spring Creek than at the other two reaches sampled in 2003. However, the ranking from this comparison agreed with the ranking obtained by the percent EPT method for data collected in July 2003. Differences in ranking between years can likely be attributed, in part, to the differences in the timing of the sample collection in addition to the other factors previously mentioned.

Trace Elements

Trace-element concentrations reported for this study generally are reported as total constituent concentrations, which refer to the combined concentration of both dissolved and suspended phases of a water sample. In general, dissolved constituent concentrations are usually less than those obtained for similar samples analyzed for total constituent concentrations. This is because total constituent concentrations include trace elements that are adsorbed to suspended sediments in the water sample. However, as discussed previously, all stream-water samples collected for this study were collected during low-flow conditions. The highest streamflow measured at site 4 during the study was 1.26 ft^3/s on May 14, 2002. The duration curve of daily mean flow (fig. 4C) indicates that between water years 1992 and 2003, that flow value was exceeded over 60 percent of the time. Furthermore, suspended-sediment concentrations for all sampling sites were very small indicating that concentrations of trace elements associated with the suspended phase also would be small.

Water-quality standards and criteria for trace elements generally apply to the dissolved phase (table 3). Therefore, comparisons between standards and criteria and trace-element concentrations determined for this study are not made. However, for any constituent for which a total concentration has been reported that is less than the designated water-quality standard, the dissolved concentration for that constituent also would be less than the standard.

Deceases in mean values were observed for concentrations of iron and manganese on Cold Spring Creek between the upstream and downstream sites during 2002-03 (table 11). Several small springs provide flow to Cold Spring Creek between site 1 and site 2, and it is possible that dilution by spring water could account for some of the observed differences in water chemistry. Mean trace-element concentrations generally were lower for the downstream site (site 4) than the upstream site (site 3) on Beaver Creek.

Table 6. General assessment of relative stream reach health using percent non-Dipterans.

Number and percent of taxa present	Cold Spring Creek (site 2)		Beaver Creek (site 4)		Highland Creek (site 7)	
Date sampled	7/2002	5/2003	7/2002	5/2003	7/2002	5/2003
Total number of taxa	4,780	5,300	2,634	5,631	8,458	4,426
Number of non-Dipterans	4,374	1,458	2,066	4,783	6,685	3,074
Percent Dipterans	8.5	72.5	21.6	15.1	21.0	30.6
Percent non-Dipterans	91.5	27.5	78.4	84.9	79.0	69.4

Mean trace-element concentrations generally were lowest in samples from Highland Creek (site 7) in comparison to samples collected at the other sites during 2002-03 (table 11). Mean concentrations of chromium, iron, manganese, and nickel were higher at site 3 on Beaver Creek than the other water-quality sampling sites indicating a general decline in water quality at this site when compared to others monitored during this study.

The Pringle Post and Pole site is located approximately 9 mi upstream from the boundary of Wind Cave National Park and about 7¾ mi upstream from site 3 on Beaver Creek. The USEPA listed the Pringle Post and Pole site on the Comprehensive Environmental Response, Compensation, Liability Information System (CERCLIS) in July 1991. The site was used for a wood treatment business for about 50 years (mid-1940s through mid-1990s) and covers about 10 acres just east of Pringle, South Dakota, which is located about 5 mi northwest of the park boundary. Initially, pentachlorophenol (PCP) was mixed with diesel fuel to treat wood; later operations used pressure treatment with a chromated copper arsenate (CCA) solution.

The USEPA conducted assessments at the site in 1992 and 1994 under the auspices of Ecology and Environment, Inc. (E&E). The results of E&E's assessments are documented in two unpublished reports (Ecology and Environment, Inc., written commun., 1992, 1994). These reports documented the presence of soils contaminated with PCP, polycyclic aromatic hydrocarbons (PAHs), dioxins, furans, arsenic, chromium, copper, and zinc at the site. These investigations also documented the presence of dioxin and furan in the sediment of Beaver Creek. A follow-up site assessment was conducted by URS Operating Services, Inc. at Pringle Post and Pole between September 4-6, 2001. The results of that assessment documented that dioxins and furans were detected in the surface water and sediments of Beaver Creek downstream from the site (URS Operating Services, Inc., 2002).

Based on USEPA's results, it is possible that the higher concentrations of chromium, nickel, and iron reported for site 3 than for other sites sampled during this study could have been a result of upstream activities. Furthermore, trace amounts of organic contaminants detected at this site could have been carried downstream from the Pringle Post and Pole site as well.

Organic (Wastewater) Compounds

Samples for the analysis of wastewater compounds were collected at least twice from four of the five water-quality sampling sites established for this study and the results are presented in table 13 in the Supplemental Information section. Samples for the analysis of wastewater compounds were not collected from the downstream site on Cold Spring Creek (site 2).

Samples for the analysis of wastewater compounds were collected at site 1 on Cold Spring Creek during three sampling events. The four compounds detected in samples from site 1 were bromoform, phenol, caffeine, and cholesterol, but only phenol was detected at concentrations greater than the MRL (table 13).

Several wastewater compounds were detected in samples collected from sites 3 and 4 on Beaver Creek (table 13). Of particular interest are detections of phenol, para-cresol, and para-nonylphenol-total. Although concentrations of two of the compounds were reported as estimated (less than the MRL but greater than the MDL), phenol was detected at both sites on Beaver Creek at concentrations greater than the MRL. It is not possible to determine the potential source(s) of these three compounds on the basis of the limited sampling undertaken for this study; however, it can not be ruled out that they were present as a result of activities associated with the operation of Pringle Post and Pole described in the Trace Elements section of this report. Additional sampling of water and sediments at selected intervals along Beaver Creek would be required to identify potential sources of the contamination.

Highland Creek was sampled on July 23, 2002, and again on May 13, 2003, and no wastewater compounds were detected from either sample at concentrations greater than the MRL for the analytical method used. Estimated concentrations were reported for bromoform; para-cresol; ethanol,2-butoxy-phosphate; and cholesterol. However, reported concentrations for these compounds were very low and were not considered to be indicative of any substantial effect from anthropogenic sources.

Bottom Sediment

The geochemical composition of bottom sediments was analyzed in one composite sample from each of the three streams (site 2 on Cold Spring Creek, site 4 on Beaver Creek, and site 7 on Highland Creek), and the results are presented in table 14 in the Supplemental Information section. Selected sediment-quality guidelines are presented in table 7 for comparison with sediment-quality results.

Constituent concentrations in bottom sediment samples from Cold Spring Creek (site 2) generally were similar to the samples from the other two sites with only a few exceptions (table 14). Concentrations of calcium, manganese, selenium, strontium, and thorium were higher than for the other two sites. The arsenic concentration of 9.5 micrograms per gram (µg/g) exceeded the USEPA threshold effects guidelines, the NOAA effects range low value, and the National Irrigation Water Quality Program (NIWQP) level of concern outlined in table 7. The percentages of organic plus inorganic carbon and inorganic carbon were higher at this site than for the other two sites sampled during this study.

The geochemical composition of bottom sediments for Beaver Creek generally were similar to the other two sites with only a few exceptions. Concentrations of chromium, copper, lithium, vanadium, and zinc were all higher in sediment samples analyzed from Beaver Creek than from the other two sites (table 14). Furthermore, the arsenic concentration of 9.4 µg/g exceeded the USEPA threshold effects guidelines, the

Table 7. Selected sediment-quality guidelines and indices.

[All values in micrograms per gram. --, not applicable]

Property or constituent	U.S. Environmental Protection Agency sediment-quality guidelines (U.S. Environmental Protection Agency, 1998d)		NOAA National Status and Trends Program Sediment Quality Guidelines (Long and others, 1995)		National Irrigation Water Quality Program (U.S. Department of the Interior, 1998)		Western U.S. soils (modified from Shacklette and Boerngen, 1984)	
	Threshold effects level	Probable effects level	Effects range low[1]	Effects range median[2]	Level of concern	Toxicity threshold	Geometric mean	Baseline range[3]
Arsenic	7.24	41.6	8.2	70	8.2	70	5.5	1.2–22
Cadmium	.676	4.21	1.2	9.6	--	--	--	--
Chromium	52.3	160	81	370	--	--	41	8.5–200
Copper	18.7	108	34	270	34	270	21	4.9–90
Lead	30.2	112	47	220	--	--	17	5.2–55
Molybdenum	--	--	--	--	--	--	.85	.18–4.0
Nickel	15.9	42.8	21	52	--	--	--	--
Selenium	--	--	--	--	1	4	.23	.039–1.4
Silver	.733	1.77	1	3.7	--	--	--	--
Vanadium	--	--	--	--	--	--	70	18–270
Zinc	124	271	150	410	150	410	55	17–180

[1]Defined as the concentration at which occasional adverse biological effects may result.

[2]Defined as the concentration at which frequent adverse biological effects may result.

[3]Defined as the range in which 95 percent of sample concentrations are expected to occur.

NOAA effects range low value, and the NIWQP level of concern (table 7). The nickel concentration also was higher at this site than the other two sites and approached the USEPA threshold effects level.

The sample from Highland Creek had the lowest percentage of inorganic plus organic, inorganic, and organic carbon of any site sampled during this study. No constituent concentrations in the sample from Highland Creek exceeded sediment-quality guidelines.

Suspended Sediment

Samples for the analysis of suspended-sediment concentration were collected from each of the five water-quality sampling sites. Sediment data are presented in table 8. Because observed streamflow during the study generally was below average due to drought conditions, suspended-sediment concentrations measured at all the sites probably were less than those expected under more normal streamflow conditions.

Suspended-sediment concentrations for Cold Spring Creek were slightly higher at the upstream site (site 1) than at the downstream site (site 2). Sediments at both sites were largely composed of fine-grained particles that were less than (<) 0.062 mm (millimeter) in diameter. Of the five sampling sites, concentrations of suspended sediment were highest in samples from Cold Spring Creek site 1.

Concentrations of suspended sediment for Beaver Creek were slightly higher at the downstream site (site 4) than at the upstream site (site 3). The composition of sediments was different at the upstream site compared to the downstream site. Suspended sediments were composed largely of fines <0.062 mm in diameter at the upstream site, whereas suspended sediments were largely composed of sands greater than 0.062 mm in diameter at the downstream site.

Suspended sediments for site 7 on Highland Creek were largely composed of fine-grained sediments of <0.062 mm in diameter. Concentrations of suspended sediments at this site were less than for the other sites sampled.

Table 8. Suspended-sediment data collected from selected sampling sites.

[mm, millimeters; >, greater than; <, less than; ND, no data]

Site name	Date	Total sediment (grams per liter)	Sands >62 mm (grams)	Percent of total	Fines <62 mm (grams)	Percent of total
Cold Spring Creek 0.1 mile from the park boundary on Hwy 385 (site 1)	01-16-02	0.0377	0.0133	35.3	0.0244	64.7
	03-04-02	.0364	.0224	61.5	.0140	38.6
	09-10-02	.0169	.0030	17.8	.0139	82.2
	11-26-02	.0268	.0122	45.5	.0146	54.5
	02-05-03	.0147	.0110	74.8	.0037	25.2
	07-09-03	.0497	.0213	42.9	.0284	57.1
	09-03-03	.0145	.0055	37.9	.0090	62.1
Cold Spring Creek 200 feet above confluence of Beaver Creek (site 2)	01-16-02	.0421	.0226	53.7	.0195	46.3
	03-04-02	.0286	.0132	46.1	.0154	53.9
	07-24-02	.0236	.0066	28.0	.0170	72.0
	09-09-02	.0045	.0017	37.8	.0028	62.2
	11-26-02	.0367	.0132	36.0	.0235	64.0
	02-05-03	.0063	.0012	19.0	.0051	81.0
	05-14-03	.0202	.0139	68.8	.0063	32.2
	07-09-03	ND	ND	ND	ND	ND
	09-03-03	ND	ND	ND	ND	ND
Beaver Creek ¼ mile south of Corey Ranch (site 3)	11-26-02	.0180	.0133	73.9	.0047	26.1
	02-05-03	.0038	.0017	44.7	.0021	55.3
	05-13-03	.0171	.0073	42.7	.0098	57.3
	07-09-03	.0111	.0038	34.2	.0073	65.8
	09-03-03	.0029	.0001	3.5	.0028	96.5
Beaver Creek near Pringle (USGS gaging station 06402430) (site 4)	01-16-02	.0327	.0239	73.1	.0088	26.9
	03-04-02	.0303	.0210	69.3	.0093	30.7
	07-24-02	.0080	.0030	37.5	.0050	62.5
	09-11-02	.0024	.0002	8.3	.0022	91.7
	11-26-02	.0306	.0111	36.3	.0195	63.7
	02-05-03	.0079	.0069	87.3	.0010	12.7
	05-14-03	.0262	.0197	75.2	.0065	24.8
	07-09-03	.0253	ND	ND	ND	ND
	09-03-03	.0029	ND	ND	ND	ND
Highland Creek above Madison outcrop near Pringle (site 7)	01-22-02	.0090	.0016	17.8	.0074	82.2
	03-04-02	.0088	.0019	21.6	.0069	78.4
	07-23-02	.0085	.0043	50.6	.0042	49.4
	09-10-02	.0015	.0004	26.7	.0011	73.3
	11-25-02	.0020	.0004	20.0	.0016	80.0
	02-05-03	.0151	.0133	88.1	.0018	11.9
	05-13-03	.0074	.0057	77.0	.0017	23.0
	07-09-03	.0094	.0026	27.7	.0068	72.3
	09-02-03	.0041	.0011	26.8	.0030	73.2

Runoff from Parking Lot

The potential influence of parking lot runoff on cave drip water within Wind Cave was investigated. This investigation was prompted by the results of studies completed by Alexander and others (1989) and Venezky (1994), which were described in the Previous Investigations section. Based on the findings of these two studies, NPS asked USGS to collect additional information concerning the composition of parking lot runoff and cave-drip water following simulated runoff events. During 2002-03, several time-dependent samples were collected from a parking lot drainage culvert downstream from the parking lot (site 11) and from Upper Minnehaha Falls (site 12) inside the cave following a series of simulated runoff events conducted on June 19, August 12, and September 4, 2002.

To simulate runoff events, NPS personnel from the park's fire management program used hydrants and hoses to apply a volume of water approximately equal to what would be deposited on the lot from one-quarter inch of precipitation. Two two-person teams began applying water at opposite ends of the parking lot and met in the middle. The total time for simulated runoff events ranged between 30 and 40 minutes. The simulations were conducted during periods of high visitation and usually followed a 14-day period with no antecedent precipitation.

Samples collected from the parking lot drainage culvert (site 11) and analyzed for BTEX compounds using ELISA techniques all resulted in non-detections for the target compounds. Samples were collected from Upper Minnehaha Falls (site 12) following the three simulated runoff events in 2002 and were sent to the NWQL for quantification using GC/MS. The results of these analyses are provided in table 15 in the Supplemental Information section.

Water samples collected at the drainage culvert (site 11) on September 4, 2002, and analyzed by GC/MS had several BTEX compounds in the effluent—toluene (0.04 μg/L), benzene (0.02 μg/L), and meta- and para-xylene (0.02 μg/L) (table 15). However, all the detected concentrations were much less than the MRL for ELISA techniques. In addition, other hydrocarbon compounds (table 15) were detected at much higher concentrations than the BTEX compounds, including chloroform (5.1 μg/L), methyl isobutyl ketone (1.00 μg/L), and acetone (23 μg/L), which were not specifically analyzed for using ELISA techniques.

Prior to the initiation of the simulated runoff event conducted on September 4, 2002, background samples were collected from Upper Minnehaha Falls and analyzed using GC/MS. Only very low levels of toluene were present and at concentrations less than the MRL. Subsequent samples were collected sequentially on September 4, 2002, from Upper Minnehaha Falls at time increments of approximately 9, 10, and 11 hours (1705, 1810, and 1900) following the simulated runoff event. These times were selected based on previous dye studies done by Alexander and others (1989) between 1985 and 1988. Alexander and others (1989) showed that it took about 8 to 9 hours for dye dumped in and flushed down the parking lot drain to appear at Upper Minnehaha Falls.

Traces of acetone, total benzene, ethyl benzene, meta- and para-xylene, ortho-xylene, and styrene were present in the sequential cave-drip samples collected following the simulated runoff event, but at much lower levels than previously reported by Venezky (1994). Venezky (1994) reported finding hydrocarbon concentrations of 0.56 mg/L (560 μg/L) in cave-drip water following a natural runoff event.

Differences in hydrocarbon concentrations detected in water collected at the drainage culvert and at Upper Minnehaha Falls could be a result of several factors. First, several of the target hydrocarbon compounds are volatile and could have partially partitioned to the air prior to entering the ground water. Second, some portion of the hydrocarbons could have been preferentially sorbed on to soil as infiltrating water passed through the soil column on the way to Upper Minnehaha Falls. Third, it could take longer than 11 hours for the plume of parking lot effluent to arrive at Upper Minnehaha Falls. If so, it is possible that the sequential samples contained only the more mobile hydrocarbons in the leading edge of the effluent plume and peak concentrations arriving later could have been missed.

Summary and Conclusions

The U.S. Geological Survey and National Park Service initiated a cooperative study of streamflow and water-quality characteristics in Wind Cave National Park in 2002. During this 2-year study, streamflow and water-quality data were collected for three of the park's perennial streams (Cold Spring, Beaver, and Highland Creeks) from January 2002 through November 2003. These data were collected to characterize streamflow loss zones and to provide baseline water-quality data that will help park management determine if changing land-use practices outside the park are affecting Wind Cave's water resources. The potential influence of parking lot runoff on cave drip water within Wind Cave also was investigated. Several time-dependent samples were collected from a drainage culvert downstream from the parking lot and from Upper Minnehaha Falls inside the cave following a series of simulated runoff events conducted on June 19, August 12, and September 4, 2002. The primary focus of the report is on data collected during the 2-year study from January 2002 to November 2003; however, data collected previously also are summarized.

To determine losing reaches and to quantify streamflow losses to the bedrock aquifers along the streams in the study area, many streamflow measurements were made as part of seepage runs that began with measurement at the most upstream site and progressed to the most downstream site along each stream. No streamflow losses occurred along Cold Spring Creek because its confluence with Beaver Creek is located upstream from the outcrop of the Madison Limestone, where most streamflow losses occur. Streamflow measurements conducted during this study showed that Beaver and Highland

Creeks gradually lost flow as the streams crossed outcrops of the bedrock aquifers until all flow was lost to bedrock aquifers.

Instream water-quality data that are summarized for Cold Spring, Beaver, and Highland Creeks include physical properties, major ions, trace elements, nutrients, bacteria, benthic macroinvertebrates, organic (wastewater) compounds, bottom sediment, and suspended sediment. Water-quality samples were collected from 2 sites on Cold Spring Creek, 2 sites on Beaver Creek, and 1 site on Highland Creek to provide baseline water-quality data.

None of the constituent concentrations for any of the samples collected during 2002-03 exceeded any of the U.S. Environmental Protection Agency drinking-water standards, with the exception of pH. The pH values for numerous samples from Beaver Creek and Highland Creek exceeded the Secondary Maximum Contaminant Level of 8.5. Additionally, several of these same samples also exceeded beneficial-use criteria for coldwater permanent fisheries and coldwater marginal fisheries of 8.6 and 8.8, respectively. Water temperature exceeded the coldwater permanent fisheries criterion in numerous samples from all three streams. Two samples from Highland Creek also exceeded the coldwater marginal fisheries criterion for temperature. Almost all of the samples that exceeded the temperature criteria were collected during July, indicating that temperature may stress fish during unusually warm summer periods with lower flows.

Mean concentrations of ammonia, orthophosphate, and phosphorous were higher for the upstream site on Beaver Creek than for other water-quality sampling sites, indicating a general decline in water quality at this site when compared to others monitored during this study. Mean values for nutrient concentrations decreased from the upstream site to the downstream site on Beaver Creek. The lower constituent concentrations at the downstream site probably result from dilution by inflows of Cold Spring Creek. The highest mean concentration for dissolved nitrite plus nitrate of the five sites sampled was from Highland Creek.

Concentrations of *E. coli*, fecal coliform, and total coliform bacteria were highest at the upstream site on Beaver Creek than for any other site. The maximum bacteria concentrations for Beaver Creek were 130 colonies per 100 milliliters (col/100 mL) for *E. coli*, 220 colony-forming units per 100 milliliters for fecal coliform, and 2,600 col/100 mL for total coliform. Concentrations of bacterial colonies in samples from Highland Creek generally were lower than in samples collected from other sites during this study.

Samples for the analysis of benthic macroinvertebrates were collected from one site on each of the three streams during July 2002 and May 2003. At the Cold Spring Creek site, the Ephemeroptera (Mayfly) *Tricorythodes* was the most prevalent taxan in 2002, and the Dipteran (true fly) *Chaetocladius* was the most prevalent taxan in 2003. At the Beaver Creek site, the Ephemeroptera (Mayfly) *Tricorythodes* was the most prevalent taxan in 2002, and the Coleoptera (beetle) *Optioservus divergens* (LeConte) was the most prevalent taxan in 2003. At the Highland Creek site, the Ephemeroptera (Mayfly) *Baetidae* was the predominate taxan in 2002, and the Coleoptera (beetle) *Optioservus* sp. was the most predominant taxan in 2003. Two new species of Caddis fly *Ceratopsyche cf. slossonae* (Banks) and *Brachycentrus occidentalis* (Banks) were identified from samples collected at Highland Creek in 2002 that had not previously been reported in South Dakota.

The benthic macroinvertebrate data were somewhat inconclusive showing that Beaver Creek had lower species diversity and a higher percentage of tolerant species than the other two streams during 2002, but just the opposite was found during 2003. However, examination of the complete data set indicates that the quality of water at the upstream site was generally poorer than the quality of water at the downstream site. Furthermore, the quality of water at the upstream site on Beaver Creek is somewhat degraded when compared to the quality of water from Highland and Cold Spring Creeks, indicating that anthropogenic activities outside the park probably are affecting the quality of water in Beaver Creek.

Samples for the analysis of wastewater compounds were collected at least twice from four of the five water-quality sampling sites. Four wastewater compounds were detected in samples from Cold Spring Creek—bromoform, phenol, caffeine, and cholesterol—but only phenol was detected at concentrations greater than the minimum reporting level. Concentrations of several wastewater compounds were estimated in samples collected from sites on Beaver Creek, including phenol, para-cresol, and para-nonylphenol-total. Phenol was detected at both sites on Beaver Creek at concentrations greater than the minimum reporting level. No wastewater compounds were detected at Highland Creek at concentrations greater than the minimum reporting level; however, estimated concentrations were provided for bromoform; para-cresol; ethanol,2-butoxy-phosphate; and cholesterol.

The geochemical composition of bottom sediments was analyzed in one composite sample from each of the three streams. Arsenic concentrations of 9.5 micrograms per gram in the sample from Cold Spring Creek and of 9.4 micrograms per gram in the sample from Beaver Creek exceeded the U.S. Environmental Protection Agency's threshold effects guidelines, the NOAA effects range low value, and the National Irrigation Water Quality Program level of concern. The bottom-sediment sample from Highland Creek had the lowest percentage of inorganic plus organic, inorganic, and organic carbon of any site sampled during this study.

Samples for the analysis of suspended-sediment concentration were collected from each of the five water-quality sampling sites. Of the five sampling sites, mean concentrations of suspended sediment were highest in samples from the upstream site on Cold Spring Creek.

The potential influence of parking lot runoff on cave drip water within Wind Cave also was investigated. Several time-dependent samples were collected from a drainage culvert downstream from the parking lot and from Upper Minnehaha Falls inside the cave following a series of simulated runoff events.

Analyses of water samples collected at the drainage culvert on September 4, 2002, showed that toluene (0.04 microgram per liter (μg/L)), benzene (0.02 μg/L), xylene (0.02 μg/L), chloroform (5.1 μg/L), methyl isobutyl keytone (1.00 μg/L), and acetone (23 μg/L) were present in the runoff. Analysis of a background sample collected from Upper Minnehaha Falls prior to the initiation of the simulated runoff event showed that only very low levels of toluene were present and at concentrations less than the minimum reporting level. Subsequent samples were collected sequentially from Upper Minnehaha Falls at time increments of approximately 9, 10, and 11 hours following the simulated runoff event. Traces of acetone, total benzene, ethyl benzene, meta- and para-xylene, ortho-xylene, and styrene were present in the sequential cave-drip samples collected following the simulated runoff event, but at much lower levels than reported in a previous study.

References

Alexander, E.C., Jr., Davis, M.A., Alexander, S.C., 1989, Hydrologic study of Jewel Cave and Wind Cave: Minneapolis, Minn., Department of Geology and Geophysics, University of Minnesota, Contract CX-1200-S-A047, 196 p.

Arbogast, B.F., 1990, Quality assurance manual for the Branch of Geochemistry, U.S. Geological Survey: U.S. Geological Survey Open-File Report 90-688, 184 p.

Barbour, M.T., Gerritsen, J., Snyder, B.D., and Stribling, J.B., 1999, Rapid bioassessment protocols for use in streams and wadeable rivers—Periphyton, benthic macroinvertebrates, and fish (2d ed.): Washington, D.C., U.S. Environmental Protection Agency, Office of Water, Assessment and Watershed Protection Division, EPA/841-B-99-002.

Brown, G.K., Zaugg, S.D., Barber, L.B., 1999, Wastewater analysis by gas chromatography/mass spectrometry, *in* U.S. Geological Survey Toxic Substances Hydrology Program Proceedings of the Technical Meeting: Charleston, South Carolina, March 8-12, 1999, p. 431-435.

Burr, M.J., Teller, R.W., Neitzert, K.M., 2004, Water resources data, South Dakota, water year 2003: U.S. Geological Survey Water-Data Report SD-03-1, 491 p.

Carter, J.M., Driscoll, D.G., Williamson, J.E., 2002, Atlas of water resources in the Black Hills area, South Dakota: U.S. Geological Survey Hydrologic Investigations Atlas HA-747, 120 p.

Childress, C. J. Oblinger, Foreman, W.T., Connor, B.F., and Maloney, T.J., 1999, New reporting procedures based on long-term method detection levels and some considerations for interpretations of water-quality data provided by the U.S. Geological Survey National Water Quality Laboratory: U.S. Geological Survey Open-File Report 99-193, 19 p.

Conn, H., 1966, Barometric wind in Wind and Jewel Caves, S. Dak.: National Speleological Society Bulletin No. 18, v. 2, p. 55-69.

Connor, B.F., Rose, D.L., Noriega, M.C., Murtagh, L.K., and Abney, S.R., 1997, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—determination of 86 volatile organic compounds in water by gas chromatography/mass spectrometry, including detections less than reporting limits: U.S. Geological Survey Open-File Report 97-829, 78 p.

Cuffney, T.F., Gurtz, M.E., and Meador, M.R., 1993, Methods for collecting benthic invertebrate samples as part of the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 93-406, 66 p.

Driscoll, D.G., and Bradford, W.L, 1994, Compilation of selected hydrologic data, through water year 1992, Black Hills Hydrology Study, Western South Dakota: U.S. Geological Survey Open-File Report 94-319, 158 p.

Driscoll, D.G., and Carter, J.M, 2001, Hydrologic conditions and budgets in the Black Hills area of South Dakota, through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 01-4226, 143 p.

Driscoll, D.G., Carter, J.M., Williamson, J.E., and Putnam, L.D., 2002, Hydrology of the Black Hills area, South Dakota: U.S. Geological Survey Water-Resources Investigations Report 02-4094, 150 p.

Eaton, A.D., Clesceri, L.S., and Greenberg, A.E., eds., 1995, Standard methods for the examination of water and wastewater (19th ed.): Washington D.C., American Public Health Association [variously paged].

Edwards, T.K., and Glysson, G.D., 1988, Field methods for measurement of fluvial sediment: U.S. Geological Survey Open-File Report 86-531, 240 p.

Feldman, R.M., and Heimlich, R.A., 1980, The Black Hills: Kent, Ohio, Kendall/Hunt Publishing Company, K/H Geology Field Guide Series, Kent State University, 190 p.

Gries, J.P., 1959, Preliminary report on potential ground water within the boundaries of Wind Cave National Park, Custer County, South Dakota: Consultant's report, June 1959, 22 p.

Guy, H.P., 1969, Laboratory theory and methods for sediment analysis: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. C1, 58 p.

Horrocks, R.D., and Szukalski, B.W., 2002, Using geographic information systems to develop a cave potential map for Wind Cave, South Dakota: Journal of Cave and Karst Studies, April 2002, v. 64, no. 1, p. 63-70.

Hortness, J.E., and Driscoll, D.G., 1998, Streamflow losses in the Black Hills of western South Dakota: U.S. Geological Survey Water-Resources Investigations Report 98-4116, 99 p.

Johnson, B.N., 1933, A climatological review of the Black Hills: The Black Hills Engineer, Rapid City, South Dakota School of Mines and Technology, 71 p.

Klemm, D.J., Lewis, P.A., Faulk, F., and Lazorchak, J.M., 1990, Macroinvertebrate field and laboratory methods for evaluating the biological integrity of surface waters: Cincinnati, Ohio, U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, EPA/600/4-90/030.

Long, E.R., MacDonald, D.D., Smith, S.L., and Calder, F.D., 1995, Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments: Environmental Management, v. 19, no. 1, p. 81-97.

Matthes, W.J., Jr., Scholar, C.J., and George, J.R., 1991, A quality assurance plan for the analysis of fluvial sediment by laboratories of the U.S. Geological Survey: U.S. Geological Survey Open-File Report 91-467, 31 p.

Moulton, II, S.R., Carter, J.L., Grotheer, S.A., Cuffney, T.F., and Short, T.M., 2000, Methods for analysis by the U.S. Geological Survey National Water Quality Laboratory—Processing, taxanomy, and quality control of benthic macroinvertebrate samples, U.S. Geological Survey Open File Report 00-212, 49 p.

National Oceanographic and Atmospheric Administration, 2003, The U.S. drought monitor: accessed October 9, 2003, at URL http://www.state.sd.us/doa/drought.htm

National Park Service, 1994, Final general management plan environmental impact statement, Wind Cave National Park: NPS D-65A, 169 p.

National Park Service, 1998, Baseline water quality data inventory and analysis Wind Cave National Park: Fort Collins, Colo., Water Resources Division, Technical Report NPS/NRWRD/NRTR-98/174, 414 p.

Nepstead, J., and Pisarowicz, J., 1988, Wind Cave map with text: Black Hills Parks and Forests Association.

Palmer, A.N., 2000, Speleogenesis of the Black Hills maze caves, South Dakota, USA, *in* Klimchouk, A.B., Ford, D.C., Palmer, A.N., and Dreybrodt, W., eds., Speleogenesis, evolution of karst aquifers: Huntsville, Ala., p. 274-281.

Piper, A.M., 1944, A graphic procedure in the geochemical interpretation of water analyses: American Geophysical Union Transactions, v. 25, p. 914-923.

Plafkin, J.L., Barbour, M.T., Porter, K.D., Gross, S.K., and Hughes, R.M., 1989, Rapid bioassessment protocols for use in streams and rivers—Benthic macroinvertebrates and fish: Washington, D.C., U.S. Environmental Protection Agency, Assessment and Watershed Protection Division, EPA/440/4-89/001.

Rahn, P.H., and Gries, J.P., 1973, Large springs in the Black Hills, South Dakota and Wyoming: South Dakota Geological Survey Report of Investigations 107, 46 p.

Rantz, S.E., and others, 1982, Measurement and computation of streamflow—volume 1, measurement of stage and discharge: U.S. Geological Survey Water-Supply Paper 2175, 284 p.

Rosenberg, D.M., and Resh, V.H., 2001, Freshwater biomonitoring and benthic macroinvertebrates: Norwell, Mass., Kluwer Academic Publishers, 488 p.

Shacklette, H.T., and Boerngen, J.G., 1984, Element concentrations in soils and other surficial materials of the conterminous United States: U.S. Geological Survey Professional Paper 1270, 105 p.

South Dakota Department of Environment and Natural Resources, 2002, Drinking water standards: Administrative rules of South Dakota, Article 74:04, Chapter 74:04:05, accessed October 9, 2003, at URL http://www.state.sd.us/denr/des/drinking/dwprg.htm

South Dakota Department of Game, Fish and Parks, 2003, List of threatened and endangered species: accessed on December 17, 2003, at URL http://www.state.sd.us/gfp/DivisionWildlife/Diversity/TES.htm

Strobel, M.L., Jarrell, G.J., Sawyer, J.F., Schleicher, J.R., and Fahrenbach, M.D., 1999, Distribution of hydrogeologic units in the Black Hills area, South Dakota: U.S. Geological Survey Hydrologic Investigations Atlas HA-743, 3 sheets, scale 1:100,000.

URS Operating Systems, Inc., 2002, Pringle Post and Pole-Site Reassessment: Contract No. 68-W-00-118, 26 p.

U.S. Department of Commerce, 1999, Climatological data annual summary of South Dakota: Asheville, North Carolina, v. 104, no. 13.

U.S. Department of the Interior, 1998, Guidelines for the interpretation of the biological effects of selected constituents in biota, water, and sediment: Denver, Colo., National Irrigation Water Quality Program Information Report No. 3, 198 p.

U.S. Environmental Protection Agency, 1996, Drinking water regulations and health advisories: Washington, D.C., Office of Water, February 1996, EPA 822-R-96-001.

U.S. Environmental Protection Agency, 1998a, National recommended water criteria: Federal Register, December 10, 1998, v. 63, no. 237, p. 68353-68364.

U.S. Environmental Protection Agency, 1998b, Drinking water standards: accessed October 9, 2003, at URL http://www.epa.gov/safewater/mcl.html#mcls

U.S. Environmental Protection Agency, 1998c, Secondary Maximum Contaminant Levels: accessed October 9, 2003, accessed at URL http://www.epa.gov/safewater/mcl.html#sec

U.S. Environmental Protection Agency, 1998d, The incidence and severity of sediment contamination in surface waters of the United States, Volume 1—National sediment quality survey: U.S. Environmental Protection Agency Report 823-R-97-006 [variously paged].

U.S. Geological Survey, 1992-2004, Water resources data, South Dakota, water years 1991-2003: U.S. Geological Survey Water Data Reports SD-91-1 to SD-03-1 (published annually).

U.S. Geological Survey, 1997-2004, National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chaps. A1-A9, 2 v., variously paged. [Also available online at http://pubs.water.usgs.gov/twri9A. Chapters were originally published from 1997-1999; updates and revisions are ongoing and are summarized at: http://water.usgs.gov/owq/FieldManual/mastererrata.html]

Venezky, D.Y., 1994, An exploration of development based ground water contamination at Wind Cave: Providence, R.I., Department of Geological Sciences, Brown University, 8 p.

Ward, J.R., and Harr, C.A., eds., 1990, Methods for collection and processing of surface-water and bed-material samples for physical and chemical analyses: U.S. Geological Survey Open-File Report 90-140, 71 p.

Williamson, J.E., and Carter, J.M, 2001, Water-quality characteristics in the Black Hills area, South Dakota: U.S. Geological Survey Water-Resources Investigations Report 01-4194, 196 p.

Supplemental Information

Table 9. Quality-assurance and quality-control data for blank and replicate samples.

[mm, millimeters; mg/L, milligrams per liter; µg/L, micrograms per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; deg. C, degrees Celsius; deg. F, degrees Fahrenheit; NTU, nephelometric turbidity units; E, estimated; <, less than; --, no data available]

Station number	Date	Time	Type of sample	Turbidity, laboratory (NTU) (99872)	Barometric pressure (mm of Hg) (00025)	Dissolved oxygen (mg/L) (00300)	Dissolved oxygen (percent saturation) (00301)	pH, whole, field (standard units) (00400)	pH, whole, laboratory (standard units) (00403)
433444103295200	5/13/2003	1130	Environmental	5.5	675	--	--	7.5	8.0
433444103295200	5/13/2003	1135	Replicate	<1.0	--	--	--	7.5	8.1
433451103284000	9/11/2002	0840	Environmental	5.5	676	9.8	84	7.0	7.7
433451103284000	9/11/2002	0841	Replicate	1.8	676	9.8	84	7.0	E7.5
433310103281701	6/19/2002	0800	Blank	--	--	--	--	--	--
433310103281701	9/4/2002	0741	Blank	--	--	--	--	--	--

Date	Type of sample	Specific conductance, laboratory (µS/cm) (90095)	Specific conductance, field (µS/cm) (00095)	Temperature, air (deg. C) (00020)	Temperature, water (deg. C) (00010)	Temperature, (deg. F) (00011)	Calcium, dissolved (mg/L as Ca) (00915)	Magnesium, dissolved (mg/L as Mg) (00925)
5/13/2003	Environmental	552	575	--	11.2	--	70.3	27.4
5/13/2003	Replicate	552	575	--	--	2	68.7	27.0
9/11/2002	Environmental	544	586	10	9.0	--	68.3	27.9
9/11/2002	Replicate	545	586	10	8.8	--	68.7	28.1
6/19/2002	Blank	--	--	--	--	--	--	--
9/4/2002	Blank	--	--	--	--	--	--	--

Date	Type of sample	Potassium, dissolved (mg/L as K) (00935)	Sodium, dissolved (mg/L as Na) (00930)	Alkalinity, laboratory (mg/L as $CaCO_3$) (90410)	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Sulfate, dissolved (mg/L as SO_4) (00945)
5/13/2003	Environmental	3.53	10.4	272	14.6	0.36	14.0	25.3
5/13/2003	Replicate	3.68	10.2	270	14.2	.35	14.7	25.1
9/11/2002	Environmental	3.95	12.4	273	13.9	.40	18.4	26.9
9/11/2002	Replicate	3.97	12.5	274	13.5	.40	18.1	26.8
6/19/2002	Blank	--	--	--	--	--	--	--
9/4/2002	Blank	--	--	--	--	--	--	--

Table 9. Quality-assurance and quality-control data for blank and replicate samples.—Continued

[mm, millimeters; mg/L, milligrams per liter; µg/L, micrograms per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; deg. C, degrees Celsius; deg. F, degrees Fahrenheit; NTU, nephelometric turbidity units; E, estimated; <, less than; --, no data available]

Station number	Date	Type of sample	Ammonia plus organic, total (mg/L as N) (00625)	Ammonia, dissolved (mg/L as N) (00608)	Nitrite plus nitrate, dissolved (mg/L as N) (00631)	Nitrite, dissolved (mg/L as N) (00613)	Ortho-phosphate, dissolved (mg/L as P) (00671)	Phosphorus, total (mg/L as P) (00665)
433444103295200	5/13/2003	Environmental	0.21	E0.008	<0.022	--	E0.004	0.013
433444103295200	5/13/2003	Replicate	.19	E.008	<.022	--	E.005	.012
433451103284000	9/11/2002	Environmental	--	<.015	.019	<0.002	.007	.015
433451103284000	9/11/2002	Replicate	--	E.009	.020	<.002	<.007	.016
433310103281701	6/19/2002	Blank	--	--	--	--	--	--
433310103281701	9/4/2002	Blank	--	--	--	--	--	--

Date	Type of sample	Arsenic, total (µg/L as As) (01002)	Beryllium, total (µg/L as Be) (01012)	Boron, dissolved (µg/L as B) (01020)	Cadmium, total (µg/L as Cd) (01027)	Chromium, total recoverable (µg/L as Cr) (01034)	Copper, total recoverable (µg/L as Cu) (01042)	Iron, dissolved (µg/L as Fe) (01046)
5/13/2003	Environmental	3	<2	30	<0.2	<0.8	<1.0	E10
5/13/2003	Replicate	6	<2	30	<.2	<.8	<1.0	12
9/11/2002	Environmental	4	<2	40	.1	<.8	<1.0	<10
9/11/2002	Replicate	3	<2	40	E.1	<.8	<1.0	<10
6/19/2002	Blank	--	--	--	--	--	--	--
9/4/2002	Blank	--	--	--	--	--	--	--

Date	Type of sample	Iron, total recoverable (µg/L as Fe) (01045)	Lead, total recoverable (µg/L as Pb) (01051)	Manganese, total recoverable (µg/L as Mn) (01055)	Mercury, total recoverable (µg/L as Hg) (71900)	Nickel, total recoverable (µg/L as Ni) (01067)	Selenium, total (µg/L as Se) (01147)
5/13/2003	Environmental	30	<1	8.2	<0.02	<2.0	<3
5/13/2003	Replicate	40	<1	9.1	<.02	<2.0	E1
9/11/2002	Environmental	30	<1	E2.2	<.01	<2.0	E2
9/11/2002	Replicate	30	<1	E2.3	<.01	<2.0	<2
6/19/2002	Blank	--	--	--	--	--	--
9/4/2002	Blank	--	--	--	--	--	--

Table 9. Quality-assurance and quality-control data for blank and replicate samples.—Continued

[mm, millimeters; mg/L, milligrams per liter; µg/L, micrograms per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; deg. C, degrees Celsius; deg. F, degrees Fahrenheit; NTU, nephelometric turbidity units; E, estimated; <, less than; --, no data available]

Station number	Date	Type of sample	Zinc, total recoverable (µg/L as Zn) (01092)	1,1,1,2-Tetrachloro-ethane, total recoverable (µg/L) (77562)	1,1,1-Trichloro-ethane, total recoverable (µg/L) (34506)	1,1,2,2-Tetrachloro-ethane, total recoverable (µg/L) (34516)	1,1,2-Trichloro-1,2,2-trifluoro-ethane, total recoverable (µg/L) (77652)	1,1,2-Trichloro-ethane, total recoverable (µg/L) (34511)
433444103295200	5/13/2003	Environmental	<20	--	--	--	--	--
433444103295200	5/13/2003	Replicate	E10	--	--	--	--	--
433451103284000	9/11/2002	Environmental	<20	--	--	--	--	--
433451103284000	9/11/2002	Replicate	<20	--	--	--	--	--
433310103281701	6/19/2002	Blank	--	<0.03	<0.03	<0.09	<0.06	<0.06
433310103281701	9/4/2002	Blank	--	<.03	<.03	<.09	<.06	<.06

Date	Type of sample	1,1-Dichloro-ethane, total recoverable (µg/L) (34496)	1,1-Dichloro-ethene, total recoverable (µg/L) (34501)	1,1-Dichloro-propene, total recoverable (µg/L) (77168)	1,2,3,4-Tetramethyl-benzene, total recoverable (µg/L) (49999)	1,2,3,5-Tetramethyl-benzene, total recoverable (µg/L) (50000)	1,2,3-Trichloro-benzene, total recoverable (µg/L) (77613)
5/13/2003	Environmental	--	--	--	--	--	--
5/13/2003	Replicate	--	--	--	--	--	--
9/11/2002	Environmental	--	--	--	--	--	--
9/11/2002	Replicate	--	--	--	--	--	--
6/19/2002	Blank	<0.04	<0.04	<0.05	<0.2	<0.2	<0.3
9/4/2002	Blank	<.04	<.04	<.05	<.2	<.2	<.3

Date	Type of sample	1,2,3-Trichloro-propane, total recoverable (µg/L) (77443)	1,2,3-Trimethyl-benzene, total recoverable (µg/L) (77221)	1,2,4-Trichloro-benzene, total recoverable (µg/L) (34551)	1,2,4-Trimethyl-benzene, total recoverable (µg/L) (77222)	1,2-Dibromo-3-chloro-propane, total recoverable (µg/L) (82625)	1,2-Dibromo-ethane, total recoverable (µg/L) (77651)
5/13/2003	Environmental	--	--	--	--	--	--
5/13/2003	Replicate	--	--	--	--	--	--
9/11/2002	Environmental	--	--	--	--	--	--
9/11/2002	Replicate	--	--	--	--	--	--
6/19/2002	Blank	<0.16	<0.1	<0.1	<0.06	<0.5	<0.04
9/4/2002	Blank	<.16	<.1	<.1	<.06	<.5	<.04

Table 9. Quality-assurance and quality-control data for blank and replicate samples.—Continued

[mm, millimeters; mg/L, milligrams per liter; µg/L, micrograms per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; deg. C, degrees Celsius; deg. F, degrees Fahrenheit; NTU, nephelometric turbidity units; E, estimated; <, less than; --, no data available]

Station number	Date	Type of sample	1,2-Dichloro-benzene, total recoverable (µg/L) (34536)	1,2-Dichloro-ethane, total recoverable (µg/L) (32103)	1,2-Dichloro-ethane-d4, surrogate, Schedule 2090, total, percent recovery (99832)	1,2-Dichloro-propane, total recoverable (µg/L) (34541)	1,3,5-Trimethyl-benzene, total recoverable (µg/L) (77226)	1,3-Dichloro-benzene, total recoverable (µg/L) (34566)
433444103295200	5/13/2003	Environmental	--	--	--	--	--	--
433444103295200	5/13/2003	Replicate	--	--	--	--	--	--
433451103284000	9/11/2002	Environmental	--	--	--	--	--	--
433451103284000	9/11/2002	Replicate	--	--	--	--	--	--
433310103281701	6/19/2002	Blank	<0.03	<0.1	108	<0.03	<0.04	<0.03
433310103281701	9/4/2002	Blank	<.03	<.1	112	<.03	<.04	<.03

Date	Type of sample	1,3-Dichloro-propane, total recoverable (µg/L) (77173)	1,4-Dichloro-benzene, total recoverable (µg/L) (34571)	1-Bromo-4-fluorobenzene, surrogate, VOC schedules, total, percent recovery (99834)	2,2-Dichloro-propane, total recoverable (µg/L) (77170)	2-Chloro-toluene, total recoverable (µg/L) (77275)	2-Ethyl-toluene, total recoverable (µg/L) (77220)
5/13/2003	Environmental	--	--	--	--	--	--
5/13/2003	Replicate	--	--	--	--	--	--
9/11/2002	Environmental	--	--	--	--	--	--
9/11/2002	Replicate	--	--	--	--	--	--
6/19/2002	Blank	<0.1	<0.05	88.3	<0.05	<0.03	<0.06
9/4/2002	Blank	<.1	<.05	87.1	<.05	<.03	<.06

Date	Type of sample	3-Chloro-propene, total recoverable (µg/L) (78109)	4-Chloro-toluene, total recoverable (µg/L) (77277)	4-Isopro-pyltoluene, total recoverable (µg/L) (77356)	Acetone, total recoverable (µg/L) (81552)	Acrylonitrile, total recoverable (µg/L) (34215)	Benzene, total recoverable (µg/L) (34030)
5/13/2003	Environmental	--	--	--	--	--	--
5/13/2003	Replicate	--	--	--	--	--	--
9/11/2002	Environmental	--	--	--	--	--	--
9/11/2002	Replicate	--	--	--	--	--	--
6/19/2002	Blank	<0.07	<0.05	<0.07	<7	<1	<0.04
9/4/2002	Blank	<.07	<.05	<.07	<7	<1	<.04

Table 9. Quality-assurance and quality-control data for blank and replicate samples.

[mm, millimeters; mg/L, milligrams per liter; µg/L, micrograms per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; deg. C, degrees Celsius; deg. F, degrees Fahrenheit; NTU, nephelometric turbidity units; E, estimated; <, less than; --, no data available]

Station number	Date	Type of sample	Bromo-benzene, total recoverable (µg/L) (81555)	Bromo-chloro-methane, total recoverable (µg/L) (77297)	Bromodi-chloro-methane, total recoverable (µg/L) (32101)	Bromo-ethene, total recoverable (µg/L) (50002)	Bromo-methane, total recoverable (µg/L) (34413)	Carbon disulfide, total (µg/L) (77041)
433444103295200	5/13/2003	Environmental	--	--	--	--	--	--
433444103295200	5/13/2003	Replicate	--	--	--	--	--	--
433451103284000	9/11/2002	Environmental	--	--	--	--	--	--
433451103284000	9/11/2002	Replicate	--	--	--	--	--	--
433310103281701	6/19/2002	Blank	<0.04	<0.07	<0.05	<0.1	<0.3	<0.07
433310103281701	9/4/2002	Blank	<.04	<.07	<.05	<.1	<.3	<.07

Date	Type of sample	Chloro-benzene, total recoverable (µg/L) (34301)	Chloro-ethane, total recoverable (µg/L) (34311)	Chloro-methane, total recoverable (µg/L) (34418)	cis-1,2-Dichloro-ethene, total recoverable (µg/L) (77093)	cis-1,3-Dichloro-propene, total recoverable (µg/L) (34704)	Dibromo-chloro-methane, total recoverable (µg/L) (32105)
5/13/2003	Environmental	--	--	--	--	--	--
5/13/2003	Replicate	--	--	--	--	--	--
9/11/2002	Environmental	--	--	--	--	--	--
9/11/2002	Replicate	--	--	--	--	--	--
6/19/2002	Blank	<0.03	<0.1	<0.2	<0.04	<0.09	<0.2
9/4/2002	Blank	<.03	<.1	<.2	<.04	<.09	<.2

Date	Type of sample	Dibromo-methane, total recoverable (µg/L) (30217)	Dichloro-difluoro-methane, total recoverable (µg/L) (34668)	Dichloro-methane, total recoverable (µg/L) (34423)	Diethyl ether, total recoverable (µg/L) (81576)	Diisopropyl ether, total recoverable (µg/L) (81577)	Ethyl methacrylate, total recoverable (µg/L) (73570)
5/13/2003	Environmental	--	--	--	--	--	--
5/13/2003	Replicate	--	--	--	--	--	--
9/11/2002	Environmental	--	--	--	--	--	--
9/11/2002	Replicate	--	--	--	--	--	--
6/19/2002	Blank	<0.05	<0.18	<0.2	<0.2	<0.10	<0.2
9/4/2002	Blank	<.05	<.18	<.2	<.2	<.10	<.2

Table 9. Quality-assurance and quality-control data for blank and replicate samples.—Continued

[mm, millimeters; mg/L, milligrams per liter; µg/L, micrograms per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; deg. C, degrees Celsius; deg. F, degrees Fahrenheit; NTU, nephelometric turbidity units; E, estimated; <, less than; --, no data available]

Station number	Date	Type of sample	Ethyl methyl ketone, total recoverable (µg/L) (81595)	Ethylbenzene, total recoverable (µg/L) (34371)	Hexachloro-butadiene, total recoverable (µg/L) (39702)	Hexachloro-ethane, total recoverable (µg/L) (34396)	Iodomethane, total recoverable (µg/L) (77424)	Isobutyl methyl ketone, total recoverable (µg/L) (78133)
433444103295200	5/13/2003	Environmental	--	--	--	--	--	--
433444103295200	5/13/2003	Replicate	--	--	--	--	--	--
433451103284000	9/11/2002	Environmental	--	--	--	--	--	--
433451103284000	9/11/2002	Replicate	--	--	--	--	--	--
433310103281701	6/19/2002	Blank	<5.0	<0.03	<0.1	<0.2	<0.25	<0.4
433310103281701	9/4/2002	Blank	<5.0	<.03	<.1	<.2	<.25	<.4

Date	Type of sample	Isopropyl-benzene, total recoverable (µg/L) (77223)	Methacrylo-nitrile, total recoverable (µg/L) (81593)	Methyl acrylate, total recoverable (µg/L) (49991)	Methyl methacrylate, total recoverable (µg/L) (81597)	Methyl tert-pentyl ether, total recoverable (µg/L) (50005)	m-Xylene plus p-xylene, total recoverable (µg/L) (85795)
5/13/2003	Environmental	--	--	--	--	--	--
5/13/2003	Replicate	--	--	--	--	--	--
9/11/2002	Environmental	--	--	--	--	--	--
9/11/2002	Replicate	--	--	--	--	--	--
6/19/2002	Blank	<0.06	<0.6	<2.0	<0.3	<0.08	<0.06
9/4/2002	Blank	<.06	<.6	<2.0	<.3	<.08	<.06

Date	Type of sample	Naphthalene, total recoverable (µg/L) (34696)	n-Butyl methyl ketone, total recoverable (µg/L) (77103)	n-Butyl-benzene, total recoverable (µg/L) (77342)	n-Propyl-benzene, total recoverable (µg/L) (77224)	o-Xylene, total recoverable (µg/L) (77135)	sec-Butyl-benzene, total recoverable (µg/L) (77350)
5/13/2003	Environmental	--	--	--	--	--	--
5/13/2003	Replicate	--	--	--	--	--	--
9/11/2002	Environmental	--	--	--	--	--	--
9/11/2002	Replicate	--	--	--	--	--	--
6/19/2002	Blank	<0.5	<0.7	<0.2	<0.04	<0.07	<0.03
9/4/2002	Blank	<.5	<.7	<.2	<.04	<.07	<.03

Table 9. Quality-assurance and quality-control data for blank and replicate samples.—Continued

[mm, millimeters; mg/L, milligrams per liter; µg/L, micrograms per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; deg. C, degrees Celsius; deg. F, degrees Fahrenheit; NTU, nephelometric turbidity units; E, estimated; <, less than; --, no data available]

Station number	Date	Type of sample	Styrene, total recoverable (µg/L) (77128)	*tert*-Butyl ethyl ether, total recoverable (µg/L) (50004)	Methyl *tert*-butyl ether, total recoverable (µg/L) (78032)	*tert*-Butyl-benzene, total recoverable (µg/L) (77353)	Tetrachloro-ethene, total recoverable (µg/L) (34475)	Tetrachloro-methane, total recoverable (µg/L) (32102)
433444103295200	5/13/2003	Environmental	--	--	--	--	--	--
433444103295200	5/13/2003	Replicate	--	--	--	--	--	--
433451103284000	9/11/2002	Environmental	--	--	--	--	--	--
433451103284000	9/11/2002	Replicate	--	--	--	--	--	--
433310103281701	6/19/2002	Blank	<0.04	<0.05	<0.2	<0.05	<0.03	<0.06
433310103281701	9/4/2002	Blank	<.04	<.05	<.2	<.05	<.03	<.06

Date	Type of sample	Tetrahydro-furan, total recoverable (µg/L) (81607)	Toluene, total recoverable (µg/L) (34010)	Toluene-d8, surrogate, Schedule 2090, total, percent recovery (99833)	trans-1,2-Dichloro-ethene, total recoverable (µg/L) (34546)	trans-1,3-Dichloro-propene, total recoverable (µg/L) (34699)	trans-1,4-Dichloro-2-butene, total recoverable (µg/L) (73547)
5/13/2003	Environmental	--	--	--	--	--	--
5/13/2003	Replicate	--	--	--	--	--	--
9/11/2002	Environmental	--	--	--	--	--	--
9/11/2002	Replicate	--	--	--	--	--	--
6/19/2002	Blank	<2	<0.05	100	<0.03	<0.09	<0.7
9/4/2002	Blank	<2	E.01	101	<.03	<.09	<.7

Date	Type of sample	Tribromo-methane, total recoverable (µg/L) (32104)	Trichloro-ethene, total recoverable (µg/L) (39180)	Trichloro-fluoro-methane, total recoverable (µg/L) (34488)	Trichloro-methane, total recoverable (µg/L) (32106)	Vinyl chloride, total recoverable (µg/L) (39175)	Number of tentatively identified compounds (TICS) from VOC analysis by GCMS, number (99871)
5/13/2003	Environmental	--	--	--	--	--	--
5/13/2003	Replicate	--	--	--	--	--	--
9/11/2002	Environmental	--	--	--	--	--	--
9/11/2002	Replicate	--	--	--	--	--	--
6/19/2002	Blank	<0.06	<0.04	<0.09	<0.02	<0.1	0
9/4/2002	Blank	<.06	<.04	<.09	<.02	<.1	0

Table 10. Quality-assurance and quality-control data for wastewater compounds in surface water and ground water.

[--, no data; E, estimated value; *, value outside acceptable range; <, less than; SURR, surrogate. Values in micrograms per liter except as indicated]

	Spike percent recovery	Spike percent recovery	Spike percent recovery	Spike percent recovery	Spike percent recovery	Acceptable recovery limits	Blank	Blank	Blank	Blank	Blank
Date	3/04/2002	5/14/2002	7/23/2002	3/12/2003	5/13/2003	--	3/04/2002	5/14/2002	7/23/2002	3/12/2003	5/13/2003
Tetrachloro-ethylene	E16.00*	32.68	39.92	12.44*	12.50*	20–110	<0.500	<0.500	<0.500	<0.500	<0.500
Bromoform	E69.00	75.24	78.40	58.21	70.00	40–110	<.500	<.500	<.500	<.500	<.500
Cumene	31.00	44.35	61.49	21.98*	24.00*	30–110	<.500	<.500	<.500	<.500	<.500
Phenol	E87.00	78.86	79.50	74.92	90.00	60–110	<.500	<.500	<.500	<.500	E.030
1,4-Dichlorobenzene	E43.00	54.00	69.87	41.42	47.00	30–110	<.500	<.500	<.500	<.500	<.500
d-Limonene	E27.00	44.89	63.42	20.04	21.50	20–110	<.500	E.097	<.500	<.500	<.500
Acetophenone	92.00	94.94	93.71	82.37	100.00	60–110	<.500	<.500	<.500	<.500	.039
Para-cresol	71.00	77.94	99.58	80.76	100.00	50–110	<1.000	<1.000	<1.000	<1.000	<1.000
Isophorone	84.00	85.04	85.69	76.60	90.00	60–110	<.500	<.500	<.500	<.500	<.500
Camphor	82.00	90.02	80.05	81.47	90.00	60–110	<.500	<.500	<.500	<.500	E.006
Isoborneol	85.00	84.77	83.31	90.39	95.00	60–110	<.500	<.500	<.500	<.500	<.500
Menthol	95.00	86.83	83.28	67.22	90.00	60–110	<.500	<.500	<.500	<.500	E.028
Naphthalene	69.00	72.97	77.19	69.78	80.00	60–110	<.500	<.500	<.500	<.500	E.006
Methyl salicylate	94.00	86.45	87.54	80.20	90.00	60–110	<.500	<.500	<.500	<.500	E.015
Dichlorvos	E98.00	94.80	87.19	80.93	100.00	1–110	<1.000	<1.000	<1.000	<1.000	<1.000
Isoquinoline	95.00	94.80	87.61	84.04	85.00	30–110	<.500	<.500	<.500	<.500	<.500
2-Methylnapthalene	63.00	64.75	73.77	64.20	75.00	50–110	<.500	<.500	<.500	<.500	E.004
Indole	89.00	97.30	75.82	79.31	95.00	50–110	<.500	<.500	<.500	<.500	<.500
3,4-Dichlorophenyl isocyanate	E66.00	60.23	88.08	81.88	49.50*	60–110	<.500	<.500	<.500	<.500	<.500
1-Methylnapthalene	86.00	68.37	77.46	64.20	75.00	50–110	<.500	<.500	<.500	<.500	E.004
Skatol	68.00	84.39	82.67	76.05	95.00	30–110	<1.000	<1.000	<1.000	<1.000	<1.000
2,6-Dimethylnapthalene	24.00*	65.22	76.78	65.31	75.00	50–110	<.500	<.500	<.500	<.500	<.500
BHA	E90.00	50.65	70.32	5.75*	39.00	20–110	<5.000	<5.000	<5.000	<5.000	<5.000
N,N-Diethyltoluamide (DEET)	93.00	87.96	94.37	81.24	100.00	60–110	<.500	<.500	<.500	<.500	<.500
5-Methyl-1H-benzotriazle	80.00	62.64	72.13	59.90	80.00	40–110	<2.000	<2.000	<2.000	<2.000	<2.000
Diethyl phthalate	91.00	91.30	106.45	86.65	95.00	60–110	<.500	<.500	<.500	<.500	E.029

Table 10. Quality-assurance and quality-control data for wastewater compounds in surface water and ground water.—Continued

[--, no data; E, estimated value; *, value outside acceptable range; <, less than; SURR, surrogate. Values in micrograms per liter except as indicated]

	Spike percent recovery	Spike percent recovery	Spike percent recovery	Spike percent recovery	Spike percent recovery	Acceptable recovery limits	Blank	Blank	Blank	Blank	Blank
4-*tert*-Octylphenol	86.00	86.17	93.37	76.18	90.00	50–110	<1.000	<1.000	E0.110	E0.110	E0.022
Benzophenone	90.00	86.48	97.70	80.79	90.00	60–110	<.500	<.500	<.500	<.500	E.075
Tributylphosphate	81.00	90.01	97.96	76.41	100.00	60–110	<.500	E.076	<.500	<.500	<.500
Ethyl citrate	98.00	83.73	87.28	75.56	95.00	70–110	<.500	<.500	<.500	<.500	<.500
Cotinine	63.00	50.29	41.30	57.03	77.50	10–110	<1.000	<1.000	<1.000	E.200	<1.000
Para-nonylphenol-total	E89.00	74.64	73.24	74.82	88.90	50–110	E8.000	<5.000	<5.000	<5.000	<5.000
Prometon	89.00	78.95	83.57	76.57	90.00	60–110	<.500	<.500	<.500	<.500	<.500
Pentachlorophenol	6.00*	74.38	74.58	69.58	90.00	20–110	<2.000	<2.000	<2.000	<2.000	<2.000
Atrazine	86.00	82.12	105.59	87.28	95.00	50–110	<.500	<.500	<.500	<.500	<.500
Tri(2-chloroethyl) phosphate	85.00	88.92	87.06	78.52	85.00	60–110	<.500	<.500	<.500	<.500	<.500
4-*n*-octylphenol	83.00	89.49	90.77	70.24	95.00	40–110	<1.000	<1.000	<1.000	<1.000	<1.000
Diazinon	81.00	80.71	78.76	81.64	85.00	50–110	<.500	<.500	<.500	<.500	<.500
Phenanthrene	73.00	81.65	92.74	76.83	90.00	50–110	<.500	<.500	<.500	<.500	E.002
Anthracene	80.00	81.14	88.90	73.81	85.00	40–110	<.500	<.500	<.500	<.500	<.500
Tonalide (AHTN)	79.00	78.07	78.37	77.52	95.00	50–110	<.500	<.500	<.500	<.500	<.500
Caffeine	80.00	72.08	81.40	76.57	85.00	30–110	<.500	<.500	<.500	<.500	<.500
Carbazole	85.00	80.58	90.67	76.89	95.00	50–110	<.500	<.500	<.500	<.500	<.500
Galaxolide (HHCB)	79.00	83.41	76.98	79.51	90.00	30–110	<.500	<.500	<.500	<.500	<.500
OPEO1	E85.00	85.02	81.57	77.45	100.00	50–110	<1.000	E.130	E.270	E.160	E.510
4-Cumylphenol	88.00	85.29	83.50	76.98	90.00	50–110	<1.000	<1.000	<1.000	<1.000	<1.000
Carbaryl	E117.00*	85.35	106.78	66.20	110.00	20–110	<1.000	<1.000	<1.000	<1.000	<1.000
Metalaxyl	87.00	80.89	89.88	84.54	95.00	70–110	<.500	<.500	<.500	<.500	<.500
Bromacil	83.00	84.26	89.88	75.57	95.00	70–110	<.500	<.500	<.500	<.500	<.500
Metolachlor	87.00	85.40	80.82	82.44	100.00	70–110	<.500	<.500	<.500	<.500	<.500
Chlorpyrifos	84.00	83.09	80.78	81.70	90.00	30–110	<.500	<.500	<.500	<.500	<.500
Anthraquinone	78.00	75.37	88.42	72.57	90.00	0–110	<.500	<.500	<.500	<.500	<.500
NPEO1-total	E83.00	77.39	83.59	71.90	93.80	50–110	<5.000	<5.000	<5.000	<5.000	<5.000

Table 10. Quality-assurance and quality-control data for wastewater compounds in surface water and ground water.—Continued

[--, no data; E, estimated value; *, value outside acceptable range; <, less than; SURR, surrogate. Values in micrograms per liter except as indicated]

	Spike percent recovery	Spike percent recovery	Spike percent recovery	Spike percent recovery	Spike percent recovery	Acceptable recovery limits	Blank	Blank	Blank	Blank	Blank
Fluoranthene	81.00	82.56	93.92	77.19	85.00	50–110	<0.500	<0.500	<0.500	<0.500	<0.500
Triclosan	83.00	82.12	94.85	69.65	95.00	40–110	<1.000	<1.000	<1.000	<1.000	<1.000
Pyrene	83.00	85.73	95.79	76.58	85.00	50–110	<.500	<.500	<.500	<.500	<.500
OPEO2	E87.00	47.43	75.48	67.54	100.00	40–110	<1.000	<1.000	<1.000	<1.000	<1.000
Bisphenol A	83.00	83.82	86.98	73.72	95.00	40–110	<1.000	<1.000	E.097	<1.000	<1.000
NPEO2-total	E84.00	74.69	83.98	67.18	96.90	40–110	E.490	<5.000	<5.000	E.940	<5.000
tri(dichlorisopropyl) phosphate	80.00	80.33	85.77	71.23	85.00	50–110	<.500	<.500	<.500	<.500	<.500
Triphenyl phosphate	100.00	84.38	89.11	73.64	90.00	40–110	<.500	<.500	<.500	<.500	<.500
Ethanol,2-butoxy-phosphate	83.00	79.43	99.84	63.89	90.00	40–110	<.500	<.500	<.500	<.500	<.500
Diethylhexyl phthalate	77.00	--	--	110.97*	95.00	60–110	<10.000	E.570	<10.000	<10.000	<.130
Estrone	62.00	--	--	68.22	83.80	40–110	<10.000	<10.000	E .380	<10.000	<5.000
17B-Estradiol	81.00	80.79	74.51	67.09	82.50	30–110	<.500	<.500	<.500	<.500	<.500
17-Alpha-ethynyl esterdiol	84.00	84.99	69.79	73.78	87.50	30–110	<10.000	<10.000	<10.000	<10.000	<5.000
Equilenin	E62.03	81.70	74.11	56.13	70.00	20–110	E.041	<5.000	E.380	E.380	<5.000
Benzo(A)pyrene	--	80.93	92.45	77.44	90.00	40–110	<5.000	<5.000	E.079	<5.000	<5.000
3-Beta-coprostanol	--	73.45	66.35	65.74	82.50	50–110	<10.000	<10.000	<10.000	<10.000	<10.000
Cholesterol	--	79.57	77.49	67.62	80.00	50–110	<5.000	<5.000	<5.000	<5.000	E.680
Beta-sitosterol	--	72.85	74.90	64.81	81.30	40–110	E.041	<5.000	<5.000	<5.000	<5.000
Stigmastanol	--	79.84	75.76	57.20	77.50	40–110	<10.000	<10.000	<10.000	<10.000	<10.000
Decafluorobiphenyl - SURR percent recovery	38.00*	48.98*	57.24	75.86	80.00	50–120	50.00	45.00*	51.00	62.00	68.20
*d*8-Caffiene -SURR percent recovery	81.00	77.85	71.34	80.94	95.00	70–120	78.00	94.00	77.00	70.00	86.40
*d*10 - Fluoranthene - SURR percent recovery	74.00	73.62	69.86	76.85	95.00	50–120	80.00	86.00	68.00	73.00	90.90
*d*8 Bisphenol A -SURR percent recovery	80.00	78.76	78.10	75.17	100.00	40–120	44.00	54.00	36.00*	18.00*	86.40

Table 11. Summary statistics for selected water-quality properties and constituents.

[Site number refers to figure 1. NPS, data collected by/for the National Park Service and reported by the U.S. Environmental Protection Agency; USGS, data collected and analyzed by U.S. Geological Survey; ft^3/s, cubic feet per second; mg/L, milligrams per liter; µg/L, micrograms per liter; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; NTU, nephelometric turbidity units; --, no data available; N, number of observations]

Property or constituent	Statistic	Cold Spring Creek (site 1) 1985 NPS[1]	Cold Spring Creek (site 1) 1993-94 NPS[2]	Cold Spring Creek (site 1) 2002-03 USGS	Cold Spring Creek (site 2) 2002-03 USGS	Beaver Creek (site 3) 2002-03 USGS	Beaver Creek (site 4) 1990-96 NPS[2]	Beaver Creek (site 4) 2002-03 USGS	Highland Creek (site 7) 1985 NPS[1]	Highland Creek (site 7) 1993-94 NPS[2]	Highland Creek (site 7) 2002-03 USGS
Discharge (ft^3/s)	Mean	--	--	0.17	0.19	0.65	3.8	0.77	--	--	1.08
	Minimum	--	--	0.08	0.09	0.44	0.02	0.41	--	--	0.86
	Maximum	--	--	0.34	0.41	0.90	60	1.3	--	--	1.5
	N	--	--	12	10	13	51	11	--	--	13
Turbidity (NTU)	Mean	--	--	2.3	2.8	7.3	0.9	1.9	--	--	2.4
	Minimum	--	--	0.5	1.0	3.4	0.9	1.2	--	--	1.0
	Maximum	--	--	2.9	5.5	13.0	0.9	2.8	--	--	5.1
	N	--	--	5	3	3	1	4	--	--	4
Dissolved oxygen (mg/L)	Mean	--	--	11.8	12.2	10.0	8.5	11.7	--	--	11.7
	Minimum	--	--	9.8	9.6	7.5	8.5	9.4	--	--	10.2
	Maximum	--	--	14.8	15.8	15.3	8.5	15.5	--	--	13.0
	N	--	--	7	7	9	1	9	--	--	10
pH (standard units)	Mean	7.4	7.7	7.8	7.7	7.8	7.8	8.2	7.8	8.5	8.1
	Minimum	7.4	7.6	7.5	6.6	7.2	7.8	7.7	7.8	8.1	7.3
	Maximum	7.4	7.8	8.2	8.5	8.5	7.8	8.6	7.8	8.8	8.7
	N	1	2	8	9	12	1	12	1	6	12
Specific conductance (µS/cm)	Mean	--	567	601	563	517	580	518	--	263	302
	Minimum	--	454	545	448	484	475	470	--	220	280
	Maximum	--	631	663	593	575	[3]2,360	576	--	281	318
	N	--	6	10	11	13	51	15	--	6	13

Table 11. Summary statistics for selected water-quality properties and constituents.—Continued

[Site number refers to figure 1. NPS, data collected by/for the National Park Service and reported by the U.S. Environmental Protection Agency; USGS, data collected and analyzed by U.S. Geological Survey; ft^3/s, cubic feet per second; mg/L, milligrams per liter; µg/L, micrograms per liter; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; NTU, nephelometric turbidity units; --, no data available; N, number of observations]

Property or constituent	Statistic	Cold Spring Creek (site 1) 1985 NPS[1]	Cold Spring Creek (site 1) 1993-94 NPS[2]	Cold Spring Creek (site 1) 2002-03 USGS	Cold Spring Creek (site 2) 2002-03 USGS	Beaver Creek (site 3) 2002-03 USGS	Beaver Creek (site 4) 1990-96 NPS[2]	Beaver Creek (site 4) 2002-03 USGS	Highland Creek (site 7) 1985 NPS[1]	Highland Creek (site 7) 1993-94 NPS[2]	Highland Creek (site 7) 2002-03 USGS
Water temperature (°C)	Mean	8.3	9.2	8.6	8.2	7.5	8.5	7.9	12.1	10.4	7.7
	Minimum	3.1	4.5	0.2	4.5	0.5	0.0	0.5	2.5	2.6	2.4
	Maximum	13.5	14.6	21.5	13.0	21.0	19.5	18.2	21.8	17.2	14.0
	N	2	6	13	10	14	51	15	2	6	14
Calcium, dissolved (mg/L)	Mean	71.1	76.8	68.9	67.4	65.9	79.0	64.3	41.7	41.8	42.1
	Minimum	65.5	64.2	64.9	65.1	64.2	79.0	61.7	39.8	40.3	39.2
	Maximum	76.6	80.3	71.5	68.7	68.0	79.0	67.0	42.7	44.1	44.2
	N	3	6	4	3	4	1	4	3	6	4
Magnesium, dissolved (mg/L)	Mean	29.9	33.1	26.4	28.8	15.9	28.0	18.6	8.4	7.5	7.9
	Minimum	29.3	30.5	25.1	27.9	15.0	28.0	16.6	8.2	7.2	7.7
	Maximum	30.4	35.6	27.4	28.9	16.7	28.0	20.4	8.7	7.8	8.2
	N	3	6	4	3	4	1	4	3	6	4
Potassium, dissolved (mg/L)	Mean	3.3	4.3	3.87	3.86	4.87	4.5	4.60	1.8	2.3	2.07
	Minimum	2.7	3.7	3.42	3.67	4.30	4.5	3.99	1.2	1.8	1.90
	Maximum	3.6	5.7	5.13	3.97	6.21	4.5	5.53	2.2	2.7	2.2
	N	3	6	4	3	4	1	4	3	6	4
Sodium, dissolved (mg/L)	Mean	10.4	10.1	10.4	12.2	13.3	11.0	12.2	8.6	7.9	8.1
	Minimum	9.4	9.5	9.4	11.7	12.6	11.0	10.8	8.2	7.2	7.6
	Maximum	11.6	11.0	11.4	12.5	14.3	11.0	13.0	9.2	8.2	8.5
	N	3	6	4	3	4	1	4	3	6	4

Table 11. Summary statistics for selected water-quality properties and constituents.—Continued

[Site number refers to figure 1. NPS, data collected by/for the National Park Service and reported by the U.S. Environmental Protection Agency; USGS, data collected and analyzed by U.S. Geological Survey; ft^3/s, cubic feet per second; mg/L, milligrams per liter; µg/L, micrograms per liter; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; NTU, nephelometric turbidity units; --, no data available; N, number of observations]

Property or constituent	Statistic	Cold Spring Creek (site 1) 1985 NPS[1]	Cold Spring Creek (site 1) 1993-94 NPS[2]	Cold Spring Creek (site 1) 2002-03 USGS	Cold Spring Creek (site 2) 2002-03 USGS	Beaver Creek (site 3) 2002-03 USGS	Beaver Creek (site 4) 1990-96 NPS[2]	Beaver Creek (site 4) 2002-03 USGS	Highland Creek (site 7) 1985 NPS[1]	Highland Creek (site 7) 1993-94 NPS[2]	Highland Creek (site 7) 2002-03 USGS
Acid neutralizing capacity (mg/L $CaCO_3$)	Mean	268	290	270	273	209	--	217	127	125	141
	Minimum	267	278	267	273	200	--	206	125	119	139
	Maximum	269	297	272	274	218	--	227	132	133	144
	N	3	6	5	3	4	--	4	3	6	4
Chloride, dissolved (mg/L)	Mean	[4]7.7	[4]13.8	13.8	13.3	16.1	[4]13.0	14.5	[4]2.0	[4]2.6	3.7
	Minimum	[4]7.0	[4]12.0	10.8	12.5	14.5	[4]13.0	12.6	[4]2.0	[4]2.0	3.2
	Maximum	[4]8.0	[4]16.0	15.5	13.9	17.8	[4]13.0	16.6	[4]2.0	[4]3.0	4.5
	N	3	5	5	3	4	1	4	3	5	4
Fluoride, dissolved (mg/L)	Mean	--	--	0.33	0.4	0.31	0.30	0.34	--	[4]0.25	0.22
	Minimum	--	--	0.30	0.4	0.30	0.30	0.30	--	[2,4].10	0.20
	Maximum	--	--	0.36	0.4	0.33	0.30	0.40	--	[4]0.36	0.24
	N	--	--	5	3	4	1	4	--	6	4
Silica, dissolved (mg/L)	Mean	--	--	14.4	16.6	14.4	16.0	13.1	--	--	15.7
	Minimum	--	--	13.9	13.2	8.7	16.0	10.0	--	--	11.2
	Maximum	--	--	15.5	18.4	18.4	16.0	18.6	--	--	20.4
	N	--	--	5	3	4	1	4	--	--	4
Sulfate, dissolved (mg/L)	Mean	[4]22.3	[4]21.7	23.4	27.2	33.8	[4]31.0	32.6	[4]15.3	[4]13.3	14.9
	Minimum	[4]21.0	[4]20.0	19.4	26.8	31.9	[4]31.0	30.5	[4]14.0	[4]12.0	14.6
	Maximum	[4]23.0	[4]25.0	25.3	27.9	35.1	[4]31.0	33.6	[4]16.0	[4]15.0	15.3
	N	3	6	5	3	4	1	4	3	6	4

Table 11. Summary statistics for selected water-quality properties and constituents.—Continued

[Site number refers to figure 1. NPS, data collected by/for the National Park Service and reported by the U.S. Environmental Protection Agency; USGS, data collected and analyzed by U.S. Geological Survey; ft^3/s, cubic feet per second; mg/L, milligrams per liter; µg/L, micrograms per liter; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; NTU, nephelometric turbidity units; --, no data available; N, number of observations]

Property or constituent	Statistic	Cold Spring Creek (site 1) 1985 NPS[1]	Cold Spring Creek (site 1) 1993-94 NPS[2]	Cold Spring Creek (site 1) 2002-03 USGS	Cold Spring Creek (site 2) 2002-03 USGS	Beaver Creek (site 3) 2002-03 USGS	Beaver Creek (site 4) 1990-96 NPS[2]	Beaver Creek (site 4) 2002-03 USGS	Highland Creek (site 7) 1985 NPS[1]	Highland Creek (site 7) 1993-94 NPS[2]	Highland Creek (site 7) 2002-03 USGS
Ammonia plus organic nitrogen, total recoverable (mg/L)	Mean	--	0.13	0.21	0.15	0.24	--	0.25	--	0.05	0.19
	Minimum	--	0.02	0.15	0.12	0.20	--	0.14	--	0.02	0.11
	Maximum	--	0.62	0.37	0.18	0.28	--	0.43	--	0.12	0.24
	N	--	6	5	2	4	--	4	--	6	4
Ammonia, as nitrogen total recoverable (mg/L)	Mean	--	--	0.01	0.010	0.020	[2]0.01	0.012	--	--	0.009
	Minimum	--	--	0.007	0.007	0.007	[2]0.01	0.007	--	--	0.007
	Maximum	--	--	0.23	0.021	0.053	[2]0.01	0.033	--	--	0.020
	N	--	--	10	7	8	1	9	--	--	7
Nitrite plus nitrate, as nitrogen dissolved (mg/L)	Mean	0.028	[4]0.038	0.014	0.052	0.339	0.025	0.146	[4]0.4	[4]0.38	0.384
	Minimum	0.005	[4]0.025	0.006	0.006	0.060	0.025	0.006	[4]0.2	[4]0.15	0.063
	Maximum	0.04	[4]0.100	0.049	0.16	0.649	0.025	0.410	[4]0.5	[4]0.70	0.544
	N	3	6	9	7	8	1	8	3	6	8
Nitrite, as nitrogen dissolved (mg/L)	Mean	--	--	0.001	0.001	0.005	0.005	0.002	--	--	0.002
	Minimum	--	--	0.001	0.001	0.002	0.005	0.001	--	--	0.002
	Maximum	--	--	0.001	0.001	0.008	0.005	0.004	--	--	0.003
	N	--	--	4	5	4	1	4	--	--	4
Orthophosphate, as phosphorus dissolved (mg/L)	Mean	--	0.05	0.003	0.007	0.038	0.005	0.024	--	0.05	0.008
	Minimum	--	0.05	0.003	0.003	0.011	0.005	0.003	--	0.05	0.003
	Maximum	--	0.05	0.003	0.016	0.075	0.005	0.046	--	0.05	0.021
	N	--	2	9	7	8	1	8	--	2	8

Table 11. Summary statistics for selected water-quality properties and constituents.—Continued

[Site number refers to figure 1. NPS, data collected by/for the National Park Service and reported by the U.S. Environmental Protection Agency; USGS, data collected and analyzed by U.S. Geological Survey; ft^3/s, cubic feet per second; mg/L, milligrams per liter; µg/L, micrograms per liter; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; NTU, nephelometric turbidity units; --, no data available; N, number of observations]

Property or constituent	Statistic	Cold Spring Creek (site 1) 1985 NPS[1]	Cold Spring Creek (site 1) 1993-94 NPS[2]	Cold Spring Creek (site 1) 2002-03 USGS	Cold Spring Creek (site 2) 2002-03 USGS	Beaver Creek (site 3) 2002-03 USGS	Beaver Creek (site 4) 1990-96 NPS[2]	Beaver Creek (site 4) 2002-03 USGS	Highland Creek (site 7) 1985 NPS[1]	Highland Creek (site 7) 1993-94 NPS[2]	Highland Creek (site 7) 2002-03 USGS
Phosphorus, total recoverable (mg/L)	Mean	--	0.034	0.021	0.017	0.070	[5]0.02	0.046	--	0.02	0.041
	Minimum	--	0.010	0.009	0.015	0.041	[5]0.02	0.017	--	0.01	0.010
	Maximum	--	0.06	0.041	0.024	0.119	[5]0.02	0.079	--	0.04	0.158
	N	--	5	9	7	8	1	8	--	6	8
Arsenic, total recoverable (µg/L)	Mean	--	3.8	3.0	3.7	2.5	4.0	2.5	--	2.8	2.2
	Minimum	--	2.0	1.0	3.0	1.0	4.0	1.0	--	2.0	2.0
	Maximum	--	8.0	6.0	4.0	4.0	4.0	6.0	--	7.0	3.0
	N	--	2	5	3	4	1	4	--	6	4
Beryllium, total recoverable (µg/L)	Mean	--	--	1.0	1.0	1.0	--	1.0	--	--	1.0
	Minimum	--	--	1.0	1.0	1.0	--	1.0	--	--	1.0
	Maximum	--	--	1.0	1.0	1.0	--	1.0	--	--	1.0
	N	--	--	5	3	4	--	4	--	--	4
Boron, dissolved (µg/L)	Mean	30.0	--	36.0	43.0	35.0	40.0	32.0	20.0	--	22.5
	Minimum	20.0	--	30.0	40.0	30.0	40.0	20.0	10.0	--	10.0
	Maximum	40.0	--	50.0	50.0	50.0	40.0	50.0	30.0	--	40.0
	N	3	--	5	3	4	1	4	3	--	4
Cadmium, total recoverable (µg/L)	Mean	[5]5.0	0.25	0.08	0.08	0.07	[5]5.0	0.09	[5]5.0	0.25	0.09
	Minimum	[5]5.0	0.25	0.05	0.05	0.05	[5]5.0	0.05	[5]5.0	0.25	0.05
	Maximum	[5]5.0	0.25	0.10	0.1	0.1	[5]5.0	0.1	[5]5.0	0.25	0.10
	N	3	6	5	3	4	1	4	3	6	4

Table 11. Summary statistics for selected water-quality properties and constituents.—Continued

[Site number refers to figure 1. NPS, data collected by/for the National Park Service and reported by the U.S. Environmental Protection Agency; USGS, data collected and analyzed by U.S. Geological Survey; ft^3/s, cubic feet per second; mg/L, milligrams per liter; µg/L, micrograms per liter; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; NTU, nephelometric turbidity units; --, no data available; N, number of observations]

Property or constituent	Statistic	Cold Spring Creek (site 1) 1985 NPS[1]	Cold Spring Creek (site 1) 1993-94 NPS[2]	Cold Spring Creek (site 1) 2002-03 USGS	Cold Spring Creek (site 2) 2002-03 USGS	Beaver Creek (site 3) 2002-03 USGS	Beaver Creek (site 4) 1990-96 NPS[2]	Beaver Creek (site 4) 2002-03 USGS	Highland Creek (site 7) 1985 NPS[1]	Highland Creek (site 7) 1993-94 NPS[2]	Highland Creek (site 7) 2002-03 USGS
Chromium, total recoverable (µg/L)	Mean	[5]11.7	2.5	0.8	0.7	1.9	[5]0.5	0.5	[5]15.0	2.5	0.8
	Minimum	[5]5.0	2.5	0.4	0.4	0.4	[5]0.5	0.4	[5]5.0	2.5	0.4
	Maximum	[5]20.0	2.5	2.2	1.3	6.2	[5]0.5	1.0	[5]20.0	2.5	2.1
	N	3	6	5	3	4	1	4	3	6	4
Copper, total recoverable (µg/L)	Mean	[5]16.7	3.3	0.05	0.60	0.60	[5]0.5	0.05	[5]5.0	2.5	0.05
	Minimum	[5]5.0	2.5	0.05	0.50	0.50	[5]0.5	0.05	[5]5.0	2.5	0.05
	Maximum	[5]40.0	7.0	0.05	0.70	0.70	[5]0.5	0.05	[5]5.0	2.5	0.05
	N	3	6	5	3	4	1	4	3	6	4
Iron, total recoverable (µg/L)	Mean	--	[4]9.7	68.0	27.0	272.0	[5]5.0	52.5	--	[5]8.3	115.0
	Minimum	--	[4]2.5	30.0	20.0	130.0	[5]5.0	40.0	--	[5]2.5	30.0
	Maximum	--	[4]22.0	110.0	30.0	580.0	[5]5.0	80.0	--	[5]16.0	300.0
	N	--	6	5	3	4	1	4	--	6	4
Lead, total recoverable (µg/L)	Mean	[5]123.0	0.5	0.5	0.5	0.5	[5]0.5	0.5	[5]80.0	0.75	0.5
	Minimum	[5]55.0	0.5	0.5	0.5	0.5	[5]0.5	0.5	[5]55.0	0.50	0.5
	Maximiu	[5]260.0	0.5	0.5	0.5	0.5	[5]0.5	0.3	[5]130.0	2.0	0.5
	N	3	6	5	3	4	1	3	3	6	4
Manganese, total recoverable (µg/L)	Mean	11.7	10.9	17.8	1.9	22.9	[5]2.0	8.0	18.3	8.0	3.5
	Minimum	5.0	0.5	8.2	1.4	12.0	[5]2.0	2.2	5.0	4.0	2.2
	Maximum	20.0	31.0	34.8	2.3	38.2	[5]2.0	25.5	30.0	23.0	5.4
	N	3	6	5	3	4	1	4	3	6	4

Table 11. Summary statistics for selected water-quality properties and constituents.—Continued

[Site number refers to figure 1. NPS, data collected by/for the National Park Service and reported by the U.S. Environmental Protection Agency; USGS, data collected and analyzed by U.S. Geological Survey; ft^3/s, cubic feet per second; mg/L, milligrams per liter; µg/L, micrograms per liter; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; NTU, nephelometric turbidity units; --, no data available; N, number of observations]

Property or constituent	Statistic	Cold Spring Creek (site 1) 1985 NPS[1]	Cold Spring Creek (site 1) 1993-94 NPS[2]	Cold Spring Creek (site 1) 2002-03 USGS	Cold Spring Creek (site 2) 2002-03 USGS	Beaver Creek (site 3) 2002-03 USGS	Beaver Creek (site 4) 1990-96 NPS[2]	Beaver Creek (site 4) 2002-03 USGS	Highland Creek (site 7) 1985 NPS[1]	Highland Creek (site 7) 1993-94 NPS[2]	Highland Creek (site 7) 2002-03 USGS
Mercury, total recoverable (µg/L)	Mean	--	--	0.008	0.050	0.007	[5]0.05	0.007	--	--	0.008
	Minimum	--	--	0.008	0.050	0.005	[5]0.05	0.005	--	--	0.005
	Maximum	--	--	0.010	0.050	0.010	[5]0.05	0.010	--	--	0.010
	N	--	--	5	3	4	1	4	--	--	3
Nickel, total recoverable (µg/L)	Mean	[5]113.0	6.0	1.0	1.0	1.8	--	1.0	[5]20.0	6.0	1.0
	Minimum	[5]15.0	6.0	1.0	1.0	1.0	--	1.0	[5]15.0	6.0	1.0
	Maximum	[5]310.0	6.0	1.0	1.0	4.2	--	1.0	[5]30.0	6.0	1.0
	N	3	6	5	3	4	--	4	3	6	4
Selenium, total recoverable (µg/L)	Mean	--	--	1.2	1.7	1.2	[5]0.50	1.2	--	--	1.6
	Minimum	--	--	1.0	1.0	1.0	[5]0.50	1.0	--	--	1.5
	Maximum	--	--	1.5	2.0	1.5	[5]0.50	1.5	--	--	2.0
	N	--	--	5	3	4	1	4	--	--	4
Zinc, total recoverable (µg/L)	Mean	[5]910.0	25.3	10.0	10.0	10.0	[5]8.0	15.0	[5]243.3	5.5	2.5
	Minimum	[5]40.0	15.0	10.0	10.0	10.0	[5]8.0	10.0	[5]20.0	2.0	10.0
	Maximum	[5]2,600	51.0	10.0	10.0	10.0	[5]8.0	30.0	[5]380.0	14.0	20.0
	N	3	6	5	3	4	1	4	3	6	4

[1]Source of analytical data is Alexander and others, 1989.

[2]Source of analytical data is U.S. Environmental Protection Agency.

[3]Value based on U.S. Geological Survey data that was subsequently determined to be erroneous.

[4]Value reported is total recoverable concentration.

[5]Value reported is dissolved concentration.

Table 12. Benthic macroinvertebrates collected from selected surface-water sites in Wind Cave National Park, 2002 and 2003.

[A, adult; L, larva(e); dam., damaged; sp., species; imm., immature; indet., indeterminate; P, pupa(e); ref., organism placed in a reference collection]

Year collected	Taxonomy	Life stage	Notes	Abundance	Phylum	Class	Order	Family	Subfamily	Genus	Species
Cold Spring Creek (site 2)											
2002	*Aeshna* sp.	L		1	Arthropoda	Insecta	Odonata	Aeshnidae		Aeshna	
2002	*Aquarius remigis* (Say)	A	ref.	1	Arthropoda	Insecta	Hemiptera	Gerridae	Gerrinae	Aquarius	Aquarius remigis
2002	*Archilestes grandis* (Rambur)	L	ref.	2	Arthropoda	Insecta	Odonata	Lestidae		Archilestes	Archilestes grandis
2002	*Argia* sp.	L		14	Arthropoda	Insecta	Odonata	Coenagrionidae		Argia	
2003	*Argia* sp.	L		115	Arthropoda	Insecta	Odonata	Coenagrionidae		Argia	
2002	*Baetidae*	L	imm.; dam.	504	Arthropoda	Insecta	Ephemeroptera	Baetidae			
2003	*Baetidae*	L	imm.; dam.	518	Arthropoda	Insecta	Ephemeroptera	Baetidae			
2003	*Baetis flavistriga* McDunnough	L		72	Arthropoda	Insecta	Ephemeroptera	Baetidae		Baetis	Baetis flavistriga
2002	*Bezzia/Palpomyia* sp.	L		28	Arthropoda	Insecta	Diptera	Ceratopogonidae	Ceratopogoninae		
2003	*Caenis* sp.	L		72	Arthropoda	Insecta	Ephemeroptera	Caenidae		Caenis	
2003	*Caloparyphus* sp.	L		72	Arthropoda	Insecta	Diptera	Stratiomyidae	Stratiomyinae	Caloparyphus	
2003	*Ceratopogonidae*	L	indet.	173	Arthropoda	Insecta	Diptera	Ceratopogonidae			
2002	*Chaetocladius* sp.	L		28	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae	Chaetocladius	
2003	*Chaetocladius* sp.	L		1,037	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae	Chaetocladius	
2003	*Cheumatopsyche* sp.	L		17	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychinae	Cheumatopsyche	
2003	*Chrysops* sp.	L	ref.	29	Arthropoda	Insecta	Diptera	Tabanidae		Chrysops	
2002	*Coenagrionidae*	L	dam.	280	Arthropoda	Insecta	Odonata	Coenagrionidae			
2003	*Corduliidae/ Libellulidae*	L		115	Arthropoda	Insecta	Odonata				
2003	*Corynoneura* sp.	L		14	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae	Corynoneura	
2002	*Cricotopus/ Orthocladius* sp.	L		28	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae		
2003	*Cricotopus/ Orthocladius* sp.	L		202	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae		
2002	*Cryptochironomus* sp.	L	ref.	14	Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Cryptochironomus	
2002	*Dasyhelea* sp.	L		14	Arthropoda	Insecta	Diptera	Ceratopogonidae	Dasyheleinae	Dasyhelea	

Table 12. Benthic macroinvertebrates collected from selected surface-water sites in Wind Cave National Park, 2002 and 2003.—Continued

[A, adult; L, larva(e); dam., damaged; sp., species; imm., immature; indet., indeterminate; P, pupa(e); ref., organism placed in a reference collection]

Year collected	Taxonomy	Life stage	Notes	Abundance	Phylum	Class	Order	Family	Subfamily	Genus	Species
Cold Spring Creek (site 2)—Continued											
2003	*Dasyhelea* sp.	L		14	Arthropoda	Insecta	Diptera	Ceratopogonidae	Dasyheleinae	Dasyhelea	
2002	*Dubiraphia* sp.	L		14	Arthropoda	Insecta	Coleoptera	Elmidae		Dubiraphia	
2003	*Dubiraphia* sp.	L		144	Arthropoda	Insecta	Coleoptera	Elmidae		Dubiraphia	
2003	*Dytiscidae*	L	imm.	43	Arthropoda	Insecta	Coleoptera	Dytiscidae			
2002	*Enchytraeidae*			14	Annelida	Oligochaeta	Enchytraeida	Enchytraeidae			
2003	*Enchytraeidae*			72	Annelida	Oligochaeta	Enchytraeida	Enchytraeidae			
2003	*Erpobdellidae*			1	Annelida	Hirudinea	Arhynchobdellae	Erpobdellidae			
2003	*Eukiefferiella* sp.	L		29	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae	Eukiefferiella	
2003	*Eukiefferiella/ Tvetenia* sp.	L		29	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae		
2003	*Euparyphus* sp.	L		115	Arthropoda	Insecta	Diptera	Stratiomyidae	Stratiomyinae	Euparyphus	
2002	*Fossaria* sp.			14	Mollusca	Gastropoda	Basommatophora	Lymnaeidae	Lymnaeinae	Fossaria	
2003	*Fossaria* sp.			15	Mollusca	Gastropoda	Basommatophora	Lymnaeidae	Lymnaeinae	Fossaria	
2002	*Gerrinae*	L	imm.	14	Arthropoda	Insecta	Hemiptera	Gerridae	Gerrinae		
2003	*Glossiphoniidae*			14	Annelida	Hirudinea	Rhynchobdellae	Glossiphoniidae			
2002	*Gomphidae*	L	imm.; dam.	84	Arthropoda	Insecta	Odonata	Gomphidae			
2003	*Heleniella* sp.	L		29	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae	Heleniella	
2002	*Helicopsyche borealis* (Hagen)	L		98	Arthropoda	Insecta	Trichoptera	Helicopsychidae		Helicopsyche	Helicopsyche borealis
2003	*Helicopsyche borealis* (Hagen)	L		1	Arthropoda	Insecta	Trichoptera	Helicopsychidae		Helicopsyche	Helicopsyche borealis
2002	*Hemerodromia* sp.	L		28	Arthropoda	Insecta	Diptera	Empididae	Hemerodromiinae	Hemerodromia	
2002	*Hyalella azteca* (Saussure)			14	Arthropoda	Malacostraca	Amphipoda	Hyalellidae		Hyalella	Hyalella azteca
2003	*Hyalella azteca* (Saussure)			2	Arthropoda	Malacostraca	Amphipoda	Hyalellidae		Hyalella	Hyalella azteca
2002	*Labrundinia* sp.	L	ref.	14	Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae	Labrundinia	
2003	*Labrundinia/ Nilotanypus* sp.	L		14	Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae		

Table 12. Benthic macroinvertebrates collected from selected surface-water sites in Wind Cave National Park, 2002 and 2003.—Continued

[A, adult; L, larva(e); dam., damaged; sp., species; imm., immature; indet., indeterminate; P, pupa(e); ref., organism placed in a reference collection]

Year collected	Taxonomy	Life stage	Notes	Abundance	Phylum	Class	Order	Family	Subfamily	Genus	Species
					Cold Spring Creek (site 2)—Continued						
2003	*Lauterborniella agrayloides* (Kieffer)	L	ref.	14	Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Lauterborniella	Lauterborniella agrayloides
2003	*Leptophlebiidae*	L	dam.	22	Arthropoda	Insecta	Ephemeroptera	Leptophlebiidae			
2003	*Limnephilidae*	L	imm.; dam.	3	Arthropoda	Insecta	Trichoptera	Limnephilidae			
2003	*Limnephilidae*	L	indet.	1	Arthropoda	Insecta	Trichoptera	Limnephilidae			
2003	*Limnephilus* sp.	L		1	Arthropoda	Insecta	Trichoptera	Limnephilidae	Limnephilinae	Limnephilus	
2003	*Micropsectra* sp.	L		893	Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Micropsectra	
2003	*Micropsectra/ Tanytarsus* sp.	L		144	Arthropoda	Insecta	Diptera	Chironomidae	Chironominae		
2002	*Nematoda*			14	Nematoda						
2003	*Nematoda*			115	Nematoda						
2002	*Nilotanypus* sp.	L		14	Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae	Nilotanypus	
2003	*Nilotanypus* sp.	L		172	Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae	Nilotanypus	
2002	*Notonecta* sp.	A		1	Arthropoda	Insecta	Hemiptera	Notonectidae		Notonecta	
2002	*Oecetis* sp.	L		14	Arthropoda	Insecta	Trichoptera	Leptoceridae	Leptocerinae	Oecetis	
2002	*Optioservus divergens* (LeConte)	A		14	Arthropoda	Insecta	Coleoptera	Elmidae		Optioservus	Optioservus divergens
2002	*Optioservus* sp.	L		14	Arthropoda	Insecta	Coleoptera	Elmidae		Optioservus	
2003	*Orthocladiinae*	L	indet.	14	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae		
2003	*Orthocladiinae*	P		14	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae		
2003	*Paramerina* sp.	L		14	Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae	Paramerina	
2003	*Paratanytarsus* sp.	L		14	Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Paratanytarsus	
2003	*Paratendipes* sp.	L		14	Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Paratendipes	
2002	*Pentaneura* sp.	L		14	Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae	Pentaneura	
2003	*Pentaneura* sp.	L		43	Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae	Pentaneura	
2002	*Pentaneurini*	L	indet.	42	Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae		
2003	*Pentaneurini*	L	imm.	29	Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae		
2002	*Physella* sp.			1	Mollusca	Gastropoda	Basommatophora	Physidae	Physinae	Physella	

Table 12. Benthic macroinvertebrates collected from selected surface-water sites in Wind Cave National Park, 2002 and 2003.—Continued

[A, adult; L, larva(e); dam., damaged; sp., species; imm., immature; indet., indeterminate; P, pupa(e); ref., organism placed in a reference collection]

Year collected	Taxonomy	Life stage	Notes	Abundance	Phylum	Class	Order	Family	Subfamily	Genus	Species
Cold Spring Creek (site 2)—Continued											
2003	*Pisidium* sp.			2	Mollusca	Bivalvia	Veneroida	Sphaeriidae	Pisidiinae	Pisidium	
2003	*Procladius* sp.	L		14	Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae	Procladius	
2003	*Pseudochironomus* sp.	L		14	Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Pseudochironomus	
2002	*Rheotanytarsus* sp.	L		28	Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Rheotanytarsus	
2003	*Sialis* sp.	L		1	Arthropoda	Insecta	Megaloptera	Sialidae		Sialis	
2002	*Simuliidae*	L	imm.	28	Arthropoda	Insecta	Diptera	Simuliidae			
2003	*Simuliidae*	L	imm.	72	Arthropoda	Insecta	Diptera	Simuliidae			
2002	*Stratiomyidae*	L	imm.	84	Arthropoda	Insecta	Diptera	Stratiomyidae			
2003	*Tanytarsini*	L	imm.; indet.	130	Arthropoda	Insecta	Diptera	Chironomidae	Chironominae		
2003	*Tanytarsus* sp.	L		130	Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Tanytarsus	
2002	*Thienemannimyia* group sp. (Coffman and Ferrington, 1996)	L		42	Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae		
2003	*Thienemannimyia* group sp. (Coffman and Ferrington, 1996)	L		72	Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae		
2002	*Tricorythodes* sp.	L		3,262	Arthropoda	Insecta	Ephemeroptera	Leptohyphidae		Tricorythodes	
2003	*Tubificidae*			29	Annelida	Oligochaeta	Tubificida	Tubificidae			
2003	*Tvetenia* sp.	L		288	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae	Tvetenia	
Beaver Creek (site 4)											
2002	*Acari*			50.4	Arthropoda	Arachnida					
2002	*Baetidae*	L	imm.; dam.	109.2	Arthropoda	Insecta	Ephemeroptera	Baetidae			
2003	*Baetidae*	L	imm.; dam.	461	Arthropoda	Insecta	Ephemeroptera	Baetidae			
2003	*Baetis flavistriga* McDunnough	L		43	Arthropoda	Insecta	Ephemeroptera	Baetidae		Baetis	Baetis flavistriga
2003	*Baetis* sp.	L		17	Arthropoda	Insecta	Ephemeroptera	Baetidae		Baetis	
2002	*Bezzia/Palpomyia* sp.	L		33.6	Arthropoda	Insecta	Diptera	Ceratopogonidae	Ceratopogoninae		

Table 12. Benthic macroinvertebrates collected from selected surface-water sites in Wind Cave National Park, 2002 and 2003.—Continued

[A, adult; L, larva(e); dam., damaged; sp., species; imm., immature; indet., indeterminate; P, pupa(e); ref., organism placed in a reference collection]

Year collected	Taxonomy	Life stage	Notes	Abundance	Phylum	Class	Order	Family	Subfamily	Genus	Species
Beaver Creek (site 4)—Continued											
2003	*Caenis* sp.	L		14	Arthropoda	Insecta	Ephemeroptera	Caenidae		Caenis	
2003	*Caloparyphus* sp.	L		43	Arthropoda	Insecta	Diptera	Stratiomyidae	Stratiomyinae	Caloparyphus	
2003	*Ceratopogonidae*	L	indet.	173	Arthropoda	Insecta	Diptera	Ceratopogonidae			
2002	*Chaetocladius* sp.	L	ref.	8.4	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae	Chaetocladius	
2003	*Chaetocladius* sp.	L		29	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae	Chaetocladius	
2002	*Cheumatopsyche* sp.	L		8.4	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychinae	Cheumatopsyche	
2003	*Cheumatopsyche* sp.	L		245	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychinae	Cheumatopsyche	
2003	*Chimarra* sp.	L		1	Arthropoda	Insecta	Trichoptera	Philopotamidae	Chimarrinae	Chimarra	
2002	*Chironomidae*	P	indet.	8.4	Arthropoda	Insecta	Diptera	Chironomidae			
2002	*Chironominae*	P		8.4	Arthropoda	Insecta	Diptera	Chironomidae	Chironominae		
2003	*Coenagrionidae*	L	dam.	16	Arthropoda	Insecta	Odonata	Coenagrionidae			
2002	*Crangonyx* sp.			50.4	Arthropoda	Malacostraca	Amphipoda	Crangonyctidae		Crangonyx	
2002	*Cricotopus bicinctus* group	L		8.4	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae	Cricotopus	
2003	*Cricotopus* sp.	L		58	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae	Cricotopus	
2002	*Cricotopus/ Orthocladius* sp.	L		8.4	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae		
2003	*Cricotopus/ Orthocladius* sp.	L		101	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae		
2002	*Cryptochironomus* sp.	L		8.4	Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Cryptochironomus	
2003	*Cryptotendipes* sp.	L		43	Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Cryptotendipes	
2002	*Dubiraphia* sp.	L		252	Arthropoda	Insecta	Coleoptera	Elmidae		Dubiraphia	
2002	*Dubiraphia* sp.	A		25.2	Arthropoda	Insecta	Coleoptera	Elmidae		Dubiraphia	
2003	*Dubiraphia* sp.	L		115	Arthropoda	Insecta	Coleoptera	Elmidae		Dubiraphia	
2003	*Elmidae*	L	imm.; dam.	187	Arthropoda	Insecta	Coleoptera	Elmidae			
2003	*Ephemerella* sp.	L		1	Arthropoda	Insecta	Ephemeroptera	Ephemerellidae		Ephemerella	
2002	*Ephemeroptera*	A	dam.	8.4	Arthropoda	Insecta	Ephemeroptera				
2002	*Erpobdellidae*			58.8	Annelida	Hirudinea	Arhynchobdellae	Erpobdellidae			

Table 12. Benthic macroinvertebrates collected from selected surface-water sites in Wind Cave National Park, 2002 and 2003.—Continued

[A, adult; L, larva(e); dam., damaged; sp., species; imm., immature; indet., indeterminate; P, pupa(e); ref., organism placed in a reference collection]

Year collected	Taxonomy	Life stage	Notes	Abundance	Phylum	Class	Order	Family	Subfamily	Genus	Species
Beaver Creek (site 4)—Continued											
2003	*Erpobdellidae*			30	Annelida	Hirudinea	Arhynchobdellae	Erpobdellidae			
2002	*Eukiefferiella* sp.	L		8.4	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae	Eukiefferiella	
2003	*Eukiefferiella* sp.	L		187	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae	Eukiefferiella	
2003	*Euparyphus* sp.	L		14	Arthropoda	Insecta	Diptera	Stratiomyidae	Stratiomyinae	Euparyphus	
2003	*Fallceon quilleri* (Dodds)	L		132	Arthropoda	Insecta	Ephemeroptera	Baetidae		Fallceon	Fallceon quilleri
2003	*Gammarus* sp.			14	Arthropoda	Malacostraca	Amphipoda	Gammaridae		Gammarus	
2002	*Helicopsyche borealis* (Hagen)	L		184.8	Arthropoda	Insecta	Trichoptera	Helicopsychidae		Helicopsyche	Helicopsyche borealis
2002	*Helicopsyche borealis* (Hagen)	P		33.6	Arthropoda	Insecta	Trichoptera	Helicopsychidae		Helicopsyche	Helicopsyche borealis
2002	*Hesperophylax* sp.	L		8.4	Arthropoda	Insecta	Trichoptera	Limnephilidae	Limnephilinae	Hesperophylax	
2003	*Hydropsyche depravata* group	L		72	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychinae	Hydropsyche	
2003	*Hydropsyche* sp.	L		14	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychinae	Hydropsyche	
2002	*Hydroptila* sp.	L		126	Arthropoda	Insecta	Trichoptera	Hydroptilidae	Hydroptilinae	Hydroptila	
2002	*Hydroptilidae*	P	indet.	25.2	Arthropoda	Insecta	Trichoptera	Hydroptilidae			
2003	*Isoperla* sp.	L		4	Arthropoda	Insecta	Plecoptera	Perlodidae	Isoperlinae	Isoperla	
2003	*Labrundinia* sp.	L		29	Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae	Labrundinia	
2002	*Leptoceridae*	L	imm.	16.8	Arthropoda	Insecta	Trichoptera	Leptoceridae			
2003	*Limnephilus* sp.	L		3	Arthropoda	Insecta	Trichoptera	Limnephilidae	Limnephilinae	Limnephilus	
2002	*Mayatrichia ayama Mosely*	L	ref.; confirmed new State record[1]	25.2	Arthropoda	Insecta	Trichoptera	Hydroptilidae	Hydroptilinae	Mayatrichia	Mayatrichia ayama
2003	*Megadrile*			1	Annelida	Oligochaeta					
2002	*Microcylloepus pusillus* (LeConte)	A		8.4	Arthropoda	Insecta	Coleoptera	Elmidae		Microcylloepus	Microcylloepus pusillus
2003	*Microcylloepus pusillus* (LeConte)	A		173	Arthropoda	Insecta	Coleoptera	Elmidae		Microcylloepus	Microcylloepus pusillus
2002	*Microcylloepus* sp.	L		67.2	Arthropoda	Insecta	Coleoptera	Elmidae		Microcylloepus	

Table 12. Benthic macroinvertebrates collected from selected surface-water sites in Wind Cave National Park, 2002 and 2003.—Continued

[A, adult; L, larva(e); dam., damaged; sp., species; imm., immature; indet., indeterminate; P, pupa(e); ref., organism placed in a reference collection]

Year collected	Taxonomy	Life stage	Notes	Abundance	Phylum	Class	Order	Family	Subfamily	Genus	Species
Beaver Creek (site 4)—Continued											
2003	*Microcylloepus* sp.	L		216	Arthropoda	Insecta	Coleoptera	Elmidae		Microcylloepus	
2003	*Micropsectra* sp.	L		29	Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Micropsectra	
2003	*Micropsectra/Tanytarsus* sp.	L		14	Arthropoda	Insecta	Diptera	Chironomidae	Chironominae		
2002	*Microtendipes* sp.	L		50.4	Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Microtendipes	
2003	*Nematoda*			29	Nematoda						
2002	*Odontomesa* sp.	L	ref.	8.4	Arthropoda	Insecta	Diptera	Chironomidae	Prodiamesinae	Odontomesa	
2002	*Optioservus divergens* (LeConte)	A		33.6	Arthropoda	Insecta	Coleoptera	Elmidae		Optioservus	Optioservus divergens
2003	*Optioservus divergens* (LeConte)	A		504	Arthropoda	Insecta	Coleoptera	Elmidae		Optioservus	Optioservus divergens
2002	*Optioservus* sp.	L		109.2	Arthropoda	Insecta	Coleoptera	Elmidae		Optioservus	
2002	*Optioservus* sp.	A		16.8	Arthropoda	Insecta	Coleoptera	Elmidae		Optioservus	
2003	*Optioservus* sp.	L		302	Arthropoda	Insecta	Coleoptera	Elmidae		Optioservus	
2002	*Orthocladiinae*	P		8.4	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae		
2003	*Orthocladiinae*	L	imm.	14	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae		
2003	*Orthocladiinae*	L	indet.	29	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae		
2003	*Pagastia* sp.	L		43	Arthropoda	Insecta	Diptera	Chironomidae	Diamesinae	Pagastia	
2003	*Paramerina* sp.	L		14	Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae	Paramerina	
2002	*Paratendipes* sp.	L	ref.	8.4	Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Paratendipes	
2003	*Paratendipes* sp.	L		29	Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Paratendipes	
2002	*Pentaneura* sp.	L		33.6	Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae	Pentaneura	
2003	*Pentaneura* sp.	L		14	Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae	Pentaneura	
2003	*Petrophila* sp.	L		3	Arthropoda	Insecta	Lepidoptera	Pyralidae	Nymphulinae	Petrophila	
2003	*Pisidium* sp.			58	Mollusca	Bivalvia	Veneroida	Sphaeriidae	Pisidiinae	Pisidium	
2002	*Polypedilum* sp.	L		285.6	Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Polypedilum	
2003	*Polypedilum* sp.	L		14	Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Polypedilum	
2003	*Procladius* sp.	L		14	Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae	Procladius	

Table 12. Benthic macroinvertebrates collected from selected surface-water sites in Wind Cave National Park, 2002 and 2003.—Continued

[A, adult; L, larva(e); dam., damaged; sp., species; imm., immature; indet., indeterminate; P, pupa(e); ref., organism placed in a reference collection]

Year collected	Taxonomy	Life stage	Notes	Abundance	Phylum	Class	Order	Family	Subfamily	Genus	Species
Beaver Creek (site 4)—Continued											
2003	*Rheocricotopus* sp.	L		14	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae	Rheocricotopus	
2002	*Rheotanytarsus* sp.	L		42	Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Rheotanytarsus	
2003	*Simuliidae*	L	imm.	43	Arthropoda	Insecta	Diptera	Simuliidae			
2003	*Simulium piperi* Dyar and Shannon	P	ref.	2	Arthropoda	Insecta	Diptera	Simuliidae		Simulium	Simulium piperi
2003	*Simulium* sp.	L		14	Arthropoda	Insecta	Diptera	Simuliidae		Simulium	
2003	*Sphaeriidae*		imm.	14	Mollusca	Bivalvia	Veneroida	Sphaeriidae			
2002	*Stratiomyidae*	L	imm.	16.8	Arthropoda	Insecta	Diptera	Stratiomyidae			
2003	*Tanytarsini*	L	imm.	14	Arthropoda	Insecta	Diptera	Chironomidae	Chironominae		
2002	*Thienemannimyia* group sp. (Coffman and Ferrington, 1996)	L		16.8	Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae		
2003	*Thienemannimyia* group sp. (Coffman and Ferrington, 1996)	L		43	Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae		
2002	*Tipulidae*	L		8.4	Arthropoda	Insecta	Diptera	Tipulidae			
2002	*Tricorythodes* sp.	L		842	Arthropoda	Insecta	Ephemeroptera	Leptohyphidae		Tricorythodes	
2003	*Tricorythodes* sp.	L		375	Arthropoda	Insecta	Ephemeroptera	Leptohyphidae		Tricorythodes	
2002	*Zaitzevia parvula* (Horn)	A		8.4	Arthropoda	Insecta	Coleoptera	Elmidae		Zaitzevia	Zaitzevia parvula
2003	*Zaitzevia parvula* (Horn)	L		115	Arthropoda	Insecta	Coleoptera	Elmidae		Zaitzevia	Zaitzevia parvula
2003	*Zaitzevia parvula* (Horn)	A		72	Arthropoda	Insecta	Coleoptera	Elmidae		Zaitzevia	Zaitzevia parvula
Highland Creek (site 7)											
2002	*Acari*			138.24	Arthropoda	Arachnida					
2003	*Acari*			29	Arthropoda	Arachnida					
2002	*Baetidae*	L	imm.; dam.	3,386.88	Arthropoda	Insecta	Ephemeroptera	Baetidae			
2003	*Baetidae*	L	imm.; dam.	72	Arthropoda	Insecta	Ephemeroptera	Baetidae			

Table 12. Benthic macroinvertebrates collected from selected surface-water sites in Wind Cave National Park, 2002 and 2003.—Continued

[A, adult; L, larva(e); dam., damaged; sp., species; imm., immature; indet., indeterminate; P, pupa(e); ref., organism placed in a reference collection]

Year collected	Taxonomy	Life stage	Notes	Abundance	Phylum	Class	Order	Family	Subfamily	Genus	Species
Highland Creek (site 7)—Continued											
2002	*Baetis flavistriga* McDunnough	L		23.04	Arthropoda	Insecta	Ephemeroptera	Baetidae		Baetis	Baetis flavistriga
2002	*Baetis* sp.	L		645.12	Arthropoda	Insecta	Ephemeroptera	Baetidae		Baetis	
2003	*Baetis* sp.	L		144	Arthropoda	Insecta	Ephemeroptera	Baetidae		Baetis	
2003	*Baetis tricaudatus* Dodds	L		308	Arthropoda	Insecta	Ephemeroptera	Baetidae		Baetis	Baetis tricaudatus
2002	*Bezzia/Palpomyia* sp.	L		23.04	Arthropoda	Insecta	Diptera	Ceratopogonidae	Ceratopogoninae		
2002	*Brachycentrus occidentalis* Banks	L	ref.; potential new State record[1]	1	Arthropoda	Insecta	Trichoptera	Brachycentridae		Brachycentrus	Brachycentrus occidentalis
2003	*Brachycera*	A		14	Arthropoda	Insecta	Diptera				
2003	*Caloparyphus* sp.	L		720	Arthropoda	Insecta	Diptera	Stratiomyidae	Stratiomyinae	Caloparyphus	
2002	*Ceratopogonidae*	L	dam.	23.04	Arthropoda	Insecta	Diptera	Ceratopogonidae			
2003	*Ceratopogonidae*	L	indet.	187	Arthropoda	Insecta	Diptera	Ceratopogonidae			
2002	*Ceratopsyche alhedra* (Ross)	L		1	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychinae	Ceratopsyche	Ceratopsyche alhedra
2002	*Ceratopsyche cf. slossonae* (Banks)	L	ref.; potential new State record[1]	92.16	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychinae	Ceratopsyche	
2002	*Ceratopsyche* sp.	L		46.08	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychinae	Ceratopsyche	
2003	*Ceratopsyche* sp.	L		32	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychinae	Ceratopsyche	
2002	*Cheumatopsyche* sp.	L		23.04	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychinae	Cheumatopsyche	
2003	*Cheumatopsyche* sp.	L		1	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychinae	Cheumatopsyche	
2003	*Chironomidae*	P	dam.	29	Arthropoda	Insecta	Diptera	Chironomidae			
2003	*Cricotopus/ Orthocladius* sp.	L		14	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae		
2002	*Dicranota* sp.	L		46.08	Arthropoda	Insecta	Diptera	Tipulidae	Limoniinae	Dicranota	
2003	*Dicranota* sp.	L		14	Arthropoda	Insecta	Diptera	Tipulidae	Limoniinae	Dicranota	
2002	*Elmidae*	L	imm.	184.32	Arthropoda	Insecta	Coleoptera	Elmidae			
2003	*Ephemerella* sp.	L		73	Arthropoda	Insecta	Ephemeroptera	Ephemerellidae		Ephemerella	

Table 12. Benthic macroinvertebrates collected from selected surface-water sites in Wind Cave National Park, 2002 and 2003.—Continued

[A, adult; L, larva(e); dam., damaged; sp., species; imm., immature; indet., indeterminate; P, pupa(e); ref., organism placed in a reference collection]

Year collected	Taxonomy	Life stage	Notes	Abundance	Phylum	Class	Order	Family	Subfamily	Genus	Species
Highland Creek (site 7)—Continued											
2002	*Ephemerellidae*	L	imm.	23.04	Arthropoda	Insecta	Ephemeroptera	Ephemerellidae			
2002	*Ephemeroptera*	L	dam.	23.04	Arthropoda	Insecta	Ephemeroptera				
2002	*Eukiefferiella* sp.	L		253.44	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae	Eukiefferiella	
2003	*Eukiefferiella* sp.	L		72	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae	Eukiefferiella	
2003	*Euparyphus* sp.	L		58	Arthropoda	Insecta	Diptera	Stratiomyidae	Stratiomyinae	Euparyphus	
2003	*Glossiphoniidae*			1	Annelida	Hirudinea	Rhynchobdellae	Glossiphoniidae			
2003	*Gomphidae*	L	imm.	14	Arthropoda	Insecta	Odonata	Gomphidae			
2003	*Heleniella* sp.	L		101	Arthropoda	Insecta	Diptera	Chironomidae	Orthocladiinae	Heleniella	
2002	*Helicopsyche borealis* (Hagen)	L		184.32	Arthropoda	Insecta	Trichoptera	Helicopsychidae		Helicopsyche	Helicopsyche borealis
2002	*Helicopsyche borealis* (Hagen)	P		46.08	Arthropoda	Insecta	Trichoptera	Helicopsychidae		Helicopsyche	Helicopsyche borealis
2003	*Helicopsyche borealis* (Hagen)	L		29	Arthropoda	Insecta	Trichoptera	Helicopsychidae		Helicopsyche	Helicopsyche borealis
2002	*Helobdella stagnalis* (Linnaeus)			23.04	Annelida	Hirudinea	Rhynchobdellae	Glossiphoniidae		Helobdella	Helobdella stagnalis
2003	*Hemerodromia* sp.	L		14	Arthropoda	Insecta	Diptera	Empididae	Hemerodromiinae	Hemerodromia	
2002	*Hesperophylax* sp.	L		2	Arthropoda	Insecta	Trichoptera	Limnephilidae	Limnephilinae	Hesperophylax	
2003	*Hexatoma* sp.	L		43	Arthropoda	Insecta	Diptera	Tipulidae	Limoniinae	Hexatoma	
2002	*Hyalella azteca* (Saussure)			23.04	Arthropoda	Malacostraca	Amphipoda	Hyalellidae		Hyalella	Hyalella azteca
2003	*Hydropsyche depravata* group	L		1	Arthropoda	Insecta	Trichoptera	Hydropsychidae	Hydropsychinae	Hydropsyche	
2002	*Hydroptila* sp.	L		115.2	Arthropoda	Insecta	Trichoptera	Hydroptilidae	Hydroptilinae	Hydroptila	
2002	*Isoperla* sp.	L		23.04	Arthropoda	Insecta	Plecoptera	Perlodidae	Isoperlinae	Isoperla	
2003	*Isoperla* sp.	L		66	Arthropoda	Insecta	Plecoptera	Perlodidae	Isoperlinae	Isoperla	
2003	*Limnephilidae*	L	imm.	72	Arthropoda	Insecta	Trichoptera	Limnephilidae			
2003	*Limnephilus* sp.	L		1	Arthropoda	Insecta	Trichoptera	Limnephilidae	Limnephilinae	Limnephilus	
2002	*Lymnaeidae*		imm.	23.04	Mollusca	Gastropoda	Basommatophora	Lymnaeidae			

Table 12. Benthic macroinvertebrates collected from selected surface-water sites in Wind Cave National Park, 2002 and 2003.—Continued

[A, adult; L, larva(e); dam., damaged; sp., species; imm., immature; indet., indeterminate; P, pupa(e); ref., organism placed in a reference collection]

Year collected	Taxonomy	Life stage	Notes	Abundance	Phylum	Class	Order	Family	Subfamily	Genus	Species
Highland Creek (site 7)—Continued											
2002	*Nematoda*			23.04	Nematoda						
2003	*Nematoda*			29	Nematoda						
2003	*Odontomesa* sp.	L		14	Arthropoda	Insecta	Diptera	Chironomidae	Prodiamesinae	Odontomesa	
2002	*Optioservus divergens* (LeConte)	A		276.48	Arthropoda	Insecta	Coleoptera	Elmidae		Optioservus	Optioservus divergens
2003	*Optioservus divergens* (LeConte)	A		284	Arthropoda	Insecta	Coleoptera	Elmidae		Optioservus	Optioservus divergens
2002	*Optioservus* sp.	L		967.68	Arthropoda	Insecta	Coleoptera	Elmidae		Optioservus	
2003	*Optioservus* sp.	L		1,786	Arthropoda	Insecta	Coleoptera	Elmidae		Optioservus	
2002	*Pagastia* sp.	L	ref.	46.08	Arthropoda	Insecta	Diptera	Chironomidae	Diamesinae	Pagastia	
2003	*Paratendipes* sp.	L		43	Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Paratendipes	
2003	*Pentaneura* sp.	L		14	Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae	Pentaneura	
2002	*Physella* sp.			23.04	Mollusca	Gastropoda	Basommatophora	Physidae	Physinae	Physella	
2003	*Physella* sp.			1	Mollusca	Gastropoda	Basommatophora	Physidae	Physinae	Physella	
2003	*Porifera*			1	Porifera						
2002	*Simuliidae*	L	imm.	1,244.16	Arthropoda	Insecta	Diptera	Simuliidae			
2002	*Simulium* sp.	L		46.08	Arthropoda	Insecta	Diptera	Simuliidae		Simulium	
2002	*Simulium* sp.	P		23.04	Arthropoda	Insecta	Diptera	Simuliidae		Simulium	
2003	*Sphaeriidae*		imm.	43	Mollusca	Bivalvia	Veneroida	Sphaeriidae			
2003	*Stagnicola* sp.			1	Mollusca	Gastropoda	Basommatophora	Lymnaeidae	Lymnaeinae	Stagnicola	
2002	*Stratiomyidae*	L	imm.	46.08	Arthropoda	Insecta	Diptera	Stratiomyidae			
2003	*Tabanidae*	L	imm.	1	Arthropoda	Insecta	Diptera	Tabanidae			
2002	*Tanypodinae*	L	indet.	23.04	Arthropoda	Insecta	Diptera	Chironomidae	Tanypodinae		
2003	*Tanytarsus* sp.	L		14	Arthropoda	Insecta	Diptera	Chironomidae	Chironominae	Tanytarsus	
2002	*Tricorythodes* sp.	L		368.64	Arthropoda	Insecta	Ephemeroptera	Leptohyphidae		Tricorythodes	
2002	*Tricorythodes* sp.	L	ref.	1	Arthropoda	Insecta	Ephemeroptera	Leptohyphidae		Tricorythodes	
2003	*Tricorythodes* sp.	L		86	Arthropoda	Insecta	Ephemeroptera	Leptohyphidae		Tricorythodes	

[1]State record means this organism has not previously been reported in the published literature for South Dakota.

Table 13. Wastewater compounds in surface water and ground water.

[Site number refers to figure 1. --, no data; E, estimated value; <, less than; SURR, surrogate. Values in micrograms per liter except as indicated]

	Cold Spring Creek (site 1)	Cold Spring Creek (site 1)	Cold Spring Creek (site 1)	Beaver Creek (site 3)	Beaver Creek (site 3)	Beaver Creek (site 4)	Beaver Creek (site 4)	Beaver Creek (site 4)	Highland Creek (site 7)	Highland Creek (site 7)	Minnehaha Falls (site 12)	Minnehaha Falls (site 12)
Date sampled	3/04/2002	7/25/2002	5/13/2003	3/12/2003	5/13/2003	5/14/2002	7/24/2002	5/14/2003	7/23/2002	5/13/2003	5/14/2002	5/14/2002
Time	1140	1015	1130	1015	1015	1000	840	930	910	0830	700	715
Tetrachloro-ethylene	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
Bromoform	<.500	<.500	**E.032**	<.500	**E.025**	<.500	<.500	**E.036**	<.500	**E.017**	<.500	<.500
Cumene	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Phenol	<.500	**1.200**	<.500	**.900**	**E.130**	**.810**	<.500	<.500	<.500	<.500	<.500	<.500
1,4-Dichlorobenzene	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
d-Limonene	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Acetophenone	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Para-cresol	<1.000	<1.000	<1.000	<1.000	**E.037**	<1.000	<1.000	**E.190**	<1.000	**E.028**	<1.000	<1.000
Isophorone	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Camphor	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Isoborneol	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Menthol	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Naphthalene	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Methyl salicylate	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Dichlorvos	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000
Isoquinoline	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
2-Methylnapthalene	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Indole	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
3,4-Dichlorophenyl isocyanate	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
1-Methylnapthalene	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Skatol	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000
2,6-Dimethylnapthalene	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
BHA	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000
N,N-Diethyltoluamide (DEET)	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
5-Methyl-1H-benzotriazle	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000

Table 13. Wastewater compounds in surface water and ground water.—Continued

[Site number refers to figure 1. --, no data; E, estimated value; <, less than; SURR, surrogate. Values in micrograms per liter except as indicated]

	Cold Spring Creek (site 1)	Cold Spring Creek (site 1)	Cold Spring Creek (site 1)	Beaver Creek (site 3)	Beaver Creek (site 3)	Beaver Creek (site 4)	Beaver Creek (site 4)	Beaver Creek (site 4)	Highland Creek (site 7)	Highland Creek (site 7)	Minnehaha Falls (site 12)	Minnehaha Falls (site 12)
Diethyl phthalate	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
4-*tert*-Octylphenol	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000
Benzophenone	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Tributylphosphate	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Ethyl citrate	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Cotinine	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000
Para-nonylphenol-total	<5.000	<5.000	<5.000	<5.000	<5.000	**E2.400**	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000
Prometon	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Pentachlorophenol	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000
Atrazine	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	**E.020**
Tri(2-chloroethyl) phosphate	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
4-*n*-octylphenol	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000
Diazinon	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Phenanthrene	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Anthracene	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Tonalide (AHTN)	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Caffeine	<.500	<.500	**E.013**	<.500	<.500	**E.056**	<.500	**E.011**	<.500	<.500	**E.087**	**E.076**
Carbazole	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Galaxolide (HHCB)	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
OPEO1	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000
4-Cumylphenol	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000
Carbaryl	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000
Metalaxyl	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Bromacil	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Metolachlor	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Chlorpyrifos	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Anthraquinone	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
NPEO1-total	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000

Table 13. Wastewater compounds in surface water and ground water.—Continued

[Site number refers to figure 1. --, no data; E, estimated value; <, less than; SURR, surrogate. Values in micrograms per liter except as indicated]

	Cold Spring Creek (site 1)	Cold Spring Creek (site 1)	Cold Spring Creek (site 1)	Beaver Creek (site 3)	Beaver Creek (site 3)	Beaver Creek (site 4)	Beaver Creek (site 4)	Beaver Creek (site 4)	Highland Creek (site 7)	Highland Creek (site 7)	Minnehaha Falls (site 12)	Minnehaha Falls (site 12)
Fluoranthene	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
Triclosan	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000
Pyrene	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
OPEO2	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000
Bisphenol A	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000	<1.000
NPEO2-total	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000
tri(dichloriso-propyl)phosphate	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Triphenyl phosphate	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
Ethanol,2-butoxy-phosphate	<.500	<.500	<.500	**E.220**	<.500	<.500	**E.320**	<.500	**E.270**	<.500	<.500	<.500
Diethylhexyl phthalate	<.500	<.500	<.500	<.500	<.500	<.500	<.500	1.70	<.500	<.500	<.500	<.500
Estrone	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000
17B-Estradiol	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000
17-Alpha-ethynyl esterdiol	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000
Equilenin	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000	<5.000
Benzo(A)pyrene	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500	<.500
3-Beta-coprostanol	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000
Cholesterol	**E.610**	**E.820**	<2.000	<2.000	**E.068**	<2.000	**E.820**	<2.000	**E.770**	<2.000	<2.000	<2.000
Beta-sitosterol	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000
Stigmastanol	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000	<2.000
Decafluorobiphenyl - SURR percent recovery	41	56	73	68	68	65	62	74	64	73	60	49
*d*8-Caffiene -SURR percent recovery	71	59	91	71	86	81	66	78	77	71	67	45
*d*10 - Fluoranthene - SURR percent recovery	69	68	100	72	91	77	71	100	91	72	77	65
*d*8 Bisphenol A -SURR percent recovery	69	37	82	63	86	80	70	83	82	63	73	58

Table 14. Concentrations of constituents in bottom-sediment samples.

[All analyses wet sieved, unless otherwise indicated. <, less than; µm, microns; µg/g, micrograms per gram]

Station number	Site number (fig. 1)	Date	Calcium, <62.5 µm, total, percent (P34830)	Magnesium, <62.5 µm, total, percent (P34900)	Potassium, <62.5 µm, total, percent (P34940)	Sodium, <62.5 µm, total, percent (P34960)	Sulfur, <62.5 µm, total, percent (P34970)	Phosphorus, <62.5 µm, total, percent (P34935)	Carbon (inorganic plus organic), <62.5 µm, (native water), recoverable, percent (P49267)	Inorganic carbon, <62.5 µm, (native water), recoverable, percent (P49269)
433451103284000	2	7/24/2002	8.7	0.88	1.5	0.28	<0.05	0.13	3.2	2.6
06402430	4	7/24/2002	3.3	.85	2	.48	.05	.12	1.8	.91
433745103261900	7	7/23/2002	1	.28	2.4	.9	<.05	.049	.47	.13

Site number (fig. 1)	Organic carbon, <62.5 µm, (native water), recoverable, percent (P49266)	Aluminum, <62.5 µm, total, percent (P34790)	Antimony, <62.5 µm, total, µg/g (P34795)	Arsenic, <62.5 µm, total, µg/g (P34800)	Barium, <62.5 µm, total, µg/g (P34805)	Beryllium, <62.5 µm, total, µg/g (P34810)	Bismuth, <177 µm, total, µg/g (P34816)	Cadmium, <62.5 µm, total, µg/g (P34825)	Cerium, <62.5 µm, total, µg/g (P34835)	Chromium, <62.5 µm, total, µg/g (P34840)
2	0.55	2.5	0.2	9.5	330	1.6	<1	0.1	54	23
4	.85	4.1	.4	9.4	370	1.7	<1	.1	43	39
7	.34	4.4	<.1	2.8	350	1.6	<1	<.1	34	31

Site number (fig. 1)	Cobalt, <62.5 µm, total, µg/g (P34845)	Copper, <62.5 µm, total, µg/g (P34850)	Europium, <62.5 µm, total, µg/g (P34855)	Gallium, <62.5 µm, total, µg/g (P34860)	Gold, <62.5 µm, total, µg/g (P34870)	Holmium, <62.5 µm, total, µg/g (P34875)	Iron, <62.5 µm, total, percent (P34880)	Lanthanum, <62.5 µm, total, µg/g (P34885)	Lead, <62.5 µm, total, µg/g (P34890)	Lithium, <62.5 µm, total, µg/g (P34895)
2	4	8	<1	6	<1	<1	0.94	26	14	15
4	6	10	<1	9	<1	<1	1.6	22	13	25
7	4	3	<1	9	<1	<1	.83	18	19	18

Table 14. Concentrations of constituents in bottom-sediment samples.—Continued

[All analyses wet sieved, unless otherwise indicated. <, less than; µm, microns; µg/g, micrograms per gram]

Site number (fig. 1)	Manganese, <62.5 µm, total, µg/g (P34905)	Mercury, <62.5 µm, total, µg/g (P34910)	Molybdenum, <62.5 µm, total, µg/g (P34915)	Neodymium, <62.5 µm, total, µg/g (P34920)	Nickel, <62.5 µm, total, µg/g (P34925)	Niobium, <62.5 µm, total, µg/g (P34930)	Scandium, <62.5 µm, total, µg/g (P34945)	Selenium, <62.5 µm, total, µg/g (P34950)	Silver, <62.5 µm, total, µg/g (P34955)	Strontium, <62.5 µm, total, µg/g (P34965)
2	460	0.02	0.7	23	10	<4	3	0.7	<0.1	130
4	310	.02	<.5	19	13	8	6	.4	<.1	100
7	110	<.02	<.5	15	7	5	4	.3	<.1	61

Site number (fig. 1)	Tantalum, <62.5 µm, total, µg/g (P34975)	Thallium, <62.5 µm, dry sieved, total digestion, µg/g (P04064)	Thorium, <62.5 µm, total, µg/g (P34980)	Tin, <62.5 µm, total, µg/g (P34985)	Titanium, <62.5 µm, (native water), recoverable, percent (P49274)	Vanadium, <62.5 µm, total, µg/g (P35005)	Ytterbium, <62.5 µm, total, µg/g (P35015)	Yttrium, <62.5 µm, total, µg/g (P35010)	Zinc, <62.5 µm, total, µg/g (P35020)	Uranium, <62.5 µm, total, µg/g (P35000)
2	<1	<1	24	1	0.052	20	<1	12	20	4.2
4	<1	<1	8	2	.15	41	1	12	40	2.6
7	<1	<1	10	2	.096	25	<1	7	21	2

Table 15. Water-quality data including organic compounds in cave drip and parking lot runoff.

[US/CM, microsiemens per centimeter at 25 degrees Celsius; MG/L, milligrams per liter; UG/L, micrograms per liter; DEG C, degrees Celsius; LAB, laboratory; DISS, dissolved; WAT, water; WH, whole; UNFLTRD, unfiltered; REC, recoverable; TOT, total; E, estimated; <, less than; --, no data]

Date	Station number	Date	Time	AGENCY ANA- LYZING SAMPLE (CODE NUMBER) (00028)	ELEV. OF LAND SURFACE DATUM (FEET ABOVE NGVD) (72000)	PH WATER WHOLE FIELD (STAND- ARD UNITS) (00400)	PH WATER WHOLE LAB (STAND- ARD UNITS) (00403)	SPE- CIFIC CON- DUCT- ANCE LAB (US/CM) (90095)	SPE- CIFIC CON- DUCT- ANCE (US/CM) (00095)	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)
433328103284700 CULVERT NR WIND CAVE NAT. PARK HQ, SD (LAT 43 33 28N LONG 103 28 47W)												
SEP 2002												
04...	433328103284700	20020904	0740	80020	4140.00	--	--	--	--	--	--	--
433310103281701 UPPER MINNEHAHA FALLS INSIDE WIND CAVE (LAT 43 33 10N LONG 103 28 17W)												
JUN 2002												
18...	433310103281701	20020618	1715	80020	--	--	--	--	--	--	--	--
18...	433310103281701	20020618	1815	80020	--	--	--	--	--	--	--	--
19...	433310103281701	20020619	0922	80020	--	--	--	--	--	--	--	--
AUG												
06...	433310103281701	20020806	1300	80020	--	8.5	8.2	453	477	82.3	10.7	3.45
12...	433310103281701	20020812	2115	80020	--	--	--	--	--	--	--	--
12...	433310103281701	20020812	2215	80020	--	--	--	--	--	--	--	--
12...	433310103281701	20020812	2315	80020	--	--	--	--	--	--	--	--
13...	433310103281701	20020813	0115	80020	--	--	--	--	--	--	--	--
13...	433310103281701	20020813	0515	80020	--	--	--	--	--	--	--	--
14...	433310103281701	20020814	1545	80020	--	--	--	--	--	--	--	--
15...	433310103281701	20020815	0830	80020	--	--	--	--	--	--	--	--
22...	433310103281701	20020822	1000	80020	--	--	--	--	--	--	--	--
SEP												
04...	433310103281701	20020904	1705	80020	--	--	--	--	--	--	--	--
04...	433310103281701	20020904	1810	80020	--	--	--	--	--	--	--	--
04...	433310103281701	20020904	1900	80020	--	--	--	--	--	--	--	--

Date	SILICA, DIS- SOLVED (MG/L AS SIO2) (00955)	RESIDUE AT 105 DEG C, DIS- SOLVED (MG/L) (00515)	NITRO- GEN, AMMONIA DIS- SOLVED (MG/L AS N) (00608)	NITRO- GEN,AM- MONIA + ORGANIC DISS (MG/L AS N) (00623)	NITRO- GEN, NO2+NO3 DIS- SOLVED (MG/L AS N) (00631)	NITRO- GEN, NITRITE DIS- SOLVED (MG/L AS N) (00613)	ORTHO- PHOS- PHATE, DIS- SOLVED (MG/L AS P) (00671)	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)	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)
433328103284700 CULVERT NR WIND CAVE NAT. PARK HQ, SD (LAT 43 33 28N LONG 103 28 47W)													
SEP 2002													
04...	--	--	--	--	--	--	--	--	--	--	--	--	--
433310103281701 UPPER MINNEHAHA FALLS INSIDE WIND CAVE (LAT 43 33 10N LONG 103 28 17W)													
JUN 2002													
18...	--	--	--	--	--	--	--	--	--	--	--	--	--
18...	--	--	--	--	--	--	--	--	--	--	--	--	--
19...	--	--	--	--	--	--	--	--	--	--	--	--	--
AUG													
06...	13.1	283	<.04	.19	.54	<.008	E.01	15	413	<.5	<8	<10	<13
12...	--	--	--	--	--	--	--	--	--	--	--	--	--
12...	--	--	--	--	--	--	--	--	--	--	--	--	--
12...	--	--	--	--	--	--	--	--	--	--	--	--	--
13...	--	--	--	--	--	--	--	--	--	--	--	--	--
13...	--	--	--	--	--	--	--	--	--	--	--	--	--
14...	--	--	--	--	--	--	--	--	--	--	--	--	--
15...	--	--	--	--	--	--	--	--	--	--	--	--	--
22...	--	--	--	--	--	--	--	--	--	--	--	--	--
SEP													
04...	--	--	--	--	--	--	--	--	--	--	--	--	--
04...	--	--	--	--	--	--	--	--	--	--	--	--	--
04...	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 15. Water-quality data including organic compunds in cave-drip and parking lot runoff.—Continued

[US/CM, microsiemens per centimeter at 25 degrees Celsius; MG/L, milligrams per liter; UG/L, micrograms per liter; DEG C, degrees Celsius; LAB, laboratory; DISS, dissolved; WAT, water; WH, whole; UNFLTRD, unfiltered; REC, recoverable; TOT, total; E, estimated; <, less than; --, no data]

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)	SILVER, DIS- SOLVED (UG/L AS AG) (01075)	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)
433328103284700 CULVERT NR WIND CAVE NAT. PARK HQ, SD (LAT 43 33 28N LONG 103 28 47W)													
SEP 2002													
04...	--	--	--	--	--	--	--	--	--	--	--	--	--
433310103281701 UPPER MINNEHAHA FALLS INSIDE WIND CAVE (LAT 43 33 10N LONG 103 28 17W)													
JUN 2002													
18...	--	--	--	--	--	--	--	--	--	--	--	--	--
18...	--	--	--	--	--	--	--	--	--	--	--	--	--
19...	--	--	--	--	--	--	--	--	--	--	--	--	--
AUG													
06...	<6	E6	<.08	5	<2.0	<.01	<50	<30	.4	<9	211	E5	<24
12...	--	--	--	--	--	--	--	--	--	--	--	--	--
12...	--	--	--	--	--	--	--	--	--	--	--	--	--
12...	--	--	--	--	--	--	--	--	--	--	--	--	--
13...	--	--	--	--	--	--	--	--	--	--	--	--	--
13...	--	--	--	--	--	--	--	--	--	--	--	--	--
14...	--	--	--	--	--	--	--	--	--	--	--	--	--
15...	--	--	--	--	--	--	--	--	--	--	--	--	--
22...	--	--	--	--	--	--	--	--	--	--	--	--	--
SEP													
04...	--	--	--	--	--	--	--	--	--	--	--	--	--
04...	--	--	--	--	--	--	--	--	--	--	--	--	--
04...	--	--	--	--	--	--	--	--	--	--	--	--	--

Date	1,1,1- TRI- CHLORO- ETHANE TOTAL (UG/L) (34506)	1,1,2- TRI- CHLORO- ETHANE TOTAL (UG/L) (34511)	1,1-DI- CHLORO- ETHANE TOTAL (UG/L) (34496)	1,1-DI- CHLORO- ETHYL- ENE TOTAL (UG/L) (34501)	1,1-DI CHLORO- PRO- PENE, WAT, WH TOTAL (UG/L) (77168)	123-TRI CHLORO- PROPANE WATER WHOLE TOTAL (UG/L) (77443)	1,2- DIBROMO ETHANE WATER WHOLE TOTAL (UG/L) (77651)	1,2-DI- CHLORO- ETHANE TOTAL (UG/L) (32103)	1,2-DI- CHLORO- PROPANE TOTAL (UG/L) (34541)	TRANS- 1,2-DI- CHLORO- ETHENE TOTAL (UG/L) (34546)	2,2-DI CHLORO- PRO- PANE WAT, WH TOTAL (UG/L) (77170)	2BUTENE TRANS-1 4-DI- CHLORO UNFLTRD REC (UG/L) (73547)	2-HEXA- NONE WATER WHOLE TOTAL (UG/L) (77103)
433328103284700 CULVERT NR WIND CAVE NAT. PARK HQ, SD (LAT 43 33 28N LONG 103 28 47W)													
SEP 2002													
04...	<.06	<.12	<.07	<.08	<.10	<.32	<.07	<.3	<.06	<.06	<.10	<1.4	<1.4
433310103281701 UPPER MINNEHAHA FALLS INSIDE WIND CAVE (LAT 43 33 10N LONG 103 28 17W)													
JUN 2002													
18...	<.03	<.06	<.04	<.04	<.05	<.16	<.04	<.1	<.03	<.03	<.05	<.7	<.7
18...	<.03	<.06	<.04	<.04	<.05	<.16	<.04	<.1	<.03	<.03	<.05	<.7	<.7
19...	<.03	<.06	<.04	<.04	<.05	<.16	<.04	<.1	<.03	<.03	<.05	<.7	<.7
AUG													
06...	--	--	--	--	--	--	--	--	--	--	--	--	--
12...	<.03	<.06	<.04	<.04	<.05	<.16	<.04	<.1	<.03	<.03	<.05	<.7	<.7
12...	<.03	<.06	<.04	<.04	<.05	<.16	<.04	<.1	<.03	<.03	<.05	<.7	<.7
12...	<.03	<.06	<.04	<.04	<.05	<.16	<.04	<.1	<.03	<.03	<.05	<.7	<.7
13...	<.03	<.06	<.04	<.04	<.05	<.16	<.04	<.1	<.03	<.03	<.05	<.7	<.7
13...	<.03	<.06	<.04	<.04	<.05	<.16	<.04	<.1	<.03	<.03	<.05	<.7	<.7
14...	<.03	<.06	<.04	<.04	<.05	<.16	<.04	<.1	<.03	<.03	<.05	<.7	<.7
15...	<.03	<.06	<.04	<.04	<.05	<.16	<.04	<.1	<.03	<.03	<.05	<.7	<.7
22...	<.03	<.06	<.04	<.04	<.05	<.16	<.04	<.1	<.03	<.03	<.05	<.7	<.7
SEP													
04...	<.03	<.06	<.04	<.04	<.05	<.16	<.04	<.1	<.03	<.03	<.05	<.7	<.7
04...	<.03	<.06	<.04	<.04	<.05	<.16	<.04	<.1	<.03	<.03	<.05	<.7	<.7
04...	<.03	<.06	<.04	<.04	<.05	<.16	<.04	<.1	<.03	<.03	<.05	<.7	<.7

Table 15. Water-quality data including organic compunds in cave-drip and parking lot runoff.—Continued

[US/CM, microsiemens per centimeter at 25 degrees Celsius; MG/L, milligrams per liter; UG/L, micrograms per liter; DEG C, degrees Celsius; LAB, laboratory; DISS, dissolved; WAT, water; WH, whole; UNFLTRD, unfiltered; REC, recoverable; TOT, total; E, estimated; <, less than; --, no data]

Date	ACETONE WATER WHOLE TOTAL (UG/L) (81552)	ACRYLO- NITRILE TOTAL (UG/L) (34215)	1,2,3- TRI- CHLORO BENZENE WAT, WH REC (UG/L) (77613)	BENZENE 123-TRI METHYL- WATER UNFLTRD REC (UG/L) (77221)	BENZENE 1,2,4- TRI- CHLORO- WATER UNFLTRD REC (UG/L) (34551)	BENZENE 124-TRI METHYL UNFLTRD REC (UG/L) (77222)	BENZENE 135-TRI METHYL WATER UNFLTRD REC (UG/L) (77226)	BENZENE 1,3-DI- CHLORO- WATER UNFLTRD REC (UG/L) (34566)	BENZENE 14BRFL- SURROG VOC UNFLTRD REC PERCENT (99834)	BENZENE 1,4-DI- CHLORO- WATER UNFLTRD REC (UG/L) (34571)	ISO- PROPYL- BENZENE WATER WHOLE REC (UG/L) (77223)	BENZENE N-BUTYL WATER UNFLTRD REC (UG/L) (77342)	BENZENE N-PROPY WATER UNFLTRD REC (UG/L) (77224)
433328103284700 CULVERT NR WIND CAVE NAT. PARK HQ, SD (LAT 43 33 28N LONG 103 28 47W)													
SEP 2002													
04...	23	<2	<.5	<.2	<.1	<.11	<.09	<.06	92.9	<.10	<.12	<.4	<.08
433310103281701 UPPER MINNEHAHA FALLS INSIDE WIND CAVE (LAT 43 33 10N LONG 103 28 17W)													
JUN 2002													
18...	<7	<1	<.3	<.1	<.1	<.06	<.04	<.03	85.2	<.05	<.06	<.2	<.04
18...	<7	<1	<.3	<.1	<.1	<.06	<.04	<.03	85.4	<.05	<.06	<.2	<.04
19...	E6	<1	<.3	<.1	<.1	<.06	<.04	<.03	84.7	<.05	<.06	<.2	<.04
AUG													
06...	--	--	--	--	--	--	--	--	--	--	--	--	--
12...	<7	<1	<.3	<.1	<.1	<.06	<.04	<.03	90.0	<.05	<.06	<.2	<.04
12...	<7	<1	<.3	<.1	<.1	<.06	<.04	<.03	91.4	<.05	<.06	<.2	<.04
12...	<7	<1	<.3	<.1	<.1	<.06	<.04	<.03	89.1	<.05	<.06	<.2	<.04
13...	<7	<1	<.3	<.1	<.1	<.06	<.04	<.03	90.7	<.05	<.06	<.2	<.04
13...	9	<1	<.3	<.1	<.1	<.06	<.04	<.03	90.0	<.05	<.06	<.2	<.04
14...	<7	<1	<.3	<.1	<.1	<.06	<.04	<.03	90.5	<.05	<.06	<.2	<.04
15...	<7	<1	<.3	<.1	<.1	<.06	<.04	<.03	89.6	<.05	<.06	<.2	<.04
22...	<7	<1	<.3	<.1	<.1	<.06	<.04	<.03	82.2	<.05	<.06	<.2	<.04
SEP													
04...	<7	<1	<.3	<.1	<.1	<.06	<.04	<.03	86.6	<.05	<.06	<.2	<.04
04...	12	<1	<.3	<.1	<.1	E.02	<.04	<.03	87.8	<.05	<.06	<.2	<.04
04...	9	<1	<.3	<.1	<.1	E.03	<.04	<.03	90.7	<.05	<.06	<.2	<.04

Date	BENZENE O-DI- CHLORO- WATER UNFLTRD REC (UG/L) (34536)	BENZENE SEC BUTYL- WATER UNFLTRD REC (UG/L) (77350)	BENZENE TERT- BUTYL- WATER UNFLTRD REC (UG/L) (77353)	BENZENE TOTAL (UG/L) (34030)	BROMO- BENZENE WATER, WHOLE, TOTAL (UG/L) (81555)	BROMO- ETHENE WATER UNFLTRD REC (UG/L) (50002)	BROMO- FORM TOTAL (UG/L) (32104)	CARBON DI- SULFIDE WATER WHOLE TOTAL (UG/L) (77041)	CARBON TETRA- CHLO- RIDE TOTAL (UG/L) (32102)	CHLORO- BENZENE TOTAL (UG/L) (34301)	CHLORO- DI- BROMO- METHANE TOTAL (UG/L) (32105)	CHLORO- ETHANE TOTAL (UG/L) (34311)	CHLORO- FORM TOTAL (UG/L) (32106)
433328103284700 CULVERT NR WIND CAVE NAT. PARK HQ, SD (LAT 43 33 28N LONG 103 28 47W)													
SEP 2002													
04...	<.06	<.06	<.10	E.02	<.07	<.2	E.18	<.14	<.12	<.06	.4	<.2	5.14
433310103281701 UPPER MINNEHAHA FALLS INSIDE WIND CAVE (LAT 43 33 10N LONG 103 28 17W)													
JUN 2002													
18...	<.03	<.03	<.05	<.04	<.04	<.1	<.06	<.07	<.06	<.03	<.2	<.1	<.02
18...	<.03	<.03	<.05	<.04	<.04	<.1	<.06	<.07	<.06	<.03	<.2	<.1	<.02
19...	<.03	<.03	<.05	<.04	<.04	<.1	<.06	<.07	<.06	<.03	<.2	<.1	<.02
AUG													
06...	--	--	--	--	--	--	--	--	--	--	--	--	--
12...	<.03	<.03	<.05	<.04	<.04	<.1	<.06	<.07	<.06	<.03	<.2	<.1	<.02
12...	<.03	<.03	<.05	<.04	<.04	<.1	<.06	<.07	<.06	<.03	<.2	<.1	<.02
12...	<.03	<.03	<.05	<.04	<.04	<.1	<.06	<.07	<.06	<.03	<.2	<.1	<.02
13...	<.03	<.03	<.05	<.04	<.04	<.1	<.06	<.07	<.06	<.03	<.2	<.1	<.02
13...	<.03	<.03	<.05	<.04	<.04	<.1	<.06	<.07	<.06	<.03	<.2	<.1	<.02
14...	<.03	<.03	<.05	<.04	<.04	<.1	<.06	<.07	<.06	<.03	<.2	<.1	<.02
15...	<.03	<.03	<.05	<.04	<.04	<.1	<.06	<.07	<.06	<.03	<.2	<.1	<.02
22...	<.03	<.03	<.05	<.04	<.04	<.1	<.06	<.07	<.06	<.03	<.2	<.1	<.02
SEP													
04...	<.03	<.03	<.05	<.04	<.04	<.1	<.06	<.07	<.06	<.03	<.2	<.1	<.02
04...	<.03	<.03	<.05	E.01	<.04	<.1	<.06	<.07	<.06	<.03	<.2	<.1	<.02
04...	<.03	<.03	<.05	E.01	<.04	<.1	<.06	<.07	<.06	<.03	<.2	<.1	<.02

Table 15. Water-quality data including organic compunds in cave-drip and parking lot runoff.—Continued

[US/CM, microsiemens per centimeter at 25 degrees Celsius; MG/L, milligrams per liter; UG/L, micrograms per liter; DEG C, degrees Celsius; LAB, laboratory; DISS, dissolved; WAT, water; WH, whole; UNFLTRD, unfiltered; REC, recoverable; TOT, total; E, estimated; <, less than; --, no data]

Date	CIS-1,2 -DI- CHLORO- ETHENE WATER TOTAL (UG/L) (77093)	CIS 1,3-DI- CHLORO- PROPENE TOTAL (UG/L) (34704)	DIBROMO CHLORO- PROPANE WATER WHOLE TOT REC (UG/L) (82625)	DI- BROMO- METHANE WATER WHOLE REC (UG/L) (30217)	BROMO- DI- CHLORO- METHANE TOTAL (UG/L) (32101)	DI- CHLORO- DI- FLUORO- METHANE TOTAL (UG/L) (34668)	DI-ISO- PROPYL- ETHER, WATER, UNFLTRD REC (UG/L) (81577)	ETHANE, 1112- TETRA- CHLORO- WATER UNFLTRD REC (UG/L) (77562)	ETHANE, 1,1,2,2 TETRA- CHLORO- WATER UNFLTRD REC (UG/L) (34516)	ETHANE 12DICL SURROG VOC UNFLTRD REC PERCENT (99832)	ETHANE HEXA- CHLORO- WATER UNFLTRD REC (UG/L) (34396)	ETHER ETHYL WATER UNFLTRD REC (UG/L) (81576)	ETHER TERT- BUTYL ETHYL UNFLTRD REC (UG/L) (50004)
433328103284700 CULVERT NR WIND CAVE NAT. PARK HQ, SD (LAT 43 33 28N LONG 103 28 47W)													
SEP 2002													
04...	<.08	<.18	<1.0	<.10	.62	<.36	<.20	<.06	<.18	114	<.4	<.3	<.10
433310103281701 UPPER MINNEHAHA FALLS INSIDE WIND CAVE (LAT 43 33 10N LONG 103 28 17W)													
JUN 2002													
18...	<.04	<.09	<.5	<.05	<.05	<.18	<.10	<.03	<.09	113	<.2	<.2	<.05
18...	<.04	<.09	<.5	<.05	<.05	<.18	<.10	<.03	<.09	115	<.2	<.2	<.05
19...	<.04	<.09	<.5	<.05	<.05	<.18	<.10	<.03	<.09	115	<.2	<.2	<.05
AUG													
06...	--	--	--	--	--	--	--	--	--	--	--	--	--
12...	<.04	<.09	<.5	<.05	<.05	<.18	<.10	<.03	<.09	117	<.2	<.2	<.05
12...	<.04	<.09	<.5	<.05	<.05	<.18	<.10	<.03	<.09	121	<.2	<.2	<.05
12...	<.04	<.09	<.5	<.05	<.05	<.18	<.10	<.03	<.09	117	<.2	<.2	<.05
13...	<.04	<.09	<.5	<.05	<.05	<.18	<.10	<.03	<.09	120	<.2	<.2	<.05
13...	<.04	<.09	<.5	<.05	<.05	<.18	<.10	<.03	<.09	119	<.2	<.2	<.05
14...	<.04	<.09	<.5	<.05	<.05	<.18	<.10	<.03	<.09	122	<.2	<.2	<.05
15...	<.04	<.09	<.5	<.05	<.05	<.18	<.10	<.03	<.09	125	<.2	<.2	<.05
22...	<.04	<.09	<.5	<.05	<.05	<.18	<.10	<.03	<.09	129	<.2	<.2	<.05
SEP													
04...	<.04	<.09	<.5	<.05	<.05	<.18	<.10	<.03	<.09	108	<.2	<.2	<.05
04...	<.04	<.09	<.5	<.05	<.05	<.18	<.10	<.03	<.09	102	<.2	<.2	<.05
04...	<.04	<.09	<.5	<.05	<.05	<.18	<.10	<.03	<.09	99.6	<.2	<.2	<.05

Date	ETHER TERT- PENTYL METHYL UNFLTRD REC (UG/L) (50005)	ETHYL- BENZENE TOTAL (UG/L) (34371)	FREON- 113 WATER UNFLTRD REC (UG/L) (77652)	FURAN, TETRA- HYDRO- WATER UNFLTRD REC (UG/L) (81607)	HEXA- CHLORO- BUT- ADIENE TOTAL (UG/L) (39702)	ISO- DURENE WATER UNFLTRD REC (UG/L) (50000)	METHAC- RYLATE ETHYL- WATER UNFLTRD REC (UG/L) (73570)	METHAC- RYLATE METHYL WATER UNFLTRD REC (UG/L) (81597)	METH- ACRYLO- NITRILE WATER UNFLTRD REC (UG/L) (81593)	METHANE BROMO CHLORO- WAT UNFLTRD REC (UG/L) (77297)	METHYL ACRY- LATE WATER UNFLTRD REC (UG/L) (49991)	METHYL IODIDE WATER UNFLTRD REC (UG/L) (77424)	METHYL TERT- BUTYL ETHER WATER UNFLTRD REC (UG/L) (78032)
433328103284700 CULVERT NR WIND CAVE NAT. PARK HQ, SD (LAT 43 33 28N LONG 103 28 47W)													
SEP 2002													
04...	<.16	<.06	<.12	<4	<.3	<.4	<.4	<.7	<1.2	<.14	<4.0	<.50	<.3
433310103281701 UPPER MINNEHAHA FALLS INSIDE WIND CAVE (LAT 43 33 10N LONG 103 28 17W)													
JUN 2002													
18...	<.08	<.03	<.06	<2	<.1	<.2	<.2	<.3	<.6	<.07	<2.0	<.25	<.2
18...	<.08	<.03	<.06	<2	<.1	<.2	<.2	<.3	<.6	<.07	<2.0	<.25	<.2
19...	<.08	<.03	<.06	<2	<.1	<.2	<.2	<.3	<.6	<.07	<2.0	<.25	<.2
AUG													
06...	--	--	--	--	--	--	--	--	--	--	--	--	--
12...	<.08	<.03	<.06	<2	<.1	<.2	<.2	<.3	<.6	<.07	<2.0	<.25	<.2
12...	<.08	<.03	<.06	<2	<.1	<.2	<.2	<.3	<.6	<.07	<2.0	<.25	<.2
12...	<.08	<.03	<.06	<2	<.1	<.2	<.2	<.3	<.6	<.07	<2.0	<.25	<.2
13...	<.08	<.03	<.06	<2	<.1	<.2	<.2	<.3	<.6	<.07	<2.0	<.25	<.2
13...	<.08	<.03	<.06	<2	<.1	<.2	<.2	<.3	<.6	<.07	<2.0	<.25	<.2
14...	<.08	<.03	<.06	<2	<.1	<.2	<.2	<.3	<.6	<.07	<2.0	<.25	<.2
15...	<.08	<.03	<.06	<2	<.1	<.2	<.2	<.3	<.6	<.07	<2.0	<.25	<.2
22...	<.08	<.03	<.06	<2	<.1	<.2	<.2	<.3	<.6	<.07	<2.0	<.25	<.2
SEP													
04...	<.08	<.03	<.06	<2	<.1	<.2	<.2	<.3	<.6	<.07	<2.0	<.25	<.2
04...	<.08	E.01	<.06	<2	<.1	<.2	<.2	<.3	<.6	<.07	<2.0	<.25	<.2
04...	<.08	E.02	<.06	<2	<.1	<.2	<.2	<.3	<.6	<.07	<2.0	<.25	<.2

Table 15. Water-quality data including organic compunds in cave-drip and parking lot runoff.—Continued

[US/CM, microsiemens per centimeter at 25 degrees Celsius; MG/L, milligrams per liter; UG/L, micrograms per liter; DEG C, degrees Celsius; LAB, laboratory; DISS, dissolved; WAT, water; WH, whole; UNFLTRD, unfiltered; REC, recoverable; TOT, total; E, estimated; <, less than; --, no data]

Date	METHYL-BROMIDE TOTAL (UG/L) (34413)	METHYL-CHLO-RIDE TOTAL (UG/L) (34418)	METHYL ENE CHLO-RIDE TOTAL (UG/L) (34423)	METHYL-ETHYL-KETONE WATER WHOLE TOTAL (UG/L) (81595)	METHYL ISO-BUTYL KETONE WAT, WH TOTAL (UG/L) (78133)	META/PARA-XYLENE WATER UNFLTRD REC (UG/L) (85795)	NAPHTH-ALENE TOTAL (UG/L) (34696)	O-CHLORO-TOLUENE WATER WHOLE TOTAL (UG/L) (77275)	O-XYLENE WATER WHOLE TOTAL (UG/L) (77135)	P-ISO-PROPYL-TOLUENE WATER WHOLE REC (UG/L) (77356)	1234-TETRA METHYL BENZENE UNFLTRD REC (UG/L) (49999)	1,3-DI-CHLORO-PROPANE WAT, WH TOTAL (UG/L) (77173)	PROPENE 3-CHLORO-WATER UNFLTRD REC (UG/L) (78109)
433328103284700 CULVERT NR WIND CAVE NAT. PARK HQ, SD (LAT 43 33 28N LONG 103 28 47W)													
SEP 2002													
04...	<.5	<.3	<.3	<10.0	E1.0	E.02	<1.0	<.05	<.14	<.14	<.5	<.2	<.14
433310103281701 UPPER MINNEHAHA FALLS INSIDE WIND CAVE (LAT 43 33 10N LONG 103 28 17W)													
JUN 2002													
18...	<.3	<.2	<.2	<5.0	<.4	<.06	<.5	<.03	<.07	<.07	<.2	<.1	<.07
18...	<.3	<.2	<.2	<5.0	<.4	<.06	<.5	<.03	<.07	<.07	<.2	<.1	<.07
19...	<.3	<.2	<.2	<5.0	<.4	<.06	<.5	<.03	<.07	<.07	<.2	<.1	<.07
AUG													
06...	--	--	--	--	--	--	--	--	--	--	--	--	--
12...	<.3	<.2	<.2	<5.0	<.4	<.06	<.5	<.03	<.07	<.07	<.2	<.1	<.07
12...	<.3	<.2	<.2	<5.0	<.4	<.06	<.5	<.03	<.07	<.07	<.2	<.1	<.07
12...	<.3	<.2	<.2	<5.0	<.4	<.06	<.5	<.03	<.07	<.07	<.2	<.1	<.07
13...	<.3	<.2	<.2	<5.0	<.4	<.06	<.5	<.03	<.07	<.07	<.2	<.1	<.07
13...	<.3	<.2	<.2	<5.0	<.4	<.06	<.5	<.03	<.07	<.07	<.2	<.1	<.07
14...	<.3	<.2	<.2	<5.0	<.4	<.06	<.5	<.03	<.07	<.07	<.2	<.1	<.07
15...	<.3	<.2	<.2	<5.0	<.4	<.06	<.5	<.03	<.07	<.07	<.2	<.1	<.07
22...	<.3	<.2	<.2	<5.0	<.4	<.06	<.5	<.03	<.07	<.07	<.2	<.1	<.07
SEP													
04...	<.3	<.2	<.2	<5.0	<.4	<.06	<.5	<.03	<.07	<.07	<.2	<.1	<.07
04...	<.3	<.2	<.2	<5.0	<.4	E.05	<.5	<.03	E.04	<.07	<.2	<.1	<.07
04...	<.3	<.2	<.2	<5.0	<.4	E.06	<.5	<.03	E.05	<.07	<.2	<.1	<.07

Date	STYRENE TOTAL (UG/L) (77128)	TETRA-CHLORO-ETHYL-ENE TOTAL (UG/L) (34475)	TOLUENE D8 SURROG VOC UNFLTRD REC PERCENT (99833)	TOLUENE O-ETHYL WATER UNFLTRD REC (UG/L) (77220)	TOLUENE P-CHLOR WATER UNFLTRD REC (UG/L) (77277)	TOLUENE TOTAL (UG/L) (34010)	TRANS-1,3-DI-CHLORO-PROPENE TOTAL (UG/L) (34699)	TRI-CHLORO-ETHYL-ENE TOTAL (UG/L) (39180)	TRI-CHLORO-FLUORO-METHANE TOTAL (UG/L) (34488)	VINYL CHLO-RIDE TOTAL (UG/L) (39175)	TICS FROM VOC BY GCMS NUMBER (99871)
433328103284700 CULVERT NR WIND CAVE NAT. PARK HQ, SD (LAT 43 33 28N LONG 103 28 47W)											
SEP 2002											
04...	<.08	<.05	103	<.12	<.10	E.04	<.18	<.08	<.18	<.2	0
433310103281701 UPPER MINNEHAHA FALLS INSIDE WIND CAVE (LAT 43 33 10N LONG 103 28 17W)											
JUN 2002											
18...	<.04	<.03	101	<.06	<.05	E.03	<.09	<.04	<.09	<.1	0
18...	<.04	<.03	101	<.06	<.05	E.04	<.09	<.04	<.09	<.1	0
19...	<.04	<.03	100	<.06	<.05	E.03	<.09	<.04	<.09	<.1	1
AUG											
06...	--	--	--	--	--	--	--	--	--	--	--
12...	<.04	<.03	99.5	<.06	<.05	E.02	<.09	<.04	<.09	<.1	0
12...	<.04	<.03	101	<.06	<.05	E.03	<.09	<.04	<.09	<.1	0
12...	<.04	<.03	102	<.06	<.05	E.02	<.09	<.04	<.09	<.1	0
13...	<.04	<.03	99.5	<.06	<.05	E.02	<.09	<.04	<.09	<.1	0
13...	<.04	<.03	100	<.06	<.05	E.03	<.09	<.04	<.09	<.1	1
14...	<.04	<.03	102	<.06	<.05	E.02	<.09	<.04	<.09	<.1	0
15...	<.04	<.03	102	<.06	<.05	E.03	<.09	<.04	<.09	<.1	0
22...	<.04	<.03	99.3	<.06	<.05	<.05	<.09	<.04	<.09	<.1	0
SEP											
04...	<.04	<.03	97.3	<.06	<.05	E.03	<.09	<.04	<.09	<.1	1
04...	E.03	<.03	97.0	<.06	<.05	.10	<.09	<.04	<.09	<.1	1
04...	E.05	<.03	97.1	<.06	<.05	.11	<.09	<.04	<.09	<.1	2

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