



Prepared in cooperation with the  
METRO WASTEWATER RECLAMATION DISTRICT

# BIOSOLIDS, SOIL, CROP, GROUND-WATER, AND STREAMBED-SEDIMENT DATA FOR A BIOSOLIDS-APPLICATION AREA NEAR DEER TRAIL, COLORADO, 2000

Open-File Report 03-400



U.S. Department of the Interior  
U.S. Geological Survey

# **Biosolids, Soil, Crop, Ground-Water, and Streambed-Sediment Data for a Biosolids-Application Area Near Deer Trail, Colorado, 2000**

By Tracy J.B. Yager, David B. Smith, James G. Crock, and Michael R. Stevens

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**U.S. Geological Survey**

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## Conversion Factors

Multiply	by	To obtain
acre	0.4047	hectares (ha.)
centimeter (cm)	0.3937	inch
foot (ft)	0.3048	meter
gallon (gal)	3.785	liter
gram (g)	0.035	ounce
inch	2.54	centimeter
liter (L)	0.2642	gallon (gal)
micrometer ( $\mu\text{m}$ )	0.00003937	inch
mile (mi)	1.609	kilometer
milliliter (mL)	0.0610	cubic inch
millimeter (mm)	0.03937	inch
square mile ( $\text{mi}^2$ )	2.590	square kilometer

Temperature in degrees Celsius ( $^{\circ}\text{C}$ ) can be converted to degrees Fahrenheit ( $^{\circ}\text{F}$ ) using the formula  

$$^{\circ}\text{F} = (1.8 \times ^{\circ}\text{C}) + 32.$$

Temperature in degrees Fahrenheit ( $^{\circ}\text{F}$ ) may be converted to degrees Celsius ( $^{\circ}\text{C}$ ) using the formula  

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32) / 1.8$$

Vertical coordinate information is referenced to National Geodetic Vertical Datum of 1929 (NGVD 29); horizontal coordinate information is referenced to North American Datum of 1927 (NAD 27) except as noted.

### ADDITIONAL ABBREVIATIONS

gal/min	gallon per minute
mg	milligrams
mg/g	milligrams per gram
$\mu\text{g/L}$	micrograms per liter
$\mu\text{S/cm}$	microsiemens per centimeter at 25 degrees Celsius
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
$\rho\text{Ci/L}$	picocuries per liter
$\rho\text{Ci/g}$	picocuries per gram
ROE	residue on evaporation

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## Abstract

In January 1999, the U.S. Geological Survey began an expanded monitoring program near Deer Trail, Colorado, in cooperation with the Metro Wastewater Reclamation District and the North Kiowa Bijou Groundwater Management District. Monitoring components were biosolids, soils, crops, ground water, and streambed sediments. The monitoring program addresses concerns from the public about chemical effects from applications of biosolids to agricultural land in the Deer Trail area. Constituents of primary concern to the public are arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, zinc, plutonium, and gross alpha and beta activity, and they are included for all monitoring components. This report presents chemical data from the second year of the monitoring program, January–December 2000, for biosolids, crops, alluvial and bedrock ground water, and streambed sediments. The ground-water section also includes climate data, water levels, and results of statistical testing of selected data for trends and for exceedance of Colorado regulatory standards. The chemical data included are for the constituents of highest concern to the public as well as for many other constituents.

## Introduction

Since 1993, the Metro Wastewater Reclamation District (MWRD) has been applying biosolids resulting from municipal sewage treatment in Denver, Colo., to their property near Deer Trail, Colo. The biosolids are transported about 75 mi east from Denver to the MWRD property and are applied to nonirrigated farmland. From 1993 to 1999, the U.S. Geological Survey (USGS), in cooperation with the MWRD, monitored the quality of shallow ground water on the MWRD central property (fig. 1 in the Data Section at the back of the report), which encompassed about 15 mi<sup>2</sup> and was the first property the MWRD purchased near Deer Trail. In 1995, the

MWRD traded some of the property and acquired additional property in the same area. The new property consisted of about 14.5 mi<sup>2</sup> known as the north property and about 50 mi<sup>2</sup> known as the south property. In 1999, the three MWRD properties together, known as the METROGRO Farm, encompassed almost 70 mi<sup>2</sup> of farmland, including land in Arapahoe and Elbert Counties. The three MWRD properties and surrounding private property are hereinafter referred to as the study area (fig. 1).

The study area is on the eastern plains of Colorado about 10 mi east of Deer Trail. The study area is on the eastern margin of the Denver Basin, a bowl-shaped sequence of sedimentary rocks that was formed in an ocean or near-ocean environment. The geology of the study area consists of interbedded shale, siltstone, and sandstone, which may be overlain by clay, windblown silt and sand, or alluvial sand and gravel (Sharps, 1980; Major and others, 1983; Robson and Banta, 1995). The primary water-supply aquifer is the Laramie-Fox Hills aquifer, which is a bedrock aquifer that ranges from 0 to about 200 ft thick in the study area and is the bottom aquifer in the Denver Basin aquifer sequence (Robson and others, 1981; Robson and Banta, 1995). Multiple alluvial aquifers are present in the study area. These aquifers are associated with the surficial drainage network but contain water of variable quality, are of limited extent, and generally yield little water (Stevens and others, 2003; Yager and Arnold, 2003). The study area is within the South Platte River drainage basin; all streams in this area drain northward to the South Platte River (U.S. Geological Survey, 1974; Seaber and others, 1987; Yager and Arnold, 2003). Short segments of some of the streams are intermittent, but in general, the streams are ephemeral and flow only after storms. No surface water flows off the MWRD properties except after storms. Most ponds in the area have been created by detention structures. Soils in the area generally are sandy or loamy on flood plains and stream terraces, clayey to loamy on gently sloping to rolling uplands, and sandy and shaley on steeper uplands (Larsen and others, 1966; Larsen and Brown, 1971).

## 2 Data for a Biosolids-Application Area near Deer Trail, Colorado, 2000

Land use in the study area was historically rangeland or cropland and pasture (U.S. Geological Survey, 1980). Some petroleum exploration was done in the area (Drew and others, 1979), but no oil or gas production took place within the study area during 2000. Land use during 2000 was rangeland or cropland. Cattle and sheep are the primary domesticated animals grazing the area, and wheat is the primary crop. Farmland is not irrigated. Land use on the MWRD properties during 2000 was primarily cropland (with biosolids applied as a fertilizer) and some rangeland.

Public concern about applications of biosolids to farmland increased after the MWRD agreed to accept treated ground water from the Lowry Landfill Superfund site in Denver. The concern was that water from the Lowry Superfund site might contain radionuclides that would then contaminate the MWRD biosolids. In January 1999, the USGS began a new monitoring program in cooperation with the MWRD and the North Kiowa Bijou Groundwater Management District. The USGS refers to the new monitoring program (1999–2005) as the “expanded monitoring program.”

The expanded monitoring program near Deer Trail is distinct from, but builds on, the previous monitoring program in which the USGS monitored the quality of shallow ground water on the MWRD central property (1993–99). Relative to the previous program, the expanded program includes a larger study area (fig. 1) (all three MWRD properties and private-property locations), more monitoring components (biosolids, soils, crops, and streambed sediments in addition to ground water), a more comprehensive list of chemical constituents, expanded statistical analyses of data, and an extended monitoring period (1999–2005). Both programs use USGS and MWRD funds. Both programs are designed, accomplished, and interpreted independently by the USGS, and quality-assured USGS data and reports are released to the public and the MWRD at the same time.

Biosolids are applied by the MWRD to their properties near Deer Trail according to agronomic loading rates. Land-applied biosolids must meet Colorado biosolids regulations for metals and radioactivity; otherwise, soils could become overloaded. Soil quality either can be improved by biosolids applications through increased nutrients and organic matter or degraded through accumulation of excessive nutrients or metals. Pesticides, herbicides, and other fertilizers also may have been applied to the MWRD properties in the past, but less information is available about these applications.

Animal waste related to grazing domestic livestock and applications of pesticides, herbicides, and fertilizers (including biosolids) can affect soil quality, crops, water quality in alluvial and bedrock aquifers, and streambed-sediment chemistry. Water quality can be affected directly by contaminated recharge water or by infiltration of water through contaminated soils or sediments (remobilization). Water quality can be affected indirectly by tilling that mobilizes or mixes subsurface chemical constituents or by contributions to natural processes such as nitrification. Contaminated ground water or surface water could contaminate other aquifers (such as

bedrock water-supply aquifers or alluvial aquifers), other surface-water bodies (ponds or streams), or streambed sediment.

The expanded monitoring program near Deer Trail addresses these concerns about biosolids applications and other farming-related effects on the environment and should increase scientific insight about Denver Basin hydrology. The objectives of this USGS program are to: (1) evaluate the combined effects of biosolids applications, land use, and natural processes on soils, crops, the bedrock aquifer, alluvial aquifers, and streambed sediments by comparing chemical data to (a) regulatory standards, (b) data from a site where biosolids are not applied (a control site), or (c) earlier data from the same site (trends); (2) monitor biosolids for trace elements and radioactivity and compare trace-element concentrations and radioactivity with regulatory standards; and (3) characterize the hydrology of the study area. The monitoring of each component (such as soil or ground water) is a stand-alone study that includes radioactivity analyses because of public concerns about effects from the Lowry Landfill Superfund site. More detailed information about the monitoring of each component is included later in this report.

### Purpose and Scope

The purpose of this report is to present information from the expanded monitoring program near Deer Trail for 2000 (January through December). This report presents data for all monitoring components of the program except soils. The report includes information about biosolids, soils, crops, ground water (alluvial and bedrock), and streambed sediment. The ground-water sections include climate data, lithologic descriptions and well-completion diagrams, hydrologic data (depth to ground water), water-quality data (chemistry and field measurements), and results of statistical testing of selected data for exceedance of regulatory standards and trends. This report does not include the hydrogeologic structure maps that were done as part of the bedrock ground-water monitoring component of the program. The structure maps were used to select bedrock-aquifer monitoring locations for the expanded monitoring program. The structure maps, along with a more detailed discussion of the hydrogeology of the region, are included in an interpretive USGS report by Yager and Arnold (2003).

This report is organized by monitoring component because each component (such as soil or ground water) is monitored as a separate study. For each monitoring component, the specific objectives, scope, approach, analytical results, quality-assurance information, and a discussion are included. Data in this report for January–June 2000 were collected by the USGS before any water transfer from the Lowry Landfill Superfund site to the MWRD treatment plant. The water transfer from the Lowry Landfill Superfund site to the MWRD began in July 2000. Therefore, some of the data in this report, along with all the data in the 1999 report (Stevens and others, 2003), provide a geochemical baseline for

each monitoring component prior to the Lowry water transfer. These baselines will enable the USGS to recognize and quantify potential chemical changes in each monitoring component from the Lowry water transfer.

## Acknowledgments

The USGS thanks all private landowners for allowing access to their properties for data collection. The USGS especially thanks the Price and Weisensee families and the MWRD for allowing USGS instrument or well installations on their property and the Kalcevic family for timely sediment information after storms and for allowing streambed-sediment sampling on their property.

## Biosolids

Biosolids are solid organic matter recovered from a sewage-treatment process that meet State and Federal regulatory criteria for beneficial use, such as for fertilizer. Land-applied biosolids must meet or exceed Grade II, Class B criteria (Colorado Department of Public Health and Environment, 1998). Grade I exceeds Grade II. The MWRD applies Grade I, Class B biosolids to its properties near Deer Trail. The biosolids-application areas, dates of application, and application rates provided by the MWRD for its properties near Deer Trail are listed in table 1 (located in the Data Section at the back of the report); application areas (called “Destination Codes”) are marked DC and shown in figure 2 (in the Data Section at the back of the report).

## Objectives of Monitoring Biosolids

The biosolids must meet regulatory standards for trace elements and radioactivity. Exceeding these standards could adversely affect the quality of soil on which the biosolids are applied and could alter MWRD plans for the application of biosolids in Arapahoe and Elbert Counties. The composition of the biosolids was monitored to provide an independently determined data set against which the MWRD chemical analyses and the regulatory standards for biosolids can be compared. The data also will constitute a chemical baseline against which any future change in the concentration of constituents analyzed for in this study may be recognized, measured, and compared.

## Approach for Monitoring Biosolids

In 2000, the USGS continued the protocol established in 1999 for monitoring MWRD biosolids for concentrations of arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, zinc, plutonium, and gross alpha and beta activity.

Radioactivity analyses were included in response to public concerns that biosolids radioactivity could increase from the transfer of water from the Lowry Landfill Superfund site.

Biosolids samples were collected directly from the MWRD facility in Denver rather than from individual trucks or fields near Deer Trail to enable the USGS to obtain a more representative sample. Normal annual sampling protocol calls for one biosolids sample to be collected each quarter. In late July 2000, however, MWRD began receiving treated water from the Lowry Landfill Superfund site. Therefore, in August 2000, the USGS initiated monthly sampling for the remainder of the year. In 2000, samples were collected for March, June, August, September, October, November, and December. The samples were prepared and analyzed at the chemical laboratories of the USGS Mineral Resources Program in Denver. The concentrations in the samples were compared to applicable Colorado standards for biosolids (Colorado Department of Public Health and Environment, 1998).

## Sampling Methods for Biosolids

Each biosolids sample is a 24-hour composite of 12 subsamples collected about every 2 hours by MWRD personnel at the MWRD facility. The subsamples were collected from the conveyor belt that transfers the biosolids into the transport trucks. Each sample was delivered to the USGS in two acid-washed, rinsed, 1-gallon plastic bottles.

## Analytical Methods for Biosolids

The biosolids material was air dried and then ground to less than 150  $\mu\text{m}$  before chemical analysis. The biosolids samples were processed and analyzed for trace elements at the laboratories of the USGS Mineral Resources Program in Denver and analyzed for radioactivity at a commercial laboratory, Acculabs in Colorado. The methods used to analyze the biosolids for each constituent are listed in table 2 (located in the Data Section at the back of the report).

## Quality Assurance for Biosolids

The purpose of the quality-assurance program developed for the biosolids monitoring component was to ensure the analytical results were within acceptable limits of both precision (the reproducibility of results) and accuracy (the degree of conformity of results for a sample having known concentrations). The precision was determined by analyzing the same biosolids sample multiple times, and accuracy was determined by analyzing National Institute of Standards and Technology (NIST) standard reference material SRM 2781, a domestic sludge. This standard reference material (SRM) was prepared by the NIST from material collected at the MWRD treatment plant in Denver. SRM 2781 has been analyzed extensively by many laboratories throughout the world, and the NIST has certified an acceptable range of values for various constituents

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in the SRM. The constituents include those of interest in this study. Each biosolids sample was submitted to the laboratories with a sample of the SRM. If the analytical results for the constituent of interest in the SRM were within the acceptable range, the results for the biosolids samples were accepted.

In 2002, the USGS became concerned about the gross alpha data for the biosolids samples. For the March 1999 through June 2000 samples, the gross alpha data from Acculabs for the NIST standard reference material 2781 (domestic sludge) ranged from 27-37 pCi/g. For the August 2000 through August 2001 samples, the gross alpha data ranged from 37- 60 pCi/g. This shift to higher values for the same standard-reference material indicates possible increasing analytical bias that could be present in the gross alpha data for the biosolids samples collected from the MWRD. Additional information about these analyses is not available because Acculabs went out of business in early 2002. Therefore, the USGS submitted split samples from a subset of the biosolids samples and NIST standard reference material to a different laboratory in an attempt to reconcile this issue. A split of the June 2000 biosolids sample and three splits of the NIST standard reference material 2781 were analyzed for radioactivity in 2002 by Severn Trent Laboratory (formerly Quanterra Analytical Services) in Richland, Wash., under a contract with the USGS National Water Quality Laboratory (NWQL).

### Biosolids Data

Summaries of all the chemical analyses for trace-element concentrations and radioactivity data (gross alpha activity, gross beta activity, and plutonium concentration) for the biosolids samples collected in 2000 are listed in table 3 (in the Data Section at the back of the report). The tables also list the maximum allowable concentrations for Grade I biosolids. Radioactivity data for the same samples from two different laboratories are listed in table 4 (at the back of the report).

### Discussion of Biosolids Data

All trace-element concentrations were less than the maximum allowable concentrations established for Grade I biosolids. The data from Severn Trent Laboratory (STL) compare with the Acculabs data from 2000. No significant analytical bias or variability likely is present in the 2000 biosolids data from Acculabs.

### Soils

Biosolids can contain elevated concentrations of certain trace constituents. Therefore, the application of biosolids to farmland has caused public concern regarding the potential short-term and long-term effects on soil quality.

### Objectives of Monitoring Soils

Soils were monitored for trace elements and plutonium and gross alpha and gross beta activity to establish independent geochemical data sets for the composition of soil before and after the application of biosolids. The data will enable the USGS to recognize and quantify significant changes in soil composition caused by the application of biosolids to agricultural soils or by other natural or human-induced processes.

### Approach for Monitoring Soils

In August 1999, the USGS began monitoring soils on two sites, one site on MWRD property in Arapahoe County and one site on MWRD property in Elbert County. The sites were monitored for arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, zinc, plutonium, and gross alpha and beta activity. Radioactivity analyses were included in response to public concerns that biosolids radioactivity could increase from the transfer of water from the Lowry Landfill Superfund site. Soil samples were collected once during 1999, before the application of biosolids to monitoring sites, and the data were reported in quarterly reports and in the annual data report for 1999 (Stevens and others, 2003). Soil monitoring will continue through two cycles of biosolids application and crop harvest, and soil sampling will be done shortly after each harvest.

### Site Selection for Monitoring Soils

Sites were selected on MWRD properties where biosolids have never been applied. One site was selected on the MWRD north property in Arapahoe County, and one site was selected on the MWRD south property in Elbert County. The Arapahoe County site is located in T. 4 S., R. 58 W., sec. 22 and lies about 0.25 mi west of Badger Creek (fig. 3). The Elbert County site is located in T. 6 S., R. 57 W., sec. 8 and lies immediately west of Beaver Creek (fig. 4).

### Sampling Methods for Soils

The sampling protocol was designed to answer the following question: What is the average composition of the top 12 inches of soil in each of the six 20-acre fields? To address this question, a standard soil auger was used to collect samples to a depth of 12 inches according to a systematic grid pattern. For each of the two fields to which biosolids will be applied, 36 subsamples are collected on approximately 133-ft centers. A similar grid is used to collect 36 subsamples from the southern "control" field on the Arapahoe County site. For the remaining three "control" fields, 30 subsamples are collected at approximately 155-ft centers.

## Analytical Methods for Soils

All soil subsamples are air dried at ambient temperature in the laboratories of the USGS Mineral Resources Program in Denver. Each of the dried subsamples is disaggregated and sieved to less than 2 mm. This minus-2-mm material then is ground to less than 150  $\mu\text{m}$ . Splits of each subsample are taken for archival storage, and the subsamples for each field are composited into one sample for chemical analysis. The composite soil samples, each representing one 20-acre field, are analyzed by the methods listed in table 2.

## Quality Assurance for Soils

The accuracy of the soil analysis was ensured by the analysis of NIST SRM 2709, an agricultural soil. Separate splits of this SRM were randomly placed among the soil samples and submitted to the laboratories. If the analytical results for the constituent of interest in the SRM are within an acceptable range, analytical results for the soil samples are accepted. Separate splits of each composited soil sample are analyzed independently and the results averaged to determine the concentration reported for a given constituent.

## Soil Data

In 2000, the Elbert County monitoring site was sampled in late November after the wheat harvest. The Arapahoe County site was not sampled until June 2001. The samples from both sites were submitted to the laboratories for analysis in September 2001. Data for both these sites will be presented in progress reports as the data become available and in the annual project data report for 2001.

## Crops

As previously mentioned, biosolids can contain elevated concentrations of certain trace elements. The application of biosolids to farmland on which grain crops are grown that will eventually be consumed by animals or humans has led to public concern about the composition of the crops grown on the fields receiving biosolids. Both the Arapahoe and Elbert County sites were originally planted in wheat during the winter of 1999–2000. The wheat on the Elbert County site reached maturity and was harvested in July 2000. The wheat crop on the Arapahoe County site failed and the field was plowed under in May 2000. Approximately the western one-half of the site was replanted with millet during spring 2000; the millet reached maturity and was harvested in September 2000.

## Objectives of Monitoring Crops

Crops were monitored for trace elements (and selected samples were monitored for plutonium and gross alpha and gross beta activity) in order to establish independent chemical data sets for the composition of the crops before and after the application of biosolids. The data will enable the USGS to recognize and quantify significant changes in crop composition caused by the application of biosolids to agricultural soils or by other natural or human-induced processes.

## Approach for Monitoring Crops

In the summer of 2000, the USGS began monitoring crops grown on the same two sites where soils were monitored. One of these sites is on MWRD property in Arapahoe County, and one site is on MWRD property in Elbert County. The crops were monitored for arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc. One sample from the Elbert County site was analyzed for plutonium and gross alpha and beta activity in response to public concerns that biosolids radioactivity could increase because of the transfer of water from the Lowry Landfill Superfund site.

Crops grown on fields that receive biosolids applications were monitored along with crops grown on fields that do not receive biosolids applications. The crops from fields that do not receive biosolids applications were used as a reference for comparison. Each of the two crop- and soil-monitoring sites consisted of three 20-acre (933-ft by 933-ft) fields separated by 100-ft buffer zones (figs. 3 and 4, in the Data Section at the back of the report). In 1999, the center 20-acre field at each site received a single biosolids application after the initial soil sampling. The other two 20-acre fields at each site will not receive biosolids and will be used as “control” fields to determine the natural variability of soil and crop composition for the duration of the study. All three 20-acre fields at each site are farmed the same way as the rest of the MWRD property and have crops planted and harvested. Crop samples from each of the six fields were collected in the summer of 2000. Data will be compared after each sampling and at the conclusion of the study to determine how the concentrations of the constituents of interest vary with time.

## Site Selection for Monitoring Crops

The soil-monitoring fields (figs. 3 and 4) also will be used for monitoring crops. Crops are planted on each of the six 20-acre soil-monitoring fields. Sites were selected on MWRD properties where biosolids have never been applied. One site was selected on the MWRD north property in Arapahoe County, and one site was selected on the MWRD south property in Elbert County. The Arapahoe County site is located in T. 4 S., R. 58 W., sec. 22 and lies about 0.25 mi west of Badger Creek (fig. 3). The Elbert County site is located in

T. 6 S., R. 57 W., sec. 8 and lies immediately west of Beaver Creek (fig. 4).

## Sampling Methods for Crops

The sampling protocol for crops was designed to determine the average composition of the crop in each of the six 20-acre fields. For the Elbert County site, whole wheat plants were collected about one month prior to harvest. For this collection, stainless-steel pruning shears were used to cut the plants about 3 inches above the ground. Approximately 30 subsamples of wheat plants were collected randomly in each of the three 20-acre fields. One month later, immediately before harvest, samples of the mature wheat grain were collected. Stainless steel pruning shears were used to cut the plant about 2 inches below the seed head. Again, about 30 subsamples were collected at random in each 20-acre field.

The wheat crop at the Arapahoe County site failed and was plowed under. The only wheat that remained was in a few scattered parts of each 20-acre field; the north control field was almost devoid of wheat plants. Most of the few plants that were still growing in the north control field were removed as whole-plant samples. Few wheat plants remained to produce seed heads. Samples of whole plants and seed heads were collected, if possible, from these limited areas of the fields. About 30 wheat subsamples were collected from the areas where wheat remained in each field. Approximately the western one-half of the Arapahoe County site was replanted with millet. At maturity (September 2000), seed heads were collected from millet in each of the three 20-acre fields. Stainless-steel pruning shears were used to cut the millet plant about 2 inches below the seed head. About 30 millet subsamples were randomly collected throughout each of the three 20-acre fields.

## Analytical Methods for Crops

Whole wheat-plant samples (hereinafter referred to as "wheat-plant samples") were dried under forced air at room temperature and were then ground to less than 2 mm using a standard Wiley mill. A split of the dried and ground wheat sample was ashed in a forced-air muffle furnace at 450°C. The ashed aliquot was analyzed for cadmium, copper, molybdenum, nickel, lead, and zinc by using a standard four-acid digestion followed by detection with an inductively-coupled-plasma mass spectrometer (Briggs and Meier, 1999). The ash values were then converted to a dry weight basis by using the ash conversion factor. The dried, unashed material was analyzed for arsenic and selenium by using a standard wet oxidation digestion followed by hydride-generation atomic absorption spectrometry (Hageman and Welsch, 1996). Mercury concentration of the dried, unashed material was determined by cold-vapor generation atomic absorption spectrometry after digestion in nitric acid – dichromate solution (O'Leary and others, 1996). Gross alpha activity, gross beta activity,

and plutonium concentration were determined by standard radiological counting methods (Greenberg, 1992; Whittaker and Grothaus, 1979; Lyon, 1980).

The grain samples were dried under forced air at room temperature. For wheat samples, the grain was separated from the head by using a test plot thrashing machine at Colorado State University. The grain was cleaned using forced air and sieving. For millet samples, the grain was separated from the head by placing the entire sample in a heavy plastic bag and manipulating the heads by hand to free the grain. The grain was cleaned using forced air and sieving. The clean samples of wheat and millet grain were then ground to a flour using a commercial table-top mill. A split of each ground sample was ashed in a forced-air muffle furnace at 450°C. The ashed grain samples and the dried, unashed grain samples were subjected to the same analytical protocol discussed previously for ashed and unashed whole-wheat samples.

## Quality Assurance for Crops

The accuracy of the crop analysis was ensured by the analysis of NIST SRM 2709, an agricultural soil. Separate splits of this SRM were randomly placed among the crop and soil samples and submitted to the laboratories. If the analytical results for the constituent of interest in the SRM are within an acceptable range, analytical results for the crop samples are accepted. Separate splits of each composited crop sample are analyzed independently and the results averaged to determine the concentration reported for a given constituent.

## Crop Data

Wheat-plant samples were collected from the Arapahoe and Elbert County sites on June 7, 2000. Mature wheat-grain samples (seed heads) were collected from each site on July 6, 2000. Millet-grain samples were collected from the Arapahoe County site on September 27, 2000. The trace-element and radioactivity data for the crops are listed in tables 5-7 (in the Data Section at the back of the report).

## Discussion of Crop Data

Because most of the Arapahoe County site was plowed under, it was impossible to collect a sample that was representative of the entire field. Therefore, the wheat-plant and wheat-grain data for the Arapahoe County site will have questionable value for monitoring purposes. Again, because of the limited area of the Arapahoe County site that was planted in millet, the millet-grain samples may not be representative of the entire site, and their value for monitoring purposes is questionable. The sample data, however, will help establish baseline and background values for wheat and millet for the Arapahoe County site.

## Ground Water

Applications of pesticides, herbicides, or fertilizers (including biosolids) to the land surface can affect the quality of shallow ground water directly by contaminated recharge or by infiltration through contaminated soils or sediments (remobilization). These applications also can affect the quality of shallow ground water indirectly by tilling (which could mobilize subsurface constituents) or by contributions to natural processes such as nitrification. Further, discharge from contaminated alluvial ground water could contaminate surface water (ponds or streams) or bedrock water-supply aquifers. For this report, alluvial ground water is defined as the water contained in subsurface, unconsolidated (uncemented), wind- or water-transported sediments in current or historical stream channels or flood plains. Bedrock ground water is defined as the water contained in the fractures or pore spaces of the rock (consolidated sediments) that underlies soil or other uncemented materials; the primary bedrock aquifer in the study area is the Laramie-Fox Hills aquifer (Robson and Banta, 1995). Alluvial and bedrock ground water are separate components in the monitoring program but are combined in this report because the data were collected in the same way and the types of data included are the same.

### Objectives of Monitoring Ground Water

Ground water was monitored to characterize the hydrology and water quality of the aquifers; to determine if concentrations of nitrate, arsenic, cadmium, copper, chromium, lead, mercury, molybdenum, nickel, selenium, zinc, and plutonium and gross alpha and gross beta activity in the ground water are significantly greater than regulatory standards; and to determine if concentrations of these constituents are increasing with time in ground water at or near the MWRD properties.

### Approach for Monitoring Ground Water

Structure maps of the top and base of the Laramie-Fox Hills aquifer were compiled for the study area by using available information such as geophysical logs from oil and gas exploration and other data. The structure maps are included in an interpretive USGS report by Yager and Arnold (2003). The structure maps were used to determine locations for well pairs: two bedrock-aquifer wells and two alluvial-aquifer wells that constitute the recharge-evaluation sites. Multiple wells in the same location enable different zones of ground water to be monitored without having to consider spatial variability and can enable inferences about vertical directions of ground-water flow between zones. Each of the two bedrock-aquifer wells are nested, which means each borehole has two separate piezometers screened at two separate zones. Therefore, three different aquifer zones are monitored at each of the two recharge-evalu-

ation sites in Muddy Creek downgradient from the MWRD properties (fig. 1). Lithologic and well-completion information for these wells is included in the 1999 data report (Stevens and others, 2003). An additional well, DTX11, was drilled in January 2000 to provide additional information about a deeper coarse-grained part of the Muddy Creek alluvial aquifer than is monitored by well DTX9. Completion information for well DTX11 is provided in figure 5 (in the Data Section at the back of the report). In 2000, electronic data-logger (EDL) equipment was installed to continuously monitor precipitation and water levels in wells DTX9, DTX10, and DTX11, and to provide more detailed information about ground-water recharge at that location. These EDL data are included in this report but are not available on the Internet.

Monitoring wells for the expanded monitoring program include selected wells installed as part of the previous monitoring program and new wells. Of the 33 USGS ground-water monitoring wells from the previous study on the MWRD central property, 7 are included in this study (all 7 wells were monitored for water levels, and water-quality samples were collected from 6 of these wells). “D”-numbered wells were drilled before 1999 as part of the previous monitoring program, and “DTX”-numbered wells were drilled in 1999 (fig. 1). Lithologic and well-completion information for these well locations is provided by Stevens and others (2003).

Water levels in the monitoring wells were measured monthly. Data-collection platforms (DCP’s) with various sensors were installed during summer and fall of 1999 at three alluvial-aquifer wells (D25, DTX2, and DTX5) to continuously monitor ground-water levels, water temperature, precipitation, and air temperature. The data were transmitted to Denver by satellite and were available on the Internet. The data provided information about the hydrology in the study area and the response of ground water to climate variables.

Water samples were collected from alluvial-aquifer wells on the MWRD properties (fig. 1), and water samples were collected from the shallowest zones of the bedrock aquifer at three locations that are important to alluvial/bedrock ground-water interactions. The remaining USGS monitoring wells were used to provide hydrologic information only. Water samples were collected and analyzed quarterly for physical properties, dissolved major ions and trace elements, and dissolved and total nutrients. Analyses were done by the USGS National Water-Quality Laboratory (NWQL) and included nitrate, arsenic, cadmium, copper, chromium, lead, mercury, molybdenum, nickel, selenium, and zinc. Samples also were collected and analyzed annually for total plutonium. Gross alpha and gross beta activity analyses were included in the 1999 monitoring but were discontinued because of matrix-interference problems caused by the high concentrations of dissolved solids in the ground-water samples. The plutonium and gross alpha and gross beta activity analyses were included in response to public concerns that radioactivity in biosolids could increase from the transfer of water from the Lowry Landfill Superfund site. Water levels and field measurements such as pH and specific conductance were recorded with the collection of each ground-

water sample. Blank and replicate samples were analyzed to evaluate bias and variability of the ground-water data. All water-quality data are maintained in a USGS database, and selected data were published in the "USGS Expanded Monitoring Program Near Deer Trail" quarterly reports. Selected water-quality data will be statistically analyzed each year of the program and after about 5 years to determine (1) if concentrations in the ground water are significantly greater than regulatory standards and (2) if the concentrations are increasing significantly with time.

## Site Selection for Monitoring Ground Water

Shallow aquifers can be recharged by runoff and streamflow or can contribute water to streamflow and ponds. Therefore, the sites for alluvial-aquifer wells were selected by the USGS according to the following criteria: (1) locations in proximity to a stream channel that could carry runoff from MWRD biosolids-applied fields, (2) locations at the most downstream point of the drainage basin, (3) locations at MWRD property boundaries to represent the condition of ground water leaving the properties and to consider only those effects from activities on MWRD properties and not from other landowners, (4) locations where most of the upstream basin is on MWRD property, (5) locations that represent the larger drainage basins, (6) locations where USGS monitoring wells already existed and where data already had been collected, and (7) locations accessible year round for drilling and sampling wells. Alluvial-aquifer wells were not installed upgradient from MWRD property boundaries because the constituents of concern generally are not conservative along the ground-water flow path; that is, subtracting upgradient concentrations from downgradient concentrations may not represent the effects of biosolids on the ground water for these constituents. Monitoring alluvial ground water near Rattlesnake Creek was a low priority because most of the basin is upstream from the MWRD properties, and that part of the basin that receives biosolids is relatively small. Therefore, the USGS installed two alluvial-aquifer wells on the MWRD north property and four on the MWRD south property (fig. 1); all wells on the MWRD central property used for this study (fig. 1) were installed before 1999 as part of the previous monitoring program.

Bedrock aquifers can be recharged by alluvial ground water or can be a source of water to alluvial aquifers. Therefore, the sites for bedrock-aquifer wells were selected by the USGS according to the following criteria: (1) locations where a particular sandstone sequence within the Laramie-Fox Hills aquifer is present at substantial areal extent and thickness, (2) locations on MWRD property where the bedrock aquifer is present without an alluvial aquifer, (3) locations where the bedrock aquifer is present beneath an alluvial aquifer that could be affected by the application of biosolids, (4) locations where USGS monitoring wells already existed and where data already had been collected, and (5) locations accessible year

round for drilling and sampling wells. Locations where the particular sandstone sequence within the bedrock aquifer is present in this area were determined by the USGS on the basis of the USGS structure map (completed in 1999) of the base of the Laramie-Fox Hills aquifer in this area. For the expanded monitoring program, the USGS installed two new bedrock-aquifer wells (DTX8 and DTX10) in 1999, along with corresponding alluvial-aquifer wells (DTX7 and DTX9) (fig. 1), at locations where the bedrock aquifer is present beneath the Muddy Creek alluvial aquifer; the Muddy Creek alluvial aquifer could be affected by the application of biosolids. One previously installed USGS ground-water monitoring well, D29 (fig. 1), was included in this monitoring program because the well is on MWRD property where the bedrock aquifer is present without an alluvial aquifer, and prior sampling data are available.

DCP sites provided information about the variability in space and time of climate and hydrology in the study area as well as about the hydrologic responses to climate. This monitoring program includes three DCP sites, one on each of the MWRD north, south, and central properties (wells DTX2, DTX5, and D25, respectively). The locations of these DCP sites were selected according to the following criteria: (1) locations where alluvial-aquifer wells are sampled, (2) locations near possible streambed-sediment sampling drainages (to indicate likely runoff conditions), (3) locations near other wells so the information may apply to more than one well, (4) locations far enough apart from each other to indicate spatial variability in hydrology, (5) locations needing additional hydrologic information to explain chemical variability (well D25), and (6) locations accessible year round.

## Sampling Methods for Ground Water

All data-collection methods used in 2000 were the same as the 1999 methods, which are detailed in the 1999 data report (Stevens and others, 2003). Monthly water-level measurements were made using a vinyl-coated electric tape. DCP and EDL data were automatically recorded hourly. Water-quality samples were collected quarterly using standard USGS methods (Horowitz and others, 1994; Wilde and others, 1998-99). All sampling equipment was used exclusively by the USGS and was used only in the study area to prevent cross contamination from other sites in other study areas. All samples and sampling equipment were kept at all times in the custody of the USGS in locked, guarded facilities.

## Analytical Methods for Ground Water

Ground-water samples were submitted to the USGS NWQL in Denver. Most analyses were done by the NWQL. Plutonium analyses were done by Severn Trent Laboratory in Richland, Wash., under a contract with the USGS NWQL; all other analyses were done at the NWQL. The methods used to

analyze the ground-water samples are listed in table 8 along with laboratory minimum reporting levels (MRL) for the elements of interest and minimum detectable concentrations (MDC) for the radiochemical samples.

## Quality Assurance for Ground Water

Quality-assurance procedures were implemented during the course of the monitoring program to ensure the quality of the data. Procedures were implemented for water-level measurements, DCP-data and core-data collection, ground-water-sampling preparation, field-parameter measurements, ground-water sampling, and laboratory analysis. Quality-assurance procedures are detailed in the 1999 data report (Stevens and others, 2003).

## Ground-Water Data

Monitoring at ground-water sites during 2000 produced meteorologic, hydrologic, and water-quality data. Meteorologic data include precipitation and air temperature at three sites. Hydrogeologic data include the lithologic description of the cores and a well-completion diagram for the new well drilled in 2000, DTX11. Hydrologic data include monthly water levels at all wells and hourly water levels and water temperature at three DCP sites. Water-quality data include analytical results from quarterly sampling.

## Meteorologic Data

Precipitation and air temperature were recorded hourly during 2000 at wells D25, DTX2, and DTX5 (figs. 6 through 8 in the Data Section at the back of the report). Precipitation was recorded hourly during April–December 2000 near well DTX11 (fig. 9 in the Data Section at the back of the report). Rain occurred during thunderstorms and frontal storms, usually during April–October. The precipitation data recorded during October through December could represent melted snow. The data indicate air temperatures can fluctuate more than 20°C during the day but were similar for all monitored sites.

## Hydrogeologic Data

Well DTX11 was cored by the USGS during drilling in 2000 to provide information about ground water and geology at the new well location. The lithologic description for the well is listed in table 9 (at the back of the report). The details of DTX11 well construction are given in the well-completion diagram shown in figure 5. Lithologic descriptions and well-completion information for the other monitoring wells are provided in the 1999 data report (Stevens and others, 2003).

Well information also is summarized in table 10 (at the back of the report). These details, which include the depth of well, screened interval, materials used, and stickup (fig. 5), provide a physical context for the other ground-water data, such as water levels, and should be considered when comparing data for different wells.

## Hydrologic Data

Monthly water-level data and continuous water-level and water-temperature data can be useful for describing the hydrology of the aquifers in the area near Deer Trail. The monthly water-level data for the USGS monitoring wells used in this study are listed in table 11 (at the back of the report), and the continuous water-level and water-temperature data for the three DCP sites (D25, DTX2, and DTX5; fig. 1) are shown in figures 6–8 (at the back of the report). Continuous water-level data for the EDL site (wells DTX9, DTX10, and DTX11; fig. 1) and precipitation data are shown in figure 9 (at the back of the report). Monthly water-level data are listed as depth to water below measuring point at a specific time. Continuous water-level data are shown as daily maximum depth to water below land surface. Water-level data can indicate seasonal effects and can aid in the interpretation of chemical data.

Water-level data also can indicate ground-water recharge information. Robson and others (1981) showed that recharge of the Laramie-Fox Hills aquifer along the margin of the Denver Basin (such as in the Deer Trail area) can be from deeper parts of the Denver Basin, from alluvial aquifers and surficial features, or from infiltration of precipitation on or near outcrop areas. Recharge of the alluvial aquifers in the Deer Trail area can be from the Laramie-Fox Hills aquifer, from surface-water features, or from infiltration of precipitation (Robson and others, 1981). Hydrologic interactions between alluvial and bedrock aquifers can be inferred using water-level data for the same point in time for wells drilled into the aquifers at the same site. The direction of the vertical movement of ground water, or the recharge direction, may be indicated by noting that water moves from areas of high hydraulic head (high water-level elevation) to areas of low hydraulic head (low water-level elevation). For the expanded monitoring program, such interactions were monitored at two recharge-evaluation sites, each of which included one alluvial-aquifer well and one bedrock-aquifer well. The interactions in the bedrock aquifer were monitored in two different zones (designated by “A” [shallow] or “B” [deep] after the well name). Therefore, three aquifer zones (one alluvial, one shallow bedrock, and one deep bedrock) were monitored at the north recharge-evaluation site (wells DTX7 and DTX8), and four aquifer zones (two alluvial, one shallow bedrock, and one deep bedrock) were monitored at the south recharge-evaluation site (wells DTX9, DTX10, and DTX11). Water levels for the paired alluvial-aquifer and bedrock-aquifer wells at the two recharge-evaluation sites are shown in figure 10 (at the back of the report) for the north recharge-evaluation site at discrete

time periods, and in figure 11 (at the back of the report) for the south recharge-evaluation site continuously for the year. The July water levels shown in figure 10 represent hot, dry summer conditions; the August and September water levels shown in figure 10 represent summer-recharge (rainy) conditions.

## Water-Quality Data

Water-quality data for samples collected quarterly from 11 alluvial-aquifer and 3 bedrock-aquifer wells (fig. 1) in 2000 are listed in tables 12 and 13 (at the back of the report). Data are given for field parameters, physical properties, major ions, nutrients, and trace elements. In addition, radioactivity data are given for January and October 2000. Quality-control water-quality data for the blank samples are listed in table 14 (at the back of the report), and comparison data for replicate samples are listed in table 15 (at the back of the report).

## Discussion of Ground-Water Data

Concentrations for the blank samples (table 14) generally indicate little or no contamination bias. January data indicate a possible slight contamination bias in aluminum, and April data indicate a possible slight contamination bias in nitrogen and zinc from field processing or laboratory analyses. Blank samples were collected April 21, 2000, using the submersible pump, and these data indicate a possible slight contamination bias in concentrations of calcium, magnesium, copper, iron, strontium, and zinc (table 14). This pump is used only at wells DTX8, DTX10, and D29, so only samples from these wells may be affected. Most concentrations for the blank samples were much less than those for the ground-water samples. Data for rerun samples (not included in this report) indicate slight contamination bias in laboratory analyses of aluminum, arsenic, copper, nickel, and zinc. Therefore, the sample data that indicate small concentrations of aluminum, arsenic, copper, nickel, and zinc could be affected by a slight high bias.

The relative percent differences (RPD) between the ground-water samples and the replicate samples were computed to summarize sample variability (table 15). Many of the larger RPD's are due to values or concentrations near the MRL where precision is expected to be poor. In these cases, concentrations may vary little but result in large RPD's. For example, a ground-water sample concentration of 0.01 mg/L and a replicate-sample concentration of 0.02 mg/L would result in an RPD of 67 percent, but the difference might be considered to be within the precision of the method at that concentration. Data values for individual replicate pairs also are listed in table 15 to help determine if large RPD's are the result of substantial differences between replicate-sample concentrations or just small differences between small concentrations. Some RPD's for potassium and nickel, however, likely are large because a few of these concentrations are affected by

analytical bias (table 13). The replicate-sample data indicate generally reproducible analytical results.

The radioactivity data in table 13 are reported in the uncensored form, as received from the laboratory, rather than censored by either the contract or calculated minimum detectable concentration (MDC). Relative to the censored form (data reported as less than the MDC), the uncensored form provides more information about the uncertainty and the very small plutonium concentrations. The negative activity reported for some of the radiochemical samples means the sample counts were less than the laboratory background counts for that day. Radioactivity data are produced from instruments that detect radioactive decay (disintegrations) in a sample as counts per minute. The background counts were subtracted from the sample counts, and the resulting value was converted to activity-concentration units of picocuries per liter. Gross alpha and gross beta activity could not be analyzed in the ground-water samples because of interference effects related to the ionic strength of these samples.

In general, the expanded monitoring program is too new for sufficient data to have been collected for meaningful interpretation of the ground-water data. However, the data included in this report indicate alluvial- and bedrock-aquifer hydrology and chemistry are variable in space (from site to site) and in time (from one data-collection time to the next at the same site) in the study area. Water-quality data in this report for samples before July 2000 provide baseline information for concerns about possible contamination of the study area from the Lowry Landfill Superfund site water transfer; no water from the Lowry site was transferred to MWRD until July 2000.

The USGS was asked to evaluate the water-quality data for biosolids effects each year of the monitoring program. Therefore, the results for selected constituents were tested to determine if statistical evidence indicated exceedance of regulatory standards and a monotonic trend in concentration with time.

## Regulatory Standards

Regulatory standards that might be used as guidelines to evaluate the ground-water quality in the study area are the human health standards and agricultural standards enforced by the State of Colorado (Colorado Department of Public Health and Environment, 1997). For this report, a one-tailed Sign Test (Helsel and Hirsch, 1995) was used to indicate the level of statistical evidence that selected median constituent concentrations were significantly greater than regulatory standards. The hypotheses tested were as follows:

- $$H_o = \text{median concentration is less than or equal to the regulatory standard, and}$$
- $$H_a = \text{median concentration is greater than the regulatory standard.}$$

A small p-value result from the Sign Test indicates  $H_0$ , the null hypothesis, should be rejected. The confidence level in rejecting  $H_0$  and, therefore, accepting  $H_a$  can be determined by subtracting the p-value from 1 and multiplying by 100. The confidence level also can be thought of as the probability (in percent) that the regulatory standard has been exceeded by the median concentration (table 16 at the back of the report). For example, if the Sign Test for a constituent results in a p-value of 0.100, there is a 90-percent confidence level or probability that the median concentration for that constituent is greater than the regulatory standard. The results of the statistical testing of the data for the 11 alluvial-aquifer wells and 3 bedrock-aquifer wells for exceedance of regulatory standards for 11 constituents identified as important by the public are listed in table 16. Nitrate concentrations at well D6 were the only data that had a statistically significant probability that the median concentration exceeded the regulatory standard.

Because quarterly samples have been collected for only 2 years to date, the power of the statistical test (level of statistical evidence) is low. As sampling continues, the power of the test will increase. Radioactivity data were not statistically tested because few radiochemical samples, an insufficient number of samples for statistical testing, were collected at each well since 1999. The distribution of concentrations at each well for selected constituents during 2000 and the regulatory standards used to test the ground-water data are shown in figure 12 (at the back of the report). Time-series graphs (concentration plotted with time) of selected constituents for selected wells are included as figure 13 (at the back of the report).

## Trends

Upward monotonic trends in concentration mean that concentration for a parameter increases over time, although not necessarily in a straight line. These upward trends could indicate biosolids, other farm practices, grazing, or even natural processes such as geochemical dissolution are affecting ground water. For this report, the Kendall's tau statistic (Helsel and Hirsch, 1995) was used as an indicator of monotonic correlation between concentration and time. Kendall's tau is a number between negative one and positive one where values approaching negative or positive one indicate increasing strength of the correlation and a number approaching zero indicates decreasing strength of correlation. Positive values of Kendall's tau indicate upward trends, and negative values indicate downward trends. The results of the statistical testing of the data for monotonic trends in 11 constituents identified as important by the public are listed in table 17 (at the back of the report). A p-value is listed to indicate the level of significance of the coefficient, the tau value. The p-value must be less than or equal to 0.05 for tau to be significant with at least 95-percent confidence. Values in table 17 indicating statistically significant trends are shown in bold. Radioactivity data were not statistically tested because only three radiochemical samples, which is an insufficient number of samples for

statistical testing, have been collected at each well since the program began in 1999.

If all data for a constituent were less than the MRL, no trend could be identified (such as for lead at any of the wells). If at least one concentration value for a constituent at a well was greater than the MRL, the data were analyzed for trend. Many of the reported concentrations included in the trend analysis were less than the MRL, and the MRL varied for most of the constituents. Therefore, the trends evaluated by the statistical analyses may be artificial--that is, the difference in MRL, not differences in concentration, may result in an apparent trend. However, none of the statistically significant trends (table 17, values in bold type) were caused by changes in the MRL. The results of trend analysis on the 1999 plus 2000 combined data set (table 17) commonly were different than the results of trend analysis on only the 1999 data set (Stevens and others, 2003). Some of the trend directions changed from upward to downward trends or from downward to upward trends when the 1999 data were retested with the 2000 data, and significance of the trend result increased. Some of these changes may be caused by the low power of the test when few data are used in the test (as in 1999), by changes in the MRL as mentioned previously, or because seasonal effects have not been considered (too few data). Because quarterly samples have been collected for only 2 years to date, the power of the trend test is still low, and too few data are available to consider seasonal effects. As sampling continues, the power of the test will increase and the amount of data available will enable seasonal effects to be removed. Time-series graphs (concentration plotted with time) of selected constituents for selected wells are included as figure 13 (at the back of the report).

## Streambed Sediment

Animal waste related to grazing livestock and applications of pesticides, herbicides, or fertilizers (including biosolids) to the land surface could affect surface-water quality directly by contaminated inflow or by runoff over contaminated soil or sediment (remobilization). These applications also can affect surface-water quality indirectly by tilling that mobilizes or changes surface constituents or surface characteristics; by inflow, base flow, or recharge to surface water from contaminated ground water; or by contributions to natural processes such as nitrification. Contaminated surface water could contaminate downstream, previously uncontaminated ponds, streams, streambed sediments, alluvial aquifers, or bedrock water-supply aquifers in aquifer-recharge zones.

Surface-water contamination from biosolids applications is a public concern. However, because streams flow off the MWRD properties only after intense thunderstorms, surface-water sampling is impractical, and monitoring extreme surface-water events is difficult. Monitoring streambed-sediment chemistry is more practical and cost effective and offers greater opportunity to establish comparison or baseline sites

than monitoring surface-water chemistry. For the expanded monitoring program, streambed sediment is defined as the fine-grained alluvium freshly deposited in the drainage bottoms by surface-water flow after rainstorms.

Sediment affected by the application of biosolids could be transported off MWRD property into streambeds when precipitation is intense enough to cause overland flow. Therefore, streambed-sediment chemistry is used as an indirect indicator of surface-water quality because of the close contact between surface flows and sediment during transport. Contaminants in the streambed sediment could cause contamination in ground water or surface water if the contaminants are resuspended in water or leached from the bed sediment. Furthermore, concentrations of trace elements and plutonium and gross alpha and gross beta activity may be higher in the bed sediment than in the surface water.

## **Objectives of Monitoring Streambed Sediment**

Streambed sediments were monitored to determine if concentrations of nitrate, arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, zinc, organic carbon, gross alpha and beta radioactivity, and plutonium in sediments derived from (or transported through) biosolids-application areas are significantly higher than in bed sediments derived from nearby farmland that did not receive biosolids applications.

## **Approach for Monitoring Streambed Sediment**

Two small drainage basins were selected for comparison of streambed-sediment chemistry (fig. 1). The basins have similar physical characteristics, but one basin (known as the biosolids-applied basin) receives biosolids applications and is part of the MWRD farming program, and the other basin (known as the control basin) receives no biosolids applications and is farmed privately.

A DCP site (with a rain gage) is near the biosolids basin. The DCP data were transmitted remotely to enable the USGS to determine when rainfall of sufficient intensity and duration had occurred near the basins. For sampling to take place, sufficient rainfall was needed to cause the fine-grained materials and dissolved constituents to wash off the hillsides of the basins into downgradient streambeds.

Paired streambed-sediment samples were collected when freshly deposited streambed sediment was available from both the biosolids basin and the control basin at the same time (after the same storm). The USGS was able to collect only one paired sample during 2000 despite several attempts. The USGS determined that at least 0.5 inch of rain in a single hour had to be received by the tipping-bucket rain gage at DTX2 to cause sufficient runoff in the biosolids-applied basin that a streambed-sediment sample could be collected. This rainfall scenario occurred only once in 2000.

Streambed-sediment samples were analyzed for nitrate, phosphorus, aluminum, arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, zinc, carbon, gross alpha and beta radioactivity, and plutonium. The radioactivity analyses were included in response to public concerns that biosolids radioactivity concentrations could increase from the transfer of water from the Lowry Landfill Superfund site. When sufficient storms occur, three to four paired samples per year are planned. When enough paired samples are collected, data will be statistically tested to determine if streambed-sediment chemistry is significantly different between the two basins.

## **Site Selection for Monitoring Streambed Sediment**

Several pairs of similar small basins (one on MWRD property and one on nearby private property) were considered by the USGS for monitoring. Only small (less than 5-mi<sup>2</sup>) basins were considered because (1) the large biosolids basins did not have a nearby corresponding control basin that had similar characteristics, (2) the thunderstorms likely to cause runoff were usually localized and were not likely to affect two large basins with the same duration and intensity, (3) sampling is more efficient in small basins because each streambed-sediment sample is a composite of sediment collected throughout the basin, and (4) the large basins in the study area are more variable with respect to geology, soil type, and land use. Sediment collected from the large basins is more likely to be affected by this variability and, therefore, may not indicate effects from biosolids. The criteria used to pair basins included distance between basins; proximity to a USGS ground-water-monitoring well that included DCP instrumentation; land use (farmed); likely accessibility even after severe thunderstorms; and similar bedrock geology, soil type, aspect, stream order, channel length, channel slope, relief, and ponding. From the three basin pairs identified as candidates for streambed-sediment monitoring (Stevens and others, 2003), the pair on Badger Creek tributaries (on and near the MWRD's north property) was selected. The selected basins are shown as streambed-sediment sampling areas in figure 1.

## **Sampling Methods for Streambed Sediment**

Before sampling, equipment was field washed with phosphate-free detergent, rinsed three times with deionized (DI) water and wrapped in clean plastic bags for transport to the next site. Trace-element sampling equipment received an additional rinse with 5-percent trace-element-grade nitric-acid solution and three more rinses with DI water. Clean sieve cloth was used for each site. The trace-element equipment was allowed to air dry and was stored in plastic bags until use. Stainless-steel equipment (which was not used to prepare trace-element samples) was allowed to air dry and was

wrapped in aluminum foil and stored in sealed plastic containers.

DCP data transmitted by satellite to the USGS were monitored daily throughout the year to determine the occurrence, intensity, and duration of rainfall in the study area. If sufficient rainfall in the area of the paired basins was indicated by the data, the sampling crew visited the sites to determine if the rainfall had produced sediment transport from the hillsides to the alluvial channel in both basins. If transport occurred in both basins, a streambed-sediment sample was collected from the newly transported sediment in the main-stream channel of the basin.

Freshly deposited bed sediment from the basins (fig. 1) was sampled after rainfall runoff by using dedicated equipment for each basin in accordance with the procedures of Radtke (1997). Bed sediment was collected from the alluvial channel in each of the selected basins by using Teflon spoons. The upper 2 cm of fine-grained, wet sediment that collects in depositional areas was removed, placed in a clean sealable plastic bag, and transported in a cooler containing ice to the USGS District laboratory in Denver for processing. Processing consisted of homogenizing, sieving, and bottling the sample. For the trace-element sample, the sediment was washed into an acid-rinsed polypropylene sample jar through a nylon, 0.63  $\mu\text{m}$  sieve using DI water. The sediment in the jar was allowed to settle, and then the clear water was removed from the top of the sample with a plastic syringe. This procedure was repeated until sufficient sediment (about 35 g total) was sieved for the sample. The procedure was repeated using a 2-mm stainless-steel sieve to fill sample containers for analyses of inorganic and organic carbon (500 g in a 1-L, baked glass jar), nutrients (20 g in a polypropylene jar), gross alpha (1 g in a polypropylene jar), and plutonium (150 g in a polypropylene jar). The samples were labeled and transported to the USGS NWQL for analyses. Laboratory analyses consisted of nutrients (total nitrogen and total phosphorus), trace elements (aluminum, arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc), and plutonium and gross alpha and gross beta activity.

## Analytical Methods for Streambed Sediment

Trace-element samples were analyzed at the USGS NWQL. Gross alpha, gross beta, and plutonium analyses were done by Severn Trent Laboratory in Richland, Wash., under a contract with the USGS NWQL. The analytical methods used to analyze the streambed-sediment samples and the laboratory MRL's or MDC's are listed in table 18 (at the back of the report).

## Quality Assurance for Streambed Sediment

Quality-assurance procedures were implemented during the course of the monitoring program to ensure the quality of the data. The DI water used in cleaning and sample process-

ing was monitored for purity according to procedures given in Horowitz and others (1994). Laboratory and field cleaning procedures were rigorous and designed to prevent contamination of samples. Before sample collection, all sampling equipment and materials were cleaned according to standard procedures given in Horowitz and others (1994), Radtke (1997), and Wilde and others (1998-99).

If results for a particular constituent were questionable, the sample was reanalyzed by the laboratory. If results from the second analysis were more consistent with known characteristics of the site or the particular sample, the new results were used instead of the previous results; otherwise, the initial result was retained. The analytical quality-assurance practices and procedures of the NWQL are described in Friedman and Erdmann (1982).

Sufficient streambed sediment was available for a replicate sample, so a replicate July 17 sample of the control site also was analyzed. These data (table 19 at the back of the report) provide information about variability in the sediment itself or contributed by field conditions, sampling equipment, or the laboratory. Other quality-control samples for 2000 included a laboratory replicate, a laboratory method blank, and a laboratory spike analyzed only for plutonium and gross alpha and gross beta activity. The laboratory replicate was used to assess analytical precision. Laboratory blanks were used to assess contamination bias. The laboratory spike was prepared by the laboratory by using known concentrations of a constituent to assess recovery and analytical precision. The quality-control samples provided information about the bias and variability contributed by the laboratory but not the bias and variability contributed by field conditions or sampling equipment or about the variability of the sediment.

## Streambed-Sediment Data

The USGS collected a single paired sample July 17, 2000. Data for these two samples and the replicate are included in table 19 at the back of the report.

## Discussion of Streambed-Sediment Data

A comparison of the limited sample data with the replicate data indicates that variability within the sample is about the same as variability between the basins for this single paired sample. However, a statistical evaluation is not useful for the limited data collected.

The radioactivity data are reported in the uncensored form as received from the laboratory rather than censored by either the contract or calculated MDC. Relative to the censored form (data reported as less than the MDC), the uncensored form provides more information about the uncertainty,

the very small concentrations of plutonium, and the gross alpha and gross beta activity. The negative activity concentration reported for one of the radiochemical samples means the sample count was less than the laboratory background count for that day. Radioactivity data are produced from instruments that detect radioactive decay (disintegrations) in a sample as counts per minute. The background count was subtracted from the sample count, and the resulting value was converted to activity-concentration units of picocuries per gram.

The streambed-sediment data in this report should provide baseline information for concerns about contamination of the study area from the Lowry Landfill Superfund site water transfer. No water from the Lowry site was transferred to MWRD until July 25, 2000, after the July 17 streambed-sediment sample was collected (table 1 and fig. 2).

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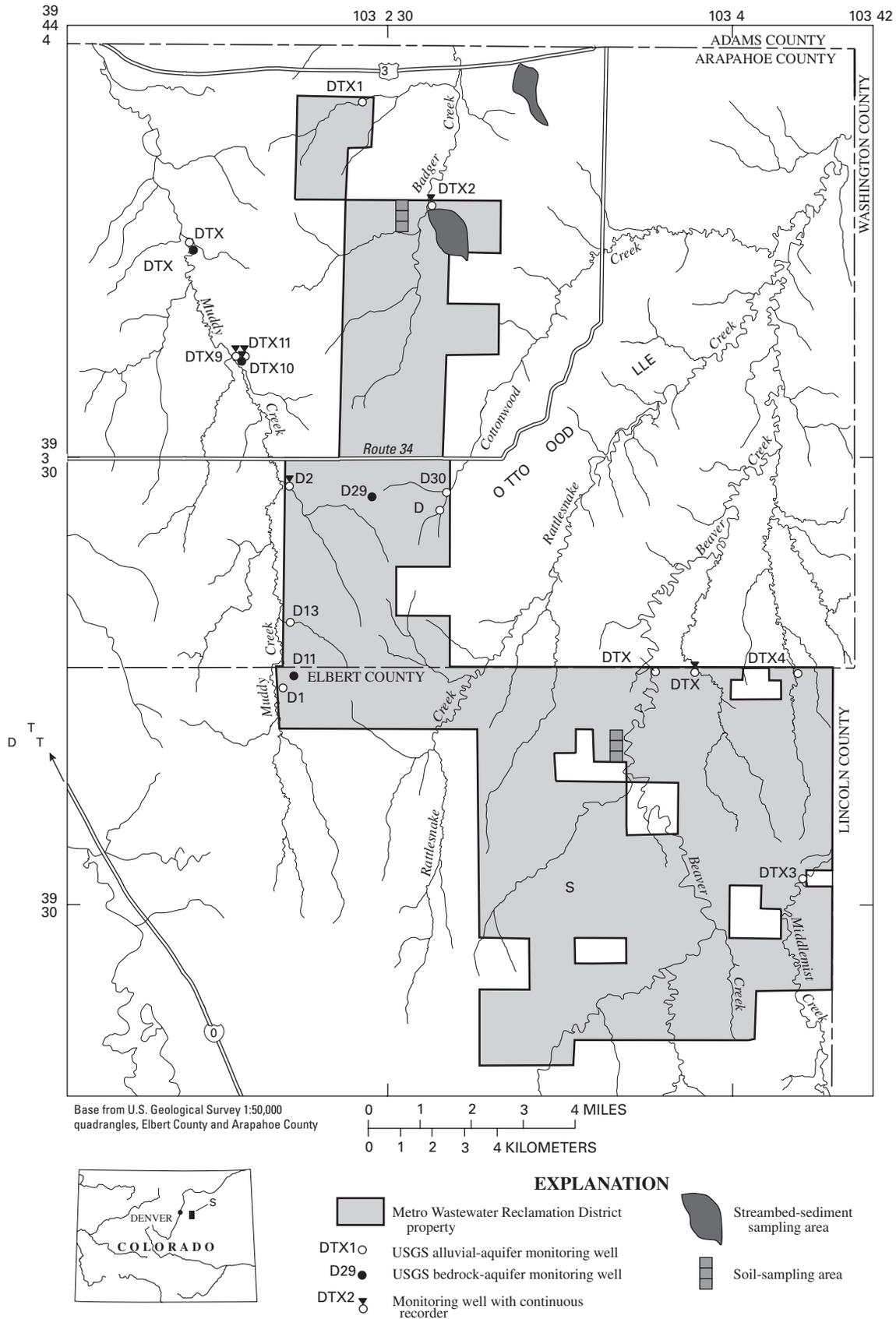
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**Data Section**





**Figure 1.** Location of study area and USGS monitorings sites near Deer Trail, Colorado, 2000. MWRD property boundaries shown are from 1999.

20 Data for a Biosolids-Application Area near Deer Trail, Colorado, 2000

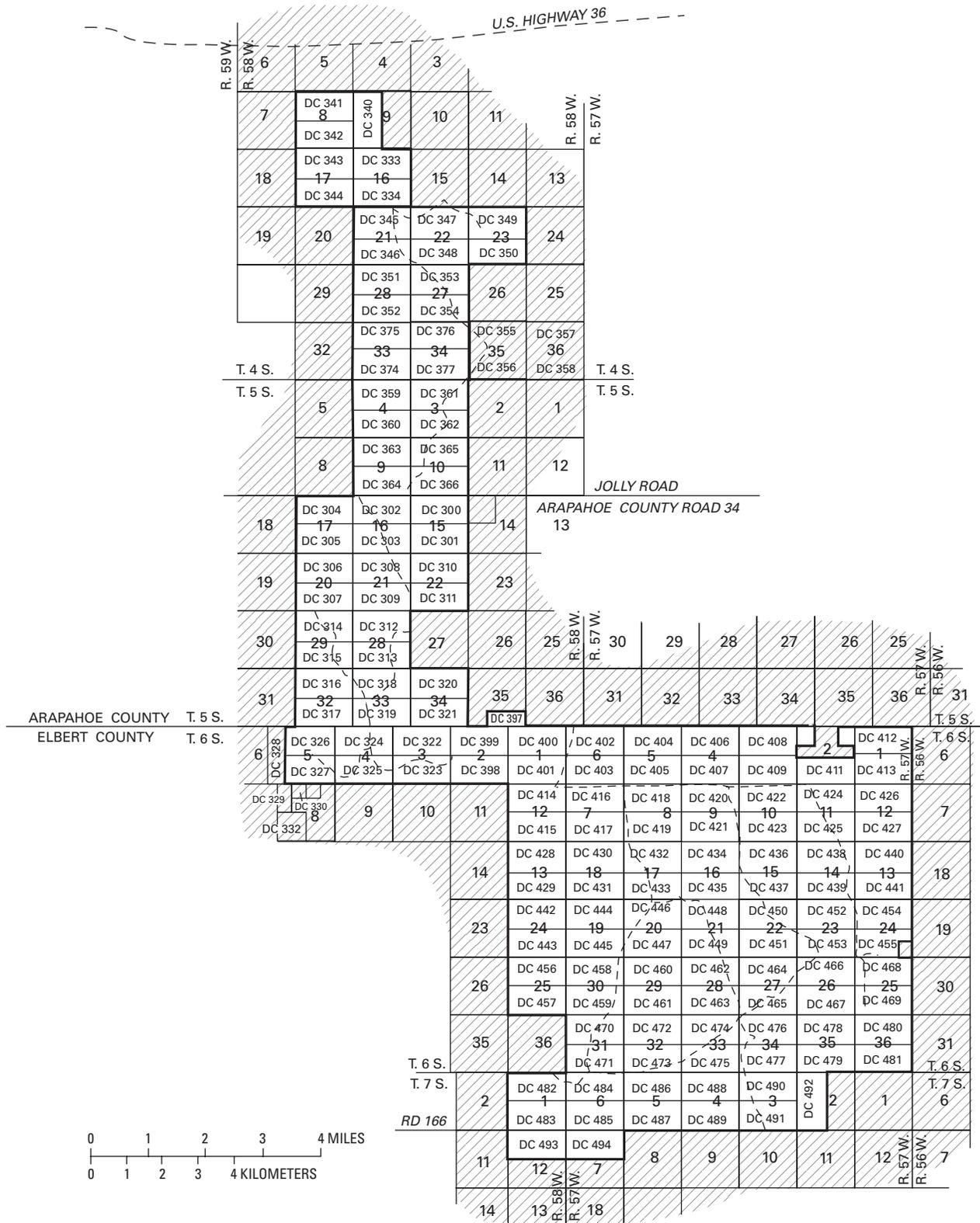
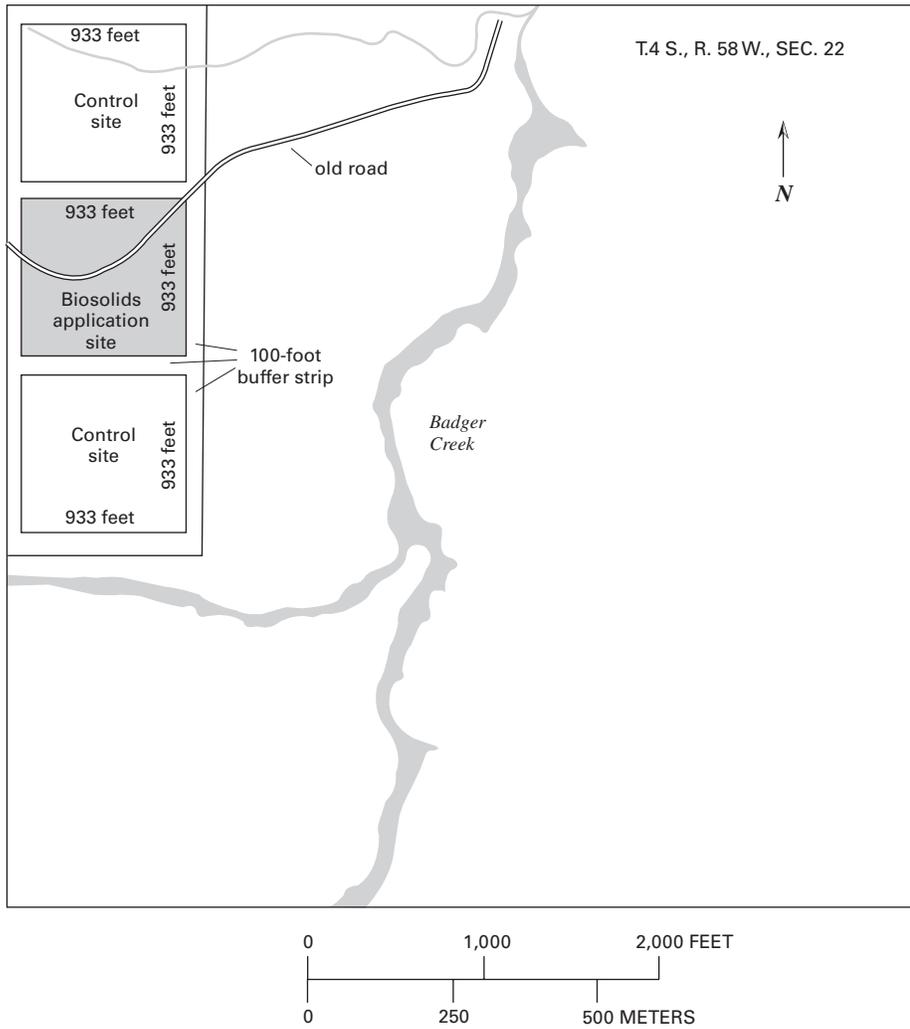
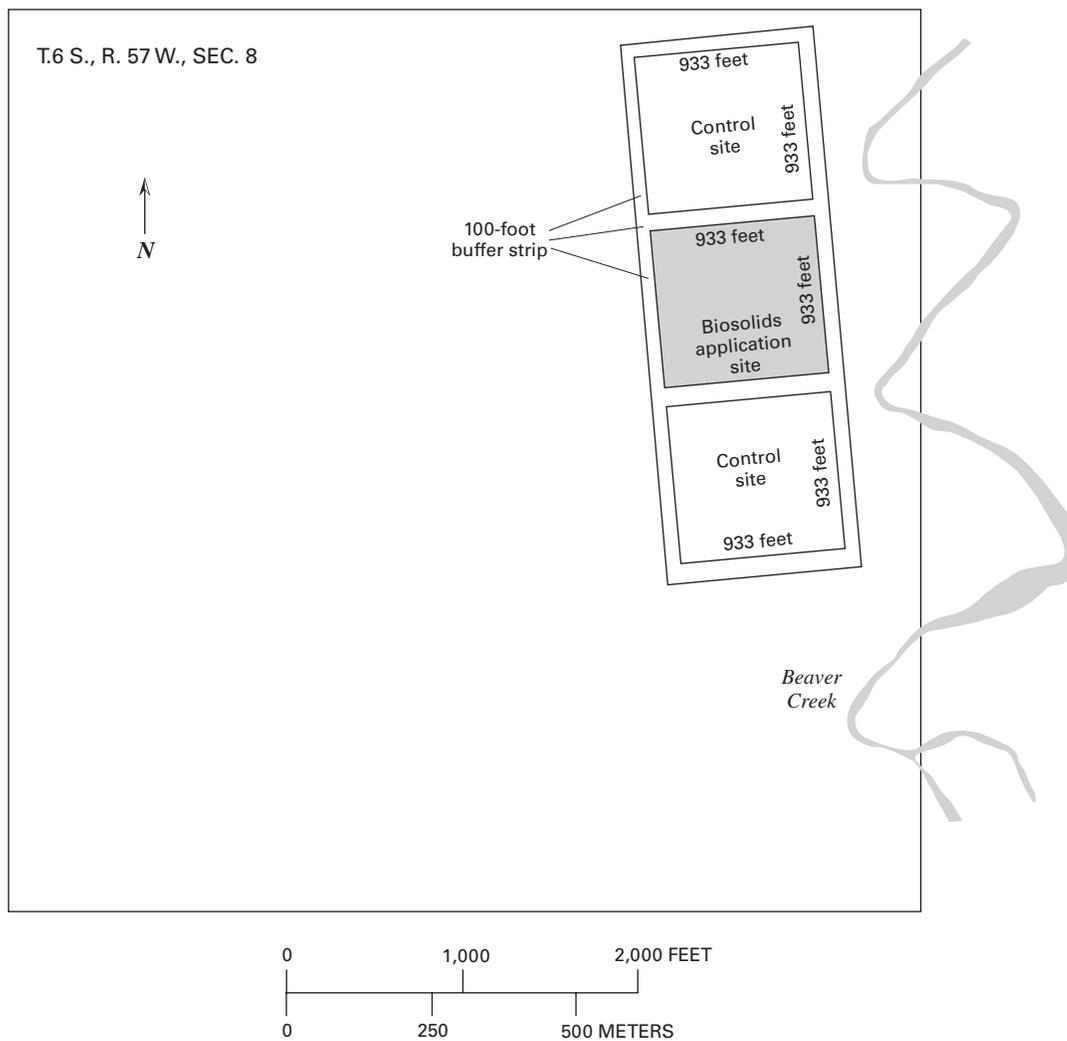


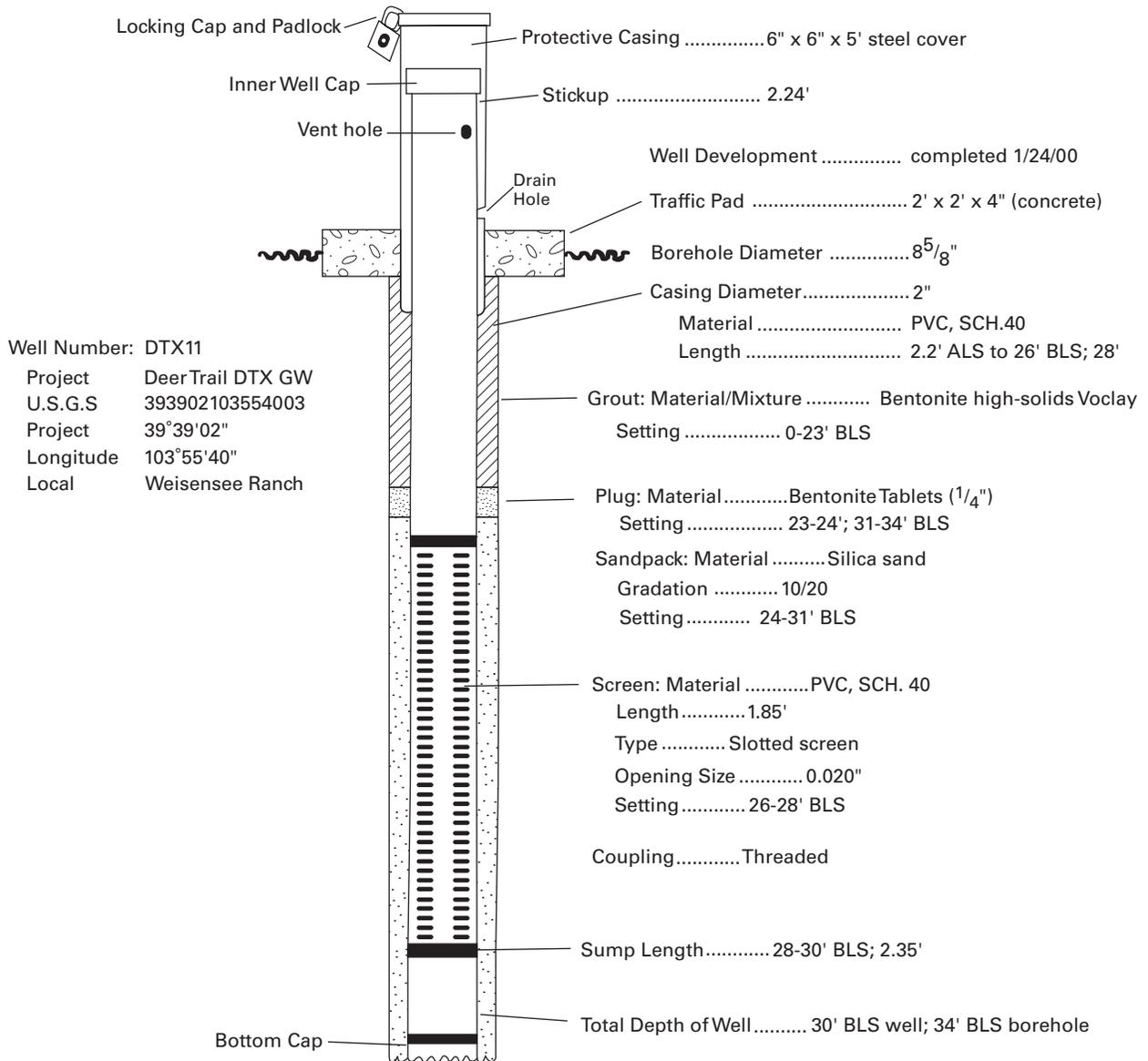
Figure 2 Metro Wastewater Reclamation District biosolids-application areas (METROGRO Farm) near Deer Trail, Colorado, 2000 (from Metro Wastewater Reclamation District).



**Figure 3.** Arapahoe County, Colorado, soil-monitoring site: T. 4 S., R. 58 W., sec. 22 (from Metro Wastewater Reclamation District).



**Figure 4.** Elbert County, Colorado, soil-monitoring site: T. 6 S., R. 57 W., sec. 8 (from Metro Wastewater Reclamation District)..



**Figure 5.** Well-completion information for U.S. Geological Survey monitoring well DTX11 near Deer Trail, Colorado, 2000 (PVC, polyvinyl chloride; SCH., schedule; ALS, above land surface; BLS, below land surface).

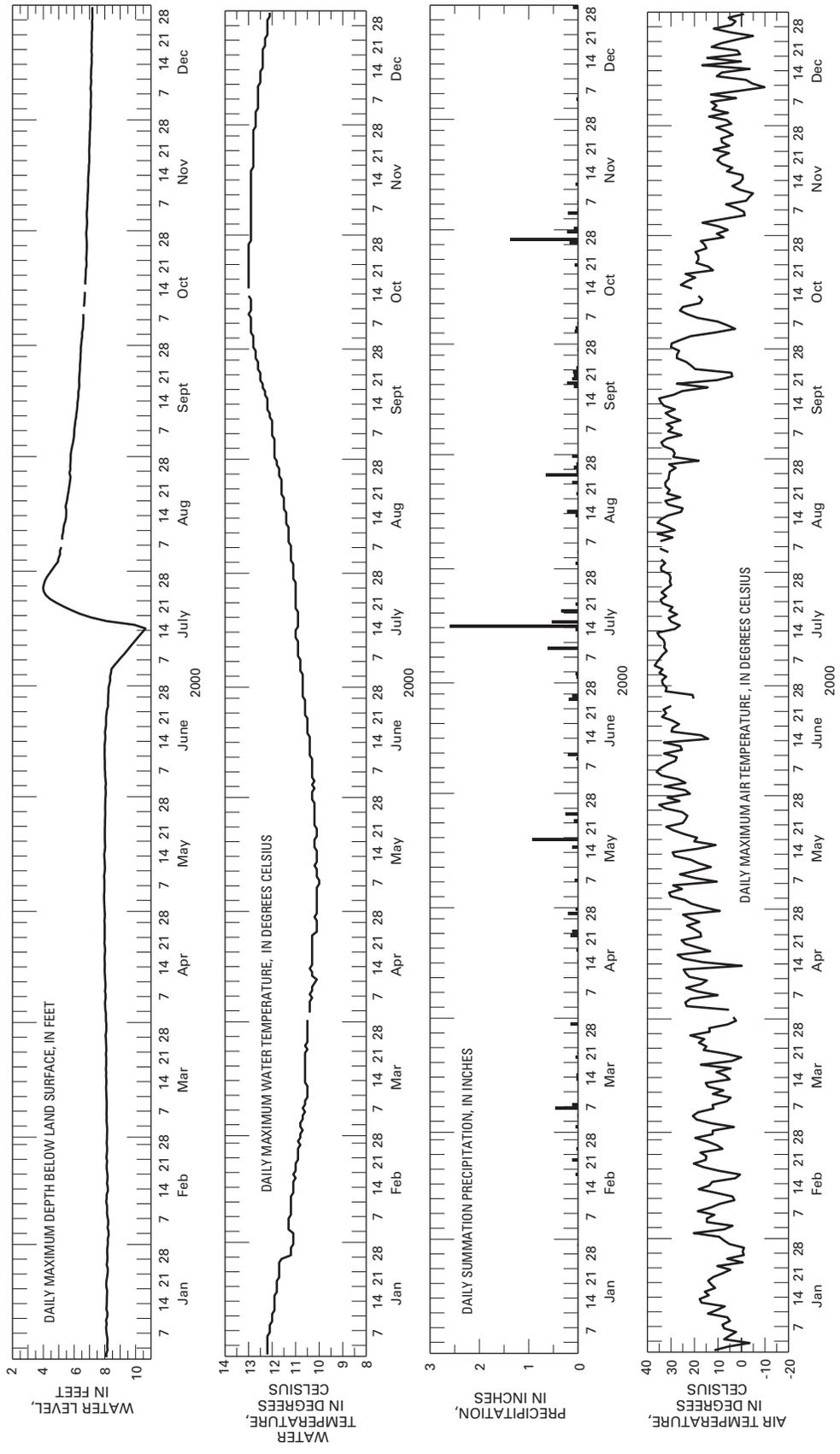


Figure 6. Continuous water-level, water-temperature, precipitation, and air-temperature data for well D25 near Deer Trail, Colorado, 2000

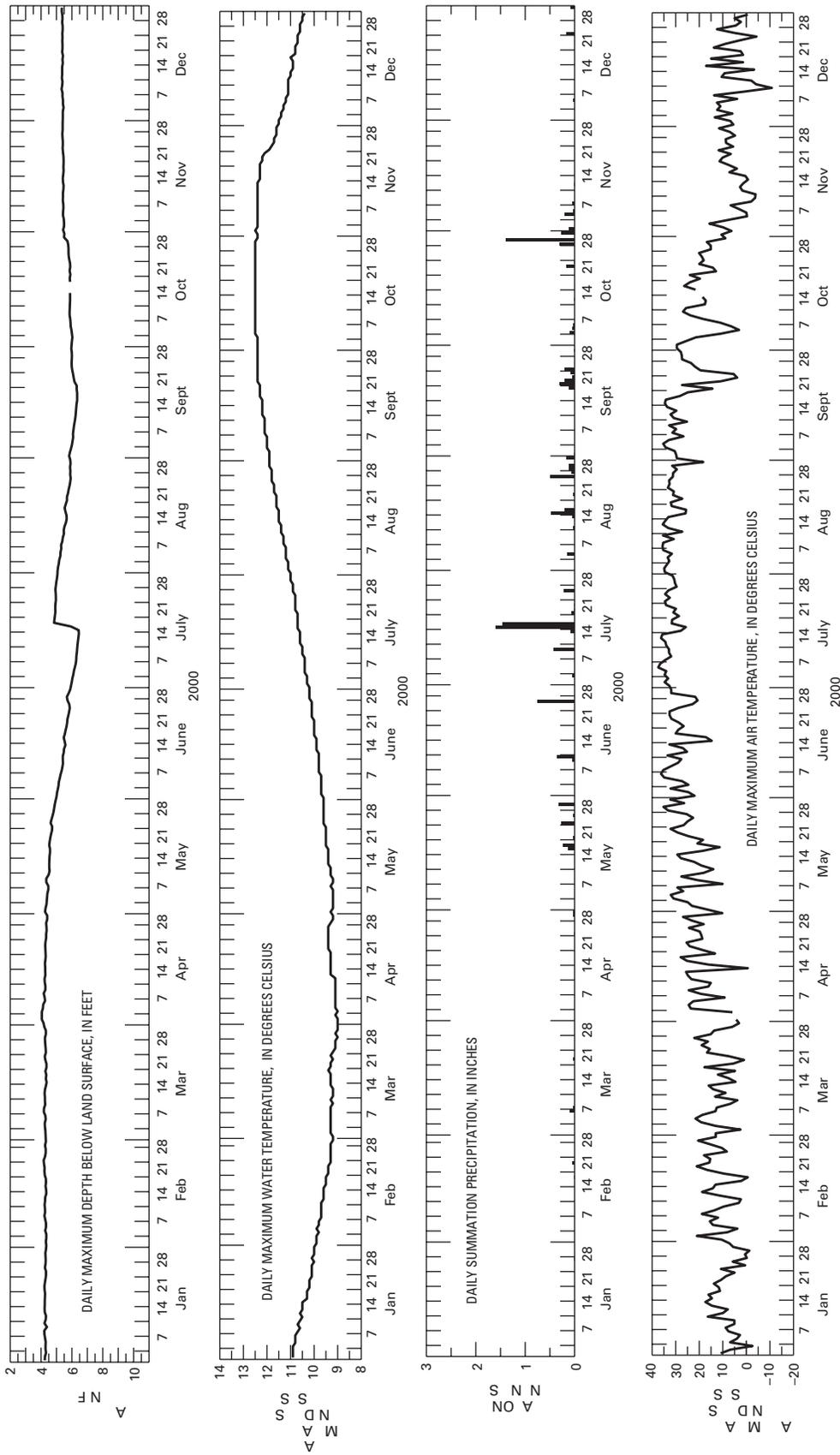


Figure 7. Continuous water-level, water-temperature, precipitation, and air-temperature data for well DTX2 near Deer Trail, Colorado, 2000

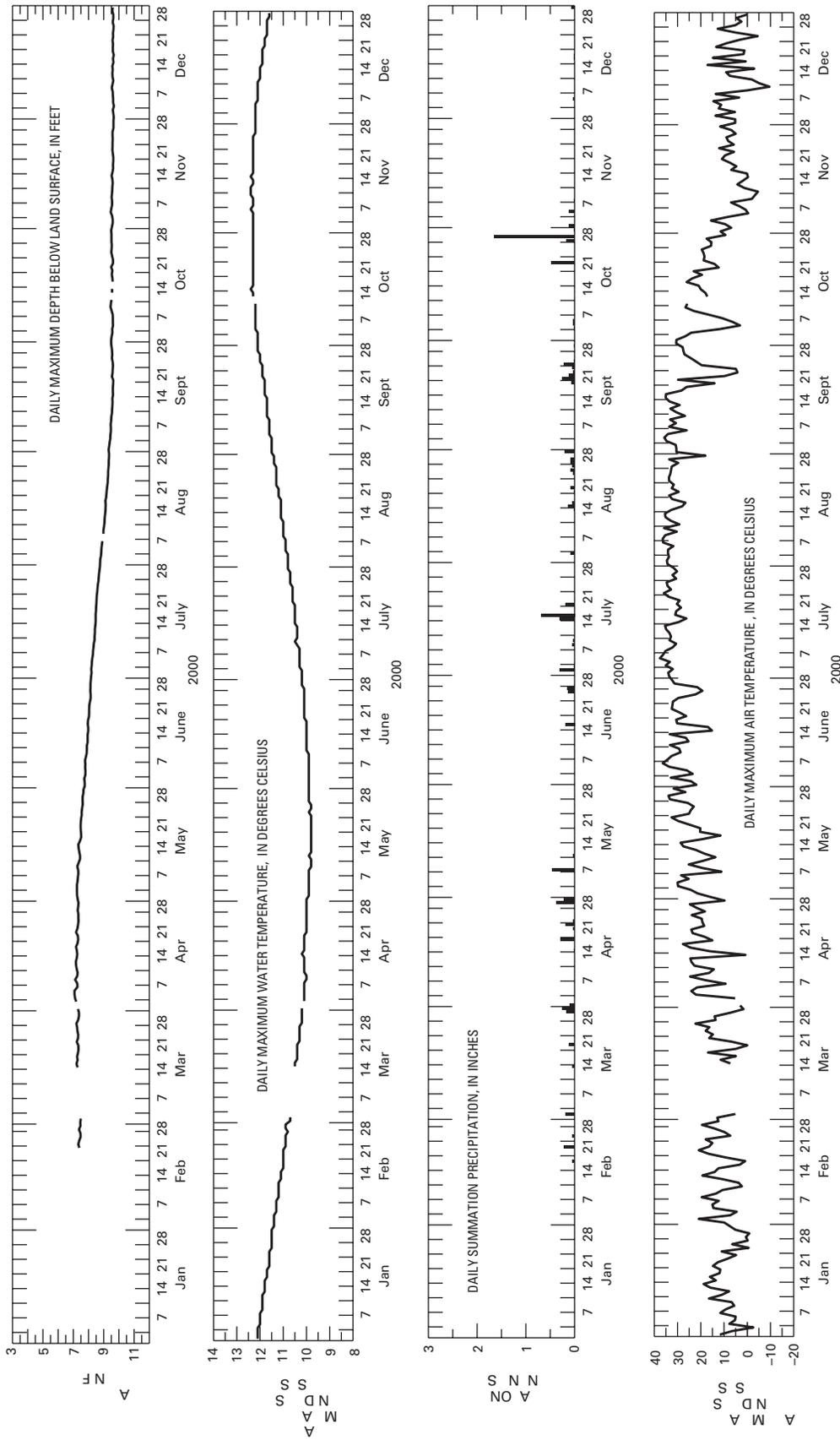


Figure 8. Continuous water-level, water-temperature, precipitation, and air-temperature data for well DTX5 near Deer Trail, Colorado, 2000

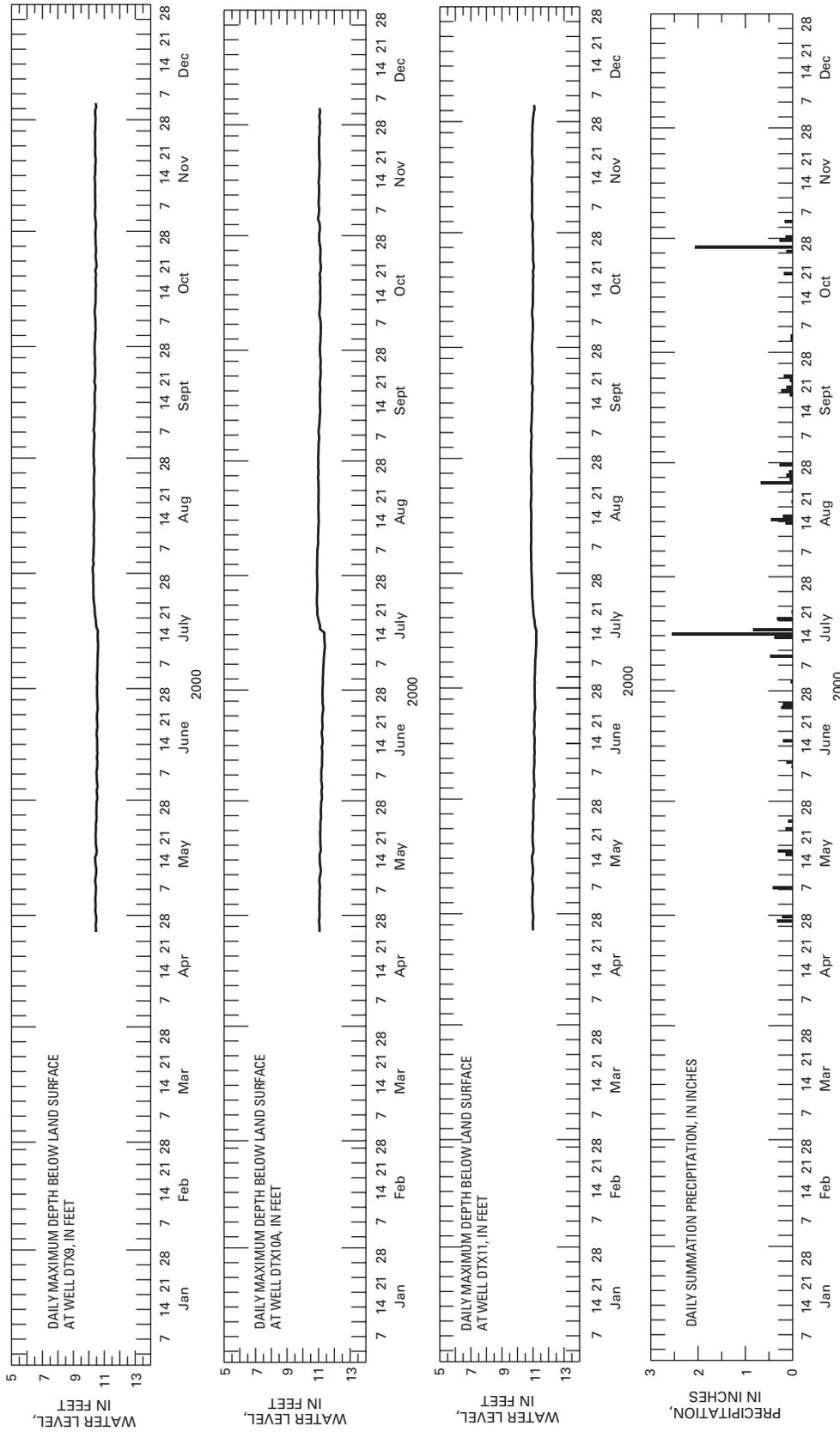
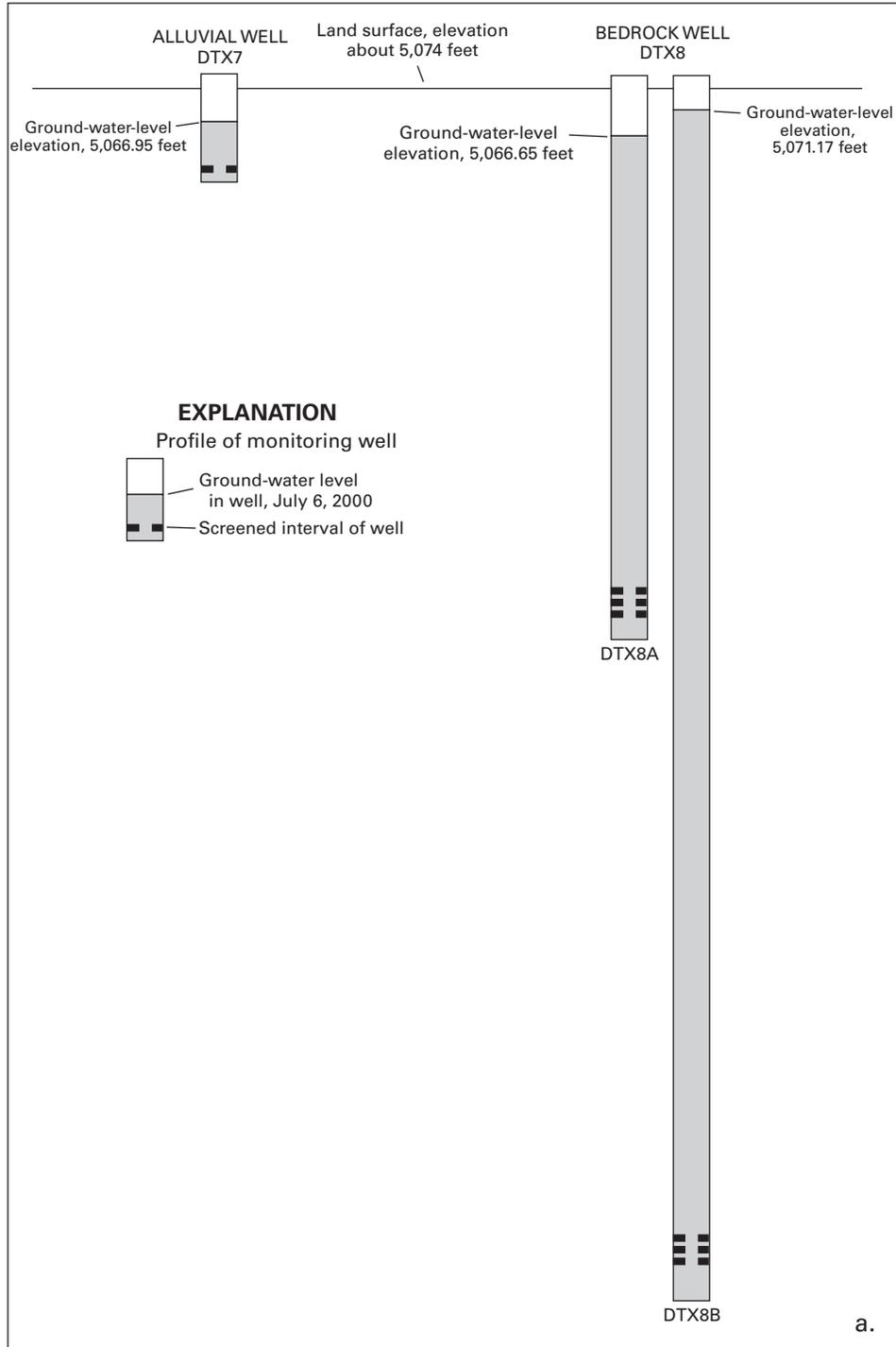
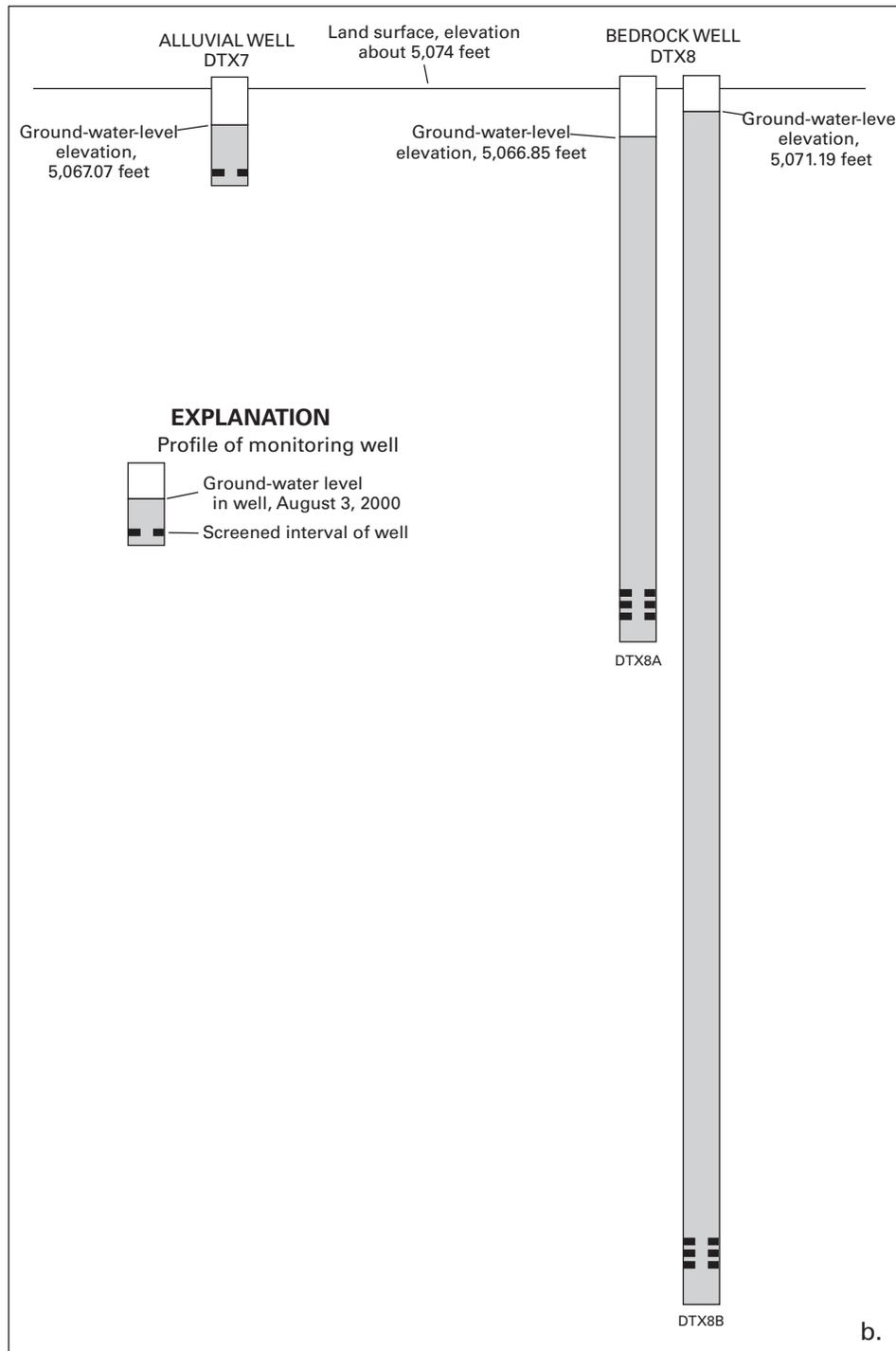


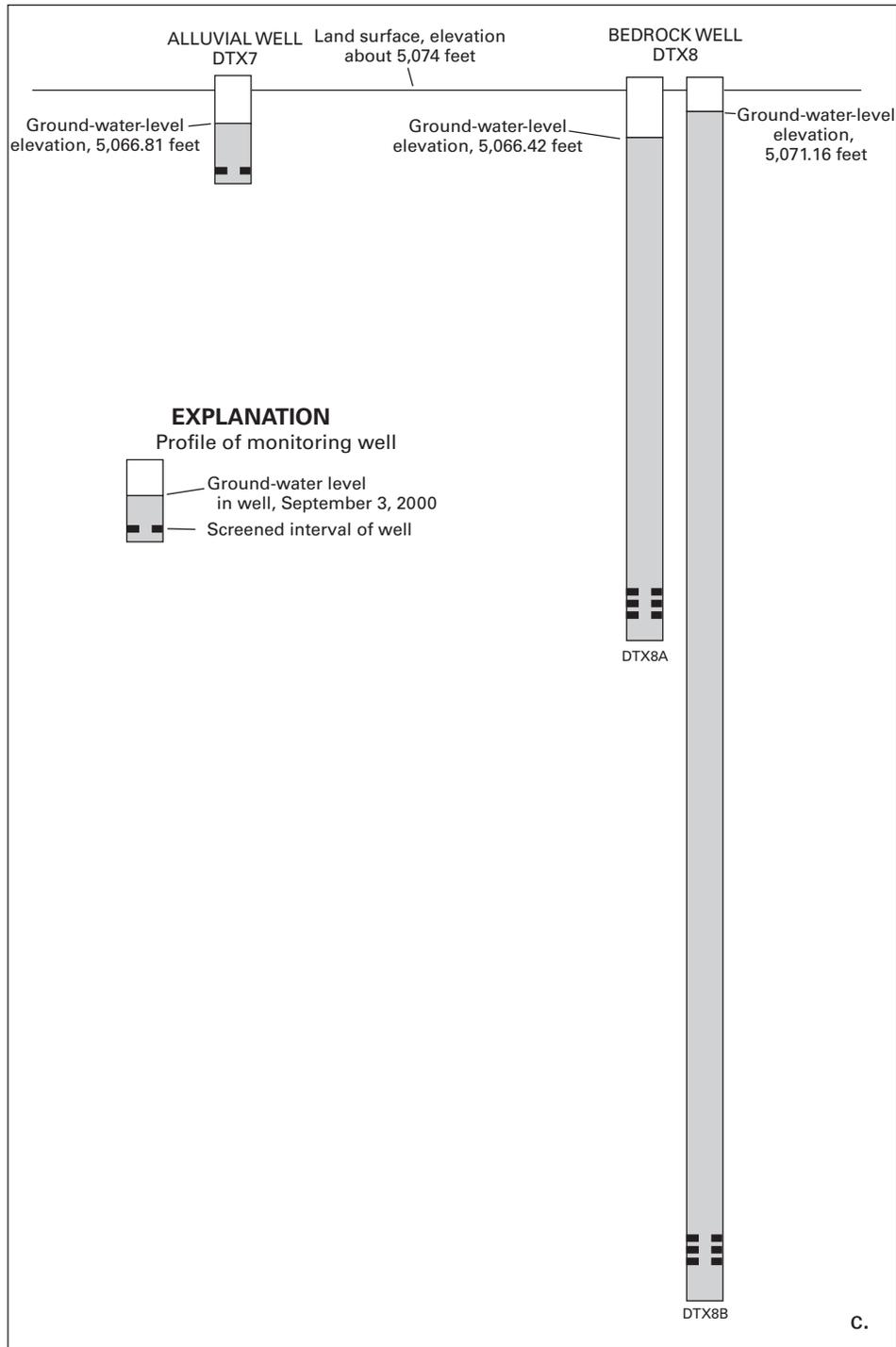
Figure 9. Continuous water-level data for wells DTX9, DTX10A, and DTX11, and precipitation data for the EDL recharge-evaluation site near Deer Trail, Colorado, 2000.



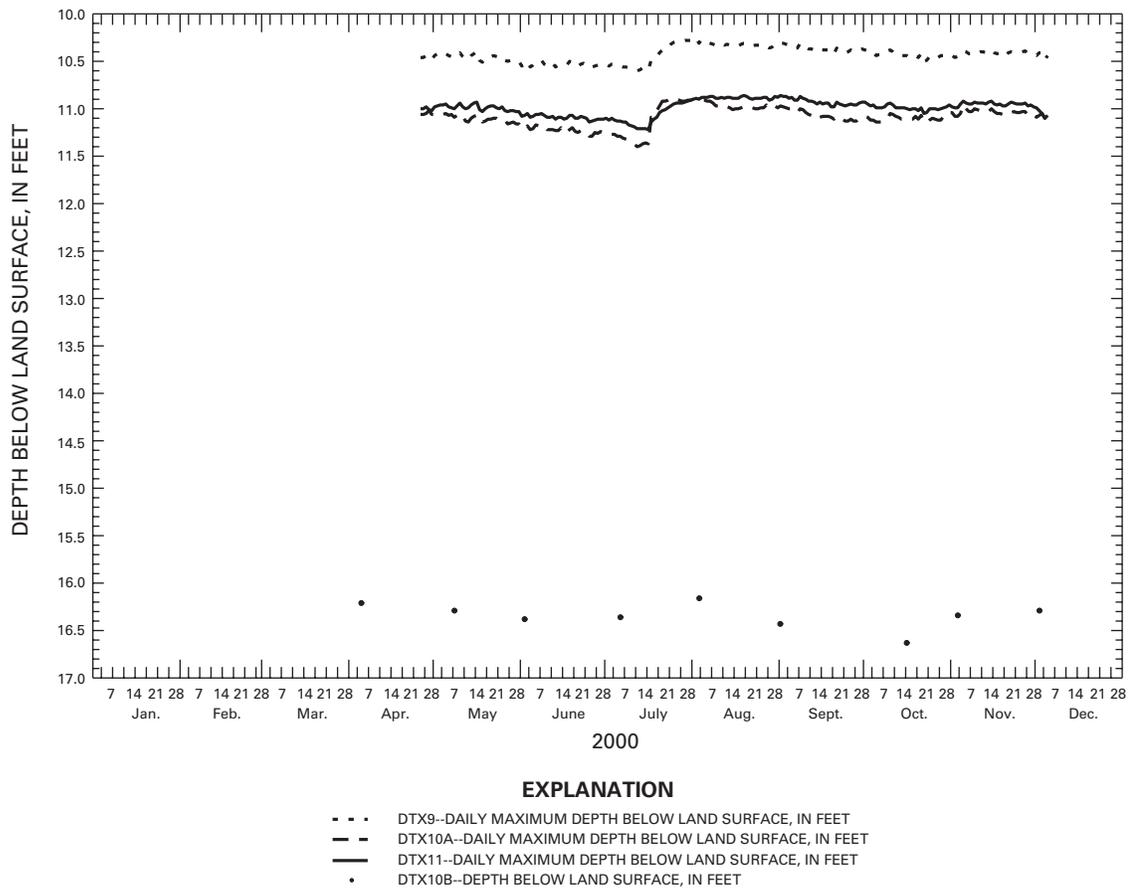
**Figure 10.** Water levels for the recharge-evaluation site containing well DTX7 and nested well DTX8 (includes DTX8A and DTX8B) near Deer Trail, Colorado, for (a) July, (b) August, and (c) September 2000. (Elevation is in feet above NAVD 88.)



**Figure 10.** Water levels for the recharge-evaluation site containing well DTX7 and nested well DTX8 (includes DTX8A and DTX8B) near Deer Trail, Colorado, for (a) July, (b) August, and (c) September 2000. (Elevation is in feet above NAVD 88.)—Continued.



**Figure 10.** Water levels for the recharge-evaluation site containing well DTX7 and nested well DTX8 (includes DTX8A and DTX8B) near Deer Trail, Colorado, for (a) July, (b) August, and (c) September 2000. (Elevation is in feet above NAVD 88.)—Continued.



**Figure 11.** Water levels for the recharge-evaluation site containing wells DTX9, DTX10, and DTX11 near Deer Trail, Colorado, 2000.

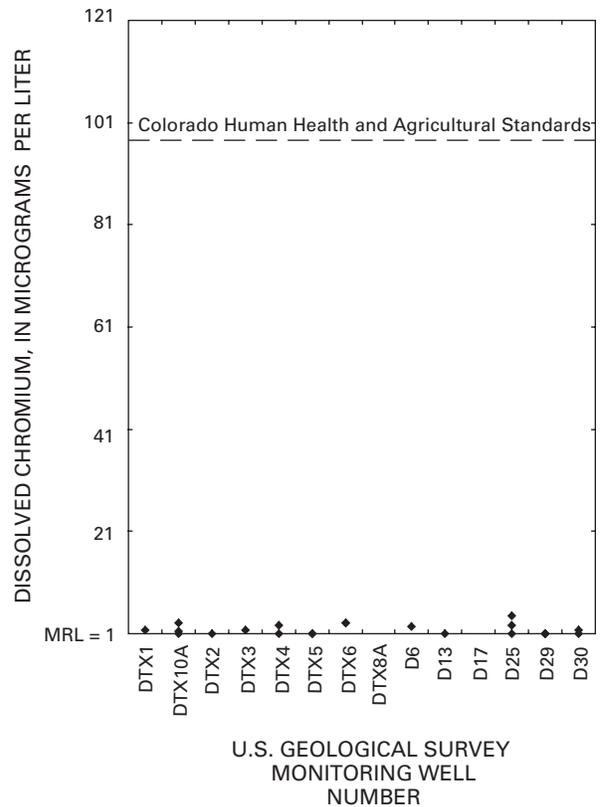
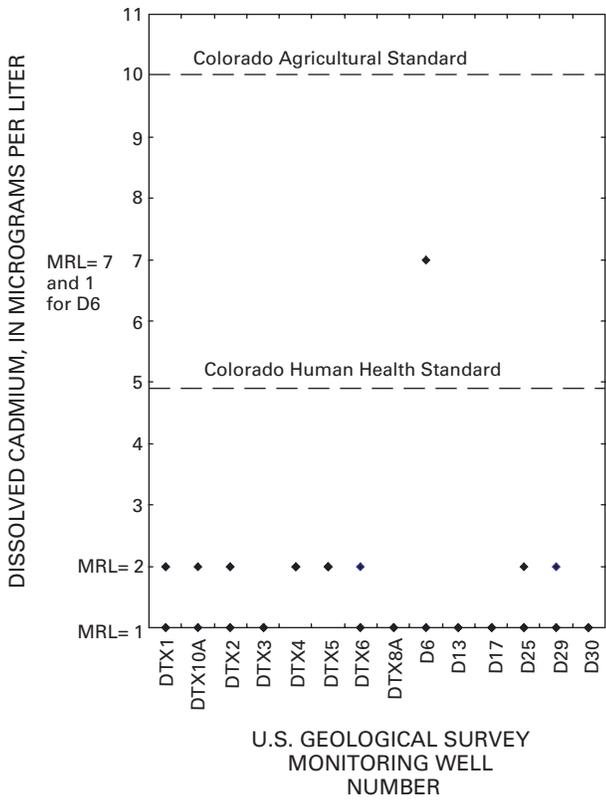
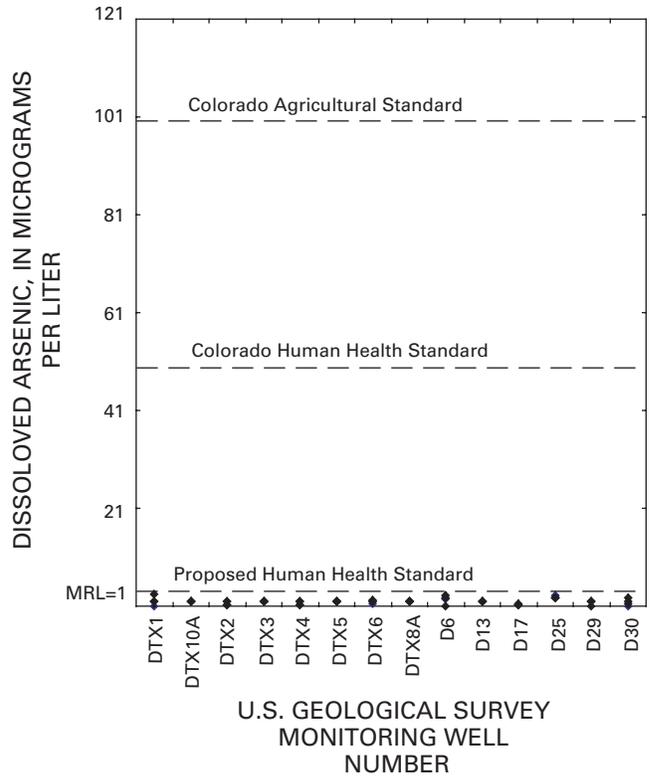
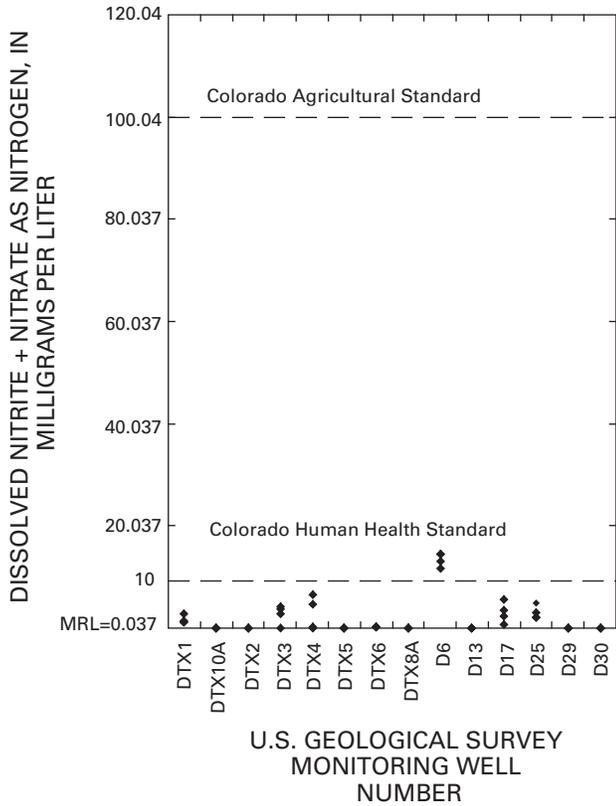


Figure 12. Distribution of ground-water constituent data collected near Deer Trail, Colorado, compared to regulatory standards for selected constituents, 2000.

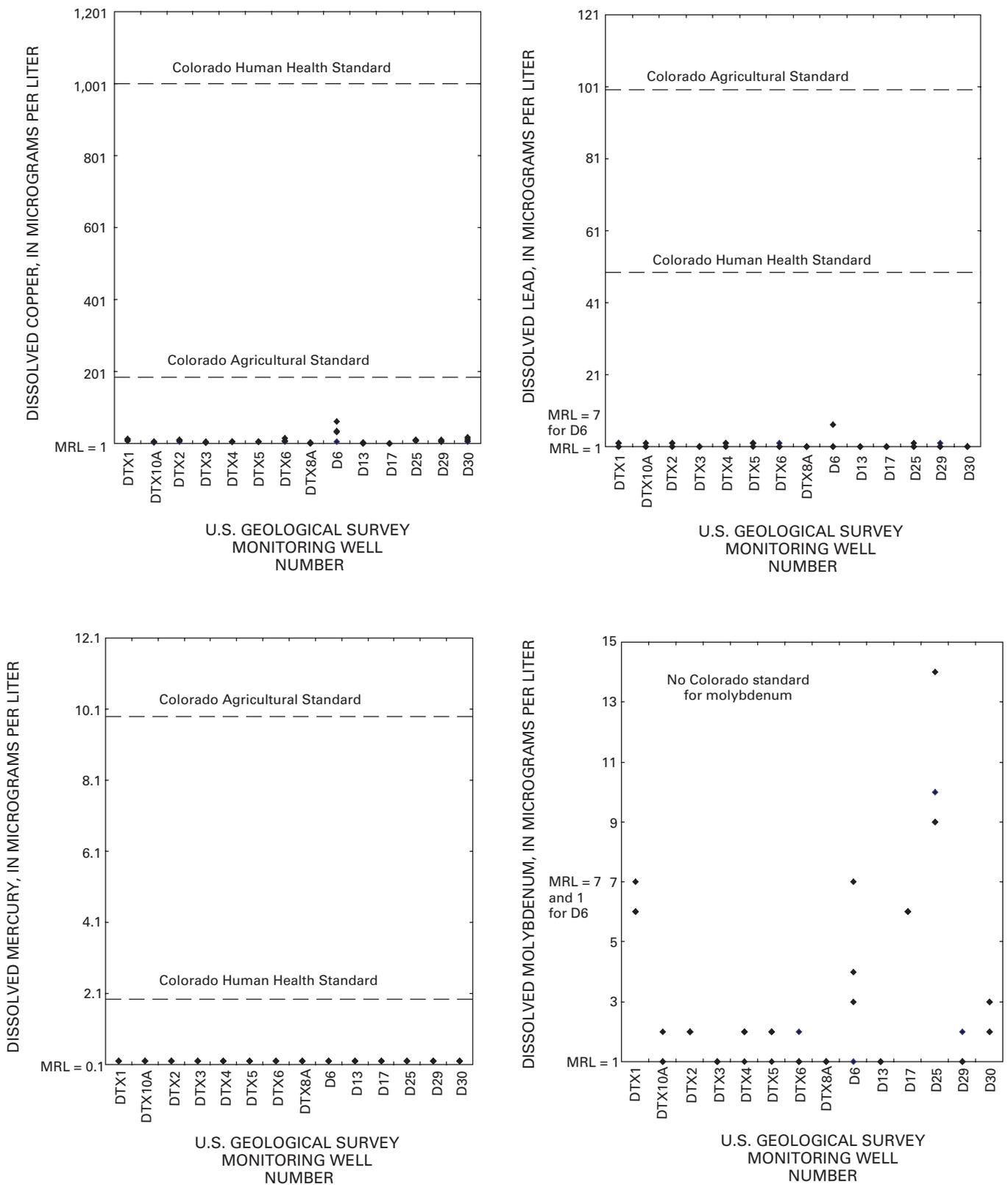
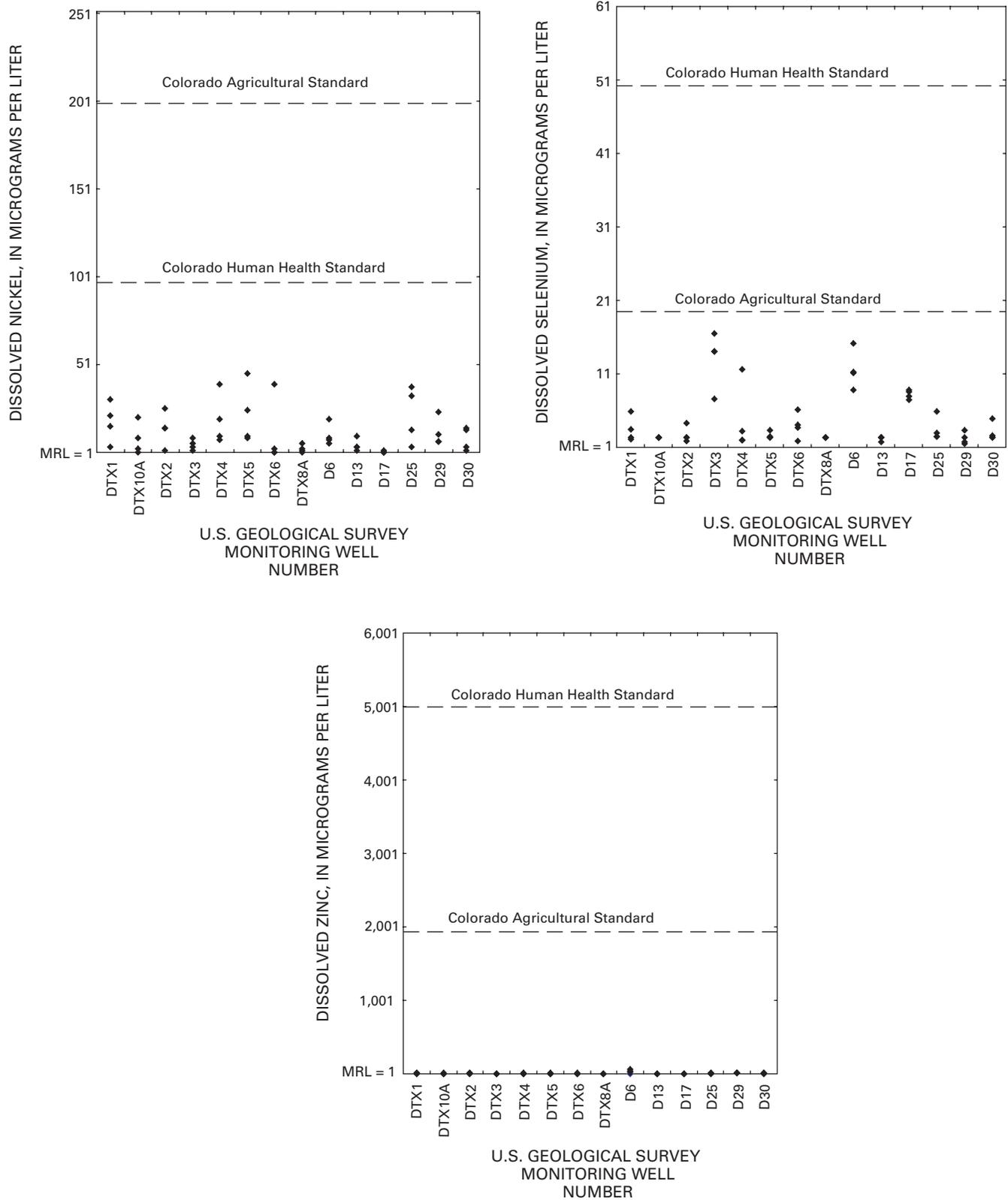


Figure 12. Distribution of ground-water constituent data collected near Deer Trail, Colorado, compared to regulatory standards for selected constituents, 2000—Continued.



**Figure 12.** Distribution of ground-water constituent data collected near Deer Trail, Colorado, compared to regulatory standards for selected constituents, 2000—Continued.

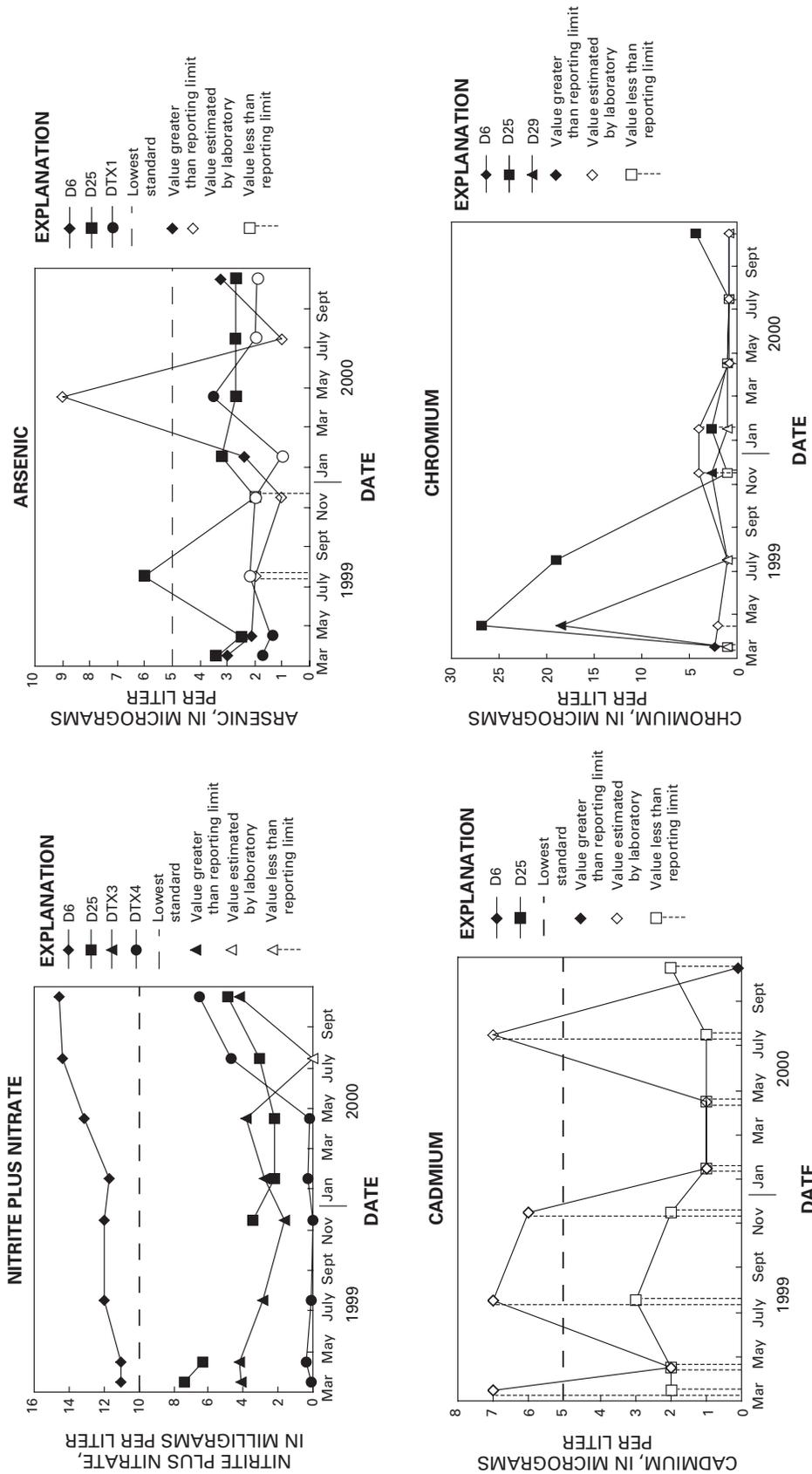


Figure 13. Ground-water concentrations near Deer Trail, Colorado, for selected constituents and selected wells, 1999-2000.

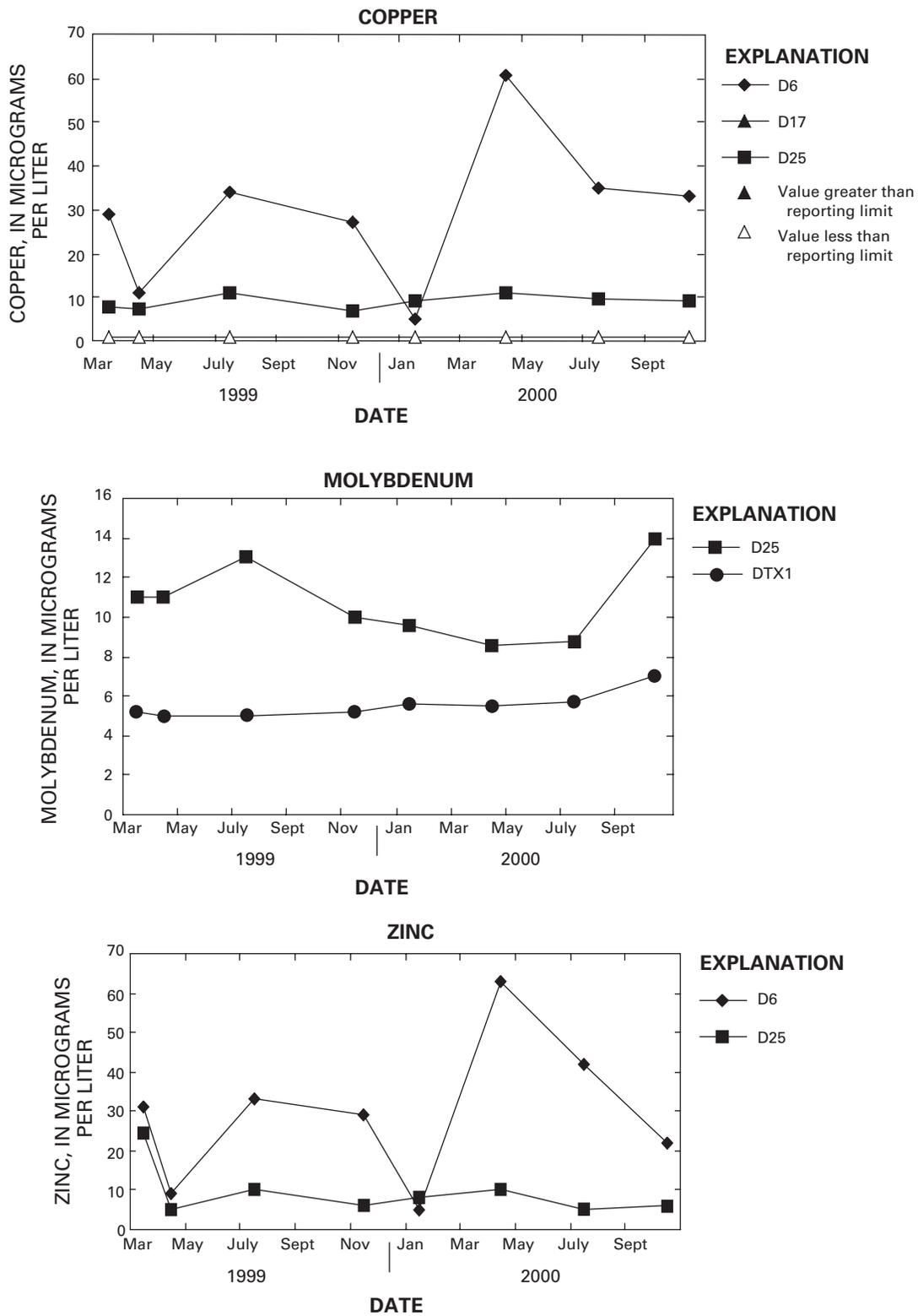


Figure 13. Ground-water concentrations near Deer Trail, Colorado, for selected constituents and selected wells, 1999-2000—Continued.

## TERMS AND ABBREVIATIONS

The following terms and abbreviations are used in tables 1–19:

bls	below land surface
bmp	below the measuring point of the well casing
mi	mile
ft	feet
hhmm	24-hour time
mm/dd/yy	numerical date format for two-digit month/two-digit day/ and the last two digits of the year
C	Celsius
cm	centimeter
°	degree
in. or "	inch
$\mu\text{S}/\text{cm}$	microsiemens per centimeter at 25°Celsius
pH units	are the negative base-10 log of the hydrogen-ion activity in moles per liter
mg/L	milligrams per liter
$\mu\text{g}/\text{L}$	micrograms per liter
pCi/L	picocuries per liter
dissolved	refers to that fraction of material in a water sample that passes through a 0.45- $\mu\text{m}$ membrane filter
>	greater than
<	less than
g/kg	grams per kilogram
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
$\mu\text{g}/\text{g}$	micrograms per gram
NAD 83	North American Datum 1983
NAVD 88	North American Vertical Datum 1988

**Table 1.** Biosolids applications near Deer Trail, Colorado, 2000

[All information provided by Metro Wastewater Reclamation District; DC, destination code (shown in fig. 2); legal description is of the form *quarter-section section township range*; Ha, hectares; CAKE, Grade I Class B biosolids; MAC, biosolids amended with wood fiber; dT, dry tons; dMT, dry metric tons; lbs/Acre, pounds per acre; Kg/Ha, kilograms per hectare; Y, yes; N, No; O/GR, oats and grass; --, no data]

DC	Legal description	Area applied to		County	Biosolids product applied	Start date	Stop date	Total loads	Total wet tons	Total dry tons		Loading rate, tons per acre		Nitrogen loading rate		Reclamation project	
		Acres	Ha							dT	dMT	Cake dT	dMT	lbs/Acre	Kg/Ha		
300	N 1/2 SEC 15 T5S R58W	160	64.8	ARAPAHOE	CAKE	7/18/00	7/21/00	82	1,835	299	271.25	1.87	4.19	46	51.57	WHEAT	N
300	N 1/2 SEC 15 T5S R58W	160	64.8	ARAPAHOE	CAKE	9/18/00	11/18/00	51	1,121	180	163.30	1.13	2.53	28	31.39	WHEAT	N
301	S 1/2 SEC 15 T5S R58W	155.7	63.0	ARAPAHOE	CAKE	7/22/00	7/25/00	95	2,125	329	298.47	2.11	4.73	52	58.30	WHEAT	N
301	S 1/2 SEC 15 T5S R58W	78	31.6	ARAPAHOE	CAKE/MAC	9/19/00	11/18/00	45	999	165	149.69	1.92	4.30	50	56.06	WHEAT	N
303	S 1/2 SEC 16 T5S R58W	148	59.9	ARAPAHOE	CAKE/MAC	7/25/00	7/30/00	118	2,628	424	384.65	2.77	6.21	70	78.48	WHEAT	N
306	N 1/2 SEC 20 T5S R58W	107.3	43.4	ARAPAHOE	CAKE	3/10/00	3/17/00	45	1,028	164	148.78	1.53	3.43	43	48.21	WHEAT	N
307	S 1/2 SEC 20 T5S R58W	107.1	43.3	ARAPAHOE	CAKE	3/11/00	6/21/00	80	1,824	279	253.11	2.61	5.85	69	77.36	WHEAT	N
308	N 1/2 SEC 21 T5S R58W	156.6	63.4	ARAPAHOE	CAKE/MAC	11/22/00	11/29/00	93	2,090	350	317.52	2.04	4.57	58	65.02	WHEAT	N
309	S 1/2 SEC 21 T5S R58W	129.3	52.3	ARAPAHOE	CAKE	11/23/00	11/28/00	75	1,707	268	243.13	2.07	4.64	56	62.78	WHEAT	N
310	N 1/2 SEC 22 T5S R58W	69.3	28.0	ARAPAHOE	CAKE	11/19/00	11/22/00	54	1,219	274	248.57	2.74	6.14	67	75.11	WHEAT	N
311	S 1/2 SEC 22 T5S R58W	66.1	26.8	ARAPAHOE	CAKE/MAC	11/18/00	11/21/00	48	1,081	180	163.30	2.50	5.61	66	73.99	WHEAT	N
312	N 1/2 SEC 28 T5S R58W	166.3	67.3	ARAPAHOE	CAKE/MAC	11/29/00	12/5/00	135	2,970	510	462.67	2.72	6.10	83	93.05	WHEAT	N
313	S 1/2 SEC 28 T5S R58W	224.7	90.9	ARAPAHOE	CAKE	11/30/00	12/8/00	71	1,585	251	227.71	1.12	2.51	32	35.88	WHEAT	N
315	S 1/2 SEC 29 T5S R58W	23.9	9.7	ARAPAHOE	CAKE	12/8/00	12/9/00	18	416	67	60.78	2.80	6.28	76	85.20	WHEAT	N
317	S 1/2 SEC 32 T5S R58W	159.6	64.6	ARAPAHOE	CAKE/MAC	6/9/99	3/4/00	722	16,122	2,674	2,425.85	16.30	36.55	415	465.26	GRASS	Y
318	N 1/2 SEC 33 T5S R58W	145.3	58.8	ARAPAHOE	CAKE/MAC	12/11/00	12/17/00	116	2,490	278	252.20	2.68	6.01	80	89.69	WHEAT	N
319	S 1/2 SEC 33 T5S R58W	94.3	38.2	ARAPAHOE	CAKE/MAC	7/9/99	2/28/00	137	3,094	519	470.84	5.20	11.66	130	145.74	O/GR	Y

**Table 1.** Biosolids applications near Deer Trail, Colorado, 2000—Continued

[All information provided by Metro Wastewater Reclamation District; DC, destination code (shown in fig. 2); legal description is of the form *quarter-section section township range*; Ha, hectares; CAKE, Grade I Class B biosolids; MAC, biosolids amended with wood fiber; dT, dry tons; dMT, dry metric tons; lbs/Acre, pounds per acre; Kg/Ha, kilograms per hectare; Y, yes; N, No; O/GR, oats and grass; --, no data]

DC	Legal description	Area applied to		County	Biosolids product applied	Start date	Stop date	Total loads	Total wet tons	Total dry tons		Loading rate, tons per acre		Nitrogen loading rate		Reclamation project	
		Acres	Ha							dT	dMT	CAKE dT	dMT	lbs/Acre	Kg/Ha		
319	S 1/2 SEC 33 T5S R58W	50.2	20.3	ARAPAHOE	CAKE/MAC	12/9/00	12/11/00	41	902	157	142.43	2.83	6.35	81	90.81	WHEAT	N
322	N 1/2 SEC 3 T6S R58W	215.7	87.3	ELBERT	CAKE	12/19/00	12/26/00	121	2,760	447	405.52	2.07	4.64	65	72.87	WHEAT	N
323	S 1/2 SEC 3 T6S R58W	230.6	93.3	ELBERT	CAKE	12/26/00	01/04/01	184	4,143	683	619.62	2.96	6.64	--	--	--	--
324	N 1/2 SEC 4 T6S R58W	38	15.4	ELBERT	CAKE/MAC	12/17/00	12/18/00	29	649	117	106.14	2.68	6.01	84	94.17	WHEAT	N
325	S 1/2 SEC 4 T6S R58W	38	15.4	ELBERT	CAKE/MAC	12/16/00	12/20/00	31	708	124	112.49	2.87	6.43	89	99.78	WHEAT	N
340	W 1/2 SEC 9 T4S R58W	258.4	104.6	ARAPAHOE	CAKE	10/06/00	06/20/01	99	2,207	487	441.81	1.88	4.22	--	--	--	--
341	N 1/2 SEC 8 T4S R58W	300	121.4	ARAPAHOE	CAKE/MAC	8/29/00	11/17/00	231	5,018	810	734.83	2.60	5.83	69	77.36	WHEAT	N
342	S 1/2 SEC 8 T4S R58W	311.3	126.0	ARAPAHOE	CAKE/MAC	8/22/00	11/13/00	217	4,763	828	751.16	2.49	5.58	66	73.99	WHEAT	N
343	N 1/2 SEC 17 T4S R58W	327.4	132.5	ARAPAHOE	CAKE/MAC	8/18/00	11/10/00	259	5,777	984	892.68	2.91	6.52	81	90.81	WHEAT	N
344	S 1/2 SEC 17 T4S R58W	280	113.3	ARAPAHOE	CAKE/MAC	8/8/00	8/18/00	223	5,125	855	775.66	2.91	6.52	75	84.08	WHEAT	N
345	N 1/2 SEC 21 T4S R58W	310	125.5	ARAPAHOE	CAKE/MAC	7/29/00	11/5/00	255	5,823	975	884.52	2.94	6.59	78	87.45	WHEAT	N
346	S 1/2 SEC 21 T4S R58W	300	121.4	ARAPAHOE	CAKE/MAC	7/31/00	10/26/00	224	5,000	831	753.88	2.67	5.99	69	77.36	WHEAT	N
351	N 1/2 SEC 28 T4S R58W	290	117.4	ARAPAHOE	CAKE/MAC	8/27/00	9/16/00	210	4,591	743	674.05	2.38	5.34	59	66.14	WHEAT	N
352	S 1/2 SEC 28 T4S R58W	299	121.0	ARAPAHOE	CAKE	9/2/00	9/9/00	211	4,674	749	679.49	2.51	5.63	61	68.39	WHEAT	N
412	N 1/2 SEC 1 T6S R57W	343	138.8	ELBERT	CAKE	9/26/00	10/2/00	140	3,117	480	435.46	1.40	3.14	40	44.84	WHEAT	N
413	S 1/2 SEC 1 T6S R57W	343	138.8	ELBERT	CAKE/MAC	10/2/00	10/15/00	248	5,465	883	801.06	2.43	5.45	66	73.99	WHEAT	N
425	S 1/2 SEC 11 T6S R57W	20	8.1	ELBERT	CAKE	1/15/00	1/15/00	12	268	39	35.38	1.95	4.37	53	59.42	WHEAT	N
448	N 1/2 SEC 21 T6S R57W	223	90.2	ELBERT	CAKE/MAC	2/10/00	3/26/00	178	3,984	655	594.22	2.81	6.30	77	86.32	WHEAT	N
449	S 1/2 SEC 21 T6S R57W	123.7	50.1	ELBERT	CAKE/MAC	3/4/00	3/30/00	100	2,237	365	331.13	2.74	6.14	76	85.20	WHEAT	N

**Table 1.** Biosolids applications near Deer Trail, Colorado, 2000—Continued

[All information provided by Metro Wastewater Reclamation District; DC, destination code (shown in fig. 2); legal description is of the form *quarter-section township range*; Ha, hectares; CAKE, Grade I Class B biosolids; MAC, biosolids amended with wood fiber; dT, dry tons; dMT, dry metric tons; lbs/Acre, pounds per acre; Kg/Ha, kilograms per hectare; Y, yes; N, No; O/GR, oats and grass; --, no data]

DC	Legal description	Area applied to		County	Biosolids product applied	Start date	Stop date	Total loads	Total wet tons	Total dry tons		Loading rate, tons per acre		Nitrogen loading rate		Reclamation project	
		Acres	Ha							dT	dMT	Cake dT	dMT	lbs/Acre	Kg/Ha		Crop
450	N 1/2 SEC 22 T6S R57W	219	88.6	ELBERT	CAKE/MAC	2/21/00	3/25/00	169	3,745	618	560.65	2.57	5.76	73	81.84	WHEAT	N
451	S 1/2 SEC 22 T6S R57W	219	88.6	ELBERT	CAKE	2/21/00	3/26/00	93	2,064	327	296.65	1.49	3.34	41	45.97	WHEAT	N
452	N 1/2 SEC 23 T6S R57W	303	122.6	ELBERT	CAKE/MAC	12/26/99	1/13/00	180	4,014	648	587.87	1.95	4.37	56	62.78	WHEAT	N
453	S 1/2 SEC 23 T6S R57W	303	122.6	ELBERT	CAKE/MAC	1/7/00	1/19/00	133	2,980	502	455.41	1.43	3.21	42	47.09	WHEAT	N
454	N 1/2 SEC 24 T6S R57W	30	12.1	ELBERT	CAKE	1/10/00	1/11/00	19	415	64	58.06	2.13	4.78	57	63.90	WHEAT	N
455	S 1/2 SEC 24 T6S R57W	35	14.2	ELBERT	CAKE	1/19/00	1/21/00	28	630	94	85.28	2.69	6.03	74	82.96	WHEAT	N
458	N 1/2 SEC 29 T6S R57W	106.2	43.0	ELBERT	CAKE/MAC	1/5/99	9/4/01	317	7,058	1,391	1,261.92	13.10	29.37	--	--	--	--
461	S 1/2 SEC 29 T6S R57W	23.9	9.7	ELBERT	CAKE/MAC	1/9/99	8/24/01	76	1,696	294	266.72	12.30	27.58	--	--	--	--
462	N 1/2 SEC 28 T6S R57W	107	43.3	ELBERT	CAKE/MAC	1/23/00	2/6/00	89	2,003	346	313.89	2.73	6.12	87	97.54	WHEAT	N
463	S 1/2 SEC 28 T6S R57W	54	21.9	ELBERT	CAKE/MAC	1/26/00	1/29/00	43	923	152	137.89	2.56	5.74	73	81.84	WHEAT	N
464	N 1/2 SEC 27 T6S R57W	213	86.2	ELBERT	CAKE/MAC	1/29/00	2/29/00	169	3,737	605	548.86	2.77	6.21	78	87.45	WHEAT	N
465	S 1/2 SEC 27 T6S R57W	172	69.6	ELBERT	CAKE/MAC	1/21/00	1/26/00	138	3,023	466	422.76	2.56	5.74	72	80.72	WHEAT	N
474	N 1/2 SEC 33 T6S R57W	52.2	21.1	ELBERT	CAKE/MAC	2/7/00	2/9/00	31	697	119	107.96	1.99	4.46	58	65.02	WHEAT	N
476	N 1/2 SEC 34 T6S R57W	61.6	24.9	ELBERT	CAKE/MAC	2/4/00	2/8/00	50	1,129	181	164.20	2.69	6.03	83	93.05	WHEAT	N

**Table 2.** Methods used to analyze biosolids and soil samples collected near Deer Trail, Colorado, 2000

Element or property	Medium	Analytical method	Reference
Arsenic	Soils and biosolids	HG-AAS <sup>1</sup>	Hageman and Welsch (1996)
Cadmium	Biosolids	ICP-MS <sup>2</sup>	Briggs and Meier (1999)
Cadmium	Soils	ICP-AES <sup>3</sup>	Motooka (1996)
Copper	Biosolids	ICP-MS <sup>2</sup>	Briggs and Meier (1999)
Copper	Soils	ICP-AES <sup>3</sup>	Briggs (1996)
Lead	Biosolids	ICP-MS <sup>2</sup>	Briggs and Meier (1999)
Lead	Soils	ICP-AES <sup>3</sup>	Briggs (1996)
Mercury	Soils and biosolids	CV-AAS <sup>4</sup>	O'Leary and others (1996)
Molybdenum	Biosolids	ICP-MS <sup>2</sup>	Briggs and Meier (1999)
Molybdenum	Soils	ICP-AES <sup>3</sup>	Motooka (1996)
Nickel	Biosolids	ICP-MS <sup>2</sup>	Briggs and Meier (1999)
Nickel	Soils	ICP-AES <sup>3</sup>	Briggs (1996)
Selenium	Soils and biosolids	HG-AAS <sup>1</sup>	Hageman and Welsch (1996)
Zinc	Biosolids	ICP-MS <sup>2</sup>	Briggs and Meier (1999)
Zinc	Soils	ICP-AES <sup>3</sup>	Briggs (1996)
Gross Alpha, Total	Soils and biosolids	Radiological method	Greenberg (1992)
Gross Beta, Total	Soils and biosolids	Radiological method	Greenberg (1992)
Plutonium-238, Total	Soils and biosolids	Radiological method	Whittaker and Grothaus (1979); Lyon (1980)
Plutonium-239+240, Total	Soils and biosolids	Radiological method	Whittaker and Grothaus (1979); Lyon (1980)

<sup>1</sup>Hydride Generation-Atomic Absorption Spectrometry.<sup>2</sup>Inductively Coupled Plasma-Mass Spectrometry.<sup>3</sup>Inductively Coupled Plasma-Atomic Emission Spectrometry.<sup>4</sup>Continuous Flow-Cold Vapor-Atomic Absorption Spectrometry.

**Table 3.** Chemical and radioactivity data for biosolids samples collected at the Metro Wastewater Reclamation District during 2000

[ppm, parts per million; pCi/g, picocuries per gram; ±, plus or minus the analytical uncertainty; maximum allowable concentrations from Colorado Department of Public Health and Environment, 1998]

Element or property	Maximum allowable for Grade I	March	June	August	September	October	November	December
Arsenic, ppm	41	1.7	1.8	2.0	2.0	1.8	1.8	1.7
Cadmium, ppm	39	3.0	2.8	2.7	2.9	2.9	5.4	3.6
Copper, ppm	1,500	530	560	580	560	570	570	610
Lead, ppm	300	64	66	78	75	120	70	65
Mercury, ppm	17	1.6	1.6	2.7	1.5	1.6	1.7	1.6
Molybdenum, ppm	No standard set for Grade I, 75 for Grade II	22	26	31	33	31	23	20
Nickel, ppm	420	30	31	33	30	29	27	28
Selenium, ppm	100	9.8	11	12	11	12	11	10
Zinc, ppm	2,800	610	630	700	690	670	690	700
Gross Alpha, pCi/g	40	23 ± 14	44 ± 11	36 ± 12	45 ± 12	43 ± 11	44 ± 11	36 ± 11
Gross Beta, pCi/g	No standard set for Grade I	26 ± 5	23 ± 6	27 ± 5	29 ± 5	29 ± 5	25 ± 4	22 ± 4
Plutonium 238, pCi/g	No standard set for Grade I	0.00 ± 0.01	0.00 ± 0.01	0.02 ± 0.03	0.01 ± 0.02	0.00 ± 0.01	-0.01 ± 0.01	0.01 ± 0.02
Plutonium 239+240, pCi/g	No standard set for Grade I	0.00 ± 0.01	0.00 ± 0.01	0.00 ± 0.01	0.00 ± 0.01	-0.01 ± 0.01	0.00 ± 0.01	0.00 ± 0.01

**Table 4.** Comparison of radioactivity data from two laboratories for biosolids samples

[Samples were run at two different laboratories for quality-assurance purposes; concentrations in picocuries per gram]

Constituent or property	Data from Acculabs received in 2001 (reported in table 3)	Data from Severn Trent Laboratory received in 2002 <sup>1</sup>
<b>June 2000 biosolids sample</b>		
Gross alpha	44 ± 11	40.2 ± 10
Gross beta	23 ± 6	30.1 ± 5.2
Plutonium-238	0.00 ± 0.01	0.00 ± 0.02
Plutonium-239+240	0.00 ± 0.01	0.00 ± 0.00
<b>NIST Standard Reference Material 2781</b>		
Gross alpha	34 ± 13, 40 ± 11, 51 ± 13, 37 ± 11, 60 ± 13, 44 ± 12, 42 ± 12	34 ± 9, 39 ± 10, 45 ± 11
Gross beta	28 ± 7, 27 ± 6, 35 ± 6, 31 ± 5, 28 ± 5, 30 ± 5, 29 ± 5	21 ± 4, 23 ± 4, 23 ± 4
Plutonium-238	0.00 ± 0.01, 0.00 ± 0.00, 0.00 ± 0.01, 0.00 ± 0.01, 0.01 ± 0.02, 0.00 ± 0.01, 0.01 ± 0.02	-0.001 ± 0.002, 0.00 ± 0.025, 0.00 ± 0.024
Plutonium-239+240	0.01 ± 0.02, 0.00 ± 0.01, 0.00 ± 0.01, 0.00 ± 0.01, 0.00 ± 0.01, 0.00 ± 0.01, 0.00 ± 0.01, 0.00 ± 0.00	0.001 ± 0.002, 0.00 ± 0.027, 0.01 ± 0.02

<sup>1</sup> U.S. Geological Survey contract laboratory used for all U.S. Geological Survey water resources radiochemical analyses in 1999 through 2002.

**Table 5.** Trace-element data for wheat whole-plant samples collected from the soil-monitoring sites near Deer Trail, Colorado, September 2000

[All data in milligrams per kilogram; &lt;, less than]

Element	Arapahoe County site			Elbert County site		
	North (control) field	Middle (biosolids application) field	South (control) field	North (control) field	Middle (biosolids application) field	South (control) field
Arsenic	0.12	0.15	0.28	<0.05	<0.05	<0.05
Cadmium	.05	.13	.14	.03	.03	.02
Copper	5.4	5.8	5.4	5.5	4.0	4.0
Lead	.17	.30	.37	.06	.04	.07
Mercury	.006	.005	.008	.006	.007	.006
Molybdenum	.86	.86	.79	1.71	1.06	1.08
Nickel	.94	1.20	1.25	.51	.45	.44
Selenium	.62	.44	.36	1.70	.40	.16
Zinc	17	15	15	21	15	16

**Table 6.** Trace-element and radioactivity data for wheat-grain samples collected from the soil-monitoring sites near Deer Trail, Colorado, September 2000

[mg/kg, milligram per kilogram; pCi/g, picocuries per gram; <, less than; ±, plus or minus the analytical uncertainty]

Element or property	Arapahoe County site		Elbert County site		
	South (control) field	Middle (biosolids application) field	North (control) field	Middle (biosolids application) field	South (control) field
Arsenic, mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium, mg/kg	.03	.04	.02	.02	.02
Copper, mg/kg	5.1	6.6	4.9	4.8	4.5
Lead, mg/kg	.01	.02	<.01	.01	<.01
Mercury, mg/kg	<.004	<.004	<.004	<.004	<.004
Molybdenum, mg/kg	.43	.80	.70	.51	.61
Nickel, mg/kg	.74	1.35	.43	.50	.50
Selenium, mg/kg	.41	1.4	2.1	.64	.38
Zinc, mg/kg	20	20	26	25	22
Gross Alpha, pCi/g	--	--	1 ± 1	1 ± 1	1 ± 1
Gross Beta, pCi/g	--	--	6 ± 2	6 ± 2	5 ± 2
Plutonium-238, pCi/g	--	--	0.00 ± -0.03	0.00 ± -0.01	0.00 ± -0.01
Plutonium-239+240, pCi/g	--	--	0.00 ± -0.00	0.00 ± -0.00	0.00 ± -0.01

**Table 7.** Trace-element data for millet-grain samples collected from the Arapahoe County soil-monitoring site near Deer Trail, Colorado, September 2000

[in milligrams per kilogram; <, less than]

Element	Arapahoe County site		
	North (control) field	Middle (biosolids application) field	South (control) field
Arsenic	0.07	0.04	0.06
Cadmium	.05	.05	.06
Copper	7.0	7.1	7.4
Lead	.21	.02	.06
Mercury	<.004	<.004	<.004
Molybdenum	.73	.78	.65
Nickel	6.4	6.5	5.3
Selenium	.26	.24	.27
Zinc	22	19	21

**Table 8.** Methods used to analyze ground-water samples collected near Deer Trail, Colorado, 2000

[MRL, minimum reporting level, and dilutions for samples having high specific conductance may result in higher MRL's for some samples; MDC, minimum detectable concentration (radiochemical samples); ICP, inductively coupled plasma; AA, atomic absorption spectrometry; MS, mass spectroscopy; ASF, automated segmented-flow spectrophotometry; IC, ion chromatography;  $\mu\text{S}/\text{cm}$ , microsiemens per centimeter at 25 degrees Celsius;  $\text{mg}/\text{L}$ , milligrams per liter;  $\mu\text{g}/\text{L}$ , micrograms per liter; GF, graphite furnace;  $\text{pCi}/\text{L}$ , picocuries per liter]

Property or constituent	Units	Analytical method	MRL or MDC	Method Reference
<b>Major ions and mineral characteristics</b>				
Specific conductance, lab	$\mu\text{S}/\text{cm}$	Wheatstone bridge	2.6	Fishman and Friedman (1989)
pH, lab	units	Electrometric electrode	0.1	Fishman and Friedman (1989)
Calcium, dissolved	$\text{mg}/\text{L}$	ICP	0.02	Fishman (1993)
Magnesium, dissolved	$\text{mg}/\text{L}$	ICP	0.014	Fishman (1993)
Sodium, dissolved	$\text{mg}/\text{L}$	ICP	0.09	Fishman (1993)
Potassium, dissolved	$\text{mg}/\text{L}$	AA	0.24	Fishman and Friedman (1989)
Acid-neutralizing capacity, lab as $\text{CaCO}_3$	$\text{mg}/\text{L}$	Electrometric titration	1	Fishman and Friedman (1989)
Sulfate, dissolved	$\text{mg}/\text{L}$	IC	0.31	Fishman and Friedman (1989)
Chloride, dissolved	$\text{mg}/\text{L}$	IC	0.29	Fishman and Friedman (1989)
Fluoride, dissolved	$\text{mg}/\text{L}$	Colorimetry, ASF, ion-selective electrode	0.1	Fishman and Friedman (1989)
Bromide, dissolved	$\text{mg}/\text{L}$	Colorimetry, ASF, fluorescein	0.01	Fishman and Friedman (1989)
Silica, dissolved	$\text{mg}/\text{L}$	Colorimetry, ASF, molybdate blue	0.09	Fishman (1993)
Dissolved solids, residue at $180^\circ\text{C}$	$\text{mg}/\text{L}$	Gravimetric	10	Fishman and Friedman (1989)
<b>Nutrients</b>				
Nitrite plus nitrate, dissolved as N	$\text{mg}/\text{L}$	Colorimetry, ASF, cadmium reduction, diazotization	0.037	Fishman (1993)
Nitrogen, ammonia, dissolved as N	$\text{mg}/\text{L}$	Colorimetry, ASF, salicylate-hypochlorite	0.029	Fishman (1993)
Nitrogen, ammonia plus organic, total as N	$\text{mg}/\text{L}$	Colorimetry, ASF, microkjeldahl digestion	0.1	Unpublished
Nitrogen, ammonia plus organic, dissolved as N	$\text{mg}/\text{L}$	Colorimetry, ASF, microkjeldahl digestion	0.1	Patton and Truitt (1992)
Phosphorus, total as P	$\text{mg}/\text{L}$	Colorimetry, ASF, microkjeldahl digestion	0.05	Patton and Truitt (1992)
Phosphorus, dissolved as P	$\text{mg}/\text{L}$	Colorimetry, ASF, microkjeldahl digestion	0.05	Patton and Truitt (1992)
<b>Trace elements</b>				
Aluminum, dissolved as Al	$\mu\text{g}/\text{L}$	ICP-MS	1	Faires (1993)
Antimony, dissolved as Sb	$\mu\text{g}/\text{L}$	ICP-MS	1	Faires (1993)
Arsenic, dissolved as As	$\mu\text{g}/\text{L}$	Hydride generation	2	Jones and Garbarino (1999)
Barium, dissolved as Ba	$\mu\text{g}/\text{L}$	ICP-MS	1	Faires (1993)
Beryllium, dissolved as Be	$\mu\text{g}/\text{L}$	ICP-MS	1	Faires (1993)

**Table 8.** Methods used to analyze ground-water samples collected near Deer Trail, Colorado, 2000—Continued

[MRL, minimum reporting level, and dilutions for samples having high specific conductance may result in higher MRL's for some samples; MDC, minimum detectable concentration (radiochemical samples); ICP, inductively coupled plasma; AA, atomic absorption spectrometry; MS, mass spectroscopy; ASF, automated segmented-flow spectrophotometry; IC, ion chromatography;  $\mu\text{S}/\text{cm}$ , microsiemens per centimeter at 25 degrees Celsius;  $\text{mg}/\text{L}$ , milligrams per liter;  $\mu\text{g}/\text{L}$ , micrograms per liter; GF, graphite furnace;  $\text{pCi}/\text{L}$ , picocuries per liter]

Property or constituent	Units	Analytical method	MRL or MDC	Method Reference
Boron, dissolved as B	$\mu\text{g}/\text{L}$	ICP-MS	16	Struzeski, DeGiacomo, and Zayhowski (1996)
Cadmium, dissolved as Cd	$\mu\text{g}/\text{L}$	ICP-MS	1	Faires (1993)
Chromium, dissolved as Cr	$\mu\text{g}/\text{L}$	GF AA	0.8	McLain (1993)
Cobalt, dissolved as Co	$\mu\text{g}/\text{L}$	ICP-MS	1	Faires (1993)
Copper, dissolved as Cu	$\mu\text{g}/\text{L}$	ICP-MS	1	Faires (1993)
Iron, dissolved as Fe	$\mu\text{g}/\text{L}$	ICP	3	Fishman (1993)
Lead, dissolved as Pb	$\mu\text{g}/\text{L}$	ICP-MS	1	Faires (1993)
Manganese, dissolved as Mn	$\mu\text{g}/\text{L}$	ICP-MS	1	Faires (1993)
Mercury, dissolved as Hg	$\mu\text{g}/\text{L}$	Hydride generation	0.2	Fishman and Friedman (1989)
Molybdenum, dissolved as Mo	$\mu\text{g}/\text{L}$	ICP-MS	1	Faires (1993)
Nickel, dissolved as Ni	$\mu\text{g}/\text{L}$	ICP-MS	1	Faires (1993)
Selenium, dissolved as Se	$\mu\text{g}/\text{L}$	Hydride generation	2.4	Jones and Garbarino (1999)
Silver, dissolved as Ag	$\mu\text{g}/\text{L}$	ICP-MS	1	Faires (1993)
Strontium, dissolved as Sr	$\mu\text{g}/\text{L}$	ICP-MS	1	Fishman (1993)
Zinc, dissolved as Zn	$\mu\text{g}/\text{L}$	ICP-MS	1	Faires (1993)
<b>Radioactivity</b>				
Uranium, natural dissolved	$\mu\text{g}/\text{L}$	ICP-MS	1	Faires (1993)
Plutonium-238, total	$\text{pCi}/\text{L}$	Alpha spectrometry	0.1*	Not Available
Plutonium-239+240, total	$\text{pCi}/\text{L}$	Alpha spectrometry	0.1*	Not Available

\*Contract required MDC; reported value may be lower depending upon the sample.

**Table 9.** Lithologic description for well DTX11 in 2000 near Deer Trail, Colorado

[Description from geologist's notes; cm, centimeter; bottom 6 feet of borehole sloughed with wet, sandy silt before well could be completed]

<b>Depth below land surface</b>	<b>Source of informa- tion</b>	<b>Description of material</b>
0-20 feet	Core	Medium-brown and dark-brown, dry, silty clay grading into damp, medium-brown, sandy silt.
20-23 feet	Core	Wet, brown silt and very fine-grained sand.
23-24.3 feet	Core	Dry, hard, orange clay grading into very dark gray clay; some small shale pebbles and sandstone fragments.
24.3-28 feet	Core	Very wet, granitic, interbedded coarse sand with pebbles and wet, gray, fine-grained sand and silt.
28-38 feet	Core	Wet, mostly gray, fine-grained sand and silt with a few thin (less than 1 inch) beds of coarse granitic sand and pebbles.
38-40 feet	Core	Dry, crumbly, gray and black striped bedrock (very fine-grained sandy silt interbedded with shale) grading into dry, crumbly, black shale.

**Table 10.** Information for U.S. Geological Survey monitoring wells near Deer Trail, Colorado, 2000

[Latitude and longitude are in the format degrees minutes seconds referenced to NAD 83; bmp, below measuring point (stickup); Wells shown in bold are sampled for water quality; Elev., elevation in feet above NAVD 88; Metro, Metro Wastewater Reclamation District]

Well	Latitude	Longitude	County	Date drilled	Stickup (feet)	Total depth (feet bmp)	Screened Interval				Elev. of measuring point (feet)	Property owner	Well diameter (inches)	
							Top (feet bmp)	Bottom (feet bmp)	Screen length (feet)	Screen opening (inches)				Sump length (feet)
<b>DTX1</b>	394333	1035251	ARAPAHOE	02/16/99	2.56	25.50	20.59	22.19	1.60	0.010	3.31	4,909	Metro	2
<b>DTX2*</b>	394149	1035138	ARAPAHOE	02/16/99	3.23	20.50	15.59	17.19	1.60	0.010	3.31	4,903	Metro	2
<b>DTX3</b>	393024	1034328	ELBERT	02/12/99	3.11	18.71	13.80	15.40	1.60	0.010	3.31	5,195	Metro	2
<b>DTX4</b>	393358	1034342	ELBERT	02/10/99	2.70	16.72	11.81	13.41	1.60	0.010	3.31	4,957	Metro	2
<b>DTX5*</b>	393358	1034548	ELBERT	02/10/99	2.30	20.90	16.09	17.69	1.60	0.010	3.21	4,975	Metro	2
<b>DTX6</b>	393358	1034648	ELBERT	02/9/99	2.43	39.21	34.30	35.90	1.60	0.010	3.31	4,970	Metro	2
<b>DTX7</b>	394054	1035646	ARAPAHOE	02/18/99	2.77	16.10	11.19	12.79	1.60	0.010	3.31	5,075	Price	2
<b>DTX8A</b>	394054	1035645	ARAPAHOE	03/2/99	2.46	77.52	67.56	71.83	4.27	0.010	5.69	5,076	Price	2
<b>DTX8B</b>	394054	1035645	ARAPAHOE	03/2/99	2.49	177.48	167.52	171.79	4.27	0.010	5.69	5,076	Price	2
<b>DTX9*</b>	393902	1035540	ARAPAHOE	02/17/99	2.46	30.15	22.72	24.32	1.60	0.010	5.83	5,121	Weisensee	2
<b>DTX10A*</b>	393902	1035540	ARAPAHOE	03/4/99	2.03	61.97	52.01	56.28	4.27	0.010	5.69	5,122	Weisensee	2
<b>DTX10B</b>	393902	1035540	ARAPAHOE	03/4/99	2.11	121.73	111.77	116.04	4.27	0.010	5.69	5,122	Weisensee	2
<b>DTX11*</b>	393902	1035540	ARAPAHOE	01/19/00	2.24	32	28	30	1.85	0.020	2.35	5,122	Weisensee	2
<b>D6</b>	393633	1035122	ARAPAHOE	09/12/93	2.65	25	15	25	10	0.010	0.3	5,128.78	Metro	2
<b>D11a</b>	393345	1035423	ELBERT	10/23/97	2.46	143.03	112.65	122.65	10	0.010	20.38	5,377	Metro	2
<b>D13</b>	393442	1035438	ARAPAHOE	04/4/94	1.81	16	6	16	10	0.010	0.3	5,235.33	Metro	2
<b>D17</b>	393334	1035436	ELBERT	04/5/94	0.90	21	11	21	10	0.010	0.3	5,277.73	Metro	2
<b>D25*</b>	393702	1035442	ARAPAHOE	05/1/95	2.23	23	13	23	10	0.010	0.3	5,167.13	Metro	2
<b>D29</b>	393641	1035248	ARAPAHOE	11/4/97	2.38	183.19	147.81	157.81	10	0.010	25.38	5,371	Metro	2
<b>D30</b>	393655	1035122	ARAPAHOE	05/5/95	1.98	19	9	19	10	0.010	0.3	5,096.43	Metro	2

\*Wells having continuous-recorder equipment.



**Table 12.** Field-parameter data associated with ground-water sampling near Deer Trail, Colorado, 2000[ $\mu\text{S/cm}$ , microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter, --, no data because equipment malfunctioned]

Well	Sample date (mm/dd/yy)	Sample time (hhmm)	Specific conduc- tance, field ( $\mu\text{S/cm}$ )	pH, field (stan- dard units)	Water temperature (degrees Celsius)	Water level before sampling, depth below measuring point (feet)	Oxygen, dissolved (mg/L)
DTX1	01/10/00	1345	4,200	7.0	11.1	7.84	0.50
DTX1	04/14/00	1220	4,210	7.0	11.3	7.46	0.52
DTX1	07/07/00	940	4,310	6.7	11.1	8.92	0.62
DTX1	10/17/00	1200	4,060	7.1	12.3	9.80	0.41
DTX2	01/10/00	1520	4,300	6.9	10.1	7.24	0.90
DTX2	04/14/00	1345	4,320	6.9	11.0	7.16	0.76
DTX2	07/07/00	1050	4,510	6.6	12.1	9.16	0.88
DTX2	10/17/00	1005	4,210	6.9	12.5	8.86	0.90
DTX3	01/10/00	1035	1,450	7.0	10.8	8.85	2.7
DTX3	04/11/00	1015	1,840	6.9	9.8	9.17	3.24
DTX3	07/10/00	1030	2,130	6.6	12.4	9.70	3.56
DTX3	10/11/00	1030	2,050	7.0	14.6	10.24	3.24
DTX4	01/06/00	955	3,000	6.6	10.1	7.93	0.90
DTX4	04/11/00	1145	3,070	6.7	8.7	7.25	1.07
DTX4	07/11/00	1010	3,210	6.4	11.6	10.12	1.33
DTX4	10/11/00	1215	3,180	6.7	14.5	12.51	0.96
DTX5	01/06/00	1310	2,950	6.8	10.8	9.78	0.90
DTX5	04/11/00	1345	2,820	6.9	10.3	9.65	0.90
DTX5	07/11/00	1150	3,100	6.6	12.5	10.80	1.23
DTX5	10/16/00	1015	2,950	6.8	12.6	11.97	1.07
DTX6	01/06/00	1530	4,150	6.9	11.7	21.66	0.80
DTX6	04/14/00	1000	4,380	7.0	12.7	21.11	1.01
DTX6	07/13/00	1300	4,500	6.7	13.5	21.90	1.35
DTX6	10/11/00	1400	4,290	7.0	13.4	22.49	1.00
DTX8A	01/13/00	1315	1,850	7.4	11.4	7.97	0.40
DTX8A	04/13/00	1415	1,850	7.3	15.4	7.54	--
DTX8A	07/10/00	1505	1,950	7.2	18.8	9.47	0.62
DTX8A	10/16/00	1435	1,830	7.3	15.1	9.58	0.95

**Table 12.** Field-parameter data associated with ground-water sampling near Deer Trail, Colorado, 2000—Continued[ $\mu\text{S/cm}$ , microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter, --, no data because equipment malfunctioned]

Well	Sample date (mm/dd/yy)	Sample time (hhmm)	Specific conduc- tance, field ( $\mu\text{S/cm}$ )	pH, field (stan- dard units)	Water temperature (degrees Celsius)	Water level before sampling, depth below measuring point (feet)	Oxygen, dissolved (mg/L)
DTX10A	01/11/00	1130	3,150	7.0	13.2	12.95	0.20
DTX10A	04/17/00	1415	3,120	6.9	17.0	13.03	0.42
DTX10A	07/13/00	1020	3,220	6.8	20.2	13.42	0.26
DTX10A	10/18/00	1040	3,070	7.1	16.2	13.12	3.04
D6	01/11/00	1355	16,000	7.0	12.0	9.35	0.30
D6	04/13/00	945	16,600	6.9	11.7	9.31	0.77
D6	07/11/00	1345	17,500	6.7	13.4	9.44	0.98
D6	10/12/00	1300	16,100	6.9	12.7	9.54	0.70
D13	01/12/00	1005	1,460	7.0	8.5	7.46	0.50
D13	04/17/00	1115	1,390	7.0	9.0	6.59	0.44
D13	07/07/00	1230	1,500	6.8	13.2	8.13	0.76
D13	10/16/00	1215	1,670	7.1	13.8	8.47	1.52
D17	01/07/00	1500	470	7.5	12.1	10.99	1.50
D17	04/10/00	1415	480	7.4	12.3	10.84	2.46
D17	07/06/00	1320	540	7.3	14.1	11.11	1.74
D17	10/10/00	1245	480	7.6	14.4	12.65	0.49
D25	01/12/00	1245	4,300	7.0	11.8	10.32	0.40
D25	04/10/00	1615	4,260	6.9	11.3	10.23	0.66
D25	07/06/00	1500	4,620	6.8	13.2	10.69	0.71
D25	10/10/00	1455	4,910	7.1	13.8	8.81	0.39
D29	01/07/00	1130	4,020	6.7	17.6	154.41	3.0
D29	04/10/00	1215	3,940	6.5	20.0	154.35	3.51
D29	07/06/00	1105	4,090	6.5	23.1	154.35	1.74
D29	10/12/00	1110	3,960	6.6	20.8	154.19	1.08
D30	01/11/00	1600	4,870	6.9	10.7	5.10	0.30
D30	04/13/00	1200	5,060	6.8	10.2	4.75	0.49
D30	07/10/00	1245	5,110	6.7	12.1	6.07	0.59
D30	10/12/00	1450	4,960	7.0	14.4	5.38	0.40

Table 13. Water-quality data for monitoring wells near Deer Trail, Colorado, 2000

[ $\mu\text{S}/\text{cm}$ , microsiemens per centimeter at 25 degrees Celsius;  $\text{mg}/\text{L}$ , milligrams per liter;  $\mu\text{g}/\text{L}$ , micrograms per liter;  $\text{pCVL}$ , picocuries per liter;  $\leq$ , less than; ND, no data available; E, value estimated by laboratory; -, no sample submitted; analytical uncertainty is the 2-sigma precision estimate calculated by the laboratory as a combined standard analytical uncertainty; MDC, minimum detectable concentration calculated for that sample; negative activity reported for some of the radiochemical samples means the sample counts were less than the laboratory background counts for that day]

Well number	Date (mm/dd/yy)	Time (hhmm)	Specific conductance, lab ( $\mu\text{S}/\text{cm}$ )	pH, laboratory (standard units)	Hardness total ( $\text{mg}/\text{L}$ as $\text{CaCO}_3$ )	Calcium, dissolved ( $\text{mg}/\text{L}$ as $\text{Ca}$ )	Magnesium, dissolved ( $\text{mg}/\text{L}$ as $\text{Mg}$ )	Potassium, dissolved ( $\text{mg}/\text{L}$ as $\text{K}$ )	Sodium adsorption ratio	Sodium, dissolved ( $\text{mg}/\text{L}$ as $\text{Na}$ )	Sodium (percent)	Acid-neutralizing capacity, titration to $\text{pH}$ 4.5, lab ( $\text{mg}/\text{L}$ as $\text{CaCO}_3$ )	Chloride, dissolved ( $\text{mg}/\text{L}$ as $\text{Cl}$ )
DTX1	01/10/00	1345	4,100	7.3	2,100	477	221	3.5	4	372	28	319	49.7
DTX1	04/14/00	1220	4,150	7.2	2,000	453	198	3.3	3	331	27	318	47.5
DTX1	07/07/00	0940	4,050	7.3	2,000	459	209	3.1	3	355	28	315	49.9
DTX1	10/17/00	1200	4,070	7.3	1,700	467	124	3.5	4	331	30	316	49.1
DTX2	01/10/00	1520	4,200	7.1	2,000	460	194	8.6	4	364	29	406	45.6
DTX2	04/14/00	1345	4,240	7.0	2,000	495	194	7.3	3	360	28	404	40.2
DTX2	07/07/00	1050	4,250	7.1	2,100	472	214	7.8	4	392	29	405	36.0
DTX2	10/17/00	1005	4,230	7.0	1,700	479	122	8.5	4	382	33	409	40.2
DTX3	01/10/00	1035	1,410	7.4	720	170	69.9	6.2	.9	58.2	15	274	17.1
DTX3	04/11/00	1015	1,880	7.3	990	240	94.2	7.3	1	72.8	14	314	26.0
DTX3	07/10/00	1030	2,020	7.4	1,100	266	102	7.3	1	94.1	16	328	28.6
DTX3	10/11/00	1030	2,100	7.1	1,100	263	102	7.5	1	99.5	17	338	28.7
DTX4	01/06/00	0955	2,950	7.0	1,700	531	86.9	8.8	2	160	17	353	15.2
DTX4	04/11/00	1145	3,140	6.9	1,800	551	90.8	7.2	2	158	16	424	16.1
DTX4	07/11/00	1010	3,070	6.9	1,700	526	89.1	7.5	2	169	18	346	17.4
DTX4	10/11/00	1215	3,200	6.9	1,800	563	95.4	8.8	2	179	18	348	16.1

**Table 13.** Water-quality data for monitoring wells near Deer Trail, Colorado, 2000—Continued

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than; ND, no data available; E, value estimated by laboratory; --, no sample submitted; analytical uncertainty is the 2-sigma precision estimate calculated by the laboratory as a combined standard analytical uncertainty; MDC, minimum detectable concentration calculated for that sample; negative activity reported for some of the radiochemical samples means the sample counts were less than the laboratory background counts for that day]

Well number	Date (mm/dd/yy)	Time (hhmm)	Specific conductance, lab (µS/cm)	pH, laboratory (standard units)	Hardness total (mg/L as CaCO <sub>3</sub> )	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Potassium, dissolved (mg/L as K)	Sodium adsorption ratio	Sodium, dissolved (mg/L as Na)	Sodium (percent)	Acid-neutralizing capacity, titration to pH 4.5, lab (mg/L as CaCO <sub>3</sub> )	Chloride, dissolved (mg/L as Cl)
DTX5	01/06/00	1310	2,900	7.1	1,800	566	86.2	4.6	1	94.6	10	275	8.6
DTX5	04/11/00	1345	2,860	7.1	1,800	568	81.8	4.9	.9	91.0	10	270	7.7
DTX5	07/11/00	1150	2,970	7.1	1,700	559	84.2	4.6	1	120	13	273	10.6
DTX5	10/16/00	1015	2,900	7.1	1,600	523	81.1	5.1	2	148	16	275	10.0
DTX6	01/06/00	1530	4,100	7.2	2,200	468	243	12.8	3	307	23	270	19.2
DTX6	04/14/00	1000	4,300	7.1	2,200	476	248	13.6	3	309	23	274	21.8
DTX6	07/13/00	1300	4,300	7.3	2,300	468	265	12.6	3	336	24	270	20.6
DTX6	10/11/00	1400	4,290	7.1	2,300	480	263	12.5	3	328	24	270	20.3
DTX8A	01/13/00	1315	1,860	7.6	490	144	32.0	6.6	5	240	51	225	26.9
DTX8A	04/13/00	1415	1,920	7.6	460	135	29.9	7.0	4	219	50	224	27.2
DTX8A	07/10/00	1505	1,870	7.8	510	149	32.4	6.1	5	241	50	216	26.3
DTX8A	10/16/00	1435	1,890	7.5	490	144	31.6	6.2	5	232	50	224	25.6
DTX10A	01/11/00	1130	3,070	7.0	1,800	443	170	112.5	2	150	15	226	17.4
DTX10A	04/17/00	1415	3,180	7.2	1,800	446	171	8.1	2	147	15	223	16.3
DTX10A	07/13/00	1020	3,140	7.2	1,800	433	170	8.8	2	152	16	222	17.9
DTX10A	10/18/00	1040	3,100	7.2	1,800	456	169	8.3	2	153	15	221	16.6

**Table 13.** Water-quality data for monitoring wells near Deer Trail, Colorado, 2000—Continued

[ $\mu\text{S}/\text{cm}$ , microsiemens per centimeter at 25 degrees Celsius;  $\text{mg}/\text{L}$ , milligrams per liter;  $\mu\text{g}/\text{L}$ , micrograms per liter;  $\text{pCl}/\text{L}$ , picocuries per liter; <, less than; ND, no data available; E, value estimated by laboratory; --, no sample submitted; analytical uncertainty is the 2-sigma precision estimate calculated by the laboratory as a combined standard analytical uncertainty; MDC, minimum detectable concentration calculated for that sample; negative activity reported for some of the radiochemical samples means the sample counts were less than the laboratory background counts for that day]

Well number	Date (mm/dd/yy)	Time (hhmm)	Specific conductance, lab ( $\mu\text{S}/\text{cm}$ )	pH, laboratory (standard units)	Hardness total ( $\text{mg}/\text{L}$ as $\text{CaCO}_3$ )	Calcium, dissolved ( $\text{mg}/\text{L}$ as $\text{Ca}$ )	Magnesium, dissolved ( $\text{mg}/\text{L}$ as $\text{Mg}$ )	Potassium, dissolved ( $\text{mg}/\text{L}$ as $\text{K}$ )	Sodium adsorption ratio	Sodium, dissolved ( $\text{mg}/\text{L}$ as $\text{Na}$ )	Sodium (percent)	Acid-neutralizing capacity, titration to pH 4.5, lab ( $\text{mg}/\text{L}$ as $\text{CaCO}_3$ )	Chloride, dissolved ( $\text{mg}/\text{L}$ as $\text{Cl}$ )
D6	01/11/00	1355	16,300	7.2	10,000	400	2,200	11.2	8	1,860	29	638	411
D6	04/13/00	0945	16,300	7.2	11,000	446	2,320	12.9	9	2,100	30	640	380
D6	07/11/00	1345	16,000	7.2	10,000	414	2,170	12.0	9	2,070	31	638	404
D6	10/12/00	1300	16,200	7.1	10,000	437	2,190	10.4	9	2,110	31	640	419
D13	01/12/00	1005	1,410	7.4	720	198	54.9	2.4	1	58.8	15	248	3.1
D13	04/17/00	1115	1,390	7.4	660	179	50.6	2.5	1	57.1	16	253	2.9
D13	07/07/00	1230	1,420	7.7	680	188	52.1	2.8	1	62.6	17	255	3.2
D13	10/16/00	1215	1,650	7.2	830	226	63.0	2.8	1	66.7	15	256	3.8
D17	01/07/00	1500	492	7.6	210	55.3	18.2	1.6	.5	16.0	14	209	2.3
D17	04/10/00	1415	523	7.7	210	54.9	18.5	1.6	.5	15.4	13	212	2.8
D17	07/06/00	1320	533	7.8	230	56.3	22.5	1.6	.4	15.1	12	215	3.6
D17	10/10/00	1245	484	7.7	220	59.7	18.0	1.6	.5	15.5	13	202	2.9
D25	01/12/00	1245	4,300	7.3	2,500	642	206	7.2	2	260	19	449	108
D25	04/10/00	1615	4,320	7.2	2,400	646	194	7.1	2	240	18	400	119
D25	07/06/00	1500	4,510	7.3	2,600	638	232	7.3	2	286	20	496	99.8
D25	10/10/00	1455	4,900	7.2	2,900	794	219	8.3	3	334	20	585	81.5

**Table 13.** Water-quality data for monitoring wells near Deer Trail, Colorado, 2000—Continued

[[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than; ND, no data available; E, value estimated by laboratory; -, no sample submitted; analytical uncertainty is the 2-sigma precision estimate calculated by the laboratory as a combined standard analytical uncertainty; MDC, minimum detectable concentration calculated for that sample; negative activity reported for some of the radiochemical samples means the sample counts were less than the laboratory background counts for that day]

Well number	Date (mm/dd/yy)	Time (hhmm)	Specific conductance, lab (µS/cm)	pH, laboratory (standard units)	Hardness total (mg/L as CaCO <sub>3</sub> )	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Potassium, dissolved (mg/L as K)	Sodium adsorption ratio	Sodium, dissolved (mg/L as Na)	Sodium (percent)	Acid-neutralizing capacity, titration to pH 4.5, lab (mg/L as CaCO <sub>3</sub> )	Chloride, dissolved (mg/L as Cl)
D29	01/7/00	1130	4,020	6.9	2,800	535	346	11.1	1	143	10	293	11.5
D29	04/10/00	1215	4,060	6.7	2,600	521	316	10.9	1	138	10	290	12.3
D29	07/06/00	1105	3,910	6.8	2,600	529	315	10.3	1	137	10	290	13.0
D29	10/12/00	1110	3,980	6.8	2,700	544	313	9.5	1	139	10	283	10.8
D30	01/11/00	1600	4,800	7.1	2,700	428	400	3.9	3	371	23	364	53.1
D30	04/13/00	1200	4,980	7.2	2,800	425	410	4.0	3	361	22	367	50.0
D30	07/10/00	1245	4,640	7.4	2,600	419	386	3.9	3	369	23	344	47.4
D30	10/12/00	1450	4,870	7.1	2,700	439	389	3.6	3	381	23	346	54.0

**Table 13.** Water-quality data for monitoring wells near Deer Trail, Colorado, 2000—Continued

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than; ND, no data available; E, value estimated by laboratory; --, no sample submitted; analytical uncertainty is the 2-sigma precision estimate calculated by the laboratory as a combined standard analytical uncertainty; MDC, minimum detectable concentration calculated for that sample; negative activity reported for some of the radiochemical samples means the sample counts were less than the laboratory background counts for that day]

Well number	Date (mm/dd/yy)	Time (hhmm)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO <sub>2</sub> )	Sulfate, dissolved (mg/L as SO <sub>4</sub> )	Nitrogen ammonia plus organic, dissolved (mg/L as N)	Nitrogen ammonia plus organic, total (mg/L as N)	Nitrite plus nitrate (mg/L as N)	Phos-phorus, dissolved (mg/L as P)	Phos-phorus, total (mg/L as P)	Solids, residue on evaporation at 180°C, dissolved (mg/L)	Dissolved solids, sum of constituents (mg/L)
DTX1	01/10/00	1345	0.8	33.9	2,440	0.22	0.23	E:0.25	0.073	0.070	4,170	3,810
DTX1	04/14/00	1220	.8	30.5	2,400	.24	.21	E:0.17	.081	.054	4,090	3,670
DTX1	07/07/00	0940	.8	32.0	2,390	.22	.20	.093	.080	.080	4,000	3,700
DTX1	10/17/00	1200	.7	32.2	2,400	E:0.09	.26	E:0.47	.085	.080	4,050	3,610
DTX2	01/10/00	1520	.5	15.9	2,430	.86	.62	.549	<.05	<.05	4,200	3,780
DTX2	04/14/00	1345	.5	16.1	2,410	.89	.84	.583	<.05	<.05	4,160	3,780
DTX2	07/07/00	1050	.5	16.6	2,480	.88	.85	.651	<.05	<.05	4,230	3,870
DTX2	10/17/00	1005	.5	16.5	2,440	1<.10	.98	.634	<.05	E:0.4	4,140	3,740
DTX3	01/10/00	1035	.4	15.7	516	.19	.16	E:0.14	<.05	<.05	1,090	1,030
DTX3	04/11/00	1015	.4	16.6	770	<.10	.17	<.029	<.05	<.05	1,550	1,440
DTX3	07/10/00	1030	.4	10.4	860	.20	.19	<.029	<.05	<.05	1,680	1,570
DTX3	10/11/00	1030	.4	17.8	901	.20	.20	E:0.36	<.05	<.06	1,760	1,640
DTX4	01/06/00	0955	.2	11.6	1,590	.26	.29	.063	<.05	<.05	2,800	2,620
DTX4	04/11/00	1145	.2	11.5	1,670	<.10	.31	.056	<.05	<.05	3,000	2,760
DTX4	07/11/00	1010	.2	10.7	1,670	.29	.29	.085	<.05	<.05	2,970	2,720
DTX4	10/11/00	1215	.3	11.6	1,760	.40	.38	.121	<.05	<.06	3,060	2,880

**Table 13.** Water-quality data for monitoring wells near Deer Trail, Colorado, 2000—Continued

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than; ND, no data available; E, value estimated by laboratory; --, no sample submitted; analytical uncertainty is the 2-sigma precision estimate calculated by the laboratory as a combined standard analytical uncertainty; MDC, minimum detectable concentration calculated for that sample; negative activity reported for some of the radiochemical samples means the sample counts were less than the laboratory background counts for that day]

Well number	Date (mm/dd/yy)	Time (hhmm)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO <sub>2</sub> )	Sulfate, dissolved (mg/L as SO <sub>4</sub> )	Nitrogen ammonia plus organic, dissolved (mg/L as N)	Nitrogen ammonia plus organic, total (mg/L as N)	Nitrite plus nitrate (mg/L as N)	Phos-phorus, dissolved (mg/L as P)	Phos-phorus, total (mg/L as P)	Solids, residue on evaporation at 180°C, dissolved (mg/L)	Dissolved solids, sum of constituents (mg/L)
DTX5	01/06/00	1310	0.2	11.7	1,720	0.12	0.16	0.048	<0.05	<0.05	2,920	2,660
DTX5	04/11/00	1345	0.3	11.2	1,670	<0.10	0.18	0.054	<0.05	<0.05	2,790	2,600
DTX5	07/11/00	1150	.3	11.2	1,750	.15	.12	.113	<.05	<.05	2,950	2,710
DTX5	10/16/00	1015	.3	11.9	1,640	.15	.18	.116	<.05	E.04	2,750	2,590
DTX6	01/06/00	1530	0.4	11.4	2,560	0.12	0.12	0.034	<0.05	<0.05	4,210	3,790
DTX6	04/14/00	1000	.5	11.2	2,660	.11	.14	E.015	<.05	<.05	4,380	3,910
DTX6	07/13/00	1300	.4	11.3	2,730	.10	.11	.060	<.05	<.05	4,440	4,010
DTX6	10/11/00	1400	.5	11.1	2,680	.14	E.10	.087	<.05	<.06	4,360	3,960
DTX8A	01/13/00	1315	.4	13.0	767	1.6	1.5	1.41	<.05	<.05	1,420	1,370
DTX8A	04/13/00	1415	.4	12.2	748	1.6	1.5	1.41	1.12	<.05	1,400	1,320
DTX8A	07/10/00	1505	.4	13.5	757	1.5	1.4	1.39	<.05	<.05	1,390	1,360
DTX8A	10/16/00	1435	.3	12.9	751	1.3	1.5	1.35	<.05	<.06	1,410	1,340
DTX10A	01/11/00	1130	0.8	16.6	1,890	1.4	1.4	1.24	<0.05	<0.05	3,100	2,850
DTX10A	04/17/00	1415	.9	16.8	1,880	1.3	<.10	1.27	<.05	<.05	3,080	2,830
DTX10A	07/13/00	1020	.9	16.7	1,880	1.4	1.4	1.28	<.05	<.05	3,090	2,820
DTX10A	10/18/00	1040	.8	16.8	1,880	<.10	1.2	1.19	<.05	<.06	3,070	2,840
D6	01/11/00	1355	.7	20.1	13,000	1.6	1.6	.067	<.05	E.04	21,000	183,000
D6	04/13/00	0945	.8	21.3	12,900	1.5	1.4	.045	E.04	E.04	20,300	18,600
D6	07/11/00	1345	.8	20.6	13,100	1.5	1.4	<.030	E.03	E.04	21,100	18,700
D6	10/12/00	1300	.8	19.8	13,100	1.1	1.5	.131	<.05	E.04	21,500	18,700

**Table 13.** Water-quality data for monitoring wells near Deer Trail, Colorado, 2000—Continued

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than; ND, no data available; E, value estimated by laboratory; --, no sample submitted; analytical uncertainty is the 2-sigma precision estimate calculated by the laboratory as a combined standard analytical uncertainty; MDC, minimum detectable concentration calculated for that sample; negative activity reported for some of the radiochemical samples means the sample counts were less than the laboratory background counts for that day]

Well number	Date (mm/dd/yy)	Time (hhmm)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO <sub>2</sub> )	Sulfate, dissolved (mg/L as SO <sub>4</sub> )	Nitrogen ammonia plus organic, dissolved (mg/L as N)	Nitrogen ammonia plus organic, total (mg/L as N)	Nitrite plus nitrate (mg/L as N)	Phos-phorus, dissolved (mg/L as P)	Phos-phorus, total (mg/L as P)	Solids, residue on evaporation at 180°C, dissolved (mg/L)	Dissolved solids, sum of constituents (mg/L)
D13	01/12/00	1005	1.4	12.7	626	.15	.13	.049	<.05	<.05	1,150	1,110
D13	04/17/00	1115	1.4	11.9	545	.14	.22	<.029	<.05	<.05	1,080	1,000
D13	07/07/00	1230	1.4	13.6	563	0.14	0.13	0.040	<.05	<.05	1,110	1,040
D13	10/16/00	1215	1.4	14.1	719	.14	.17	E.027	<.05	<.06	1,340	1,250
D17	01/07/00	1500	1.6	18.2	44.9	E.10	E.10	E.026	.08	.10	298	294
D17	04/10/00	1415	1.7	17.5	42.4	.12	.12	<.029	.09	.09	305	298
D17	07/06/00	1320	1.7	18.8	40.6	.16	.17	<.029	.08	.07	325	315
D17	10/10/00	1245	1.6	19.0	49.3	E.10	E.10	<.049	E.05	.07	287	292
D25	01/12/00	1245	1.0	27.8	2,460	0.69	0.67	0.045	0.12	0.12	4,520	4,000
D25	04/10/00	1615	1.1	26.3	2,420	.62	.72	.070	.10	.10	4,390	3,900
D25	07/06/00	1500	1.0	28.5	2,520	.74	.77	.138	.15	.15	4,640	4,130
D25	10/10/00	1455	1.0	28.8	2,860	.11	.88	.110	.11	.12	5,270	4,710
D29	01/07/00	1130	.5	21.1	2,690	.45	.51	.446	<.05	E.04	4,260	3,950
D29	04/10/00	1215	.6	20.6	2,630	.44	.47	.428	<.05	<.05	4,280	3,830
D29	07/06/00	1105	.5	20.4	2,620	.45	.49	.466	E.04	E.04	4,300	3,830
D29	10/12/00	1110	.5	20.2	2,660	.41	.45	.431	<.05	.06	4,120	3,880
D30	01/11/00	1600	.7	21.8	3,070	.29	.29	.065	E.04	.06	5,110	4,580
D30	04/13/00	1200	.8	20.7	3,070	.29	.27	.047	E.03	E.05	5,070	4,570
D30	07/10/00	1245	.8	21.0	3,060	.28	.29	.134	<.05	E.04	5,000	4,520
D30	10/12/00	1450	.8	21.8	3,100	.30	.34	.120	<.05	E.06	4,980	4,600

Table 13. Water-quality data for monitoring wells near Deer Trail, Colorado, 2000—Continued

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; pCVL, picocuries per liter; <, less than; ND, no data available; E, value estimated by laboratory; -, no sample submitted; analytical uncertainty is the 2-sigma precision estimate calculated by the laboratory as a combined standard analytical uncertainty; MDC, minimum detectable concentration calculated for that sample; negative activity reported for some of the radiochemical samples means the sample counts were less than the laboratory background counts for that day]

Well number	Date (mm/dd/yy)	Time (hhmm)	Aluminum, dissolved (µg/L as Al)	Anti-mony, dissolved (µg/L as Sb)	Arsenic, dissolved (µg/L as As)	Barium, dissolved (µg/L as Ba)	Beryllium, dissolved (µg/L as Be)	Boron, dissolved (µg/L as B)	Bromide, dissolved (mg/L as Br)	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)	Cobalt, dissolved (µg/L as Co)	Copper, dissolved (µg/L as Cu)
DTX1	01/10/00	1345	7	<2	E1	9	<2	670	0.67	<2.0	<1.0	<2	8
DTX1	04/14/00	1220	<4	<1	4	8	<1	530	.71	<1.0	<.8	<1	14
DTX1	07/07/00	0940	<1	<1	E2	8	<1	550	.33	<1.0	<.8	1	9
DTX1	10/17/00	1200	2	<2	E2	8	<2	590	.70	<2.0	<.8	2	12
DTX2	01/10/00	1520	18	<2	<2	16	<2	310	.53	<2.0	<1.0	5	6
DTX2	04/14/00	1345	<3	<1	E2	15	<1	290	.40	<1.0	<.8	4	11
DTX2	07/07/00	1050	<1	<1	E1	14	<1	350	.41	<1.0	<.8	5	8
DTX2	10/17/00	1005	<2	<2	E1	14	<2	360	.48	<2.0	<.8	7	11
DTX3	01/10/00	1035	2	<1	<2	23	<1	210	.22	<1.0	E.6	<1	3
DTX3	04/14/00	1015	<6	<1	<2	23	<1	220	.28	<1.0	<.8	<1	3
DTX3	07/10/00	1030	<6	<1	<2	21	<1	230	.29	<1.0	<.8	<1	5
DTX3	10/17/00	1030	<1	<1	<2	21	<1	230	.27	<1	1.7	1	3
DTX4	01/06/00	0955	<2	<2	E1	14	<2	290	.22	<2.0	<.8	<1	5
DTX4	04/14/00	1145	<29	<2	E1	13	<2	270	.23	<2.0	<1.0	<2	6
DTX4	07/11/00	1010	<1	<2	<2	12	<2	240	.29	<2.0	<.8	<2	7
DTX4	10/17/00	1215	<2	E.1	<2	14	<1	310	.31	E.1	2.6	1	6

**Table 13.** Water-quality data for monitoring wells near Deer Trail, Colorado, 2000—Continued

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; pCVL, picocuries per liter; <, less than; ND, no data available; E, value estimated by laboratory; ~, no sample submitted; analytical uncertainty is the 2-sigma precision estimate calculated by the laboratory as a combined standard analytical uncertainty; MDC, minimum detectable concentration calculated for that sample; negative activity reported for some of the radionuclide samples means the sample counts were less than the laboratory background counts for that day]

Well number	Date (mm/dd/yy)	Time (hhmm)	Aluminum, dissolved (µg/L as Al)	Antimony, dissolved (µg/L as Sb)	Arsenic, dissolved (µg/L as As)	Barium, dissolved (µg/L as Ba)	Beryllium, dissolved (µg/L as Be)	Boron, dissolved (µg/L as B)	Bromide, dissolved (mg/L as Br)	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)	Cobalt, dissolved (µg/L as Co)	Copper, dissolved (µg/L as Cu)
DTX5	01/06/00	1310	2	<2	<2	16	<2	400	0.20	<2.0	0.9	3	6
DTX5	04/11/00	1345	<2	<2	<2	13	<2	330	.19	<2.0	<1.0	3	6
DTX5	07/11/00	1150	<1	<2	<2	13	<2	390	2.1	<2.0	<.8	2	7
DTX5	10/16/00	1015	<2	1	<2	14	<1	470	.25	<1	<.8	2	7
DTX6	01/06/00	1530	3	<2	E1	9	<2	360	.15	<2.0	<.8	<2	7
DTX6	04/14/00	1000	<2	<1	2	9	<1	340	.17	<1.0	.8	<1	16
DTX6	07/13/00	1300	3	<1	<2	9	<1	340	.23	<1.0	<3.2	<1	9
DTX6	10/11/00	1400	3	<1	<2	8	<1	350	.17	E.1	3.0	1	9
DTX8A	01/13/00	1315	2	<1	<2	22	<1	260	.26	<1.0	E.8	<1	2
DTX8A	04/13/00	1415	<2	<1	<2	21	<1	240	.25	<1.0	<.8	<1	4
DTX8A	07/10/00	1505	<4	<1	<2	19	<1	260	.26	<1.0	<.8	<1	3
DTX8A	10/16/00	1435	3	E.03	<2	17	<1	260	.27	<1	<.8	1	2
DTX10A	01/11/00	1130	2	<1	<2	16	<1	230	0.25	<1.0	1.5	<1	3
DTX10A	04/17/00	1415	<4	<2	<2	13	<2	240	.26	<2.0	<1.0	<2	6
DTX10A	07/13/00	1020	3	<1	<2	12	<1	250	.25	<1.0	<3.2	1	6
DTX10A	10/18/00	1040	<2	<1	<2	12	<1	250	.28	<1	<.8	1	5

Table 13. Water-quality data for monitoring wells near Deer Trail, Colorado, 2000—Continued

$\mu\text{S/cm}$ , microsiemens per centimeter at 25 degrees Celsius;  $\text{mg/L}$ , milligrams per liter;  $\mu\text{g/L}$ , micrograms per liter;  $\text{pCi/L}$ , picocuries per liter; ND, no data available; E, value estimated by laboratory; -, no sample submitted; analytical uncertainty is the 2-sigma precision estimate calculated by the laboratory as a combined standard analytical uncertainty; MDC, minimum detectable concentration calculated for that sample; negative activity reported for some of the radiochemical samples means the sample counts were less than the laboratory background counts for that day

Well number	Date (mm/dd/yy)	Time (hhmm)	Aluminum, dissolved ( $\mu\text{g/L}$ as Al)	Antimony, dissolved ( $\mu\text{g/L}$ as Sb)	Arsenic, dissolved ( $\mu\text{g/L}$ as As)	Barium, dissolved ( $\mu\text{g/L}$ as Ba)	Beryllium, dissolved ( $\mu\text{g/L}$ as Be)	Boron, dissolved ( $\mu\text{g/L}$ as B)	Bromide, dissolved ( $\text{mg/L}$ as Br)	Cadmium, dissolved ( $\mu\text{g/L}$ as Cd)	Chromium, dissolved ( $\mu\text{g/L}$ as Cr)	Cobalt, dissolved ( $\mu\text{g/L}$ as Co)	Copper, dissolved ( $\mu\text{g/L}$ as Cu)
D6	01/11/00	1355	121	<1	2	<1	<1	890	4.32	<1.0	<4.0	1	15
D6	04/13/00	0945	1	<1	E9	6	<1	E750	4.32	<1.0	<.8	6	61
D6	07/11/00	1345	<1	<7	E1	<7	<7	820	3.95	<7.0	<.8	<7	35
D6	10/12/00	1300	<1	<1	3	5	<1	970	4.15	.1	<.8	6	33
D13	01/12/00	1005	<1	<1	<2	20	<1	80	.18	<1.0	.9	<1	3
D13	04/17/00	1115	<7	<1	<2	17	<1	80	.17	<1.0	<.8	<1	2
D13	07/07/00	1230	<1	<1	<2	19	<1	100	.15	<1.0	E.5	<1	2
D13	10/16/00	1215	<1	<1	<2	24	<1	110	.19	E.02	<.8	1	3
D17	01/07/00	1900	3	<1	E1	61	<1	60	.08	<1.0	<.8	<1	<1
D17	04/10/00	1415	<1	<1	E1	58	<1	60	.09	<1.0	<.8	<1	<1
D17	07/06/00	1320	<1	<1	E1	56	<1	90	.09	<1.0	<.8	<1	1
D17	10/10/00	1245	<1	<1	E1	59	<1	60	.09	<1	<.8	1	1
D25	01/12/00	1245	4	<1	3	20	<1	300	1.57	<1.0	2.6	4	9
D25	04/10/00	1615	1	<1	3	19	<1	250	1.26	<1.0	<1.0	3	11
D25	07/06/00	1500	<1	<1	3	17	<1	440	1.05	<1.0	<.8	3	10
D25	10/10/00	1455	<2	<2	3	23	<2	400	1.38	<2.0	4.4	5	9

Table 13. Water-quality data for monitoring wells near Deer Trail, Colorado, 2000—Continued

[pSiO<sub>2</sub>, micrograms per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than; ND, no data available; E, value estimated by laboratory; -, no sample submitted; analytical uncertainty is the 2-sigma precision estimate calculated by the laboratory as a combined standard analytical uncertainty; MDC, minimum detectable concentration calculated for that sample; negative activity reported for some of the radiochemical samples means the sample counts were less than the laboratory background counts for that day]

Well number	Date (mm/dd/yy)	Time (hhmm)	Aluminum, dissolved (µg/L as Al)	Antimony, dissolved (µg/L as Sb)	Arsenic, dissolved (µg/L as As)	Barium, dissolved (µg/L as Ba)	Beryllium, dissolved (µg/L as Be)	Boron, dissolved (µg/L as B)	Bromide, dissolved (mg/L as Br)	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)	Cobalt, dissolved (µg/L as Co)	Copper, dissolved (µg/L as Cu)
D29	01/07/00	1130	6	<2	<2	9	<2	180	0.18	<2.0	<1.0	<2	6
D29	04/10/00	1215	3	<1	E1	9	<1	190	.18	<1.0	<1.0	1	10
D29	07/06/00	1105	<1	<1	<2	9	<1	190	.20	<1.0	.8	2	8
D29	10/12/00	1110	<1	<1	<2	8	<1	200	.22	<1.0	<.8	1	7
D30	01/11/00	1600	2	<1	E1	5	<1	490	.72	<1.0	<1	1	5
D30	04/13/00	1200	<2	<1	3	10	<1	440	.70	<1.0	.9	2	18
D30	07/10/00	1245	<13	<1	<2	10	<1	450	.66	<1.0	<.8	2	12
D30	10/12/00	1450	1	<1	E2	10	<1	460	.64	<1.0	<.8	2	9

Table 13. Water-quality data for monitoring wells near Deer Trail, Colorado, 2000—Continued

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than; ND, no data available; E, value estimated by laboratory; --, no sample submitted; analytical uncertainty is the 2-sigma precision estimate calculated by the laboratory as a combined standard analytical uncertainty; MDL, minimum detectable concentration calculated for that sample; negative activity reported for some of the radiochemical samples means the sample counts were less than the laboratory background counts for that day]

Well number	Date (mm/dd/yy)	Time (hhmm)	Iron, dissolved (µg/L as Fe)	Lead, dissolved (µg/L as Pb)	Manganese, dissolved (µg/L as Mn)	Mercury, dissolved (µg/L as Hg)	Molybdenum, dissolved (µg/L as Mo)	Nickel, dissolved (µg/L as Ni)	Selenium, dissolved (µg/L as Se)	Silver, dissolved (µg/L as Ag)	Strontium, dissolved (µg/L as Sr)	Zinc, dissolved (µg/L as Zn)	Uranium, natural (µg/L as U)
DTX1	01/10/00	1345	<10	<2	90	<0.2	6	22	<2	<2	5,960	7	54
DTX1	04/14/00	1220	<30	<1	77	<2	6	4	6	<1	5,340	<14	54
DTX1	07/07/00	0940	<30	<1	96	<2	6	16	E2	<1	5,640	4	48
DTX1	10/17/00	1200	<30	<2	130	<2	7	31	3	<2	5,460	8	50
DTX2	01/10/00	1520	370	<2	3,890	<2	<2	15	<2	<2	4,840	7	36
DTX2	04/14/00	1345	400	<1	3,700	<2	2	2	4	<1	5,000	<10	36
DTX2	07/07/00	1050	460	<1	4,130	<2	2	15	E2	<1	5,450	4	36
DTX2	10/17/00	1005	510	<2	3,640	<2	<2	26	3	<2	5,200	9	34
DTX3	01/10/00	1035	<10	<1	<1	<2	<1	4	8	<1	2,070	2	20
DTX3	04/14/00	1015	<10	<1	<1	<2	<1	6	14	<1	2,770	<3	28
DTX3	07/10/00	1030	<30	<1	<1	<2	<1	9	14	<1	3,070	<5	28
DTX3	10/11/00	1030	<30	<1	E,1	<2	1	2	17	<1	2,910	2	31
DTX4	01/06/00	0955	<10	<2	37	<2	<2	<1	E2	<2	4,180	3	32
DTX4	04/14/00	1145	<30	<2	33	<2	<2	20	3	<2	4,470	<11	35
DTX4	07/11/00	1010	<30	<1	36	<2	<2	10	E2	<2	4,200	3	27
DTX4	10/11/00	1215	<30	<1	69	<2	1	8	12	<2	4,300	5	32

Table 13. Water-quality data for monitoring wells near Deer Trail, Colorado, 2000—Continued

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than; ND, no data available; E, value estimated by laboratory; -, no sample submitted; analytical uncertainty is the 2-sigma precision estimate calculated by the laboratory as a combined standard analytical uncertainty; MDC, minimum detectable concentration calculated for that sample; negative activity reported for some of the radiochemical samples means the sample counts were less than the laboratory background counts for that day]

Well number	Date (mm/dd/yy)	Time (hhmm)	Iron, dissolved (µg/L as Fe)	Lead, dissolved (µg/L as Pb)	Manganese, dissolved (µg/L as Mn)	Mercury, dissolved (µg/L as Hg)	Molybdenum, dissolved (µg/L as Mo)	Nickel, dissolved (µg/L as Ni)	Selenium, dissolved (µg/L as Se)	Silver, dissolved (µg/L as Ag)	Strontium, dissolved (µg/L as Sr)	Zinc, dissolved (µg/L as Zn)	Uranium, natural (µg/L as U)
DTX5	01/06/00	1310	100	<2	157	<0.2	<2	146	2	<2	5,270	3	39
DTX5	04/11/00	1345	120	<2	140	<2	<2	25	<2	<2	5,080	<14	38
DTX5	07/11/00	1150	90	<2	120	<2	<2	10	<2	<2	5,110	3	34
DTX5	10/16/00	1015	160	<1	126	<2	1	9	3	<2	4,540	5	35
DTX6	01/06/00	1530	<10	<2	<2	<2	<2	140	4	<2	5,240	5	37
DTX6	04/14/00	1000	<30	<1	<1	<2	<1	<1	6	<1	5,360	<11	38
DTX6	07/13/00	1300	<30	<1	<1	<2	<1	<1	E2	<1	5,720	5	41
DTX6	10/11/00	1400	<30	<1	1	<2	1	3	4	<2	5,370	7	38
DTX8A	01/13/00	1315	80	<1	180	<2	<1	6	<2	<1	2,460	2	<1
DTX8A	04/13/00	1415	120	<1	181	<2	<1	<1	<2	<1	2,320	<3	<1
DTX8A	07/10/00	1505	170	<1	181	<2	<1	3	<2	<1	2,520	<4	<1
DTX8A	10/16/00	1435	220	<1	172	<2	1	2	<2	<1	2,420	2	<1
DTX10A	01/11/00	1130	3,850	<1	158	<0.2	<1	9	<2	<1	5,450	2	<1
DTX10A	04/17/00	1415	3,970	<2	327	<2	<2	121	<2	<2	5,430	<12	<2
DTX10A	07/13/00	1020	4,130	<1	290	<2	1	3	<2	<1	5,490	4	<1
DTX10A	10/18/00	1040	4,110	<1	294	<2	1	1	<2	<2	5,510	4	M

Table 13. Water-quality data for monitoring wells near Deer Trail, Colorado, 2000—Continued

$\mu\text{SiO}_4$ , microsiemens per centimeter at 25 degrees Celsius;  $\text{mg/L}$ , milligrams per liter;  $\mu\text{g/L}$ , micrograms per liter;  $\text{pCi/L}$ , picocuries per liter;  $\leq$ , less than; ND, no data available; E, value estimated by laboratory; --, no sample submitted; analytical uncertainty is the 2-sigma precision estimate calculated by the laboratory as a combined standard analytical uncertainty; MDC, minimum detectable concentration calculated for that sample; negative activity reported for some of the radiochemical samples means the sample counts were less than the laboratory background counts for that day]

Well number	Date (mm/dd/yy)	Time (hhmm)	Iron, dissolved ( $\mu\text{g/L}$ as Fe)	Lead, dissolved ( $\mu\text{g/L}$ as Pb)	Manganese, dissolved ( $\mu\text{g/L}$ as Mn)	Mercury, dissolved ( $\mu\text{g/L}$ as Hg)	Molybdenum, dissolved ( $\mu\text{g/L}$ as Mo)	Nickel, dissolved ( $\mu\text{g/L}$ as Ni)	Selenium, dissolved ( $\mu\text{g/L}$ as Se)	Silver, dissolved ( $\mu\text{g/L}$ as Ag)	Strontium, dissolved ( $\mu\text{g/L}$ as Sr)	Zinc, dissolved ( $\mu\text{g/L}$ as Zn)	Uranium, natural ( $\mu\text{g/L}$ as U)
D6	07/11/00	1345	<200	<7	3,970	E:2	<7	20	9	<7	16,500	42	151
D6	01/11/00	1355	<10	<1	1571	<2	<1	6	11	<1	15,600	15	121
D6	04/13/00	0945	<500	<1	3,680	<2	3	9	E:17	<1	17,500	63	164
D6	10/12/00	1300	<150	<1	3,760	<2	4	8	15	<1	16,500	22	169
D13	01/12/00	1005	20	<1	84	<2	1	10	<2	<1	1,010	2	6
D13	04/17/00	1115	10	<1	82	<2	1	4	<2	<1	968	<3	8
D13	07/07/00	1230	10	<1	76	<2	1	4	<2	<1	997	<1	7
D13	10/16/00	1215	<10	<1	48	<2	1	2	E:2	<1	1,160	2	7
D17	01/07/00	1500	<10	<1	249	<2	6	2	8	<1	288	<1	5
D17	04/10/00	1415	<10	<1	213	<2	6	<1	9	<1	305	<1	6
D17	07/06/00	1320	<10	<1	298	<2	6	1	9	<1	340	<1	7
D17	10/10/00	1245	<10	<1	347	<2	6	1	8	<1	295	<1	4
D25	01/12/00	1245	<10	<1	3,100	<0.2	10	38	3	<1	3,230	8	35
D25	04/10/00	1615	<30	<1	3,120	<2	9	14	2	<2	3,200	10	37
D25	07/06/00	1500	<30	<1	3,290	<2	9	33	2	<1	3,370	5	41
D25	10/10/00	1455	<30	<2	3,790	<2	14	14	6	<2	3,550	6	60

Table 13. Water-quality data for monitoring wells near Deer Trail, Colorado, 2000—Continued

[pS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than; ND, no data available; E, value estimated by laboratory; -, no sample submitted; analytical uncertainty is the 2-sigma precision estimate calculated by the laboratory as a combined standard analytical uncertainty; MDC, minimum detectable concentration calculated for that sample; negative activity reported for some of the radiochemical samples means the sample counts were less than the laboratory background counts for that day.]

Well number	Date (mm/dd/yy)	Time (hhmm)	Iron, dissolved (µg/L as Fe)	Lead, dissolved (µg/L as Pb)	Manganese, dissolved (µg/L as Mn)	Mercury, dissolved (µg/L as Hg)	Molybdenum, dissolved (µg/L as Mo)	Nickel, dissolved (µg/L as Ni)	Selenium, dissolved (µg/L as Se)	Silver, dissolved (µg/L as Ag)	Strontium, dissolved (µg/L as Sr)	Zinc, dissolved (µg/L as Zn)	Uranium, natural (µg/L as U)
D29	01/07/00	1130	7,210	<2	817	<2	<2	<1	<2	<2	5,830	8	<2
D29	04/10/00	1215	5,970	<1	813	<2	1	7	E2	<2	5,840	19	<1
D29	07/06/00	1105	7,080	<1	788	<2	<1	24	E1	<1	5,810	9	<1
D29	10/12/00	1110	6,540	<1	868	<2	1	7	3	<1	5,740	13	<1
D30	01/11/00	1600	50	<1	149	<2	2	15	<2	<1	5,880	4	17
D30	04/13/00	1200	E40	<1	293	<2	3	2	5	<1	6,010	<16	40
D30	07/10/00	1245	100	<1	253	<2	3	14	<2	<1	5,740	<11	35
D30	10/12/00	1450	1,560	<1	260	<2	2	4	3	<1	5,780	6	35

Table 13. Water-quality data for monitoring wells near Deer Trail, Colorado, 2000—Continued

[μS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; μg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than; ND, no data available; E, value estimated by laboratory; --, no sample submitted; analytical uncertainty is the 2-sigma precision estimate calculated by the laboratory as a combined standard analytical uncertainty; MDC, minimum detectable concentration calculated for that sample; negative activity reported for some of the radiochemical samples means the sample counts were less than the laboratory background counts for that day]

Well number	Date (mm/dd/yy)	Time (hhmm)	Plutonium-238, whole water (pCi/L)	Analytical uncertainty, Plutonium-238 (pCi/L)	MDC, Plutonium-238 (pCi/L)	Plutonium-239+240, whole water (pCi/L)	Analytical uncertainty, Plutonium-239+240 (pCi/L)	MDC, Plutonium-239+240 (pCi/L)
DTX1	01/10/00	1345	0	0.012	0.013	-0.002	0.004	0.027
DTX1	04/14/00	1220	--	--	--	--	--	--
DTX1	07/07/00	0940	--	--	--	--	--	--
DTX1	10/17/00	1200	0	0.012	0.014	0.005	0.010	0.014
DTX2	01/10/00	1520	0.008	0.016	0.022	0	0.020	0.022
DTX2	04/14/00	1345	--	--	--	--	--	--
DTX2	07/07/00	1050	--	--	--	--	--	--
DTX2	10/17/00	1005	0	0.007	0.008	0	0.007	0.008
DTX3	01/10/00	1035	0	0.004	0.004	0.001	0.004	0.009
DTX3	04/14/00	1015	--	--	--	--	--	--
DTX3	07/10/00	1030	--	--	--	--	--	--
DTX3	10/17/00	1030	0	0.008	0.009	0.002	0.007	0.018
DTX4	01/06/00	0955	-0.003	0.008	0.027	0.006	0.008	0.008
DTX4	04/14/00	1145	--	--	--	--	--	--
DTX4	07/10/00	1010	--	--	--	--	--	--
DTX4	10/17/00	1215	-0.002	0.003	0.024	0.009	0.012	0.012

Table 13. Water-quality data for monitoring wells near Deer Trail, Colorado, 2000—Continued

[ $\mu\text{S/cm}$ , microsiemens per centimeter at 25 degrees Celsius;  $\text{mg/L}$ , milligrams per liter;  $\mu\text{g/L}$ , micrograms per liter;  $\text{pCi/L}$ , picocuries per liter; <, less than; ND, no data available; E, value estimated by laboratory; --, no sample submitted; analytical uncertainty is the 2-sigma precision estimate calculated by the laboratory as a combined standard analytical uncertainty; MDC, minimum detectable concentration calculated for that sample; negative activity reported for some of the radiochemical samples means the sample counts were less than the laboratory background counts for that day]

Well number	Date (mm/dd/yy)	Time (hhmm)	Plutonium-238, whole water (pCi/L)	Analytical uncertainty, Plutonium-238 (pCi/L)	MDC, Plutonium-238 (pCi/L)	Plutonium-239+240, whole water (pCi/L)	Analytical uncertainty, Plutonium-239+240 (pCi/L)	MDC, Plutonium-239+240 (pCi/L)
DTX5	01/06/00	1310	0	0.013	0.014	0.003	0.012	0.030
DTX5	04/11/00	1345	--	--	--	--	--	--
DTX5	07/11/00	1150	--	--	--	--	--	--
DTX5	10/16/00	1015	-0.001	0.002	0.016	0.003	0.006	0.008
DTX6	01/06/00	1530	-0.003	0.006	0.042	0	0.018	0.020
DTX6	04/14/00	1000	--	--	--	--	--	--
DTX6	07/13/00	1300	--	--	--	--	--	--
DTX6	10/11/00	1400	0	0.004	0.004	0.002	0.003	0.004
DTX8A	01/13/00	1315	0	0.006	0.006	-0.002	0.003	0.017
DTX8A	04/13/00	1415	--	--	--	--	--	--
DTX8A	07/10/00	1505	--	--	--	--	--	--
DTX8A	10/16/00	1435	0	0.004	0.005	-0.001	0.001	0.010
DTX10A	01/11/00	1130	0.003	0.012	0.030	0.003	0.012	0.030
DTX10A	04/17/00	1415	--	--	--	--	--	--
DTX10A	07/13/00	1020	--	--	--	--	--	--
DTX10A	10/18/00	1040	0.006	0.012	0.022	-0.001	0.010	0.030

Table 13. Water-quality data for monitoring wells near Deer Trail, Colorado, 2000—Continued

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than; ND, no data available; E, value estimated by laboratory; --, no sample submitted; analytical uncertainty is the 2-sigma precision estimate calculated by the laboratory as a combined standard analytical uncertainty; MDC, minimum detectable concentration calculated for that sample; negative activity reported for some of the radiochemical samples means the sample counts were less than the laboratory background counts for that day]

Well number	Date (mm/dd/yy)	Time (hhmm)	Plutonium-238, whole water (pCi/L)	Analytical uncertainty, Plutonium-238 (pCi/L)	MDC, Plutonium-238 (pCi/L)	Plutonium-239+240, whole water (pCi/L)	Analytical uncertainty, Plutonium-239+240, (pCi/L)	MDC, Plutonium-239+240 (pCi/L)
D6	01/11/00	1355	0.005	0.020	0.051	-0.004	0.007	0.051
D6	04/13/00	0945	--	--	--	--	--	--
D6	07/11/00	1345	--	--	--	--	--	--
D6	10/12/00	1300	0	0.007	0.008	0.001	0.007	0.020
D13	01/12/00	1005	-0.001	0.002	0.013	0.000	0.004	0.013
D13	04/17/00	1115	--	--	--	--	--	--
D13	07/07/00	1230	--	--	--	--	--	--
D13	10/16/00	1215	0.001	0.009	0.026	0.002	0.008	0.022
D17	01/07/00	1500	-0.001	0.001	0.008	0	0.004	0.004
D17	04/10/00	1415	--	--	--	--	--	--
D17	07/06/00	1320	--	--	--	--	--	--
D17	10/10/00	1245	-0.001	0.002	0.011	0.002	0.003	0.004
D25	01/12/00	1245	-0.004	0.006	0.034	0.001	0.011	0.034
D25	04/10/00	1615	--	--	--	--	--	--
D25	07/06/00	1500	--	--	--	--	--	--
D25	10/10/00	1455	0	0.008	0.009	0.003	0.006	0.009

Table 13. Water-quality data for monitoring wells near Deer Trail, Colorado, 2000—Continued

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than; ND, no data available; E, value estimated by laboratory; --, no sample submitted; analytical uncertainty is the 2-sigma precision estimate calculated by the laboratory as a combined standard analytical uncertainty; MDC, minimum detectable concentration calculated for that sample; negative activity reported for some of the radiochemical samples means the sample counts were less than the laboratory background counts for that day]

Well number	Date (mm/dd/yy)	Time (hh:mm)	Plutonium-238, whole water (pCi/L)	Analytical uncertainty, Plutonium-238 (pCi/L)	MDC, Plutonium-238 (pCi/L)	Plutonium-239+240, whole water (pCi/L)	Analytical uncertainty, Plutonium-239+240, (pCi/L)	MDC, Plutonium-239+240 (pCi/L)
D29	01/07/00	1130	-0.002	0.005	0.034	0.006	0.012	0.016
D29	04/10/00	1215	--	--	--	--	--	--
D29	07/06/00	1105	--	--	--	--	--	--
D29	10/12/00	1110	-0.010	0.010	0.051	-0.002	0.005	0.034
D30	01/11/00	1600	0	0.019	0.021	0.008	0.016	0.021
D30	04/13/00	1200	--	--	--	--	--	--
D30	07/10/00	1245	--	--	--	--	--	--
D30	10/12/00	1450	-0.002	0.004	0.031	-0.002	0.004	0.031

<sup>1</sup>Value is significantly different from historical or subsequent data at the same site, and analytical bias is suspected. However, insufficient evidence from laboratory to reject or change value.

**Table 14.** Quality-control data for blank samples associated with ground-water samples collected near Deer Trail, Colorado, 2000

[ $\mu\text{Si/cm}$ , microsiemens per centimeter at 25 degrees Celsius;  $\text{mg/L}$ , milligrams per liter;  $\mu\text{g/L}$ , micrograms per liter;  $\text{pCi/L}$ , picocuries per liter; Q, equipment blank; F, field blank; S, source-water blank; <, less than; E, value estimated by laboratory; --, no sample submitted; analytical uncertainty is the 2-sigma precision estimate calculated by the laboratory as a combined standard analytical uncertainty; MDC, minimum detectable concentration calculated for that sample; negative activity reported for some of the radiochemical samples means the sample counts were less than the laboratory background counts for that day]

Blank type	Date (mm/dd/yy)	Time (hhmm)	Well number	Specific conductance, lab ( $\mu\text{S/cm}$ )	pH, laboratory (standard units)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Potassium, dissolved (mg/L as K)	Sodium, dissolved (mg/L as Na)	Acid-neutralizing capacity, titration to pH 4.5 lab (mg/L as $\text{CaCO}_3$ )	Chloride, dissolved (mg/L as Cl)
F	01/07/00	1430	D17	4	7.8	<0.02	<0.01	<0.2	<0.1	2	<0.3
F	01/11/00	1400	D6	E1	7.3	<0.02	<0.01	<2	<1	2	<3
F <sup>1</sup>	01/11/00	1405	D6	--	--	<0.01	<0.01	--	<1	--	--
F	04/11/00	1315	DTX5	4	7.4	<0.02	<0.01	<2	<1	2	<3
F	04/17/00	1045	D13	E2	8.0	<0.02	<0.01	<2	<1	2	<3
Q	04/21/00	1015	DTX10A	E2	7.5	.08	.02	<2	<1	2	<3
Q <sup>1</sup>	04/21/00	1016	DTX10A	--	--	.07	.01	--	<1	--	--
F	07/13/00	1240	DTX6	3	8.4	<0.02	<0.01	<2	<1	2	<3
S <sup>1</sup>	07/14/00	1045	DTX6	--	--	<0.01	<0.01	--	<1	--	--
S <sup>1</sup>	07/14/00	1050	None	--	--	<0.01	<0.01	--	<1	--	--
F	10/11/00	0940	DTX3	4	7.9	<0.01	<0.01	<2	<1	2	<1
F	10/17/00	1140	DTX1	4	8.1	<0.01	<0.01	<2	<1	1	<1

**Table 14.** Quality-control data for blank samples associated with ground-water samples collected near Deer Trail, Colorado, 2000—Continued

[µS/cm, micromhos per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; Q, equipment blank; F, field blank; S, source-water blank; <, less than; E, value estimated by laboratory; --, no sample submitted; analytical uncertainty is the 2-sigma precision estimate calculated by the laboratory as a combined standard analytical uncertainty; MDC, minimum detectable concentration calculated for that sample; negative activity reported for some of the radiochemical samples means the sample counts were less than the laboratory background counts for that day]

Blank type	Date (mm/dd/yy)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO <sub>2</sub> )	Sulfate, dissolved (mg/L as SO <sub>4</sub> )	Nitrogen ammonia plus organic, dissolved (mg/L as N)	Nitrogen ammonia, organic, total (mg/L as N)	Nitrogen ammonia, dissolved (mg/L as N)	Nitrite plus nitrate (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Phosphorus, total (mg/L as P)
F	01/07/00	<0.1	<0.1	<0.3	E:10	<0.10	E:021	<0.04	<0.05	<0.05
F	01/11/00	<0.1	<0.1	<0.3	<0.10	<0.10	<0.029	E:0.02	<0.05	<0.05
F <sup>1</sup>	01/11/00	--	<.1	--	--	--	--	--	--	--
F	04/11/00	<.1	<.1	<.3	<.10	<.10	<.029	.06	<.05	<.05
F	04/17/00	<.1	<.1	<.3	<.10	<.12	<.029	<.04	<.05	<.05
Q	04/21/00	<.1	E:04	<.3	<.10	<.10	<.029	<.04	<.05	<.05
Q <sup>1</sup>	04/21/00	--	<.1	--	--	--	--	--	--	--
F	07/13/00	<.1	<.1	<.3	<.10	<.10	<.029	<.04	<.05	<.05
S <sup>1</sup>	07/14/00	--	<.1	--	--	--	--	--	--	--
S <sup>1</sup>	07/14/00	--	<.1	--	--	--	--	--	--	--
F	10/11/00	<.2	<.1	E:1	<.10	<.10	<.049	<.04	<.05	<.06
F	10/17/00	<.2	<.1	.2	<.10	<.10	<.049	<.04	<.05	<.06

**Table 14.** Quality-control data for blank samples associated with ground-water samples collected near Deer Trail, Colorado, 2000—Continued

[ $\mu\text{S/cm}$ , micromhos per centimeter at 25 degrees Celsius;  $\text{mg/L}$ , milligrams per liter;  $\mu\text{g/L}$ , micrograms per liter;  $\text{pCVL}$ , picocuries per liter; Q, equipment blank; F, field blank; S, source-water blank; <, less than; E, value estimated by laboratory; --, no sample submitted; analytical uncertainty is the 2-sigma precision estimate calculated by the laboratory as a combined standard analytical uncertainty; MDC, minimum detectable concentration calculated for that sample; negative activity reported for some of the radiochemical samples means the sample counts were less than the laboratory background counts for that day]

Blank type	Date (mm/dd/yy)	Chromium, dissolved ( $\mu\text{g/L as Cr}$ )	Cobalt, dissolved ( $\mu\text{g/L as Co}$ )	Copper, dissolved ( $\mu\text{g/L as Cu}$ )	Iron, dissolved ( $\mu\text{g/L as Fe}$ )	Lead, dissolved ( $\mu\text{g/L as Pb}$ )	Manganese, dissolved ( $\mu\text{g/L as Mn}$ )	Mercury, dissolved ( $\mu\text{g/L as Hg}$ )	Molybdenum, dissolved ( $\mu\text{g/L as Mo}$ )	Nickel, dissolved ( $\mu\text{g/L as Ni}$ )	Selenium, dissolved ( $\mu\text{g/L as Se}$ )
F	01/07/00	<0.8	<1	<1	<10	<1	<1	<0.2	<1	<1	<2
F	01/11/00	<8	<1	<1	<10	<1	<1	<2	<1	<1	<2
F <sup>1</sup>	01/11/00	<2	<1	<1	<3	<1	<1	--	<1	<1	--
F	04/11/00	<8	<1	<1	<10	<1	<1	<2	<1	<1	<2
F	04/17/00	<8	<1	<1	<10	<1	<1	<2	<1	<1	<2
Q	04/21/00	<8	<1	16	E10	<1	<1	<2	<1	<1	<2
Q <sup>1</sup>	04/21/00	<2	<1	16	10	<1	<1	--	<1	<1	--
F	07/13/00	E6	<1	<1	<10	<1	<1	<2	<1	<1	<2
S <sup>1</sup>	07/14/00	<2	<1	<1	<3	<1	<1	--	<1	<1	--
S <sup>1</sup>	07/14/00	<2	<1	<1	<3	<1	<1	--	<1	<1	--
F	10/11/00	<8	<1	<1	<10	<1	<1	<2	<1	<1	<2
F	10/17/00	<8	<1	E.22	<10	<1	<1	<2	<1	<1	<2

**Table 14.** Quality-control data for blank samples associated with ground-water samples collected near Deer Trail, Colorado, 2000—Continued

[pS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; Q, equipment blank; F, field blank; S, source-water blank; <, less than; E, value estimated by laboratory; —, no sample submitted; analytical uncertainty is the 2-sigma precision estimate calculated by the laboratory as a combined standard analytical uncertainty; MDC, minimum detectable concentration calculated for that sample; negative activity reported for some of the radiochemical samples means the sample counts were less than the laboratory background counts for that day]

Blank type	Date (mm/dd/yy)	Solids,											
		residue on evaporation at 180°C, dissolved (mg/L)	Aluminum, dissolved (µg/L as Al)	Antimony, dissolved (µg/L as Sb)	Arsenic, dissolved (µg/L as As)	Barium, dissolved (µg/L as Ba)	Beryllium, dissolved (µg/L as Be)	Boron, dissolved (µg/L as B)	Bromide, dissolved (mg/L as Br)	Cadmium, dissolved (µg/L as Cd)			
F	01/07/00	<10	<2	<1	<2.0	<1	<1	<2.0	<1.0	<1	<2.0	<0.01	<1.0
F	01/11/00	<10	<1	<1	<2.0	<1	<1	<2.0	<1.0	<1	<2.0	<0.01	<1.0
F <sup>1</sup>	01/11/00	—	<1	<1	—	<1	<1	<2	<3	<1	<2	—	<3
F	04/11/00	<10	<9	<1	<2.0	<1	<1	<2.0	<1.0	<1	<2.0	<0.01	<1.0
F	04/17/00	<10	<1	<1	<2.0	<1	<1	<2.0	<1.0	<1	<2.0	<0.01	<1.0
Q	04/21/00	<10	<1	<1	<2.0	<1	<1	<2.0	<1.0	<1	<2.0	<0.01	<1.0
Q <sup>1</sup>	04/21/00	—	<1	<1	—	<1	<1	<2	<3	<1	<2	—	<3
F	07/13/00	<10	<1	<1	<2.0	<1	<1	<2.0	<1.0	<1	<2.0	<0.01	<1.0
S <sup>1</sup>	07/14/00	—	<1	<1	—	<1	<1	<2	<3	<1	<2	—	<3
S <sup>1</sup>	07/14/00	—	<1	<1	—	<1	<1	<2	<3	<1	<2	—	<3
F	10/11/00	<10	<1	<1	<2.0	<1	<1	<2.0	<1.0	<1	<10	<0.01	<1
F	10/17/00	<10	<1	E.03	<2.0	<1	<1	<10	<1	<1	<10	<0.01	<1

**Table 14.** Quality-control data for blank samples associated with ground-water samples collected near Deer Trail, Colorado, 2000—Continued

[pCi/cm, microsieverts per centimeter at 25 degrees Celsius; ng/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; Q, equipment blank; F, field blank; S, source-water blank; <, less than; E, value estimated by laboratory; --, no sample submitted; analytical uncertainty is the 2-sigma precision estimate calculated by the laboratory as a combined standard analytical uncertainty; MDC, minimum detectable concentration calculated for that sample; negative activity reported for some of the radiochemical samples means the sample counts were less than the laboratory background counts for that day]

Blank type	Date (mm/dd/yy)	Strontium				Uranium, natural (µg/L as U)	Zinc, dissolved (µg/L as Zn)	Plutonium-238 (pCi/L)	Analytical uncertainty		MDC, Plutonium-238 (pCi/L)	Analytical uncertainty		MDC, Plutonium-239+240 (pCi/L)
		Silver, dissolved (µg/L as Ag)	Thallium, dissolved (µg/L as Sr)	Thallium, dissolved (µg/L)	Plutonium-238 (pCi/L)				Plutonium-239+240 (pCi/L)	Plutonium-239+240 (pCi/L)				
F	01/07/00	<1	<1.0	--	<1	<1	0	0.004	0.004	0.001	0.003	0.004	0.004	
F	01/11/00	<1	<1.0	--	<1	<1	-0.001	0.001	0.001	0	0.004	0.004	0.004	
F <sup>1</sup>	01/11/00	<1	<1	<1	<1	<1	--	--	--	--	--	--	--	
F	04/11/00	<1	<1.0	--	<1	<1	--	--	--	--	--	--	--	
F	04/17/00	<1	<1.0	--	2	<1	--	--	--	--	--	--	--	
Q	04/21/00	<1	E.8	--	<3	<1	2,0.012	0.008	0.008	0.001	0.002	0.004	0.004	
Q <sup>1</sup>	04/21/00	<1	8	<1	1	<1	--	--	--	--	--	--	--	
F	07/13/00	<1	<1.0	--	<1	<1	--	--	--	--	--	--	--	
S <sup>1</sup>	07/14/00	<1	<1	<1	<1	<1	--	--	--	--	--	--	--	
S <sup>1</sup>	07/14/00	<1	<1	<1	<1	<1	--	--	--	--	--	--	--	
F	10/11/00	<1	<8	--	<1	<1	0.003	0.004	0.004	0.002	0.005	0.009	0.009	
F	10/17/00	<1	<8	--	<1	<1	0.001	0.003	0.003	0	0.004	0.004	0.004	

<sup>1</sup>Blank sample for low-level trace-element analysis.

<sup>2</sup>Analytical bias is suspected. However, insufficient evidence from laboratory to reject or change value.

Table 15. Comparison of water-quality data for replicate and regular ground-water samples collected near Deer Trail, Colorado, 2000

[RPD, relative percent difference, which is defined as  $[(\text{sample value} - \text{replicate value}) / (\text{sample value} + \text{replicate value}) / 2] \times 100$ ; relative percent difference was calculated on unrounded data; --, not analyzed; ND, not determined because data were less than the minimum reporting limit or estimated; <, less than; E, value estimated by laboratory]

Property or constituent	Well number									
	DTX4			D29			DTX3			
	0955	1000	1130	1135	1035	1040	01/06/00	01/07/00	01/10/00	
Date	Sample	Replicate	RPD	Sample	Replicate	RPD	Sample	Replicate	RPD	
Time										
Specific conductance, lab ( $\mu\text{S}/\text{cm}$ at $25^\circ\text{C}$ )	2,950	2,960	7.0	0	4,020	4,010	0	1,410	1,410	0
pH, WHI laboratory (standard units)	7.0	7.0	0	0	6.9	6.8	1	7.4	7.4	0
Hardness total (mg/L as $\text{CaCO}_3$ )	1,700	1,700	0	0	2,800	2,700	4	720	660	9
Calcium, dissolved (mg/L as Ca)	531	523	2	2	535	526	2	170	158	7
Magnesium, dissolved (mg/L as Mg)	86.9	84.0	3	3	34.6	32.7	6	69.9	63.6	9
Sodium, dissolved (mg/L as Na)	160	158	1	1	143	140	2	58.2	54.0	8
Potassium, dissolved (mg/L as K)	8.8	8.9	-1	-1	11.1	11.6	-4	6.2	6.0	3
Acid neutralizing capacity, titration to 4.5, lab (mg/L as $\text{CaCO}_3$ )	353	393	-11	-11	293	292	0	274	274	0
Sulfate, dissolved (mg/L as $\text{SO}_4$ )	1,590	1,620	-2	-2	2,690	2,710	-1	516	516.86	0
Chloride, dissolved (mg/L as Cl)	15.2	15.6	-3	-3	11.5	11.6	-1	17.1	17.2	-1
Fluoride, dissolved (mg/L as F)	.2	.2	6	6	.5	.4	13	.4	.4	0
Bromide, dissolved (mg/L as Br)	.22	.22	0	0	.18	.2	-5	.22	.22	0
Silica, dissolved (mg/L as $\text{SiO}_2$ )	11.6	11.8	-1	-1	21.1	20.8	1	15.7	15.4	2
Solids, residue on evaporation at $180^\circ\text{C}$ , dissolved (mg/L)	2,800	2,850	-2	-2	4,260	4,270	0	1,090	1,090	0
Dissolved solids, sum of constituents (mg/L)	2,620	2,670	-2	-2	3,950	3,930	1	1,090	1,010	2
Nitric plus nitrate (mg/L as N)	.33	.32	3	3	E.02	E.02	0	2.78	2.78	0
Nitrogen ammonia, dissolved (mg/L as N)	.063	.09	-31	-31	.446	.446	0	E.014	<.029	ND
Nitrogen ammonia plus organic, total (mg/L as N)	.29	.30	-2	-2	.51	.50	2	.16	.14	10
Nitrogen ammonia plus organic, dissolved (mg/L as N)	.26	.25	6	6	.45	.48	-6	.19	.14	32
Phosphorus, total (mg/L as P)	<.05	<.05	0	0	E.04	<.05	ND	<.05	<.05	0
Phosphorus, dissolved (mg/L as P)	<.05	<.05	0	0	<.05	E.04	ND	<.05	<.05	0

Table 15. Comparison of water-quality data for replicate and regular ground-water samples collected near Deer Trail, Colorado, 2000—Continued

[RPD, relative percent difference, which is defined as  $[(\text{sample value} - \text{replicate value}) / (\text{sample value} + \text{replicate value}) / 2] \times 100$ ; relative percent difference was calculated on unrounded data; --, not analyzed; ND, not determined because data were less than the minimum reporting limit or estimated; <, less than; E, value estimated by laboratory]

Property or constituent	Well number													
	DTX4				D29				DTX3					
	0955	1000	1130	1035	01/07/00	1135	1035	1040	01/10/00	1135	1035	1040		
Sample	Replicate	RPD	Sample	Replicate	RPD	Sample	Replicate	RPD	Sample	Replicate	RPD	Sample	Replicate	RPD
Aluminum, dissolved (µg/L as Al)	<2	<2	0	6	5	18	2	<1	ND					
Antimony, dissolved (µg/L as Sb)	<2	<2	0	<2	<2	0	<1	<1	0					
Arsenic, dissolved (µg/L as As)	E1	<2	ND	<2	<2	0	<2	<2	0					
Barium, dissolved (µg/L as Ba)	14	14	0	9	9	0	23	23	0					
Beryllium, dissolved (µg/L as Be)	<2	<2	0	<2	<2	0	<1	<1	0					
Boron, dissolved (µg/L as B)	290	280	3	180	190	-3	210	210	0					
Cadmium, dissolved (µg/L as Cd)	<2.0	<2.0	0	<2.0	<2.0	0	<1	<1	0					
Chromium, dissolved (µg/L as Cr)	<.8	E.7	ND	<1.0	<1.0	0	E.6	<.8	ND					
Cobalt, dissolved (µg/L as Co)	<1	<1	0	<2	<2	0	<1	<1	0					
Copper, dissolved (µg/L as Cu)	5	5	0	6	7	-15	3	2	40					
Iron, dissolved (µg/L as Fe)	<10	E9	ND	7,210	7,110	1	<10	<10	0					
Lead, dissolved (µg/L as Pb)	<2	<2	0	<2	<2	0	<1	<1	0					
Manganese, dissolved (µg/L as Mn)	37	36	3	817	818	0	<1	<1	0					
Mercury, dissolved (µg/L as Hg)	<2	<2	0	<2	<2	0	<2	<2	0					
Molybdenum, dissolved (µg/L as Mo)	<2	<2	0	<2	<2	0	<1	<1	0					
Nickel, dissolved (µg/L as Ni)	<1	<1	0	<1	<1	0	4	4	0					
Selenium, dissolved (µg/L as Se)	E2	E2	0	<2	<2	0	8	8	0					
Silver, dissolved (µg/L as Ag)	<2	<2	0	<2	<2	0	<1	<1	0					
Strontium, dissolved (µg/L as Sr)	4,180	4,120	1	5,830	5,760	1	2,070	2,010	3					
Zinc, dissolved (µg/L as Zn)	3	3	0	8	8	0	2	2	0					
Uranium, natural (µg/L as U)	32	32	0	<2	<2	0	20	20	0					
Plutonium-238, whole water (pCi/L as Pu)	-0.003	0	200	0.002	0	200	0	0.001	-200					
Plutonium-239-240, whole water (pCi/L as Pu)	0.006	0	200	0.006	0	200	0.001	-0.001	ND					

**Table 15.** Comparison of water-quality data for replicate and regular ground-water samples collected near Deer Trail, Colorado, 2000—Continued

[RPD, relative percent difference, which is defined as  $[(\text{sample value} - \text{replicate value}) / (\text{sample value} + \text{replicate value}) / 2] \times 100$ ; relative percent difference was calculated on unrounded data; --, not analyzed; ND, not determined because data were less than the minimum reporting limit or estimated; <, less than; E, value estimated by laboratory]

Property or constituent	Well number									
	DTX3			D6			D25			
	04/11/00		04/13/00		07/06/00					
Date	1015	1016	0945	0950	1500	1505	1500	1505	1500	1505
Time	Sample	Replicate	Sample	Replicate	RPD	Sample	Replicate	RPD	Sample	Replicate
Specific conductance, lab (µS/cm at 25 °C)	1,880	1,880	16,300	16,300	0	4,510	4,490	0	4,510	4,490
pH, WH, laboratory (standard units)	7.3	7.3	7.2	7.2	0	7.3	7.3	0	7.3	7.3
Hardness total (mg/L as CaCO <sub>3</sub> )	990	960	11,000	10,000	3	2,600	2,500	4	2,600	2,500
Calcium, dissolved (mg/L as Ca)	240	232	446	431	3	638	624	2	638	624
Magnesium, dissolved (mg/L as Mg)	94.2	91.1	2,320	2,230	3	232	223	4	232	223
Sodium, dissolved (mg/L as Na)	72.8	72.3	2,100	2,000	1	286	271	5	286	271
Potassium, dissolved (mg/L as K)	7.3	7.0	12.9	12.6	4	7.3	6.0	20	7.3	6.0
Acid neutralizing capacity, titration to 4.5, lab (mg/L as CaCO <sub>3</sub> )	314	314	640	639	0	496	486	2	496	486
Sulfate, dissolved (mg/L as SO <sub>4</sub> )	770	762	12,900	13,100	1	2,520	2,530	0	2,520	2,530
Chloride, dissolved (mg/L as Cl)	26.0	25.1	380	384	4	99.8	100	0	99.8	100
Fluoride, dissolved (mg/L as F)	.4	.4	.8	.7	0	1.0	1.0	3	1.0	1.0
Bromide, dissolved (mg/L as Br)	.28	.28	4.32	4.44	0	0.05	0.06	-18	0.05	0.06
Silica, dissolved (mg/L as SiO <sub>2</sub> )	16.6	16.0	21.3	21.2	4	28.5	27.7	3	28.5	27.7
Solids, residue on evaporation at 180°C, dissolved (mg/L)	1,580	1,530	20,300	20,800	1	4,640	4,690	-1	4,640	4,690
Dissolved solids, sum of constituents (mg/L)	1,440	1,410	18,600	18,700	2	4,130	4,090	1	4,130	4,090
Nitrite plus nitrate (mg/L as N)	3.80	3.80	13.1	12.4	0	3.0	3.0	0	3.0	3.0
Nitrogen ammonia, dissolved (mg/L as N)	<.029	<.029	.045	.059	0	.138	.148	-7	.138	.148
Nitrogen ammonia plus organic, total (mg/L as N)	.17	.16	1.4	1.2	7	.77	.79	-3	.77	.79
Nitrogen ammonia plus organic, dissolved (mg/L as N)	<.10	<.10	1.5	1.5	0	.74	.70	6	.74	.70
Phosphorus, total (mg/L as P)	<.05	<.05	E.04	E.03	0	.15	.15	0	.15	.15
Phosphorus, dissolved (mg/L as P)	<.05	<.05	E.04	<.05	0	.15	.15	0	.15	.15



**Table 15.** Comparison of water-quality data for replicate and regular ground-water samples collected near Deer Trail, Colorado, 2000—Continued

[RPD, relative percent difference, which is defined as [(sample value - replicate value)/(sample value + replicate value)(2)] × 100; relative percent difference was calculated on unrounded data; -, not analyzed; ND, not determined because data were less than the minimum reporting limit or estimated; <, less than; E, value estimated by laboratory]

Property or constituent	Well number					
	D6			D25		
	1345	1350	1305	1445	1500	1305
	Sample	Replicate	RPD	Sample	Replicate	RPD
Specific conductance, lab (µS/cm at 25 °C)	16,000	16,000	0	4,900	4,910	0
pH, WH, laboratory (standard units)	7.2	7.2	0	7.2	7.2	0
Hardness total (mg/L as CaCO <sub>3</sub> )	10,000	10,000	0	2,900	2,900	0
Calcium, dissolved (mg/L as Ca)	414	417	-1	794	797	0
Magnesium, dissolved (mg/L as Mg)	2,170	2,180	0	219	220	0
Sodium, dissolved (mg/L as Na)	2,070	2,070	0	334	334	0
Potassium, dissolved (mg/L as K)	12.0	12.7	-5	8.3	8.2	1
Acid neutralizing capacity, titration to 4.5, lab (mg/L as CaCO <sub>3</sub> )	638	639	0	585	473	21
Sulfate, dissolved (mg/L as SO <sub>4</sub> )	13,100	13,200	-1	2,860	2,850	0
Chloride, dissolved (mg/L as Cl)	404	403	0	81.5	79.1	3
Fluoride, dissolved (mg/L as F)	.8	.7	9	1.0	1.0	0
Bromide, dissolved (mg/L as Br)	3.95	3.94	0	1.38	1.39	-1
Silica, dissolved (mg/L as SiO <sub>2</sub> )	20.6	20.9	-1	28.8	29.0	-1
Solids, residue on evaporation at 180°C, dissolved (mg/L)	21,100	21,200	0	5,270	5,170	2
Dissolved solids, sum of constituents (mg/L)	18,700	18,700	0	4,710	4,620	2
Nitrite plus nitrate (mg/L as N)	14.4	15.5	-7	4.9	5.0	-2
Nitrogen ammonia, dissolved (mg/L as N)	<0.30	<0.30	0	.110	.11	0
Nitrogen ammonia plus organic, total (mg/L as N)	1.4	1.4	0	.88	.73	19
Nitrogen ammonia plus organic, dissolved (mg/L as N)	1.5	1.5	0	1.11	.83	-153
Phosphorus, total (mg/L as P)	E.04	<0.05	ND	.12	.11	5
Phosphorus, dissolved (mg/L as P)	E.03	E.04	ND	.11	.11	0
Aluminum, dissolved (µg/L as Al)	<1	<1	0	<2	<2	0
	Sample	Replicate	RPD	Sample	Replicate	RPD
	16,200	16,100	0	16,200	16,100	1
	7.1	7.1	0	10,000	10,000	0
	437	439	0	2,190	2,200	0
	2,110	2,100	0	10.4	10.0	4
	640	640	0	13,300	13,300	-2
	418	418	0	.8	.8	0
	4.15	4.14	0	19.8	19.6	1
	21,500	20,900	3	18,700	19,000	-2
	14.6	14.6	0	.131	.135	-3
	1.5	1.5	0	1.1	1.1	0
	1.1	.98	12	E.04	<0.05	ND
	0	E.04	ND	<0.05	E.04	ND
	<1	<1	1	<1	<1	ND

Table 15. Comparison of water-quality data for replicate and regular ground-water samples collected near Deer Trail, Colorado, 2000—Continued

[RPD, relative percent difference, which is defined as [(sample value - replicate value)/(sample value + replicate value)/2] × 100; relative percent difference was calculated on unrounded data; --, not analyzed; ND, not determined because data were less than the minimum reporting limit or estimated; <, less than; E, value estimated by laboratory]

Property or constituent	Well number								
	D6			D25					
	Date	07/11/00		10/10/00		10/12/00			
Time	1345	1350	1445	1500	1300	1305			
	Sample	Replicate	RPD	Sample	Replicate	RPD	Sample	Replicate	RPD
Antimony, dissolved (µg/L as Sb)	<7	<7	0	<2	<2	0	<1	<1	0
Arsenic, dissolved (µg/L as As)	E1	E1	0	3	3	0	3	3	0
Barium, dissolved (µg/L as Ba)	<7	<7	0	23	23	0	5	5	0
Beryllium, dissolved (µg/L as Be)	<7	<7	0	<2	<2	0	<1	<1	0
Boron, dissolved (µg/L as B)	820	800	2	400	420	-6	970	970	0
Cadmium, dissolved (µg/L as Cd)	<7.0	<7.0	0	<2.0	<2.0	0	.1	.1	0
Chromium, dissolved (µg/L as Cr)	<8	<8	0	4.4	4.6	-4	<.8	<.8	0
Cobalt, dissolved (µg/L as Co)	<7	<7	0	5	5	0	6	7	-15
Copper, dissolved (µg/L as Cu)	35	28	22	9	9	0	33	35	-6
Iron, dissolved (µg/L as Fe)	<200	<200	0	<30	<30	0	<150	<150	0
Lead, dissolved (µg/L as Pb)	<7	<7	0	<2	<2	0	<1	E.04	ND
Manganese, dissolved (µg/L as Mn)	3,970	3,450	14	3,790	3,870	-2	3,760	3,730	1
Mercury, dissolved (µg/L as Hg)	E.2	<2	ND	<2	<2	0	<2	<2	0
Molybdenum, dissolved (µg/L as Mo)	<7	<7	0	14	13	7	4	3	29
Nickel, dissolved (µg/L as Ni)	20	21	-5	14	12	15	8	11	-32
Selenium, dissolved (µg/L as Se)	9	8	8	6	6	0	15	14	7
Silver, dissolved (µg/L as Ag)	<7	<7	0	<2	<2	0	<1	<1	0
Strontium, dissolved (µg/L as Sr)	16,500	16,600	-1	3,550	3,550	0	16,500	16,500	0
Zinc, dissolved (µg/L as Zn)	42	49	-15	6	6	0	22	24	-9
Uranium, natural (µg/L as U)	151	146	3	60	58	3	169	171	-1
Plutonium-238, whole water (pCi/L as Pu)	--	--	--	0	0.002	-200	0	0	0
Plutonium-239-240, whole water (pCi/L as Pu)	--	--	--	0.003	-0.002	1,000	0.001	-0.002	-600

**Table 16.** Statistical comparison of median concentrations for selected chemical constituents in ground-water samples collected near Deer Trail, Colorado, 1999-2000, and lowest applicable water-quality standard

[--, not computed or not applicable ; standard is from Colorado Department of Public Health and Environment (1997); H, health-based standard; A, agricultural standard; E, value estimated by laboratory; \*, value estimated because variance was zero]

Well	Sample size for statistical comparison	Minimum ground-water value used for statistical comparison <sup>1</sup>	Maximum ground-water value used for statistical comparison <sup>1</sup>	Median ground-water value used for statistical comparison <sup>1</sup>	Colorado standard	Type of regulatory standard	Probability that the median concentration exceeded the regulatory standard <sup>2</sup>
Nitrate <sup>3</sup> (mg/L as N)							
D6	8	11	14.6	12	10	H	0.9961
D13	7	.018	.049	.025	10	H	.0078
D17	8	.679	5.68	2.60	10	H	.0039
D25	7	2.2	7.4	3.4	10	H	.0078
D29	8	.018	.03	.023	10	H	.0039
D30	8	.018	.06	.018	10	H	.0039
DTX1	7	1.1	2.8	1.29	10	H	.0078
DTX10A	8	.018	.025	.018	10	H	.0039
DTX2	8	.018	.05	.022	10	H	.0039
DTX3	8	.018	4.3	3.3	10	H	.0039
DTX4	8	.018	6.52	.241	10	H	.0039
DTX5	8	.018	.1	.018	10	H	.0039
DTX6	8	.22	.32	.25	10	H	.0039
DTX8A	8	.018	.06	.018	10	H	.0039
Arsenic <sup>4</sup> (µg/L as As)							
D6	8	1	3.2	2.2	5	H	.0039
D13	8	.05	1	1	5	H	.0039
D17	8	1	2	1.35	5	H	.0039
D25	8	2	6	2.7	5	H	.0352
D29	8	.05	2	1	5	H	.0039
D30	8	.05	2.7	1	5	H	.0039
DTX1	8	1	3.5	1.95	5	H	.0039
DTX10A	8	.05	1	1	5	H	.0039
DTX2	8	.05	2	1.15	5	H	.0039
DTX3	8	.05	1	1	5	H	.0039
DTX4	8	.05	2	1	5	H	.0039
DTX5	8	.05	1	1	5	H	.0039
DTX6	8	.05	2.2	1	5	H	.0039
DTX8A	8	.05	1	1	5	H	.0039
Cadmium <sup>5</sup> (µg/L as Cd)							
D6	8	.1	3.5	2	5	H	.0039
D13	8	0.022	0.5	0.5	5	H	.0039
D17	8	.05	.5	.5	5	H	.0039

**Table 16.** Statistical comparison of median concentrations for selected chemical constituents in ground-water samples collected near Deer Trail, Colorado, 1999-2000, and lowest applicable water-quality standard—Continued

[--, not computed or not applicable; standard is from Colorado Department of Public Health and Environment (1997); H, health-based standard; A, agricultural standard; E, value estimated by laboratory; \*, value estimated because variance was zero]

Well	Sample size for statistical comparison	Minimum ground-water value used for statistical comparison <sup>1</sup>	Maximum ground-water value used for statistical comparison <sup>1</sup>	Median ground-water value used for statistical comparison <sup>1</sup>	Colorado standard	Type of regulatory standard	Probability that the median concentration exceeded the regulatory standard <sup>2</sup>
Cadmium <sup>5</sup> (µg/L as Cd)--Continued							
D25	8	.5	1.5	1	5	H	.0039
D29	8	.038	1	1	5	H	.0039
D30	8	.037	1	.5	5	H	.0039
DTX1	8	.5	1	1	5	H	.0039
DTX10A	8	.05	1	.75	5	H	.0039
DTX2	8	.5	1	1	5	H	.0039
DTX3	8	.05	.5	.5	5	H	.0039
DTX4	8	.1	1	1	5	H	.0039
DTX5	8	.05	1	1	5	H	.0039
DTX6	8	.1	1	1	5	H	.0039
DTX8A	8	.05	.5	.5	5	H	.0039
Chromium (µg/L as Cr)							
D6	8	.4	18	.5	100	H, A	.0039
D13	8	.4	11	.45	100	H, A	.0039
D17	8	.4	3	.4	100	H, A	.0039
D25	8	.4	27	1.55	100	H, A	.0039
D29	8	.4	18	.5	100	H, A	.0039
D30	8	.4	9.5	.95	100	H, A	.0039
DTX1	8	.4	14	.5	100	H, A	.0039
DTX10A	8	.4	5.7	.75	100	H, A	.0039
DTX2	8	.4	11	.7	100	H, A	.0039
DTX3	8	.4	13	.5	100	H, A	.0039
DTX4	8	.4	11	.75	100	H, A	.0039
DTX5	8	.4	8.2	.95	100	H, A	.0039
DTX6	8	.4	11	1.1	100	H, A	.0039
DTX8A	8	.4	.8	.45	100	H, A	.0039

**Table 16.** Statistical comparison of median concentrations for selected chemical constituents in ground-water samples collected near Deer Trail, Colorado, 1999-2000, and lowest applicable water-quality standard—Continued

[-, not computed or not applicable; standard is from Colorado Department of Public Health and Environment (1997); H, health-based standard; A, agricultural standard; E, value estimated by laboratory; \*, value estimated because variance was zero]

Well	Sample size for statistical comparison	Minimum ground-water value used for statistical comparison <sup>1</sup>	Maximum ground-water value used for statistical comparison <sup>1</sup>	Median ground-water value used for statistical comparison <sup>1</sup>	Colorado standard	Type of regulatory standard	Probability that the median concentration exceeded the regulatory standard <sup>2</sup>
Copper (µg/L as Cu)							
D6	8	5	61	31	200	A	.0039
D13	8	2	4	2.5	200	A	.0039
D17	8	.05	1	.275	200	A	.0039
D25	8	7	11	9	200	A	.0039
D29	8	6	10	7.5	200	A	.0039
D30	8	5	18	8.5	200	A	.0039
DTX1	8	6	14	8.5	200	A	.0039
DTX10A	8	3	6	5.5	200	A	.0039
DTX2	8	5	11	7	200	A	.0039
DTX3	8	2	5	3	200	A	.0039
DTX4	8	4	8	6	200	A	.0039
DTX5	8	4	8	6.5	200	A	.0039
DTX6	8	6	16	8.5	200	A	.0039
DTX8A	8	2	4	2	200	A	.0039
Lead <sup>6</sup> (µg/L as Pb)							
D6	8	.5	3.5	2	50	H	.0039
D13	8	.5	.5	.5	50	H	.0039*
D17	8	.5	.5	.5	50	H	.0039*
D25	8	.5	1.5	1	50	H	.0039
D29	8	.5	1	1	50	H	.0039
D30	8	.5	1	.5	50	H	.0039
DTX1	8	.5	1	1	50	H	.0039
DTX10A	8	.5	1	.75	50	H	.0039
DTX2	8	.5	1	1	50	H	.0039
DTX3	8	.5	.5	.5	50	H	.0039*
DTX4	8	.5	1	1	50	H	.0039
DTX5	8	.5	1	1	50	H	.0039
DTX6	8	.5	1	1	50	H	.0039
DTX8A	8	.5	.5	.5	50	H	.0039*

**Table 16.** Statistical comparison of median concentrations for selected chemical constituents in ground-water samples collected near Deer Trail, Colorado, 1999-2000, and lowest applicable water-quality standard—Continued

[--, not computed or not applicable; standard is from Colorado Department of Public Health and Environment (1997); H, health-based standard; A, agricultural standard; E, value estimated by laboratory; \*, value estimated because variance was zero]

Well	Sample size for statistical comparison	Minimum ground-water value used for statistical comparison <sup>1</sup>	Maximum ground-water value used for statistical comparison <sup>1</sup>	Median ground-water value used for statistical comparison <sup>1</sup>	Colorado standard	Type of regulatory standard	Probability that the median concentration exceeded the regulatory standard <sup>2</sup>
Mercury (µg/L as Hg)							
D6	8	.05	.2	.1	2	H	.0039
D13	8	.05	.1	.1	2	H	.0039
D17	8	.05	.1	.1	2	H	.0039
D25	8	.05	.1	.1	2	H	.0039
D29	8	.05	.1	.1	2	H	.0039
D30	8	.05	.1	.1	2	H	.0039
DTX1	8	.05	.1	.1	2	H	.0039
DTX10A	8	.05	.1	.1	2	H	.0039
DTX2	8	.05	.1	.1	2	H	.0039
DTX3	8	0.05	0.1	0.1	2	H	.0039
DTX4	8	.05	.1	.1	2	H	.0039
DTX5	8	.05	.1	.1	2	H	.0039
DTX6	8	.05	.1	.1	2	H	.0039
DTX8A	8	.05	.1	.1	2	H	.0039
Molybdenum <sup>7</sup> (µg/L as Mo)							
D6	8	.5	4	3.25	.. <sup>6</sup>	--	--
D13	8	.5	1	1	.. <sup>6</sup>	--	--
D17	8	6	7	6	.. <sup>6</sup>	--	--
D25	8	9	14	10.5	.. <sup>6</sup>	--	--
D29	8	.5	1	1	.. <sup>6</sup>	--	--
D30	8	1	4	2.5	.. <sup>6</sup>	--	--
DTX1	8	5	7	5.5	.. <sup>6</sup>	--	--
DTX10A	8	.5	3	1	.. <sup>6</sup>	--	--
DTX2	8	1	2	1	.. <sup>6</sup>	--	--
DTX3	8	.5	1	1	.. <sup>6</sup>	--	--
DTX4	8	1	1	1	.. <sup>6</sup>	--	--
DTX5	8	1	1	1	.. <sup>6</sup>	--	--
DTX6	8	.5	1	1	.. <sup>6</sup>	--	--
DTX8A	8	.5	2	.5	.. <sup>6</sup>	--	--

**Table 16.** Statistical comparison of median concentrations for selected chemical constituents in ground-water samples collected near Deer Trail, Colorado, 1999-2000, and lowest applicable water-quality standard—Continued

[-, not computed or not applicable; standard is from Colorado Department of Public Health and Environment (1997); H, health-based standard; A, agricultural standard; E, value estimated by laboratory; \*, value estimated because variance was zero]

Well	Sample size for statistical comparison	Minimum ground-water value used for statistical comparison <sup>1</sup>	Maximum ground-water value used for statistical comparison <sup>1</sup>	Median ground-water value used for statistical comparison <sup>1</sup>	Colorado standard	Type of regulatory standard	Probability that the median concentration exceeded the regulatory standard <sup>2</sup>
Nickel (µg/L as Ni)							
D6	8	6	23	12	100	H	.0039
D13	8	2	10	4	100	H	.0039
D17	8	.5	2	1	100	H	.0039
D25	8	4	38	16.5	100	H	.0039
D29	8	.5	24	15	100	H	.0039
D30	8	2	15	12	100	H	.0039
DTX1	8	4	31	16	100	H	.0039
DTX10A	8	1	21	6.5	100	H	.0039
DTX2	8	2	26	14	100	H	.0039
DTX3	8	2	9	3.5	100	H	.0039
DTX4	8	.5	20	12	100	H	.0039
DTX5	8	6	46	11.5	100	H	.0039
DTX6	8	.5	40	6	100	H	.0039
DTX8A	8	0.5	6	3	100	H	.0039
Selenium (µg/L as Se)							
D6	8	6	17	8.4	20	A	.0039
D13	8	.5	1.7	1.1	20	A	.0039
D17	8	7.5	9	8.3	20	A	.0039
D25	8	1	6	2.7	20	A	.0039
D29	8	.5	3.3	1.35	20	A	.0039
D30	8	.5	4.9	1.2	20	A	.0039
DTX1	8	1	5.9	2.55	20	A	.0039
DTX10A	8	.5	2	1.2	20	A	.0039
DTX2	8	.5	4.3	1.55	20	A	.0039
DTX3	8	4	16.5	14.05	20	A	.0039
DTX4	8	1	11.6	2	20	A	.0039
DTX5	8	.5	3.3	1.2	20	A	.0039
DTX6	8	.5	6.1	3.35	20	A	.0039
DTX8A	8	.5	1.2	1.1	20	A	.0039

**Table 16.** Statistical comparison of median concentrations for selected chemical constituents in ground-water samples collected near Deer Trail, Colorado, 1999-2000, and lowest applicable water-quality standard—Continued

[--, not computed or not applicable; standard is from Colorado Department of Public Health and Environment (1997); H, health-based standard; A, agricultural standard; E, value estimated by laboratory; \*, value estimated because variance was zero]

Well	Sample size for statistical comparison	Minimum ground-water value used for statistical comparison <sup>1</sup>	Maximum ground-water value used for statistical comparison <sup>1</sup>	Median ground-water value used for statistical comparison <sup>1</sup>	Colorado standard	Type of regulatory standard	Probability that the median concentration exceeded the regulatory standard <sup>2</sup>
Zinc (µg/L as Zn)							
D6	8	5	63	30	2,000	A	.0039
D13	8	.5	3	1.75	2,000	A	.0039
D17	8	.5	.5	.5	2,000	A	.0039*
D25	8	5	25	7	2,000	A	.0039
D29	8	8	19	11	2,000	A	.0039
D30	8	4	10	6.5	2,000	A	.0039
DTX1	8	4	8	6	2,000	A	.0039
DTX10A	8	2	10	4.5	2,000	A	.0039
DTX2	8	4	9	6	2,000	A	.0039
DTX3	8	1	2.5	2	2,000	A	.0039
DTX4	8	3	6	4	2,000	A	.0039
DTX5	8	3	7	4	2,000	A	.0039
DTX6	8	5	7	6	2,000	A	.0039
DTX8A	8	1.5	2	2	2,000	A	.0039

<sup>1</sup>Many of the values used in the statistical comparison were derived from concentrations that are less than the minimum reporting limit and therefore were set equal to one-half the minimum reporting limit.

<sup>2</sup>Value is 1 minus the p-value resulting from a one-tailed Sign Test (Helsel and Hirsch, 1995), which is used to indicate the level of statistical evidence that selected constituent concentrations are significantly greater than regulatory standards. A value close to 1.0 indicates more evidence that the median concentration exceeded the standard, whereas a value close to 0 indicates little evidence that the median concentration exceeded the standard. The percent confidence of the test can be determined by subtracting the p-value from 1 and multiplying by 100. For example, if the p-value is 0.100, 1-p is 0.900, so the median concentration is greater than the regulatory standard with 90-percent confidence.

<sup>3</sup>Data compared to standard are for nitrite plus nitrate. Results indicate nitrite is a minor component.

<sup>4</sup>During 2000, standard was a proposed maximum contaminant level.

<sup>5</sup>All data were less than laboratory minimum reporting limit, except for one value (D6). Minimum reporting limits were sometimes greater than the water-quality standard.

<sup>6</sup>All data were less than laboratory minimum reporting limit. Laboratory minimum reporting limit is less than the water-quality standard.

<sup>7</sup>No regulatory standard for this constituent.

**Table 17.** Statistical evaluation of monotonic time-series trend using the Kendall's tau correlation coefficient for selected constituents in ground-water samples collected near Deer Trail, Colorado, 1999-2000

[Only values in bold indicate statistically significant trends. For this report, the Kendall's tau statistic (Helsel and Hirsch, 1995) is used as an indicator of monotonic correlation between concentration and time. By this method, positive values of Kendall's tau indicate upward trends and negative values indicate downward trends. Kendall's tau is a number between -1 and 1 that indicates increasing strength of the correlation. A p-value is listed to indicate the level of significance of the correlation; -, not computed]

Well	Nitrate		Arsenic		Cadmium		Chromium		Copper		Lead	
	Tau	p-value	Tau	p-value	Tau	p-value	Tau	p-value	Tau	p-value	Tau	P-value
D6	<b>.786</b>	<b>.009</b>	.107	.804	-.428	.174	<b>-.643</b>	<b>.035</b>	.214	.536	-- <sup>1</sup>	-- <sup>1</sup>
D13	.238	.548	.428	.174	-- <sup>1</sup>	-- <sup>1</sup>	-.571	.063	-.036	1.000	-- <sup>1</sup>	-- <sup>1</sup>
D17	.214	.536	-.428	.174	-- <sup>1</sup>	-- <sup>1</sup>	<b>-.607</b>	<b>.048</b>	<b>.714</b>	<b>.019</b>	-- <sup>1</sup>	-- <sup>1</sup>
D25	-.428	.230	-.071	.902	-- <sup>1</sup>	-- <sup>1</sup>	-.250	.458	.250	.458	-- <sup>1</sup>	-- <sup>1</sup>
D29	-- <sup>1</sup>	-- <sup>1</sup>	.071	.902	-- <sup>1</sup>	-- <sup>1</sup>	-.286	.386	-.036	1.000	-- <sup>1</sup>	-- <sup>1</sup>
D30	<b>-.607</b>	<b>.048</b>	.500	.108	-- <sup>1</sup>	-- <sup>1</sup>	-.500	.108	.071	.902	-- <sup>1</sup>	-- <sup>1</sup>
DTX1	.048	1.000	.071	.902	-- <sup>1</sup>	-- <sup>1</sup>	-.571	.063	.428	.173	-- <sup>1</sup>	-- <sup>1</sup>
DTX10A	-- <sup>1</sup>	-- <sup>1</sup>	.357	.266	-- <sup>1</sup>	-- <sup>1</sup>	-.036	1.000	-.178	.621	-- <sup>1</sup>	-- <sup>1</sup>
DTX2	-.393	.216	.142	.710	-- <sup>1</sup>	-- <sup>1</sup>	<b>-.607</b>	<b>.048</b>	.393	.216	-- <sup>1</sup>	-- <sup>1</sup>
DTX3	-.214	.536	-- <sup>1</sup>	-- <sup>1</sup>	-- <sup>1</sup>	-- <sup>1</sup>	-.214	.536	.178	.621	-- <sup>1</sup>	-- <sup>1</sup>
DTX4	.500	.108	.036	1.000	-- <sup>1</sup>	-- <sup>1</sup>	-.286	.386	<.001	1.000	-- <sup>1</sup>	-- <sup>1</sup>
DTX5	-.464	.138	.428	.174	-- <sup>1</sup>	-- <sup>1</sup>	<b>-.750</b>	<b>.013</b>	.071	.902	-- <sup>1</sup>	-- <sup>1</sup>
DTX6	-.250	.458	.464	.138	-- <sup>1</sup>	-- <sup>1</sup>	.071	.902	.214	.536	-- <sup>1</sup>	-- <sup>1</sup>
DTX8A	<b>-.607</b>	<b>.048</b>	-- <sup>1</sup>	.107	.804	-- <sup>1</sup>	-- <sup>1</sup>					

Well	Mercury		Molybdenum		Nickel		Selenium		Zinc	
	Tau	p-value	Tau	p-value	Tau	p-value	Tau	p-value	Tau	p-value
D6	-- <sup>1</sup>	-- <sup>1</sup>	.214	.536	-.107	.804	.464	.138	.071	.902
D13	-- <sup>1</sup>	-- <sup>1</sup>	.428	.174	.071	.902	-- <sup>1</sup>	-- <sup>1</sup>	-.071	.902
D17	-- <sup>1</sup>	-- <sup>1</sup>	-.107	.804	<.001	1.000	-.286	.386	-- <sup>1</sup>	-- <sup>1</sup>
D25	-- <sup>1</sup>	-- <sup>1</sup>	-.250	.458	-.178	.621	.036	1.000	-.250	.458
D29	.357	.266	-.178	.621	-.464	.138	.464	.138	.107	.804
D30	-- <sup>1</sup>	-- <sup>1</sup>	<.001	1.000	-.250	.458	.428	.174	-.500	.108
DTX1	-- <sup>1</sup>	-- <sup>1</sup>	<b>.678</b>	<b>.026</b>	.214	.536	.214	.536	.286	.386
DTX10A	-- <sup>1</sup>	-- <sup>1</sup>	-.428	.174	-.464	.138	.250	.458	-.357	.266
DTX2	-- <sup>1</sup>	-- <sup>1</sup>	.286	.386	.143	.710	.464	.138	.071	.902
DTX3	-- <sup>1</sup>	-- <sup>1</sup>	-.321	.322	.214	.536	.250	.458	.178	.621
DTX4	-- <sup>1</sup>	-- <sup>1</sup>	<.001	1.000	-.393	.216	<b>.643</b>	<b>.035</b>	-.143	.710
DTX5	-- <sup>1</sup>	-- <sup>1</sup>	<.001	1.000	-.143	.710	.428	.174	-.036	1.000
DTX6	-- <sup>1</sup>	-- <sup>1</sup>	-.286	.386	-.321	.322	.250	.458	-.25	.458
DTX8A	-- <sup>1</sup>	-- <sup>1</sup>	-.250	.458	-.178	.621	-- <sup>1</sup>	-- <sup>1</sup>	-.107	.804

<sup>1</sup> No concentrations were greater than the laboratory minimum reporting limit.

**Table 18.** Methods used to analyze streambed-sediment samples collected near Deer Trail, Colorado, 2000

[Samples were analyzed at the National Water Quality Laboratory in Denver, except for constituents footnoted; MRL, minimum reporting level; MDC, minimum detectable concentration (radiochemical samples); ICP, inductively coupled plasma; GFAA, graphite furnace atomic absorption; AA, atomic absorption; ASF, automated segmented-flow spectrophotometry; \*, not applicable; mg/kg, milligrams per kilogram; µg/g, micrograms per gram; g/kg, grams per kilogram; pCi/g, picocuries per gram]

Property or Constituent	Units	Analytical method	MRL or MDC
<b>Nutrients</b>			
Nitrogen, ammonia plus organic <sup>1</sup>	mg/kg	Colorimetry, ASF, salicylate-hypochlorite	*
Phosphorus, total as P	mg/kg	Colorimetry, ASF, phosphomolybdate	40
<b>Trace elements</b>			
Aluminum	µg/g	DCP	2.8
Arsenic	µg/g	GFAA	1
Cadmium	µg/g	AA	.1
Chromium	µg/g	AA	.4
Copper	µg/g	AA	2
Lead	µg/g	AA	.1
Mercury	µg/g	AA manual cold vapor	.01
Molybdenum	µg/g	AA	.1
Nickel	µg/g	AA	.1
Selenium	µg/g	AA, Hydride generation, ASF	1
Zinc	µg/g	AA	3.1
<b>Carbons</b>			
Inorganic carbon	g/kg	Coulometric	.2
Organic carbon	g/kg	Wet oxidation	.2
Total carbon	g/kg	Induction furnace (Leco)	.1
<b>Radioactivity</b>			
Gross alpha <sup>2</sup>	pCi/g	Thorium-230	*
Gross beta <sup>2</sup>	pCi/g	Cesium-137	*
Plutonium-238 <sup>2</sup>	pCi/g	Alpha spectrometry	*
Plutonium-239+240 <sup>2</sup>	pCi/g	Alpha spectrometry	*

<sup>1</sup> Analyses done by Severn Trent Laboratory in Arvada, Colorado. MRL calculated for each sample.

<sup>2</sup> Analyses done by Severn Trent Laboratory in Richland, Washington. MDC calculated for each sample.

**Table 19.** Streambed-sediment data collected near Deer Trail, Colorado, July 17, 2000

[mg/kg, milligrams per kilogram; µg/g, micrograms per gram; g/kg, grams per kilogram; pCi/g, picocuries per gram; &lt;, less than; ±, plus or minus the analytical uncertainty]

Site	Date	Time	Total nitrogen (mg/kg)	Phosphorus (mg/kg)	Aluminum (µg/g)	Arsenic (µg/g)	Cadmium (µg/g)	Chromium (µg/g)	Copper (µg/g)	Lead (µg/g)	Mercury (µg/g)	Molybdenum (µg/g)
Biosolids-applied basin	07/17/00	1500	824	580	8,500	<1	0.11	8.0	12.3	13.1	0.02	0.18
Control basin (no biosolids)	07/17/00	1645	836	540	9,240	<1	.12	10.2	10.5	13.8	.02	.20
Control basin, replicate	07/17/00	1705	730	600	10,400	<1	.14	10.8	12.8	15.4	.02	.21

Site	Date	Time	Nickel (µg/g)	Selenium (µg/g)	Zinc (µg/g)	Carbon, inorganic (g/kg)	Carbon, organic (g/kg)	Gross alpha (pCi/g)	Gross beta (pCi/g)	Plutonium-238 (pCi/g)	Plutonium-239+240 (pCi/g)
Biosolids-applied basin	07/17/00	1500	10.3	<1	40.8	4.7	7.4	9.8 ± 4.4	44.3 ± 7.7	0 ± 0.002	0.002 ± 0.003
Control basin (no biosolids)	07/17/00	1645	12.5	<1	44.4	4.1	7.2	10.4 ± 4.7	44.2 ± 7.8	0 ± .003	.002 ± .004
Control basin, replicate	07/17/00	1705	12.6	<1	48.0	4.5	8.2	16.9 ± 5.9	44.1 ± 7.6	.001 ± .002	.003 ± .003