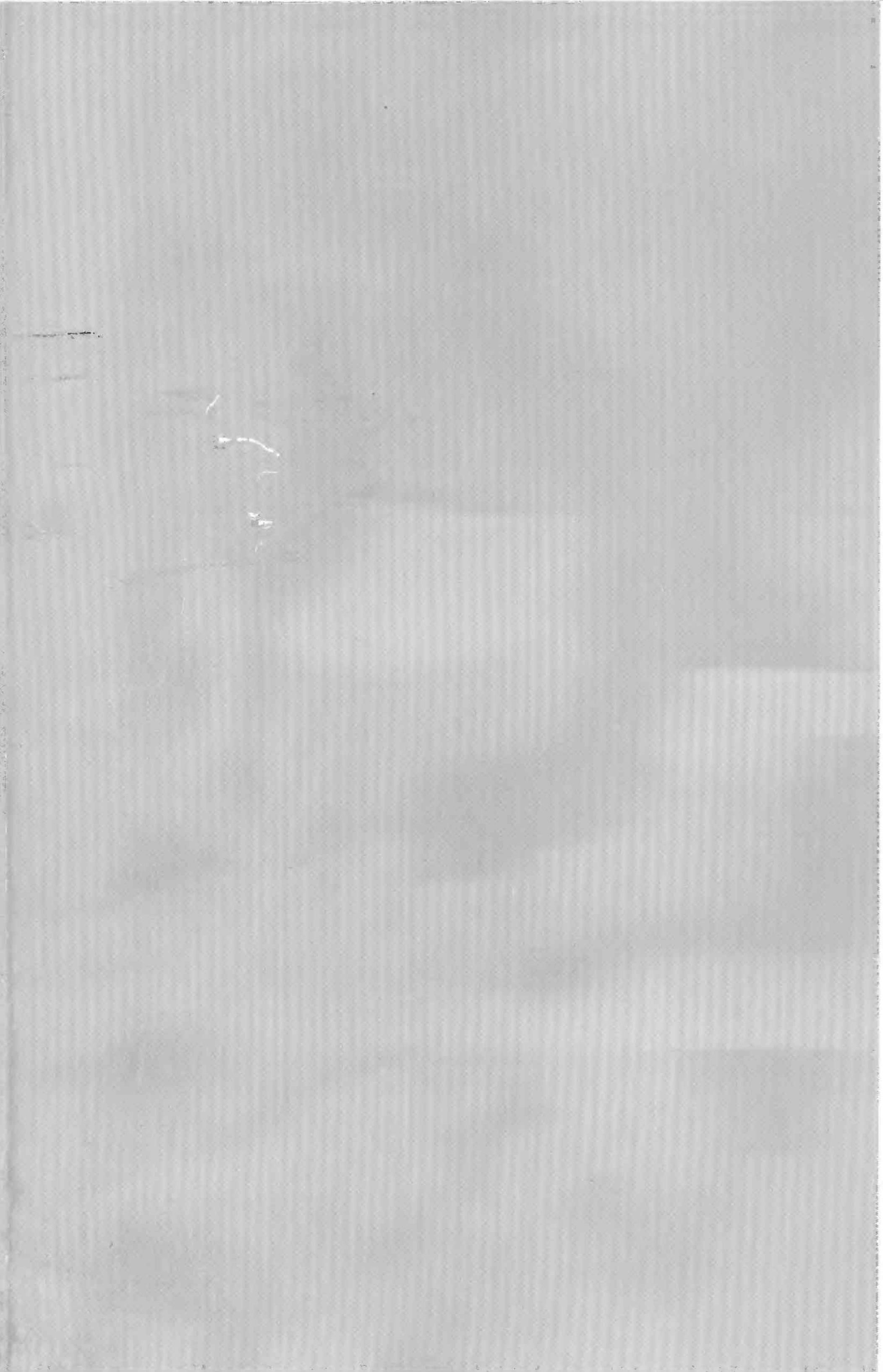
Effects of Land Use on Water Quality of the Fountain Creek Alluvial Aquifer, East–Central Colorado



United States
Geological
Survey
Water–Supply
Paper 2381–D

U.S. DEPARTMENT OF THE INTERIOR
MARCH 3, 1849

AVAILABILITY OF BOOKS AND MAPS OF THE U.S. GEOLOGICAL SURVEY

Instructions on ordering publications of the U.S. Geological Survey, along with prices of the last offerings, are given in the current-year issues of the monthly catalog "New Publications of the U.S. Geological Survey." Prices of available U.S. Geological Survey publications released prior to the current year are listed in the most recent annual "Price and Availability List." Publications that may be listed in various U.S. Geological Survey catalogs **(see back inside cover)** but not listed in the most recent annual "Price and Availability List" may be no longer available.

Reports released through the NTIS may be obtained by writing to the National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161; please include NTIS report number with inquiry.

Order U.S. Geological Survey publications **by mail or over the counter** from the offices given below.

BY MAIL

Books

Professional Papers, Bulletins, Water-Supply Papers, Techniques of Water-Resources Investigations, Circulars, publications of general interest (such as leaflets, pamphlets, booklets), single copies of Earthquakes & Volcanoes, Preliminary Determination of Epicenters, and some miscellaneous reports, including some of the foregoing series that have gone out of print at the Superintendent of Documents, are obtainable by mail from

U.S. Geological Survey, Branch of Information Services
Box 25286
Denver, CO 80225–0286

Subscriptions to periodicals (Earthquakes & Volcanoes and Preliminary Determination of Epicenters) can be obtained ONLY from the

Superintendent of Documents
Government Printing Office
Washington, DC 20402

(Check or money order must be payable to Superintendent of Documents.)

Maps

For maps, address mail orders to

U.S. Geological Survey, Branch of Information Services
Box 25286
Denver, CO 80225–0286

Residents of Alaska may order maps from

U.S. Geological Survey, Earth Science Information Center
101 Twelfth Ave. - Box 12
Fairbanks, AK 99701

OVER THE COUNTER

Books and Maps

Books and maps of the U.S. Geological Survey are available over the counter at the following U.S. Geological Survey offices, all of which are authorized agents of the Superintendent of Documents:

- **ANCHORAGE, Alaska**—Rm. 101, 4230 University Dr.
- **LAKEOOD, Colorado**—Federal Center, Bldg. 810
- **MENLO PARK, California**—Bldg. 3, Rm. 3128, 345 Middlefield Rd.
- **RESTON, Virginia**—USGS National Center, Rm. 1C402, 12201 Sunrise Valley Dr.
- **SALT LAKE CITY, Utah**—Federal Bldg., Rm. 8105, 125 South State St.
- **SPOKANE, Washington**—U.S. Post Office Bldg., Rm. 135, West 904 Riverside Ave.
- **WASHINGTON, D.C.**—Main Interior Bldg., Rm. 2650, 18th and C Sts., NW.

Maps Only

Maps may be purchased over the counter at the following U.S. Geological Survey offices:

- **FAIRBANKS, Alaska**—New Federal Bldg., 101 Twelfth Ave.
- **ROLLA, Missouri**—1400 Independence Rd.
- **STENNIS SPACE CENTER, Mississippi**—Bldg. 3101

Chapter D

Effects of Land Use on Water Quality of the Fountain Creek Alluvial Aquifer, East-Central Colorado

By DANIEL T. CHAFIN

UNITED STATES GEOLOGICAL SURVEY WATER-SUPPLY PAPER 2381-D

ANALYSIS OF NONPOINT-SOURCE GROUND-WATER CONTAMINATION IN RELATION TO LAND USE

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
GORDON P. EATON, Director

UNITED STATES GOVERNMENT PRINTING OFFICE: 1996

For sale by the
U.S. Geological Survey, Branch of Information Services
Box 25286, Denver, CO 80225-0286

Library of Congress Cataloging in Publication Data

Chafin, Daniel T.
Effects of land use on water quality of the Fountain Creek alluvial aquifer, east-central Colorado / by Daniel T. Chafin.
p. cm. — (Analysis of nonpoint-source ground-water contamination in relation to land use ; ch. D) (U.S. Geological Survey water-supply paper ; 2381–D)
Includes bibliographical references (p.).
1. Land use—Environmental aspects—Colorado—Fountain Creek Region. 2. Ground water—Colorado--Fountain Creek Region—Quality. 3. Water quality—Colorado—Fountain Creek.
I. Title. II. Series. III. Series: U.S. Geological Survey water-supply paper ; 2381-D.
TD428.L35A53 1994 ch. D
628.1'68—dc20 94-31131
CIP

ISBN 0-607-86427-3

CONTENTS

PLATE

FIGURES

TABLES

[Tables 16–19 follow "References Cited" section]

CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

Multiply	By	To obtain
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
foot per day (ft/d)	0.3048	meter per day
foot per mile (ft/mi)	0.1894	meter per kilometer
inch (in.)	25.4	millimeter
gallon (gal)	3.785	liter
gallon per minute (gal/min)	0.06308	liter per second
mile (mi)	1.609	kilometer
mile per year (mi/yr)	1.609	kilometer per year
square foot (ft^2)	0.0929	square meter

Degree Celsius (°C) may be converted to degree Fahrenheit (°F) by using the following equation:

$$°F=9/5(°C)+32.$$

Degree Fahrenheit (°F) may be converted to degree Celsius (°C) by using the following equation:

$$°C=5/9(°F-32).$$

Other terms and abbreviations used in this report:

microgram per liter (µg/L)

micrometer (µm)

microsiemens per centimeter at 25 degrees Celsius (µS/cm)

milligrams per liter (mg/L)

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Effects of Land Use on Water Quality of the Fountain Creek Alluvial Aquifer, East-Central Colorado

By Daniel T. Chafin

Abstract

The Fountain Creek alluvial aquifer was selected for study as part of the Toxic-Waste—Ground-Water Contamination Program of the U.S. Geological Survey because of the potential for recharge of the aquifer by sewage-contaminated surface water, the presence of urban and agricultural land uses, and the semiarid setting. A randomly located well network consisting of 22 sites in the urban area and 20 sites in the agricultural area was established.

Analyses of samples collected during July and August 1988 indicate that dissolved solids, most major ions, fluoride, ammonium, boron, lithium, selenium, and strontium were significantly (at the 90-percent confidence level) more concentrated in ground water underlying the agricultural area than in the upgradient urban area. Nitrate and phosphate had significantly larger concentrations, and volatile organic compounds had significantly greater detection frequencies in the urban area. Most trace-metal concentrations were controlled by sorption or solubility, although evaporative concentration and chemical complexing allowed significantly larger detection frequencies for cadmium and lead in ground water underlying the agricultural area despite more land-use sources in the urban area. Pesticide detections in ground water were few, and concentrations were small. Depth-paired samples revealed substantial ground-water-quality stratification only in the agricultural area.

INTRODUCTION

The Toxic-Waste—Ground-Water Contamination Program of the U.S. Geological Survey was begun in 1984 (Ragone, 1984). The objective of this program is to assess the effects of nonpoint and point sources on the quality of ground water (with emphasis on trace elements and organic constituents) in a variety of hydrologic settings so that the results can be used to appraise the quality of ground water in similar settings (Helsel and Ragone, 1984). To meet this objective, 14 study areas were selected for reconnaissance studies. Cain and others (1989) summarized the results of six of these studies. The Fountain Creek alluvial aquifer in east-central Colorado (fig. 1), the study area of this report, was selected for the following reasons:

1. It is a stream-aquifer system that will provide insights into chemical changes in ground water caused by surface-water recharge that contains sewage effluent and other contaminants.
2. Water withdrawals from the aquifer are large locally and supply water for urban and agricultural needs.
3. The stream-aquifer system is in a semiarid setting; small area recharge from precipitation, large evapotranspiration, and irrigation practices can cause changes in ground-water quality that do not occur in a humid climate.

Cain and Edelmann (1986) reported the results of the reconnaissance phase of this study. Their results and a report by Edelmann and Cain (1985), who studied the sources of water and nitrogen for a large part of the northern (urban) part of the study area, provide important background information for this second, more detailed phase of the study.

The primary purpose of this study was to determine the effects of land use on ground-water quality in the alluvial aquifer system of Fountain Creek. The urban area in the northern part of the study area potentially affects ground-water quality (especially with respect to trace elements and volatile organic compounds) because of industrial uses, atmospheric emissions, and weathering of synthetic materials. The agricultural area in the southern part of the study area potentially affects ground-water quality because of (1) tillage, application of fertilizers and pesticides, cattle grazing, and other activities associated with agricultural land use and (2) intensive growing-season irrigation of crops with water diverted from Fountain Creek and pumped from the alluvial aquifer. Another important purpose of this study was to determine the degree to which the water quality of the agricultural land-use area is affected by urban land use in upgradient areas.

To determine the effects of land use on the quality of the water in the alluvial aquifer, the potential effects of surface-water recharge had to be evaluated. Fountain Creek, which provides most of the recharge water to the alluvial aquifer, receives sewage effluent near the northern boundary of the study area. Sewage effluent potentially affects ground-water quality beneath the urban land-use area by seepage (1) from Fountain Creek, (2) from canals that divert water from Fountain Creek, and (3) from artificial-recharge ponds filled with water diverted from Fountain Creek. An understanding of these potential effects is important because large quantities of water are pumped from the alluvial aquifer for public water supplies. Sewage effluent potentially affects ground-water quality beneath the agricultural land-use area by seepage (1) from Fountain Creek, (2) from canals and irrigation ditches that divert water from Fountain Creek, and (3) from fields flooded with irrigation water.

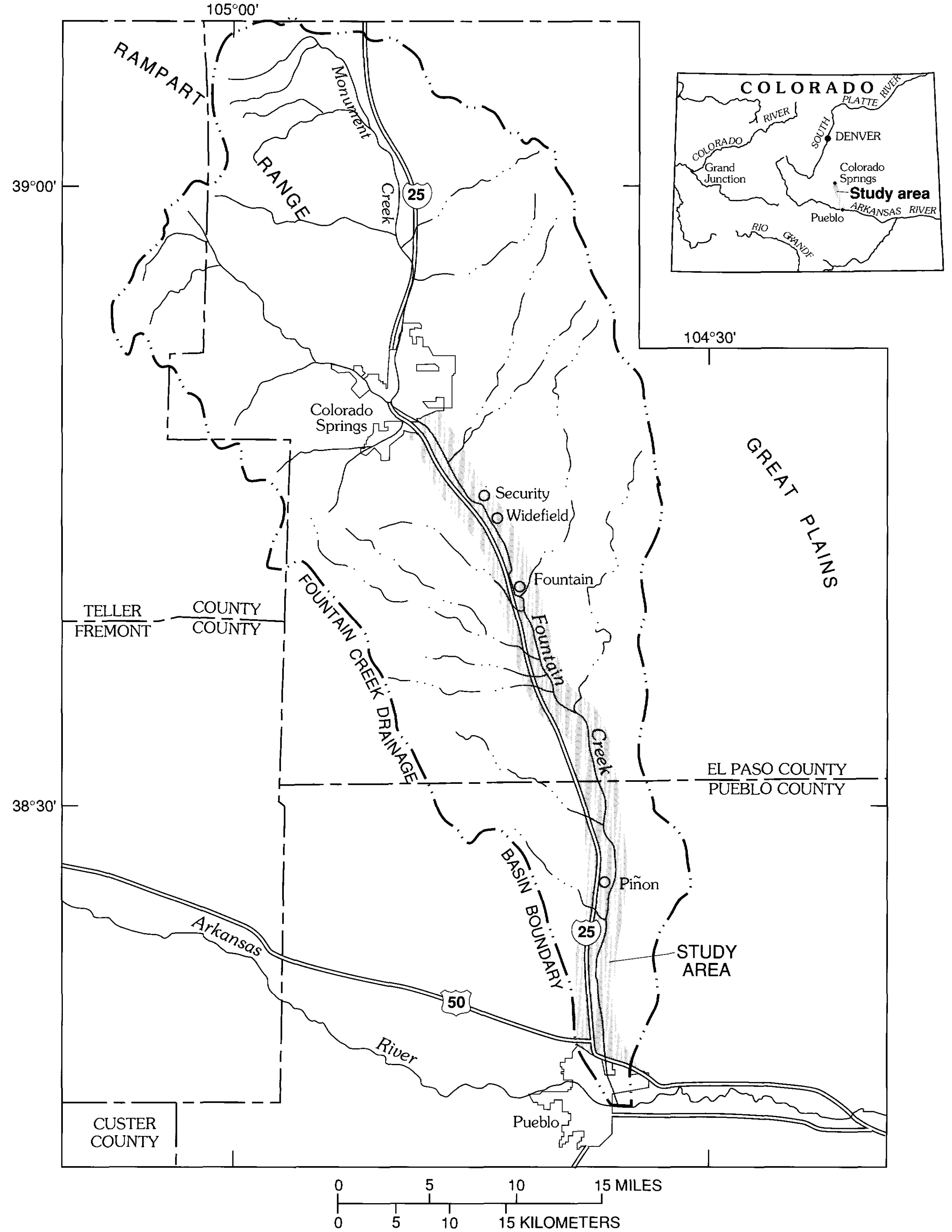


Figure 1. Generalized location of study area. Shaded area approximates area underlain by the Fountain Creek alluvial aquifer (study area).

Another purpose of the study was to determine short-term, seasonal variability of ground-water quality. Moderately greater pumpage of the aquifer, lawn and garden irrigation, and temperature increases in the urban land-use area during summer potentially affect water-quality characteristics compared with those characteristics in winter. In the agricultural land-use area, aquifer-withdrawal and irrigation rates during spring and summer greatly exceed those rates during fall and winter. A determination of water-quality changes between summer and winter was made to further understanding of land use and of hydrologic and geochemical processes affecting ground-water quality.

The effects of land-use practices on ground-water quality at different depths in the aquifer were determined. Because land-use practices potentially affect water quality near the water table more than at deeper levels, an assessment of water-quality stratification in the aquifer can provide either supportive evidence for the effects of these practices or an improved understanding of the hydrologic and geochemical processes that affect ground-water quality.

Purpose and Scope

This report describes the effects of land use on the quality of water in the Fountain Creek alluvial aquifer. The report also presents the data, collected during July and August 1988 and during January through early March 1989 from five sites on Fountain Creek and at 42 randomly located ground-water sites, which were used to make interpretive conclusions. Ground-water sites consist of 22 sites in the urban area and 20 sites in the agricultural area. At 10 randomly selected sites in each area, matched-pair deep wells were installed. The matched-pair deep wells had slotted intervals near the top of the bedrock and were installed adjacent to shallow wells, which had slotted intervals near the water table. Matched-pair deep wells were sampled only during July and August 1988.

The report includes evaluations of the differences in quality of water from the Fountain Creek alluvial aquifer associated with land-use area, surface-water recharge, sampling season, and relative depth in the water column. Although effects on major ions are discussed, the primary focus is on nutrients, trace elements, volatile organic compounds, and pesticides. These constituents are of greater interest because of their potential land-use and sewage-effluent sources.

Description of the Study Area

The Fountain Creek alluvial aquifer is located between Colorado Springs in El Paso County and Pueblo in Pueblo County, where Fountain Creek flows into the Arkansas River (fig. 1). Fountain Creek originates in the mountains (Rampart Range) northwest of Colorado Springs, but because the alluvium there is thin and discontinuous, the upstream boundary of the study area was designated as Nevada Street in southern Colorado Springs (pl. 1). From there, the creek flows about 40 mi south-southeasterly to its confluence with the Arkansas River.

Climate

The climate of the study area is semiarid and has an annual average precipitation (1951–80) ranging from 15.4 in. in the northern part of the study area to 10.9 in. at Pueblo (National Oceanic and Atmospheric Administration, 1986). Winters are mild with little snow, and summers often have days with temperatures that exceed 38°C. Edelmann and Cain (1985, p. 6) estimated potential evapotranspiration in 1982 to be 32.7 in. and actual evapotranspiration to be 21.9 in.

Land Use

Land use in the study area was described by Cain and Edelmann (1986) for the reconnaissance phase of the study (fig. 2). They divided the study area into two general land-use categories—urban and agricultural or undeveloped. These two categories are used without modification or elaboration in this report. Interstate highway I–25 and two railroad tracks traverse the entire length of the study area (pl. 1).

The northern one-third of the study area is predominantly urban, encompassing the towns of Colorado Springs, Security, Widefield, and Fountain. The urban land consists mostly of residential areas, but also has commercial, industrial, and transportation areas. Housing density generally is five housing units per acre, although small areas have as many as nine units per acre. Commercial services include automobile-fueling stations, mechanic and body shops, retail stores, restaurants, motels, dry cleaners, medical facilities, print shops, and car washes. Industries include salvage yards; machine shops; and manufacturing of batteries, chemicals, pharmaceuticals, film products, and electronic components. Transportation areas consist of railroad yards and tracks, freight yards, streets, highways, and public-transportation depots. Several large areas in this predominantly urban tract, however, are agricultural, in pasture, or undeveloped. Additional urban land exists in the vicinity of Pueblo.

The southern two-thirds of the study area (south of Fountain) is primarily agricultural. This category includes irrigated land, rangeland, and about 30 percent undeveloped land (mostly wetlands over the alluvial aquifer and grasslands on the upland areas). Land is irrigated predominantly by flooding, and about 85 percent of irrigated land is used for pasture or for growing hay or alfalfa; the remainder is used for growing wheat, oats, or corn. Little nitrogen fertilizer is applied to crops because of the availability of

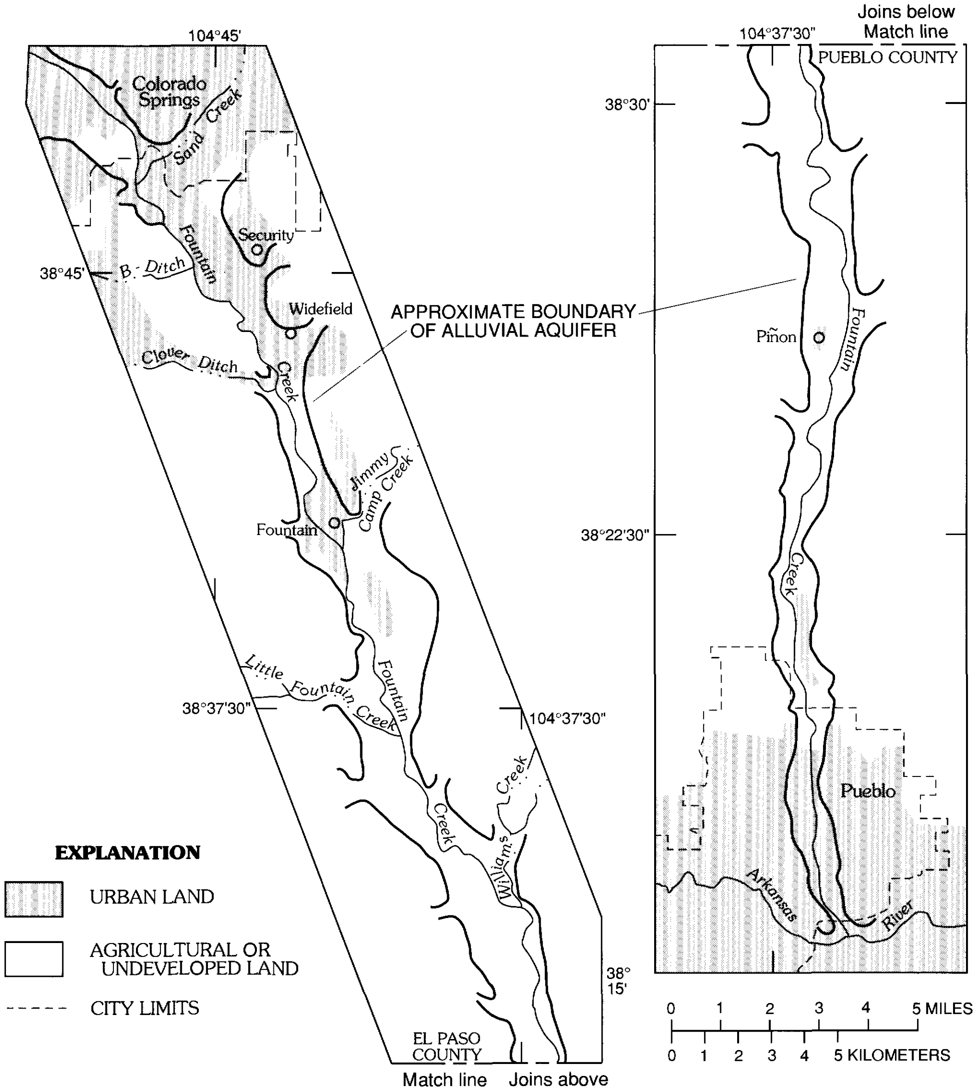


Figure 2. Generalized land use during 1989 (modified from Cain and Edelmann, 1986).

nitrogen from sewage effluent in irrigation water and the ability of alfalfa to fix atmospheric nitrogen on its roots. Pesticides applied to these crops are not substantial in quantity or variety.

Hydrologic System

The Fountain Creek alluvial aquifer is about 0.75 to 1.5 mi wide in the study area. The alluvium thickness ranges from a few feet along the valley margins to about 80 ft on terraces, which are present primarily in the urban area. Saturated thickness is as much as 35 ft in the northern (urban) part of the study area and as much as 50 ft in the southern (agricultural) part. Saturated thickness differs considerably areally and with time, depending on climatic variation, the distribution of ground-water withdrawal by irrigation and public-supply wells, and the irregularities of bedrock-surface elevation. Depths to water range from a few feet on the flood plain near Fountain Creek to about 50 ft on the higher terraces in the northern part of the study area. In the southern part of the study area, depths to water are greatest along the valley margins and seldom exceed 30 ft. These estimates are based on drilling logs and water levels for wells drilled for this study.

The Fountain Creek alluvial aquifer consists mainly of sand and gravel containing thin layers of silt and clay that become thicker near the edges of the aquifer. Cobbles are sporadically associated with the gravel. Eleven sand and gravel samples collected from the saturated zone during drilling for this study indicate that the organic carbon content of the water-yielding sediment is very small; the content, by weight, ranges from 0.03 to 0.12 percent and has a mean of 0.06 percent. Throughout the entire study area, the alluvium is underlain by the Pierre Shale of Cretaceous age. The soils overlying the alluvium generally are well drained (Larsen and others, 1979; Larsen, 1981), allowing rapid percolation of surface water to the water table.

Cain and Edelmann (1986, p. 6) estimated the hydraulic gradient to be about 30 ft/mi (0.006) and estimated that ground water flows southward with linear velocities that range from 10 to 40 ft/d; the average is about 20 ft/d (1.4 mi/yr). These estimates are based on values of hydraulic conductivity ranging from 400 to 1,600 ft/d, which are provided by other investigators (Jenkins, 1964; Wilson, 1965; Taylor, 1975) and a representative value of 0.25 for effective porosity estimated by Jenkins (1964, p. 25). Although ground-water flow generally is southward, localized and transient variations from the natural flow direction may result from water-table declines in areas of intensive pumpage. This pumpage is likely to be most intensive and continuous in the northern part of the study area near Colorado Springs, Security, Widefield, and Fountain because of pumpage of more than 100 wells, mostly for municipal and industrial use. These wells reportedly have yields of more than 100 gal/min (Cain and Edelmann, 1986). In the southern part of the study area, more than 100 wells (mostly used for irrigation), which have yields greater than 100 gal/min, cause variations from the natural flow direction mainly during late spring and summer. Although water levels may fluctuate considerably in areas of seasonal pumpage, long-term changes in water levels have not occurred because Fountain Creek is an effective source of recharge to the aquifer (Cain and Edelmann, 1986).

Cain and Edelmann (1986) outlined the sources of recharge and discharge for the Fountain Creek alluvial aquifer. Recharge comes from seepage (from Fountain Creek, canals, and reservoirs), percolation from the land surface (from irrigation, artificial-recharge ponds, precipitation, and sewage lagoons), and tributary-valley ground water. Discharge occurs as well pumpage, flow to Fountain Creek, evapotranspiration by phreatophytes, and outflow to the Arkansas River Valley to the south. Average residence time of ground water in the aquifer is estimated to be less than 10 years (Cain and Edelmann, 1986). This short residence time indicates that virtually all the water in the stream-aquifer system could have been affected by human activities.

Cain and Edelmann (1986) described Fountain Creek as perennial in the northern part of the study area, but during the summer months of many years, as having sporadic, no-flow conditions south of the town of Fountain because of agricultural diversions. Perennial flow in the northern part of the study area is partly maintained by sewage effluent. Edelmann and Cain (1985) reported that in 1982, an annual mean flow of 54.4 ft^3/s at Colorado Springs was augmented by an annual mean flow of 40.1 ft^3/s from the Colorado Springs Wastewater Treatment Plant. The augmentation resulted in an average contribution of 42 percent by sewage outfall; this percentage was equaled or exceeded 67 percent of the time in 1982.

System of Numbering Wells

The well locations (local identifiers) listed in this report are given numbers based on the Bureau of Land Management system of land subdivision and show the position of well by quadrant, township, range, section, and position within the section. An illustration of this system of numbering wells is shown in figure 3. The first letter of the location number indicates which principal meridian governs the area in which the well is located; S indicates the sixth principal meridian. The second letter indicates the quadrant in which the well is located. Four quadrants are formed by the intersection of the base line and the principal meridian; A indicates the northeast quadrant, B the northwest, C the southwest, and D the southeast.

The first number indicates the township; the second, the range; and the third, the section in which the well is located. The letters following the section number indicate the location of the well within the section. The first letter denotes the quarter section; the second, the quarter-quarter section; and the third, the quarter-quarter-quarter section. The letters are assigned within the section in a counterclockwise direction, beginning with A in the northeast quarter. Letters are assigned within each quarter section and within each quarter-quarter section in the same manner. Where two or more locations are within the smallest subdivision, consecutive numbers, beginning with 1, are added in the order in which the wells are inventoried. For example, SC00304921CCB indicates a well in the northwestern quarter of the southwestern quarter of the southwestern quarter of section 21, Township 3 South, Range 49 West.

Acknowledgments

The U.S. Geological Survey thanks the many landowners and public agencies that allowed the emplacement of monitoring wells on their properties and permitted access to those wells. Without such cooperation, this study would not have been possible.

APPROACH AND METHODS

Ground water was sampled and analyzed to provide water-quality data for statistical comparisons between land-use areas, sampling seasons, and relative depths in the water column. These comparisons were made for values of onsite measurements and concentrations of major water-quality constituents, nutrients, trace elements, dissolved organic carbon (DOC), and volatile organic compounds (VOC's). Ground water was sampled during periods of

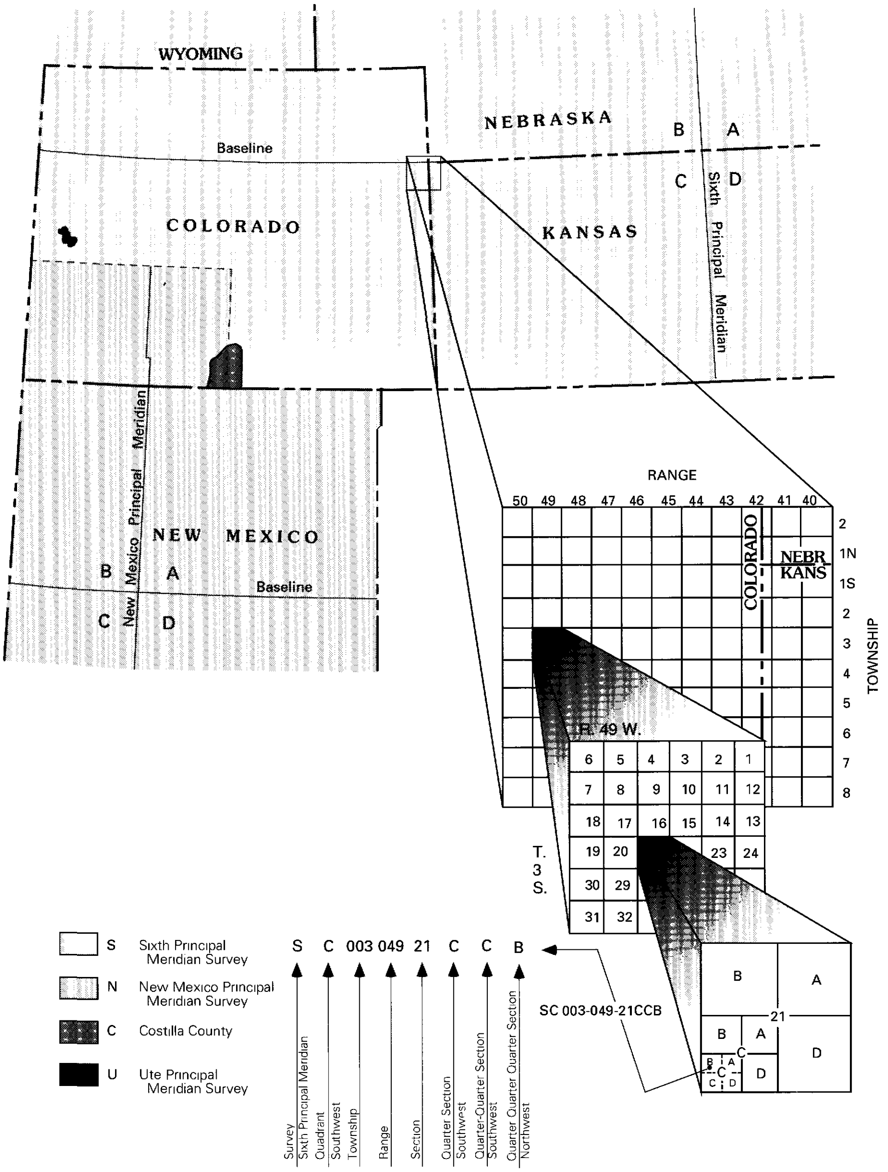


Figure 3. System of numbering wells.

maximum (summer) and minimum (winter) water use. Fountain Creek was sampled to assess the possibility that water-quality constituents in ground water originate from recharged surface water rather than from land-use effects. Fountain Creek was sampled at five sites during three hydrologically significant events that represent a broad possible range of contaminant conditions in the creek. The creek is a substantial source of recharge for ground water.

Statistical hypothesis tests were used to identify significant differences in values of onsite measurements, concentrations of constituents, or detection frequencies of constituents between ground-water sample sets defined on the basis of land-use area, sampling season, and relative depth in the water column. The approach was to conduct hypothesis tests routinely and then examine the results conceptually (especially with regard to the corresponding quality of surface water) to evaluate what factors contributed to significant differences (or the lack thereof). This approach is especially relevant to hypothesis tests that compare variables between the urban and agricultural land-use areas. For instance, concentrations of nitrite plus nitrate were significantly greater in ground water sampled from beneath the urban land-use area than in ground water sampled from beneath the agricultural land-use area. The difference could not be attributed completely to the effects of urban land use, however, because greater concentrations of nitrate in the urban land-use area probably resulted partially from recharge of sewage effluent from Fountain Creek or Canal No. 4.

The statistical hypothesis tests used for this study are based on the assumption that all samples were randomly collected from the populations to be compared. Because of this assumption, wells were randomly located and drilled in separate urban and agricultural land-use areas. No attempt was made to subdivide land into more detailed land-use categories because (1) large ground-water flow distances per year relative to the narrow width of the valley and the limited size of finer subdivisions would have prevented resolution of water-quality effects based on finer subdivisions, and (2) limitations in funds for well emplacement and sample analyses would not have permitted meaningful statistical interpretations of more than two land-use categories. Existing wells were not suitable for this study because of their areally limited, nonrandomized distribution and their full penetration of the saturated zone. Other potential problems were the common use of submersible pumps that could have caused contamination of water samples with organic compounds by leakage of oils and the use of steel casings that could have caused contamination of water samples with trace metals.

Selection of Well Sites

Emplacement of wells in randomly selected locations involved the careful development of and adherence to an experimental procedure. This procedure consisted of the following steps:

1. Delineating land-use subareas to define urban and agricultural land-use areas suitable for drilling;
2. Selecting sites for drilling of wells;
3. Following a proper order of well emplacement; and
4. Drilling holes and constructing wells properly and uniformly.

Delineating Land-Use Subareas for Drilling

Subareas of the study area were selected to define urban and agricultural land-use areas suitable for drilling (pl. 1). This selection was accomplished by first defining a conservative alluvial-aquifer boundary to decrease drilling costs. Areas of greatest depths to water on highest terraces were excluded on the assumption that the relatively small areas involved, rapid percolation rates, and rapid ground-water velocities would prevent potential biases in the water-quality data for the urban land-use area. Zones where saturated thickness was probably insufficient for suitable well installation were avoided. These unsuitable areas can exist beneath highest terraces, near exposed bedrock in the channel of Fountain Creek, and beneath fine-grained flood-plain deposits. Most tributary alluvium also was excluded from the decreased area.

Next, certain areas were excluded from the modified area of the alluvial aquifer (pl. 1). In the urban area, exclusions were areas potentially affected by point-source contamination (Colorado Springs Wastewater Treatment Plant, other sewage lagoons, and artificial recharge ponds) and a 2-mi-long parcel of land situated immediately north of Fountain and used primarily for agriculture. Smaller parcels of undeveloped or agricultural land in the urban area between Colorado Springs and Fountain were not excluded from the drilling area of the urban land-use area. Exclusion of these parcels was not considered necessary because rapid flow velocities of ground water ensure that ground-water quality beneath these parcels is as likely to be affected by urban land-use practices as is ground-water quality beneath urban areas. In the agricultural area, the excluded areas were near potential point-source contamination (an abandoned gold-leaching plant and two freeway rest-stop septic tanks) and a small urban area around a highway truck stop at Piñon.

Lightly developed residential and urban land just north of and in Pueblo also was excluded from the selected subareas. These areas were not included as a separate urban land-use area because budgetary restraints did not permit emplacement of a statistically meaningful number of wells in those areas, and changing the location of some of the urban wells north of the agricultural area to the southern urban area would complicate data interpretation and diminish the statistical reliability of the data collected from the urban land-use area in the northern part of the study area.

Finally, a 7-mi-long section of land immediately south of Fountain was excluded from the drilling area to avoid a zone of mixed land use and to avoid unmixed and partially mixed tributary ground water of Jimmy Camp Creek at Fountain. Another important reason for this exclusion was to provide a buffer zone between the urban and agricultural land-use areas to minimize flow-through effects and to help ensure valid statistical definition of water-quality data.

The final result of these exclusions was the selection of subareas that largely avoided the direct effects of point-source contamination and that provided separate and disconnected urban and agricultural land-use areas. In addition, the urban land-use area was split into one large area (Colorado Springs to Widefield) and one small area (Fountain).

Site Selection

To locate wells randomly in the urban and agricultural land-use areas, each area first was divided into approximately 0.5-mi by 0.5-mi cells on the basis of sections of the U.S. Land Grant System. Irregular area remnants were grouped together to keep cell areas roughly equal. These cells then were numbered consecutively from west to east and north to south (reading order). This system resulted in cells numbered 1–122 for the urban areas and 1–190 for the agricultural area. A computer random-number generator then was used to order the cells in a random sequence.

In each land-use area, landowners were contacted according to the random sequence order and were asked for permission to drill wells on their property. Inaccessible cells or those cells for which access was denied were deleted from the sequence, and arrangements to drill in the next cell in the sequence were attempted. This process was repeated until a number of drilling sites in excess of the total number needed was obtained. Budget limitations and statistical considerations determined that about 20 sites were needed in each area.

The drilling site in each cell generally was located according to the preference of the landowner. In the urban area, many of the sites, by necessity, were located in remote corners of school yards or along State highway rights-of-way. In the agricultural area, it was necessary to locate many of the sites near access roads and commonly on small tracts of land that were not economically useful and were out of the way of agricultural activities. When options existed for the placement of drilling sites, wells were located as near to the cell centroid as possible or as far away from sites in adjacent cells as possible. To minimize the chance of surface water entering the wells, sites were not placed in flood-prone areas along Fountain Creek.

Order of Well Emplacement

The intent of the well emplacement plan was to establish a network of about 20 well sites in each land-use area. At each site, a shallow well was to be installed. The bottom of a 2.5-ft screened interval would penetrate to as much as 15 ft below the water table. At 10 sites in each land-use area, a deeper well was to be installed within a few feet of the shallow well. The deeper well was to have the 2.5-ft screened interval as near to the bedrock surface as possible and was to have at least 10 ft of vertical separation between the centers of the screened intervals of the shallow and the deep wells (fig. 4).

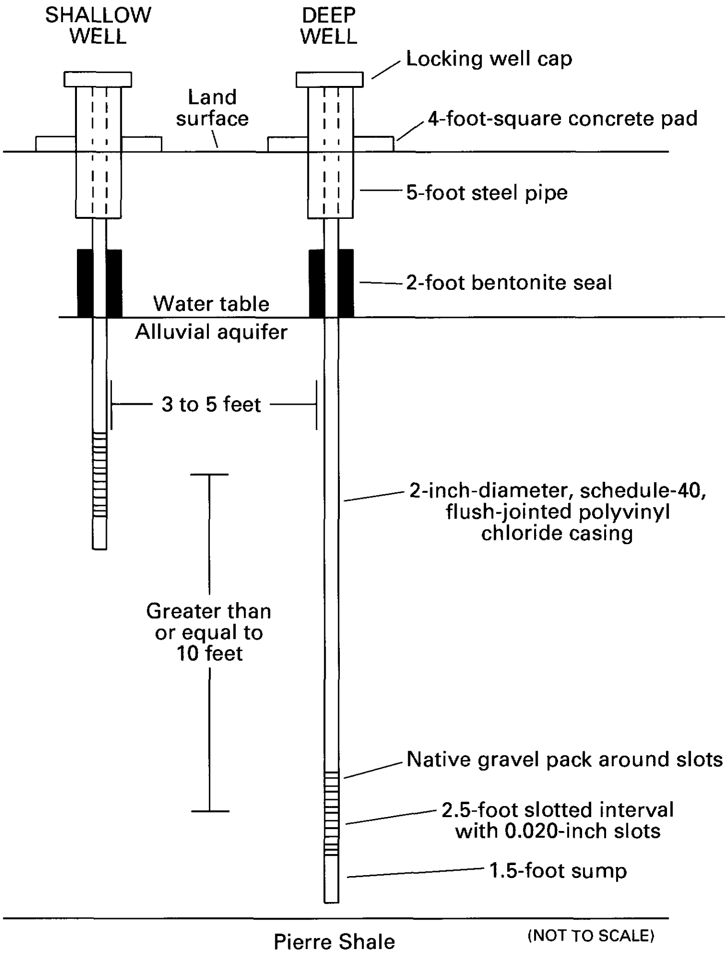


Figure 4. Well construction and general relation between shallow and deep matched-pair wells.

The first hole at each site was drilled to bedrock. If at least 5 ft of saturated thickness was penetrated and the saturated zone contained aquifer materials sufficiently coarse to yield water at rates adequate for sampling, a well was installed, and the water level was measured. If at least 15 ft of saturated aquifer material was present, a second hole was drilled about 3 to 5 ft from the first well in a cross-valley direction, and another well with about 5 ft of saturated thickness above the bottom of the screen was installed. If the site was not suitable for well installation, it was abandoned, and a hole was drilled for possible well installation at the next site. This procedure was continued in each land-use area until 10 depth-paired well sets were installed. The remaining unpaired wells then were drilled according to the random sequence.

Well emplacement resulted in a network consisting of 22 sites in the urban area and 20 sites in the agricultural area. At 10 of these sites in each area, depth-paired deep wells were emplaced. Hereafter in this report, the network consisting of all wells, except depth-paired deep wells, will be referred to by the term "basic well network," and the wells will be referred to by the term "basic-network wells." Well locations are shown on plate 1. Land-surface elevation, total depth, and depths to the top and bottom of sampling (slotted) intervals for each well are listed in table 16 in the "Supplemental Data" section at the back of this report. The wells are numbered in a north-to-south sequence. Wells in the urban area are identified with the letter "U" (for example, U04), and wells in the agricultural area are identified with the letter "A" (for example, A14). All deep wells include the letter "D" following the identification number (for example, A14D). The addition of a "D" to the well number indicates matched-pair shallow and deep wells at a site. All wells identified without the letter "D" constitute the basic well network.

Drilling Method and Well Construction

Holes were drilled with a 3.5-in. inside-diameter hollow-stem auger rig. The outside diameter of the holes was about 8 in. Auger flights were steam cleaned before drilling at each site to prevent possible cross-contamination of aquifer materials with organic contaminants or trace metals.

Wells were constructed from nominal 2-in., flush-jointed polyvinyl chloride (PVC) casing (fig. 4). This material was chosen because of budget constraints and because it was determined that PVC would not affect concentrations of pesticides and VOC's. This determination was based on the following considerations: (1) the wells were to be developed and then left inactive for 1 year before sampling; (2) stagnant water in the casing was to be thoroughly purged immediately before sampling; (3) the water was to have little contact with the casing during sampling; (4) the slotted interval of the casing would be near sorption equilibrium with organic contaminants in the ground water and, therefore, would cause negligible short-term effects on concentrations of dissolved organic contaminants during sampling; and (5) PVC would be relatively nonreactive in this aqueous environment.

Wells were installed with a 1.5-ft sump under a 2.5-ft slotted interval with 0.020-in. openings (fig. 4). The length of the slotted interval provides adequate yields, yet permits sampling of discrete intervals in this relatively thin aquifer. The installation of a gravel pack around the slotted interval was not necessary because of the presence of relatively coarse sand and gravel in the aquifer. The hole was allowed to collapse around the casing up to the water table and to form a natural gravel pack. If the slotted interval was placed near the water table, the hole was backfilled with a few more feet of native sand and gravel. Next, a 2-ft layer of bentonite pellets was poured into the open hole to form a seal to prevent downward leakage of surface water around the casing. The remainder of the hole was backfilled with native sand and gravel to within 2 to 3 ft of the ground surface. A 5-ft steel pipe with a 4-in. inside diameter was set in concrete around the casing. A 4-ft concrete pad at the land surface diverted surface water away from the hole. Each well was developed for 30 to 90 minutes with an air-lift pump. Finally, a locking cap was placed over the end of the steel pipe.

Surface-Water Sampling

The five surface-water sampling sites on Fountain Creek are at (1) Nevada Street at the northern end of the study area, (2) Janitell Road, about 1 mi downstream from the effluent of the Colorado Springs Wastewater Treatment Plant, (3) the city of Fountain, about 1 mi upstream from the southern end of the urban land-use area, (4) a bridge about 1.5 mi upstream from the northern part of the agricultural land-use area, and (5) Piñon Bridge, about 2 mi north of the southernmost agricultural well. These sites are designated in the above order as sites SW1 through SW5 (pl. 1). The five sites were sampled during three hydrologically distinct periods: (1) a moderate thunderstorm on August 17–18, 1988, which caused a slight rise in streamflow; (2) a low-flow stage of the creek on August 30–31, 1988, when municipal sewage effluent from the wastewater-treatment plant constituted most of the streamflow and when surface-water diversions, ground-water withdrawals, and irrigation-return flows were at a seasonal maximum; and (3) a moderate, stable-flow period on February 28 and March 1, 1989, when water usage was at a minimum and water temperatures were at or near 0°C.

All samples were collected from the centroid of flow at each site because present technology does not permit the collection of a cross-section-integrated sample for analysis of VOC's. This method of sampling is assumed to be representative because complete mixing of inflows should occur within short streamflow distances, considering the turbulent and curvilinear nature of Fountain Creek. Water at SW2 was sampled as soon as possible following sampling at SW1 because of the small distance between these sites. Sites downstream from site SW2 (Janitell Road) were sampled at times calculated from sampling time at site SW2, estimated discharge, and time-of-travel measurements (Gerhard Kuhn, U.S. Geological Survey, written commun., 1988). This approach enabled sampling of approximately the same parcel of water as it moved downstream, although the parcel was affected by inflows and outflows. Sample collection at summer low-flow stage and at winter moderate stage was begun in midmorning so that the sampled parcels of water would be affected by the Colorado Springs Wastewater Treatment Plant peak effluent discharge, which occurs from about 10 a.m. to about noon. This timing ensured that the maximum effect of the effluent on water quality could be assessed. Because Fountain Creek is not greatly affected by sewage effluent at Nevada Street, the quality of the water at this sampling site largely reflects the effects of urban runoff. The effects of urban runoff on surface-water quality probably is not as great along sections downstream from Nevada Street where urban development is not as intensive.

Ground-Water Sampling

Ground water in the urban and agricultural land-use areas was sampled in the summer and the winter. Summer (July and August 1988) samples were collected when ground-water withdrawals and surface-water diversions were at a seasonal maximum. Winter (January through early March 1989) samples were collected when water usage was at a seasonal minimum and after water levels in the aquifer had recovered from the summer decline. Both basic-network wells and matched-pair deep wells were sampled during the summer, whereas because of budgetary limitations only the basic-network wells were sampled during the winter. Well U07 was not sampled during the winter because it was inaccessible.

Wells in each land-use area were sampled in approximately the random order in which they were drilled to ensure that local hydrologic changes during the sampling periods did not bias data sets for either area. Because two teams collected the samples, the teams alternated between areas after every two or three sites. This precaution ensured that a team bias would not affect data. At sites with matched-pair shallow and deep wells, both wells were sampled during the same visit so that depth would be the only variable tested in statistical matched-pair analysis.

Each well was thoroughly purged before sampling. The pump body (3 ft long) was placed under just enough water to submerge it, and the pumping rate was stabilized at about 0.15 gal/min. After a few minutes, the pump body was lowered about 3 ft, and pumping continued until about two casing volumes of water (a volume equal to the volume of water in the casing string before pumping) were removed from the well. This procedure ensured that the stagnant water in the well bore would be removed by piston flow of fresh water up the casing. The pump intake next was lowered to about the middle of the slotted interval, the pumping rate was maximized (generally at 0.3 to 0.7 gal/min), and several more casing volumes of water were pumped until almost no sediment was visible in the discharge. This purging procedure resulted in a total flushing of 5 to 15 casing volumes, which usually totaled less than 25 gal. The discharge then was immediately sampled without cessation of pumpage.

Wells were sampled with a Teflon bladder pump that had Teflon-lined polyethylene tubing and a stainless-steel body. The pump was driven by an oilless compressor. The pumping apparatus was cleaned after pumping at each site by flushing the pump and the discharge line with organic-free water to which was added 2 to 10 percent methanol. This solution then was recirculated for 10 to 15 minutes.

Onsite Measurements and Chemical Constituents Analysis

Specific conductance, pH, and temperature were measured at each well and surface-water site. Incremental electrometric alkalinity titration (Edmond, 1970) and an iodometric titration for dissolved oxygen (American Public Health Association and others, 1980, p. 418–419) also were made onsite for all samples. Water samples from all of the surface-water sites and basic-network wells were analyzed for a wide variety of inorganic and organic constituents. Dissolved inorganic constituents included major ions, silica, nitrite plus nitrate, ammonium, phosphorus, arsenic, barium, beryllium, boron, cadmium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, selenium, strontium, vanadium, and zinc. Organic constituents included DOC, methylene blue active substances, VOC's, polychlorinated biphenyls, and pesticides (chlorophenoxy-acid herbicides, organochlorine compounds, organophosphorus insecticides, triazine herbicides, and other nitrogen-containing herbicides). Pesticides were sampled only during July and August 1988 because of budgetary limitations. Deep matched-pair wells (which were sampled only during July and August 1988) were sampled for all of these inorganic constituents and all of these organic constituents, except polychlorinated biphenyls, herbicides, and insecticides. Pesticides were sampled at the surface-water sites only for summer storm runoff on August 17–18, 1988, and low flow on August 30–31, 1988.

Samples to be analyzed for cations, trace metals, arsenic, boron, and selenium were passed through a 0.45-μm cellulose acetate filter and stabilized with nitric acid. Samples to be analyzed for sulfate, chloride, fluoride, nutrients, and mercury also were passed through the same filter. Samples to be analyzed for nutrients were stabilized with mercuric chloride, and samples to be analyzed for mercury were stabilized with potassium dichromate. Samples to be analyzed for DOC were filtered through a 0.45-µm silver filter. All samples to be analyzed for nutrients and organics were shipped on ice and then refrigerated prior to analysis. Inorganic constituents were analyzed by methods documented by Fishman and Friedman (1989). Organic constituents were analyzed according to methods documented by Wershaw and others (1983). All analyses were done at the U.S. Geological Survey's National Water-Quality Laboratory in Arvada, Colo.

Hypothesis Tests for Chemical Constituents in Ground Water

All statistical hypothesis tests for ground-water-quality constituents were conducted with a two-tailed significance of 0.10 (Iman and Conover, 1983, p. 211–215). When a statistically significant conclusion was determined for a given constituent (variable), test statistics were examined to determine which land-use area, sampling period, or matched-pair well set had the significantly greater distribution or detection frequency.

All test types used are nonparametric; that is, they do not assume that data sets conform to any particular type of distribution (Hipel, 1988, p. 488). Nonparametric tests were used in lieu of transforming large numbers of data sets with nonnormal distributions so that parametric statistical tests could be applied. In addition, Hipel (1988, p. 488) indicated that nonparametric statistical analysis has an advantage over parametric analysis because nonparametric analysis can be used to analyze data that have some observations with concentrations at less than a detection level, which is true for a large number of constituents in this study. Slight, but consistent, differences between observations in two sample sets can result in a highly significant difference between those two sample sets; however, a comparison of median values for each sample set can be used to estimate the magnitude of the difference in concentrations between the two sample sets.

Several different types of hypothesis tests were required. Values of onsite measurements and concentrations of major constituents, nutrients, DOC, and certain trace elements that were detected in most of the samples were tested by the Wilcoxon-Mann-Whitney rank-sum test for comparison of samples obtained from each land-use area and by the Wilcoxon signed-ranks (matched-pair) test for comparison of (1) samples obtained during July and August 1988 and during January through early March 1989 and (2) samples obtained from shallow and deep matched-pair wells. Contingency-table tests were used to compare detection frequencies of infrequently detected trace metals and all VOC's among (1) samples collected in each land-use area, (2) samples collected during July and August 1988 and during January through early March 1989, and (3) samples collected from shallow and deep matched-pair wells.

Wilcoxon-Mann-Whitney Rank-Sum Test

The Wilcoxon-Mann-Whitney rank-sum test was described by Iman and Conover (1983, p. 280–281). This test is a nonparametric *t*-test on the joint ranks of two sample sets. This test was used to compare values of onsite measurements and concentrations of major and minor constituents and frequently detected trace elements from basic-network wells in the urban and the agricultural land-use areas. Separate tests were conducted for data sets collected during July and August 1988 and January through early March 1989.

Tests were set up by defining a null hypothesis (H_0) stating that the distribution of values for onsite measurements and concentrations is not significantly different for the two areas and an alternative hypothesis (H_1) stating that a significant difference does exist. A test resulting in a two-tailed significance less than or equal to 0.10 indicates that the alternative hypothesis is accepted, whereas a significance greater than 0.10 indicates that the null hypothesis is not rejected. Not rejecting the null hypothesis does not indicate a lack of difference in sample distributions; it merely indicates that the chance of erroneously rejecting a true null hypothesis exceeds 10 percent, given the variability in the data.

A few constituents have some censored observations (those with concentrations reported at less than the detection level of the analytical method). These constituents are nitrite plus nitrate, ammonium, phosphorus, iron, lithium, manganese, selenium, and zinc. Iron and lithium have only one censored observation in both sample sets in each test and, because these observations rank lowest, these observations do not affect the outcome of the tests. The censored observations for the other constituents, however, occur in sample sets for the urban and the agricultural areas. In each test where censored observations occurred, observations were assigned joint ranks of the lowest value. Median values were reported for each sample set.

Contingency-Table Test

Contingency-table tests (2×2) were required for most trace elements and all VOC's because these constituents were detected in a minority of samples. This test, described by Iman and Conover (1983, p. 291–300), operates on detection frequencies of the constituent rather than on concentrations. This test was used to test for significant differences in detection frequencies (1) between constituents in samples from urban and agricultural land-use areas (with separate tests for data collected during July and

August 1988 and from January through early March 1989); (2) between constituents in samples collected during July and August 1988 and January through early March 1989 (with separate tests for urban and agricultural areas); and (3) between constituents in samples collected during July and August 1988 from shallow and deep matched-pair wells (with separate tests for urban and agricultural areas).

Tests were set up by defining a null hypothesis (H_0) that indicated no significant difference for detection frequencies (or probabilities) between the two sample sets of each test and an alternative hypothesis (H_1) that indicated a significant difference. A test was not made for a variable unless there were at least three detections in both sample sets to be compared because the approximate nature of the distribution used in the test is not appropriate for fewer detections, according to limitations outlined by Iman and Conover (1983, p. 299).

Wilcoxon Signed-Ranks Test

The Wilcoxon signed-ranks test was described by Iman and Conover (1983, p. 256–258). This test is a nonparametric test based on the differences in matched pairs of values and was used to test differences in values or concentrations of onsite measurements, major constituents, nutrients, DOC, and frequently detected trace elements between (1) data collected from basic-network wells during July and August 1988 and data collected from January through early March 1989, and (2) data collected during July and August 1988 from shallow and deep matched-pair wells. In both cases, separate tests were made for data from urban and agricultural areas. In the first case, because the same basic-network wells were sampled during July and August 1988 and January through early March 1989, the only variable tested was the period of sampling. In the second case, because the matched-pair wells are only 3 to 5 ft apart and they were sampled during the same day, the only variable tested was the depth of the slotted interval of the wells; therefore, the test indicates whether significant stratification of the ground water had occurred with respect to each water-quality variable.

Tests were set up with null (H_0) and alternative (H_1) hypotheses as described above for the Wilcoxon-Mann-Whitney rank-sum test, except that, in the first case, sample distributions were tested for differences between July and August 1988 and January through early March 1989 values at each well; in the second case, sample distributions were tested for differences in values between each shallow and deep well pair. The problem of censored observations was treated the same way as discussed above.

WATER-QUALITY CHARACTERISTICS

The following sections describe the data for surface-water and ground-water quality in each land-use area and provide an overall characterization of water quality in the study area. This overview eliminates those constituents that were detected in very few samples from further treatment and discussion. Water-quality analytical results are presented in tables 17 through 19 in the "Supplemental Data" section at the end of this report.

Fountain Creek

An understanding of the water quality of Fountain Creek is important because Fountain Creek is the major source of recharge to the alluvial aquifer. Water quality is described according to the following categories: (1) onsite measurements, major and minor constituents, and trace elements; (2) volatile organic compounds; and (3) pesticides.

Onsite Measurements, Major and Minor Constituents, and Trace Elements

Downstream trends in mean values of selected onsite measurements and concentrations of selected major water-quality constituents, nutrients, and DOC from samples collected at sites on Fountain Creek are shown in figure 5. These means are based on data for the three sampling periods: moderate storm runoff, August 17–18, 1988; low flow, August 30–31, 1988; and moderate, stable flow, February 28 and March 1, 1989. Means for pH were based on mean concentrations of the hydrogen ion.

Fountain Creek had the smallest concentrations of dissolved solids at the most upstream site (SW1), but the dissolved solids became more concentrated a short distance downstream at site SW2 (fig. 5), which is located about 1 mi downstream from the effluent of the Colorado Springs Wastewater Treatment Plant, a large fraction of the flow to Fountain Creek. Downstream from site SW2, the dissolved solids became more concentrated to site SW5 at the southern part of the agricultural area. This trend is indicated by steady increases in mean specific conductance and mean concentrations of dissolved solids, magnesium, sodium, sulfate, and chloride from sites SW2 to SW5. Bicarbonate concentrations generally followed this trend. Calcium concentrations at site SW1 were greater than concentrations at site SW2 because calcium concentrations were smaller in the effluent from the wastewater-treatment plant than at site SW1. Calcium concentrations increased from site SW2 to site SW5. Potassium concentrations increased between site SW1 and site SW2 because of sewage effluent, but decreased slightly downstream to site SW5. Silica concentrations at site SW2 were diluted by sewage effluent, but maintained relatively constant concentrations downstream to site SW5.

In general, these trends were the result of sewage-effluent inflow between sites SW1 and SW2, minor irrigation-return flows and smaller inputs of sewage effluent between sites SW2 and SW3, and major irrigation-return

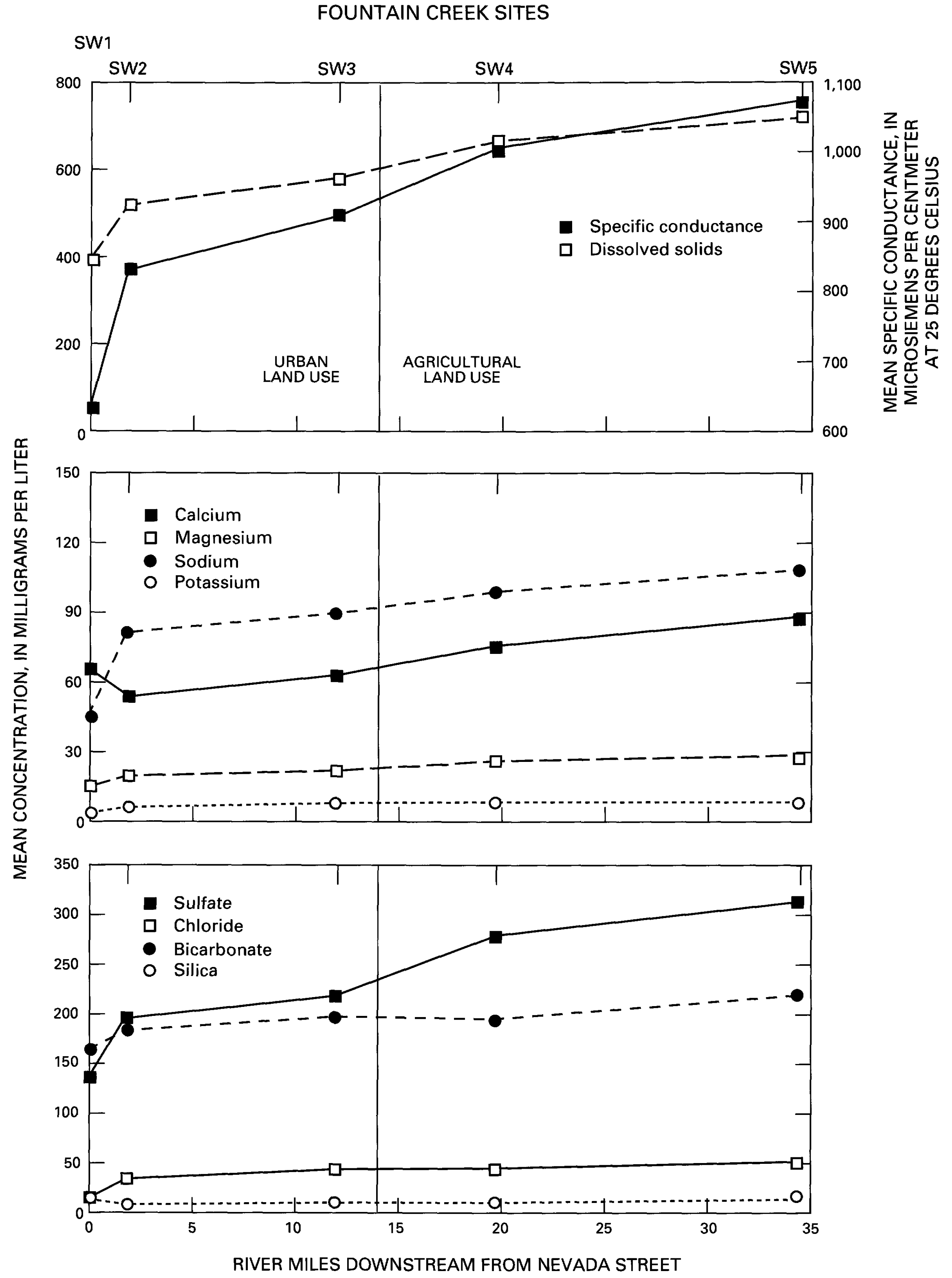


Figure 5. Downstream trends in mean specific conductance, mean concentrations of selected water-quality constituents, and mean pH in three samples collected from Fountain Creek, August 17–18, 1988; August 30–31, 1988; and February 28 and March 1, 1989.

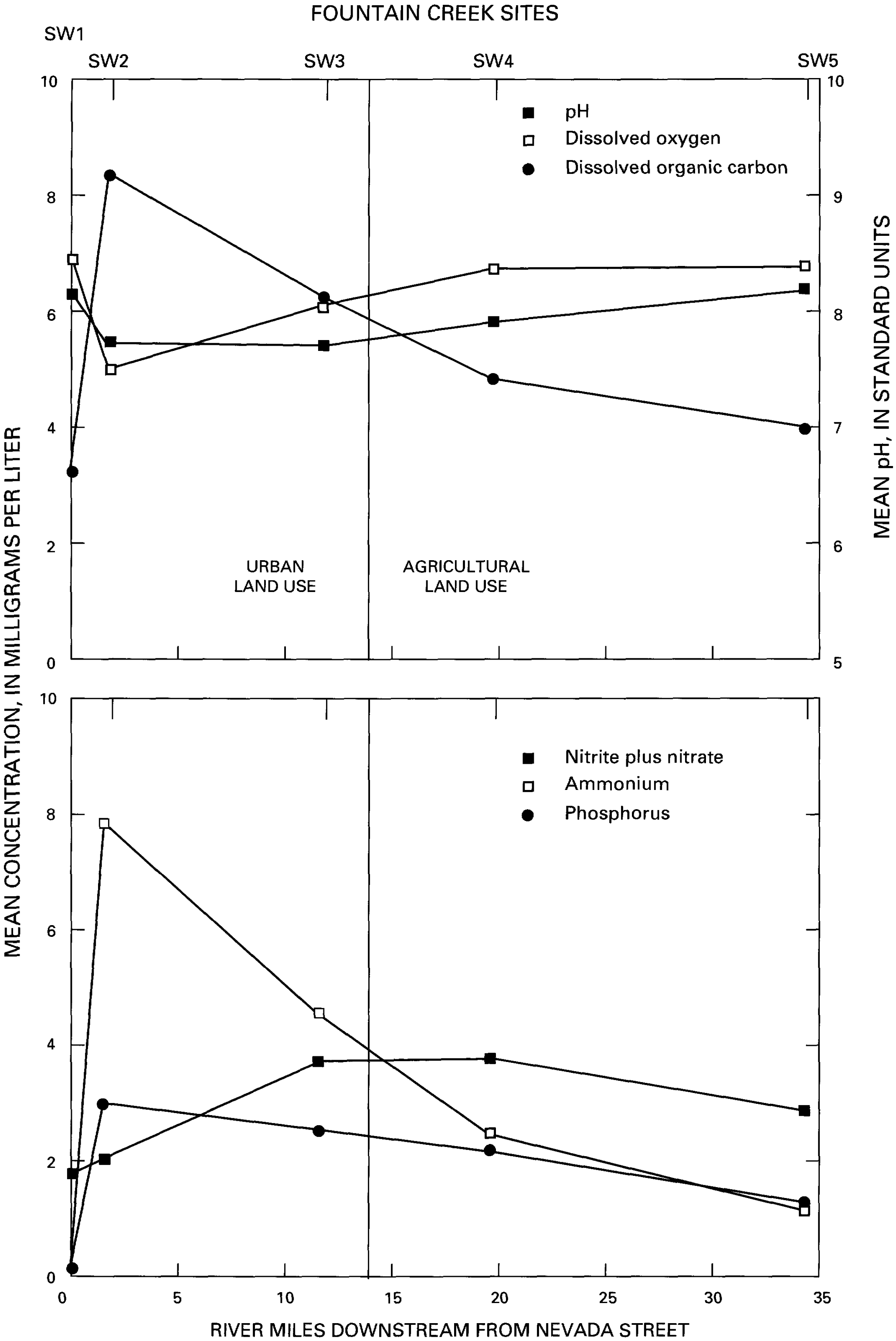


Figure 5. Downstream trends in mean specific conductance, mean concentrations of selected water-quality constituents, and mean pH in three samples collected from Fountain Creek, August 17–18, 1988; August 30–31, 1988; and February 28 and March 1, 1989—Continued.

flows and base flow from ground water between sites SW3 and SW5 (which approximately bracket the largely agricultural area).

Substantial input of sewage effluent between sites SW1 and SW2 decreased mean pH and mean concentrations of dissolved oxygen; substantially increased mean concentrations of DOC, ammonium, and phosphorus; and slightly increased the mean concentration of nitrite plus nitrate (fig. 5). Mean pH continued to decrease slightly to site SW3, probably because of continued oxidation of DOC and nitrification of ammonium. Mean pH increased at both sites in the agricultural area, possibly because of a decrease in the rate of DOC oxidation, enabling net degassing of carbon dioxide gas. Reaeration steadily increased mean dissolved-oxygen concentrations from sites SW2 to SW4, but dissolved-oxygen concentrations stabilized through the remainder of the agricultural area. Mean DOC concentrations decreased steadily downstream from site SW2 because of microbial oxidation of organic constituents from the wastewater-treatment plant.

Nitrification of ammonium steadily decreased mean concentrations of ammonium from site SW2 to site SW5 (fig. 5) and increased mean concentration of nitrite plus nitrate to site SW3. Mean nitrite-plus-nitrate concentration peaked in the reach between sites SW3 and SW4 in the northern part of the agricultural area and decreased downstream to site SW5, probably as a result of dilution by irrigation-return-flow and base-flow water that was depleted in nitrite plus nitrate by plant uptake. Mean phosphorus concentrations decreased steadily between sites SW2 and SW5, probably as a result of plant uptake and sorption by iron and manganese oxides coating streambed sediments.

Dissolved trace-element concentrations (table 17 in the "Supplemental Data" section) generally were small in Fountain Creek. Mean arsenic concentrations ranged from about 2 to 3 μg/L from sites SW1 through SW5. Mean barium concentrations were relatively constant from 40 to 48 μg/L among sites SW1 through SW5. Mean boron concentrations increased substantially from 80 μg/L at site SW1 to 170 μg/L at site SW2, probably because of sewage effluent, and increased gradually to 190 μg/L at site SW5. Mean iron concentrations increased from 15 μg/L at site SW1 to 60 μg/L at site SW2, presumably because of sewage effluent, but generally decreased downstream. Mean lithium concentrations increased gradually from 38 μg/L at site SW1 to 47 μg/L at site SW5. Mean manganese concentrations increased (from 43 to 110 μg/L) between sites SW1 and SW2, presumably because of sewage effluent, but generally decreased downstream to 29 μg/L at site SW5, except that the summer low-flow concentration of 230 μg/L at site SW3 skewed the mean concentration at that site to 136 μg/L. Mean selenium concentrations were small (5 to 7 μg/L) among sites SW1 through SW5. Mean strontium concentrations were relatively constant from 430 to 460 μg/L in the urban reach (SW1 through SW3), but increased slightly to as much as 580 μg/L at site SW5 in the agricultural reach because of evaporative concentration of irrigation-return flows. Mean zinc concentrations increased from about 15 μg/L at site SW1 to 40 μg/L at site SW2, probably because of sewage effluent, but steadily decreased to about 8 μg/L at site SW5. Trace elements that were either never detected or were seldom detected and were at concentrations near detection levels include beryllium, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, silver, and vanadium.

Volatile Organic Compounds

A summary of the VOC's that were detected in samples from Fountain Creek is presented in table 1. Other compounds that were analyzed for, but not detected, can be determined from table 18 in the "Supplemental Data" section. All methylene chloride concentrations were reported as maximum values (that is, considered to be less than analyzed concentrations) because quality-control blanks indicated large background concentrations during laboratory analysis.

Most of the VOC's detected at site SW1 were in samples collected during small storm runoff, which presumably washed these compounds from the land surface, streets, and storm drains (table 1). The compounds were tetrachloroethylene; 1,1,1-trichloroethane; and xylene. The compound 1,2-dichloroethane was detected in samples collected at site SW1 during summer low flow and moderate winter flow, possibly indicating that upstream from site SW1, a continuous source of this compound was diluted to nondetectable concentrations during the storm. Of the compounds detected in samples collected at site SW1, only tetrachloroethylene was detected in samples collected at site SW2. Most of the compounds detected in samples from the entire reach of Fountain Creek were detected in samples collected at site SW2, presumably because of the inflow of sewage effluent about 1 mi upstream. Compounds detected in samples collected at site SW2 were chloroform (all flows); 1,3-dichlorobenzene (low flow); 1,4-dichlorobenzene (winter flow); tetrachloroethylene (all flows); and toluene (all flows). None of these compounds were detected downstream at site SW3.

All VOC's detected in samples from the agricultural reach of Fountain Creek were sampled during storm runoff (table 1). In samples collected at site SW4, only methylchloride was detected, but it was not detected at site SW5. Chlorobenzene; 1,4-dichlorobenzene; tetrachloroethylene; and trichloroethylene were detected in the sample collected at site SW5.

Pesticides

Pesticide samples were collected only during summer low flow and the summer storm runoff. Results of analyses are presented in table 19 in the "Supplemental Data"

Table 1. Volatile organic compounds detected in samples collected from Fountain Creek, July and August 1988 and January through early March 1989

[Detection level for all compounds was 0.2 microgram per liter; µg/L, micrograms per liter; S, storm runoff, August 17–18, 1988; L, summer low flow on August 30–31, 1988; W, stable, moderate winter flow on February 28 and March 1, 1989; --, compound not detected; see pl. 1 for site locations]

Compound (µg/L)	Sites in urban area									Sites in agricultural area					
	SW1			SW2			SW3			SW4			SW5		
	S	L	W	S	L	W	S	L	W	S	L	W	S	L	W
Chlorobenzene	--	--	--	--	--	--	--	--	--	--	--	--	3.2	--	--
Chloroform	--	--	--	0.4	0.7	0.9	--	--	--	--	--	--	--	--	--
1,3-Dichlorobenzene	--	--	--	--	.4	--	--	--	--	--	--	--	--	--	--
1,4-Dichlorobenzene	--	--	--	--	--	.3	--	--	--	--	--	--	.4	--	--
1,2-Dichloroethane	--	0.2	0.2	--	--	--	--	--	0.2	--	--	--	--	--	--
Methylchloride	--	--	--	--	--	--	--	--	--	0.3	--	--	--	--	--
Tetrachloroethylene	0.3	--	--	3.4	.2	.2	---	--	--	--	--	--	.6	--	--
Toluene	--	--	--	.3	.2	.2	--	--	--	--	--	--	--	--	--
1,1,1-Trichloroethane	.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Trichloroethylene	--	--	--	--	--	--	--	--	--	--	--	--	.2	--	--
Xylene	.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--

section. Pesticide detections in Fountain Creek samples are summarized in table 2. No compounds of the chlorophenoxy-acid herbicides were detected. Lindane was the only organochlorine insecticide detected. This compound was detected in samples collected at sites SW2 and SW3 during low flow. That finding possibly indicates a sewage-effluent source.

Diazinon and malathion were the only organophosphorus insecticides detected in samples from Fountain Creek (table 2). Diazinon was detected in all samples for storm runoff and low flow, but the largest concentrations were detected in samples collected at site SW2 (table 19). Those large concentrations possibly indicate input from sewage effluent. During low flow, concentrations decreased steadily from sites SW2 to SW5; that decrease indicates a primarily urban source for this insecticide. During the storm runoff, concentrations were relatively constant between sites SW2 and SW5; that constancy probably indicates urban and agricultural sources. Malathion, which is used primarily in small, residential gardens, was detected in all storm-runoff samples; maximum concentrations were detected at site SW3, probably because of runoff from yards in the urban area. Minimal concentrations of malathion were detected in samples collected at site SW2 during low flow; because this compound was not detected in samples from other sites during low flow, a minor sewage-effluent source may be indicated.

Of the triazines and other nitrogen-containing herbicides, prometon and simazine were detected in Fountain Creek samples (table 2). Prometon was detected in all low-flow and storm-runoff samples (excluding the low-flow sample for site SW5, which was lost in shipment), and that finding indicates urban and agricultural sources. Minimal concentrations of simazine were detected in storm-runoff samples collected at sites SW1 through SW4, but were not detected in low-flow samples.

Fountain Creek Alluvial Aquifer

An overall description of the quality of water in the Fountain Creek alluvial aquifer facilitates understanding the results of statistical hypothesis tests discussed in the following section. Water quality is described according to the following categories: (1) Onsite measurements, major and minor constituents, and trace elements; (2) volatile organic compounds; and (3) pesticides.

Onsite Measurements, Major and Minor Constituents, and Trace Elements

Table 3 presents a summary of statistics for onsite measurements, concentrations of major and minor water-quality constituents, and frequently detected trace elements for samples collected from the basic well network during July and August 1988 and January through early March 1989 (combined). Dissolved-solids concentrations ranged from 249 mg/L in samples collected from wells in the urban land-use area to 3,047 mg/L in samples collected from wells in the agricultural land-use area. Median dissolved-solids concentrations were 615 mg/L for urban samples and 1,220 mg/L for agricultural samples. Similarly, median concentrations for alkalinity, calcium, magnesium, sodium, potassium, sulfate, chloride, and fluoride were greater in agricultural samples than in urban samples. Mean pH (cal-

Table 2. Pesticides and polychlorinated biphenyls detected in samples collected from sites on Fountain Creek and basic-network wells, July and August 1988

[μg/L, micrograms per liter; see pl. 1 for site locations; storm-runoff sampling was done August 17–18, 1988, and low-flow sampling was done August 30–31, 1988; --, compound not detected]

Compound	Detection level (μg/L)	Fountain Creek sites where detected		Urban land-use wells where detected	Agricultural land-use wells where detected
		Storm runoff	Low flow		
Lindane	0.01	--	SW2, SW3	--	--
Diazinon	.01	SW1, SW2, SW3, SW4, SW5	SW1, SW2, SW3, SW4, SW5	--	A02
Malathion	.01	SW2, SW3, SW4, SW5	SW2	-- --	--
Atrazine	.1	--	--	--	--
Cyanazine	.1	--	--	U03, U19, U21	A13
Prometon	.1	SW1, SW2, SW3, SW4, SW5	SW1, SW2, SW3, SW4	U21	A14
Simazine	.1	SW1, SW2, SW3, SW4	--	--	--
Polychlorinated biphenyls	.1	--	--	--	--

culated on the basis of hydrogen-ion concentrations) was slightly greater in agricultural samples (7.10) than in urban samples (6.93).

In general, ground water in the study area was well oxygenated, and median dissolved-oxygen concentrations were 4.8 mg/L in the urban samples and 3.5 mg/L in the agricultural samples (table 3). Both areas, however, had localized zones of relatively small dissolved-oxygen concentrations that indicate reducing conditions.

Piper diagrams (Freeze and Cherry, 1979, p. 249–250) for samples collected from the basic well network in the urban and agricultural land-use areas during July and August 1988 are shown in figure 6. Ground-water samples from the urban area indicated substantial variability in water type, although calcium was the predominant cation in about one-third of the samples. Anions ranged from a predominance by bicarbonate to no predominance to sulfate. Ground water in the agricultural land-use area had no predominant cation type. Sulfate was the predominant anion.

Median nitrite-plus-nitrate concentration (table 3) was about three times greater in samples from urban wells (6.5 mg/L) than from agricultural wells (2.3 mg/L). Ammonium concentrations were very small in ground water from both areas; median concentrations were 0.01 mg/L in urban samples and 0.04 mg/L in agricultural samples. Median phosphorus concentrations also were small—0.03 mg/L in urban samples and 0.01 mg/L in agricultural samples.

Summary statistics for trace elements that were most commonly detected in samples from both land-use areas (table 3) indicate that median barium concentrations decreased from 56 μg/L in the urban land-use wells to 22 μg/L in the agricultural land-use wells. Downgradient increases in median ground-water concentrations from the urban area to the agricultural area were detected for boron (140 to 255 μg/L), lithium (44 to 65 μg/L), selenium (3 to 12 μg/L), and strontium (590 to 1,000 μg/L). Median iron and manganese concentrations were small and similar in ground water from both areas; these concentrations were 10 μg/L for iron in samples from both areas and 3 μg/L in urban and 2 μg/L in agricultural samples for manganese. Both iron and manganese, however, had maximum values that exceeded 1,000 μg/L in samples from both areas. These values indicate local variations in oxidation potentials. Median zinc concentrations were small and similar in ground water from both areas (7 μg/L in the urban and 6 μg/L in the agricultural) and had maximum values of 48 μg/L in the urban and 52 μg/L in the agricultural samples.

Most trace elements were seldom detected in analyses of ground-water samples, but when detected, the elements were present at concentrations near detection levels (table 17 of the "Supplemental Data" section). These trace elements are arsenic, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, silver, and vanadium. Arsenic, cadmium, lead, mercury, and silver were detected frequently enough to warrant statistical treatment and will be discussed in the "Effects of Land Use on Ground-Water Quality" section.

The statistical distributions of DOC in the ground water beneath the two areas were similar (table 3). Median concentrations were 2.2 mg/L in urban and agricultural samples.

Table 3. Summary statistics for values of onsite measurements and concentrations of major water-quality constituents, nutrients, frequently detected trace elements, and dissolved organic carbon in samples collected from basic-network wells for July and August 1988 and January through early March 1989 combined

[Std Dev, standard deviation; µS/cm, microsiemens per centimeter at 25 degrees Celsius; ---, not calculated; mg/L, milligrams per liter; <, less than; µg/L, micrograms per liter]

Variable	Urban land-use samples					Agricultural land-use samples				
	Mean	Std Dev	Minimum	Median	Maximum	Mean	Std Dev	Minimum	Median	Maximum
Specific conductance, µS/cm	992	398	441	930	2,180	1,760	580	1,150	1,600	3,750
pH, standard units[1]	6.93	--	6.43	7.08	7.43	7.10	--	6.77	7.14	7.40
Dissolved oxygen, mg/L	4.4	2.5	0.2	4.8	8.2	3.1	2.0	0.3	3.5	6.2
Alkalinity, mg/L as $CaCO_3$	215	73	90	216	338	269	57	197	255	458
Dissolved solids, sum of constituents, mg/L	674	316	249	615	1,658	1,310	513	771	1,220	3,056
Calcium, mg/L as Ca	98	37	34	96	200	161	49	95	150	300
Magnesium, mg/L as Mg	31	21	9.1	26	110	53	28	27	44	150
Sodium, mg/L as Na	74	35	28	61	170	176	66	120	160	430
Potassium, mg/L as K	3.7	1.3	1.7	3.2	7.7	3.8	1.0	2.1	3.9	6.3
Sulfate, mg/L as SO_4	255	185	59	205	900	665	338	340	580	1,800
Chloride, mg/L as Cl	34	12	9.3	36	55	57	11	42	56	83
Fluoride, mg/L as F	1.4	0.8	.3	1.5	3.2	2.1	0.5	1.0	2.2	2.8
Silica, mg/L as SiO_2	20	3	13	20	25	16	2	13	16	23
Nitrite plus nitrate, mg/L as N	--	--	<.1	6.5	14	--	--	<.1	2.3	5.6
Ammonium, mg/L as N	--	--	<.01	.01	.06	--	--	<.01	.04	.12
Phosphorus, mg/L as P	--	--	<.01	.03	.11	--	--	<.01	.01	.05
Barium, µg/L as Ba	66	36	19	56	150	24	10	9	22	67
Boron, µg/L as B	147	78	40	140	310	273	72	200	255	540
Iron, µg/L as Fe	139	514	4	10	2,400	--	--	<3	10	1,100
Lithium, µg/L as Li	--	--	<4	44	140	72	25	50	65	170
Manganese, µg/L as Mn	--	--	<1	3	1,300	--	--	<1	2	1,200
Selenium, µg/L as Se	--	--	<1	3	17	--	--	<1	12	47
Strontium, µg/L as Sr	600	290	100	590	1,400	1,270	740	590	1,000	3,900
Zinc, µg/L as Zn	--	--	<3	7	48	--	--	<3	6	52
Dissolved organic carbon, mg/L as C	2.3	.9	.8	2.2	4.9	2.3	.7	1.3	2.2	5.0

[1] Mean pH calculated on basis of hydrogen-ion concentrations.

Volatile Organic Compounds

Results of determinations of VOC's in the ground water of the study area for July and August 1988 and January through early March 1989 are listed in table 18 in the "Supplemental Data" section. VOC's were detected at or greater than 0.2 μg/L in many samples from basic-network wells in the urban land-use area: benzene (5 wells); chlorodibromomethane (3 wells); chloroform (15 wells); dichlorobromomethane (7 wells); 1,1-dichloroethane (2 wells); 1,1-dichloroethylene (1 well); ethylbenzene (2 wells); tetrachloroethylene (11 wells); toluene (3 wells); 1,1,1-trichloroethane (5 wells); trichloroethylene (3 wells); and xylene (1 well). At least one VOC was detected in samples from all urban basic-network wells during either July and August 1988 or January through early March 1989 (except for well U07, which was sampled only during July and August 1988), and more than one VOC was detected in samples from all but five of these wells. Few VOC concentrations exceeded 1 μg/L, and the maximum concentration was 23 μg/L for 1,1,1-trichloroethane in the sample from well U04 during July and August 1988.

By contrast, only four VOC's were detected in samples from basic-network wells in the agricultural land-use area: benzene (3 wells), chlorobenzene (1 well), chloroform (2 wells), and 1,4-dichlorobenzene (1 well) (table 18). Water from only four wells in the agricultural area had detections, and the maximum concentration was 1.9 μg/L for chlorobenzene.

Pesticides

Pesticide detections were few in ground-water samples collected during July and August 1988, and all detected concentrations were at or very near detection levels (table 19 in the "Supplemental Data" section). Table 2 presents a summary of wells that yielded samples with pesticide detections. Chlorophenoxy-acid herbicides were not detected in any ground-water samples. The only organophosphorus insecticide detected was diazinon at well A02. Because diazinon was detected in all Fountain Creek samples during storm runoff and low flow, this detection cannot be confidently attributed to land-use activities in the agricultural area. No organochlorine pesticide was detected in samples from wells.

Most detections of pesticides in ground-water samples were triazines or other nitrogen-containing herbicides. Cyanazine was detected in samples from three urban wells (U03, U19, and U21) and one agricultural well (A13) (table 2). The fact that this compound was not detected in any Fountain Creek sample indicates that its presence probably can be attributed to nearby land-use practices instead of stream seepage. Prometon was detected in samples from wells U21 and A14 and in all Fountain Creek samples for which pesticides were analyzed; therefore, its presence in

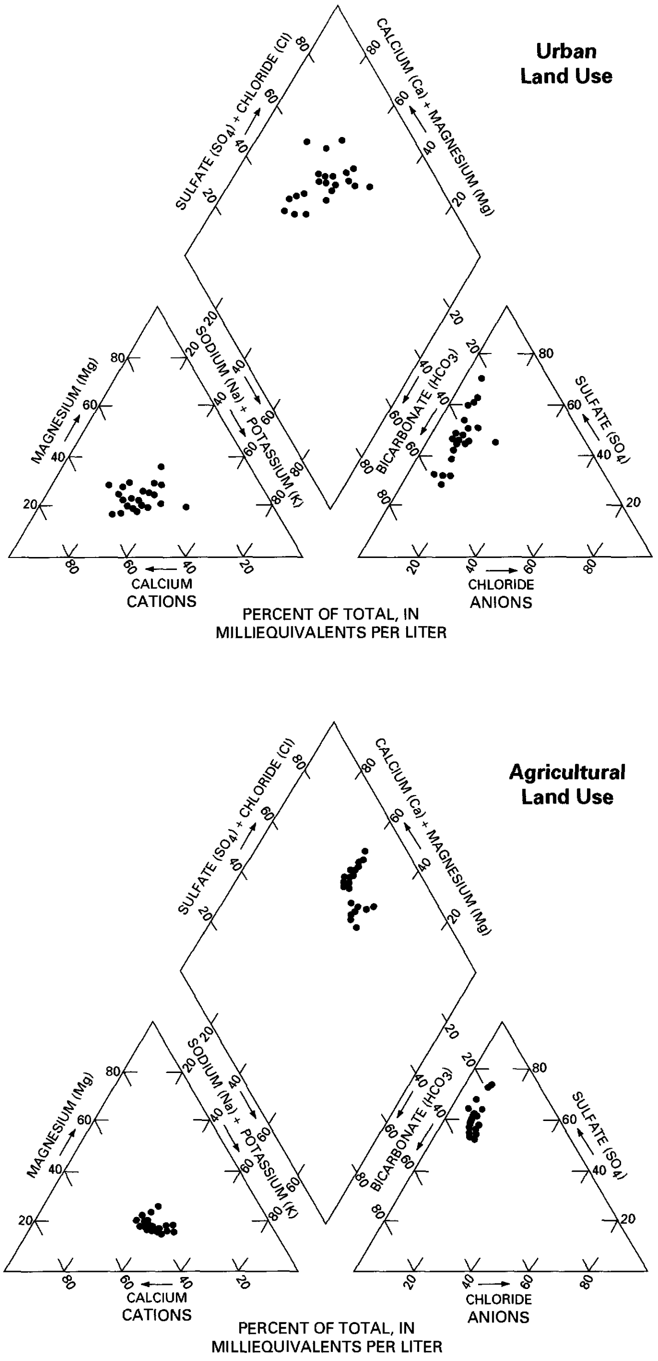


Figure 6. Piper diagrams showing water types for ground water collected from urban and agricultural land-use areas, July and August 1988.

ground water from these wells may not be because of nearby land use.

Only 3 of 22 urban land-use wells and 2 of 20 agricultural land-use wells yielded samples with detections of pesticides, and concentrations did not exceed 0.2 µg/L (tables 2 and 19). Because of these facts and because many of these pesticides also were detected in samples from adjacent reaches of Fountain Creek—making determination of their source difficult—pesticides will not be analyzed by statistical tests or discussed further in this report.

EFFECTS OF LAND USE ON GROUND-WATER QUALITY

Statistical hypothesis testing for ground-water-quality properties and constituents follows three main lines of comparison: (1) Data from urban compared with data from agricultural land-use areas, (2) July and August 1988 data compared with January through early March 1989 data, and (3) data from shallow matched-pair wells compared with data from deep matched-pair wells. The conclusions from one line of comparison are incorporated into the discussion of subsequent lines of comparison where appropriate to improve the conceptualization of the alluvial-aquifer flow system.

Differences in Quality of Ground Water Beneath Urban and Agricultural Land-Use Areas, July and August 1988

Tests for significant (at a significance, *p*, of 0.10) differences between data collected from basic-network wells in the urban and agricultural land-use areas during July and August 1988 were done by Wilcoxon-Mann-Whitney rank-sum tests and contingency-table tests. Wilcoxon-Mann-Whitney rank-sum tests were used to test onsite measurements and concentrations of major constituents, nutrients, frequently detected trace elements, and DOC. Contingency-table tests were used to test detection frequencies of infrequently detected trace elements and VOC's.

Onsite Measurements, Major Constituents, Nutrients, Frequently Detected Trace Elements, and Dissolved Organic Carbon

Table 4 presents a summary of the results of Wilcoxon-Mann-Whitney rank-sum tests that were used to determine significant differences between onsite measurements and concentrations of major constituents, nutrients, frequently detected trace elements, and DOC from samples collected during July and August 1988 from basic-network wells in the urban land-use area and onsite measurements and concentrations from samples collected from basic-network wells in the agricultural land-use area. Many statistically significant differences between the ground-water qualities of the land-use areas are indicated.

Boxplots are a useful way to show relations between sets of data from wells in the urban and agricultural areas. An example of a boxplot is shown in figure 7. Side-by-side boxplots illustrating the distribution of data for pH and concentrations of selected water-quality constituents in table 4 are shown in figure 8.

Depth to water was significantly greater in samples from the urban area than from the agricultural area. Specific conductance was significantly greater in samples from the agricultural area than in samples from the urban area, although pH (fig. 8), temperature, and dissolved-oxygen concentrations (fig. 8) were not significantly different. Concentrations of alkalinity, dissolved solids (fig. 8), and all major ions—calcium, magnesium, sodium, sulfate, and chloride, except potassium (fig. 8)—were significantly greater in samples from the agricultural area than in samples from the urban area. Fluoride, boron, lithium, selenium, and strontium also indicated significantly greater concentrations in samples from the agricultural area. Cain and Edelmann (1986) explained similar findings (except for selenium) during the reconnaissance study as the result of

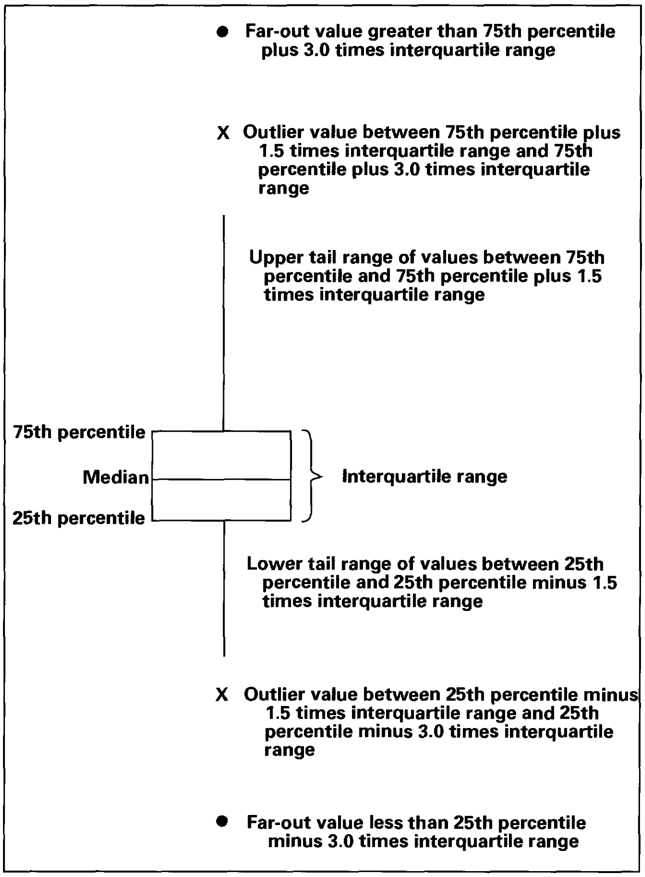


Figure 7. Example of a boxplot.

Table 4. Summary of Wilcoxon-Mann-Whitney rank-sum tests comparing physical properties of water and constituent concentrations in samples collected from basic-network wells in the urban land-use area with those properties and concentrations from the agricultural land-use area, July and August 1988

[Tests were made with a two-tailed significance level of 0.10 and a null hypothesis (H_0) defined as no significant difference between distributions of values or concentrations in samples from urban and agricultural land-use areas and an alternative hypothesis (H_1) defined as a significant difference between values or concentrations; ft, feet; *N*, total number of samples for given land use; *p*-value, significance level; U, urban land-use area; >, greater than; A, agricultural land-use area; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; <, less than; mg/L, milligrams per liter; µg/L, micrograms per liter]

Test variable	Unit	Urban		Agricultural		Test result	Test *p*-value
		Median	*N*	Median	*N*		
Depth to water	ft	30.9	22	10.8	20	H_1: U>A	0.003
Specific conductance	µS/cm	928	22	1,505	20	H_1: A>U	<.001
pH	Standard units	7.08	22	7.11	20	H_0	.338
Temperature	°C	14.8	22	14.0	20	H_0	.160
Dissolved oxygen	mg/L	4.4	22	3.5	20	H_0	.154
Alkalinity	mg/L as $CaCO_3$	212	22	259	20	H_1: A>U	.016
Dissolved solids, sum of constituents	mg/L	598	22	1,152	20	H_1: A>U	<.001
Calcium	mg/L as Ca	95	22	150	20	H_1: A>U	<.001
Magnesium	mg/L as Mg	23	22	44	20	H_1: A>U	<.001
Sodium	mg/L as Na	62	22	160	20	H_1: A>U	<.001
Potassium	mg/L as K	3.1	22	3.9	20	H_0	.824
Sulfate	mg/L as SO_4	205	22	560.8	20	H_1: A>U	<.001
Chloride	mg/L as Cl	37	22	56	20	H_1: A>U	<.001
Fluoride	mg/L as F	1.6	22	2.3	20	H_1: A>U	.014
Silica	mg/L as SiO_2	19	22	16	20	H_1: U>A	<.001
Nitrite plus nitrate	mg/L as N	6.4	22	2.2	20	H_1: U>A	.004
Ammonium	mg/L as N	.01	22	.03	20	H_1: A>U	<.001
Phosphorus	mg/L as P	.03	22	.02	20	H_1: U>A	.089
Barium	µg/L as Ba	56	22	22	20	H_1: U>A	<.001
Boron	µg/L as B	135	22	250	20	H_1: A>U	<.001
Iron	µg/L as Fe	9	22	12	20	H_0	.646
Lithium	µg/L as Li	44	22	64	20	H_1: A>U	<.001
Manganese	µg/L as Mn	3	22	2	20	H_0	.851
Selenium	µg/L as Se	3	22	12	20	H_1: A>U	.007
Strontium	µg/L as Sr	550	22	990	20	H_1: A>U	<.001
Zinc	µg/L as Zn	8	22	7	20	H_0	.601
Dissolved organic carbon	mg/L as C	2.2	22	2.4	20	H_0	.398

cyclic evaporative concentration of ground water as it flows downgradient and is pumped for irrigation and the result of the longer cumulative residence time of ground water in the agricultural area, a condition that is conducive to greater dissolution of aquifer materials. Evaporative concentration probably is the major cause of the significantly greater concentration of these elements in the agricultural area, but inflow of ground water with substantial dissolved-solids concentrations from tributary alluvium, especially from Jimmy Camp Creek alluvium at Fountain (Klein and Bingham, 1975), probably exceeds the effect of residence time because aquifer materials predominantly consist of relatively nonreactive quartz and feldspars, and residence times generally are less than a few decades in this system. Cain and Edelmann (1986, p. 24) explained the enrichment in selenium as the result of cumulative dissolution from seleniferous beds in the shale bedrock. Although this source probably contributes to the enrichment, evidence indicating that selenium is leached from soil and concentrated by evaporation like major ions is presented in the "Differences in Quality of Ground Water from Shallow and Deep Matched-Pair Wells Completed in the Agricultural Land-Use Area, July and August 1988" section. Deverel and Fujii (1988, p. 516) documented selenium enrichment resulting from evaporation or transpiration of ground water in the San Joaquin Valley, Calif.

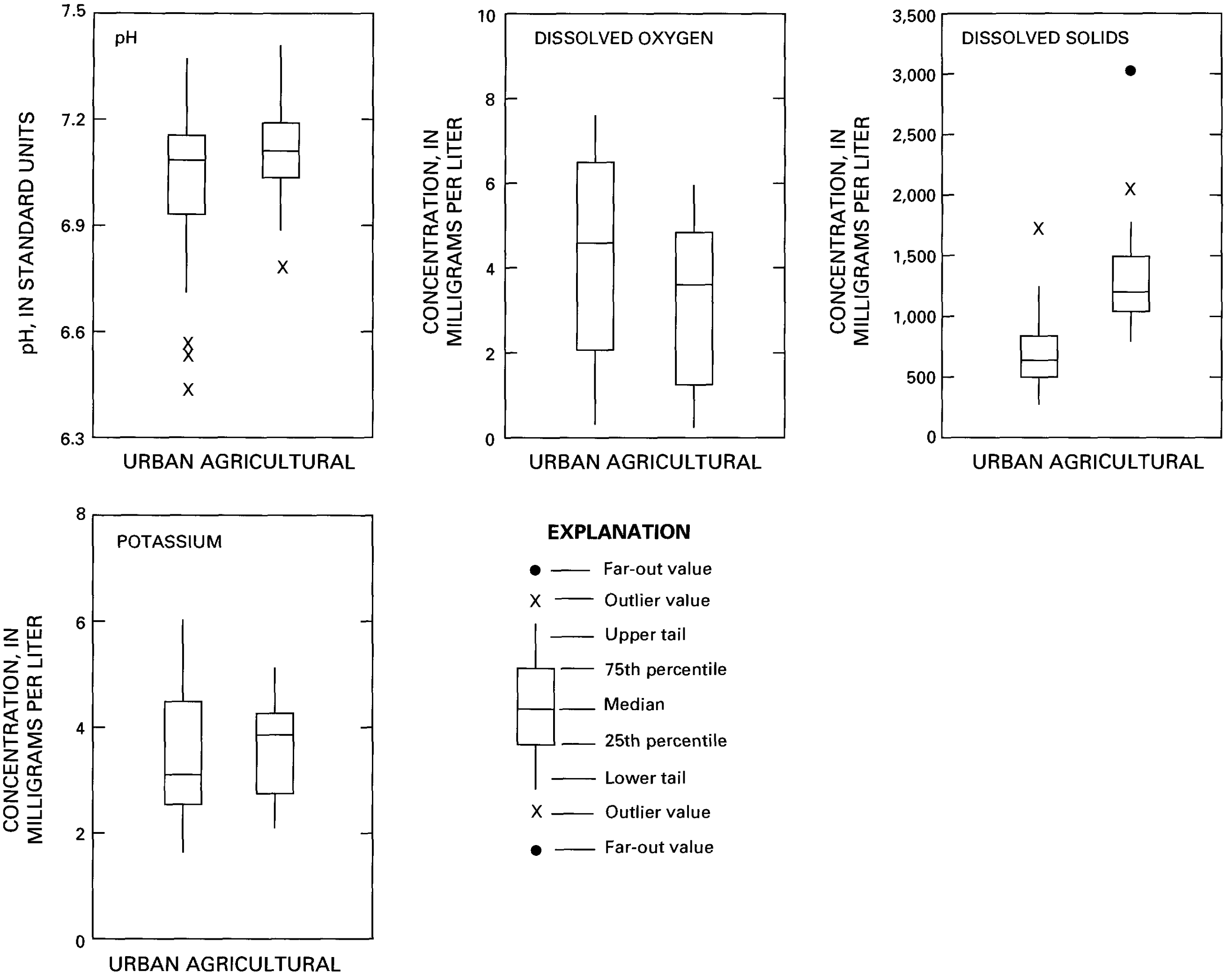


Figure 8. Values of pH and concentrations of selected water-quality constituents for samples collected from basic-network wells in the urban and agricultural land-use areas, July and August 1988.

The differences in concentrations indicated for the preceding constituents mainly resulted from irrigation and tributary ground-water inflows. Water diverted from Fountain Creek and pumped from the alluvial aquifer is used for irrigation of crops (mainly alfalfa and hay), undergoes evaporation, and either returns to Fountain Creek as irrigation-return flows (ditch drainage) or percolates to the water table. This cycle is repeated as the water flows down the creek and downgradient in the alluvial aquifer and becomes progressively more saline. Transpiration by native plants in the valley causes additional evaporative concentration of water-quality constituents. Downstream trends in mean concentrations of dissolved solids and major ions in Fountain Creek (fig. 5)—concentrations that are smaller than the concentrations of those constituents in adjacent ground water—illustrate the effects of irrigation-return flows and base flow.

The chemical speciation model WATEQ4F (Ball and others, 1987) was used to calculate the saturation states of selected water samples with respect to common mineral phases. These calculations indicate that supersaturation of common minerals did not limit concentrations of major ions in the agricultural area enough to (1) cause the conclusion of null hypotheses in comparisons between land-use areas or (2) cause significantly greater concentrations in the urban area. For example, although calcite ($CaCO_3$) was supersaturated in samples from the most downgradient agricultural wells, calcium and alkalinity were significantly more concentrated in samples from the agricultural area.

Silica and barium were significantly more concentrated in samples from the urban area than in samples from the agricultural area (table 4). Cain and Edelmann (1986, p. 22) did not collect samples for silica, but determined a significant downgradient correlation for barium. Silica

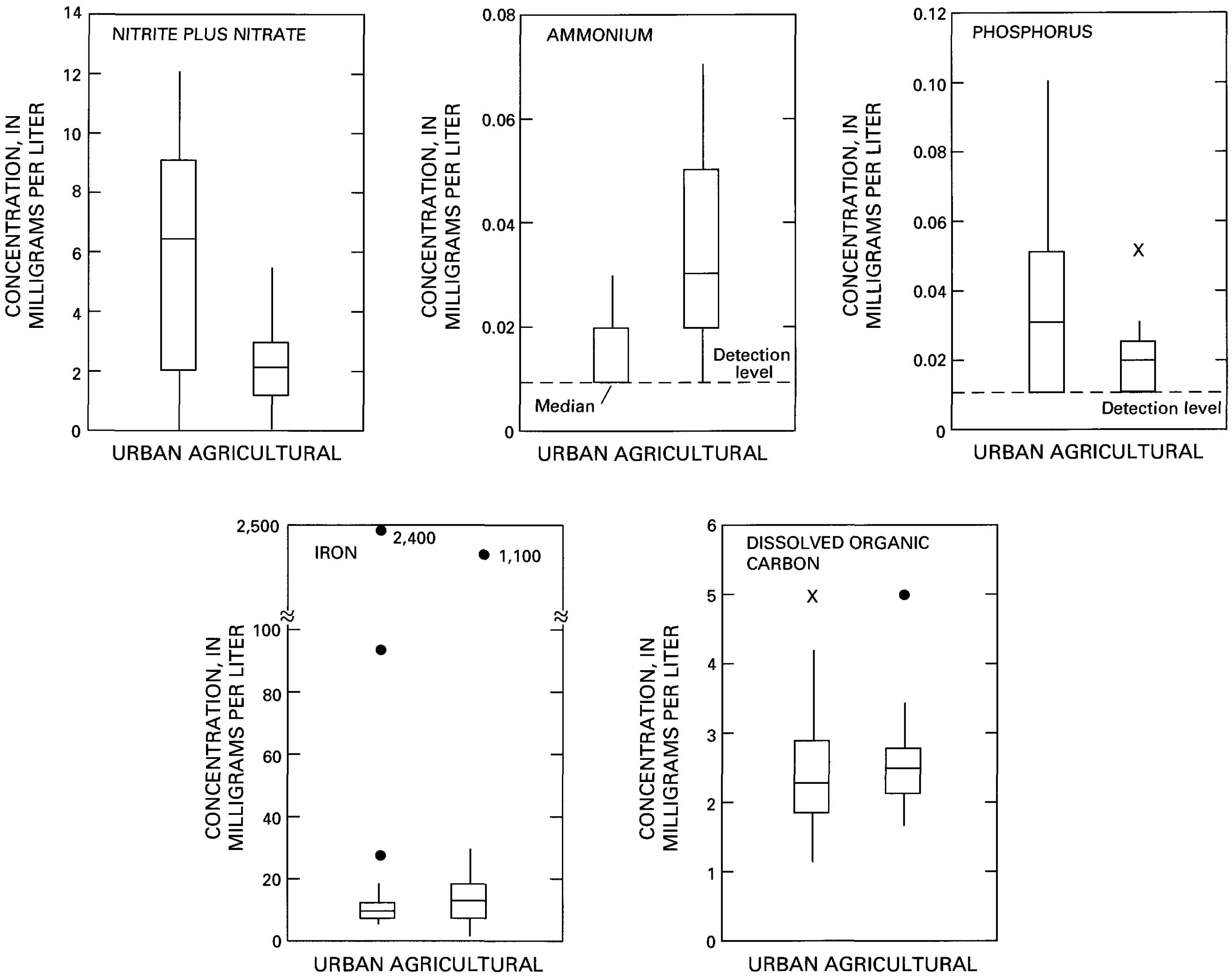


Figure 8. Values of pH and concentrations of selected water-quality constituents for samples collected from basic-network wells in the urban and agricultural land-use areas, July and August 1988—Continued.

concentrations in the agricultural area probably were decreased by precipitation of aluminous clay minerals because of slightly greater pH values and greater concentrations of cations—factors favoring clay-mineral precipitation. This hypothesis cannot be evaluated by WATEQ4F calculations, however, because samples were not analyzed for aluminum, a component that contributes to clay-mineral precipitation. WATEQ4F indicates that amorphous silica was undersaturated and, therefore, was not being precipitated. Cain and Edelmann (1986, p. 24) hypothesized that the downgradient decrease in barium resulted from precipitation of the relatively insoluble mineral barite ($BaSO_4$) as sulfate-ion concentrations increased in the downgradient direction. This hypothesis is supported by WATEQ4F calculations, which indicate that barite was similarly supersaturated in ground water beneath both land-use areas. The greater sulfate concentrations in ground water beneath the agricultural area resulted in increased barite precipitation, which resulted in smaller concentrations of barium.

Concentrations of nitrite plus nitrate (fig. 8) were significantly greater in samples from the urban area than in samples from the agricultural area. Cain and Edelmann (1986, p. 22) reported a significant downgradient decrease for nitrite-plus-nitrate concentrations. The significantly greater concentrations of nitrite plus nitrate in ground water underlying the urban area partly resulted from recharge of sewage effluent from Fountain Creek and from Canal No. 4 and Big Johnson Reservoir (pl. 1) along the eastern edge of the urban area. Ammonium from sewage effluent largely is converted to nitrite and nitrate within short distances after seeping into the aquifer. This process is indicated by the fact that no samples collected in summer from basic-network wells in the urban area had ammonium concentrations exceeding 0.04 mg/L, although Fountain Creek had mean ammonium concentrations of 7.9 mg/L at SW2 and 4.6 mg/L at SW3 (table 17).

The application of fertilizer to lawns and gardens probably contributed to elevated nitrite-plus-nitrate concentrations in ground water beneath the urban area. This probability is indicated by relatively large concentrations of nitrite plus nitrate in samples from wells supplied predominantly from Sand Creek tributary alluvium (U09, U11, and U12). This water source is indicated by water samples from those wells that had considerably smaller concentrations of dissolved solids than did samples from wells immediately upgradient in Fountain Creek alluvium and from Fountain Creek at SW2 and SW3. Potential point sources for the nitrite and nitrate present in Sand Creek alluvium, however, could account for these concentrations of nitrite plus nitrate. Edelmann and Cain (1985, p. 54) estimated that potential uptake of nitrogen by lawns in this area exceeded the quantity of nitrogen applied with fertilizer and irrigation water, although they conceded that some nitrogen could have reached the water table during periods of excessive precipitation or irrigation. Therefore, although land use probably affected nitrogen concentrations in the alluvial aquifer in the urban land-use area, the effects of recharge by sewage effluent are almost certain.

The small concentrations of nitrite plus nitrate in water samples from wells at Fountain and in the agricultural area probably were the result of uptake by plants. Substantially greater nitrite-plus-nitrate concentrations were measured in samples collected during July and August 1988 from wells U17 (8.1 mg/L), U18 (9.3 mg/L), and U19 (9.1 mg/L) at south Widefield than from wells U20 (1.4 mg/L), U21 (3.4 mg/L), and U22 (2.1 mg/L) (table 17, pl. 1) about 3 mi downgradient at Fountain. No important source of water existed to dilute nitrite-plus-nitrate concentrations over this 3-mi distance. Furthermore, nitrogen concentrations in most water recharging Fountain Creek alluvium were too large to support the hypothesis that nitrite-plus-nitrate concentrations were diluted between the urban and agricultural areas. Klein and Bingham (1975, p. 20) reported nitrite-plus-nitrate concentrations of 5.3 and 19 mg/L for water from two wells in Jimmy Camp Creek alluvium within 1 mi of Fountain Creek alluvium; mean sums of nitrite-plus-nitrate and ammonium concentrations in Fountain Creek at SW4 (6.3 mg/L) and SW5 (4.1 mg/L) were greater than mean sums in ground-water samples collected from the agricultural area (2.2 mg/L). Also, ammonification of nitrite and nitrate and subsequent loss by ion exchange is not likely to have occurred because dissolved-oxygen concentrations generally were too large in ground water underlying the agricultural area. Therefore, plant uptake of nitrogen is the most likely mechanism for significant downgradient decreases in nitrite-plus-nitrate concentrations between the urban and agricultural areas. Donahue and others, (1977, p. 128) referred to the ability of plants to use nitrogen as either ammonium (NH_4^+) or nitrate (NO_3^-).

Ammonium concentrations were significantly greater in ground-water samples from the agricultural area than in samples from the urban area (fig. 8), although mean ammonium concentrations in Fountain Creek were smaller in samples from the agricultural area (2.5 mg/L at SW4 and 1.2 mg/L at SW5) than in samples from the urban area (7.9 mg/L at SW2 and 4.6 mg/L at SW3) (table 17). The number of livestock in the agricultural land-use area is not sufficient to contribute substantially to this ground-water trend, and little nitrogen fertilizer has been applied to crops because of the availability of nitrogen in irrigation water.

The greater concentrations of ammonium in ground water beneath the agricultural area can be attributed to the infiltration of ammonium from sewage effluent in irrigation water and the decomposition of organic matter in the soil. Donahue and others (1977, p. 129–130) stated that decomposition of soil organic matter is the most important source of usable nitrogen in unfertilized fields and that this decomposition releases ammonium. Ammonium has a short lifetime in aerated ground water because of adsorption to negatively charged surfaces of organic matter and mineral (especially clay) surfaces and oxidation by bacteria to nitrate. The generally well-drained soils and the relatively small depths to water, however, favor percolation of ammonium to the water table near wells in the agricultural area. In the urban area, less organic matter is available to decompose and, therefore, less ammonium is produced. Ammonium that enters the aquifer by recharge of sewage-contaminated water from Fountain Creek and Canal No. 4 has long, horizontal flow paths in the saturated zone and, thereby, has more time to be adsorbed on mineral grains and undergo nitrification before reaching wells.

Phosphorus concentrations were significantly greater in ground water underlying the urban area than in ground water underlying the agricultural area (fig. 8). This trend probably resulted from processes similar to those affecting nitrite-plus-nitrate concentrations. Recharge of sewage-contaminated Fountain Creek water, which had a mean phosphorus concentration of 3.0 mg/L at SW2 (table 17), resulted in ground-water concentrations of phosphorus less than 0.10 mg/L in the urban area. This relation probably indicates the adsorption of phosphate onto oxide surfaces, as described by Drever (1982, p. 79), within short distances of recharge zones. Downgradient plant uptake from irrigation water and adsorption onto mineral surfaces caused phosphorus concentrations in ground water beneath the agricultural area to be 0.05 mg/L or less.

Iron (fig. 8), manganese, and zinc concentrations in ground water were not significantly different between urban and agricultural areas (table 4). Cain and Edelmann (1986, p. 24) reported a weak downgradient increase for iron concentrations. Because the ground water beneath each land-use area generally was well oxygenated, iron and manganese concentrations generally should have been controlled by solubility equilibria with oxides. Drever (1982, p. 275) reported that, at the pH range and dissolved-oxygen concentrations of most of these samples, hematite (Fe_2O_3) is the most stable iron oxide and controls ferrous iron concentrations with respect to dissolution. Amorphous ferric iron hydroxide [$Fe(OH)_3$], however, controls ferrous iron concentrations with respect to precipitation (Drever, 1982, p. 264). Most of the iron concentrations in samples from both land-use areas were less than 15 µg/L. Of the few that had greater concentrations, most occurred in samples with minimal dissolved oxygen and, at these near-neutral pH values, consisted of ferrous iron. Solubility controls prevented significantly greater concentrations of iron in ground water beneath the urban area where land-use sources of iron greatly exceeded sources in the agricultural area.

The median concentration of manganese was slightly greater in samples from the urban area than in samples from the agricultural area, but the difference was not statistically significant (table 4). All but five manganese concentrations in the urban land-use area and two in the agricultural land-use area were less than 25 µg/L (table 17). This concentration range agrees well with an oxidation mechanism proposed by Hem (1978, 1985, p. 87–88) for aerated water. Most of the observations with manganese concentrations greater than 25 µg/L occurred in water with minimal dissolved oxygen. As previously discussed, mean manganese concentrations substantially decreased between the urban and agricultural reaches of Fountain Creek. However, solubility or adsorption controls prevented recharge of Fountain Creek water, which had greater manganese concentrations in the urban reach, from causing greater concentrations in the ground water beneath the urban area.

Median concentrations of zinc in water samples from both land-use areas were less than 9 µg/L, and no significant difference in concentrations between areas was determined (table 4). Zinc is widely used as plating on galvanized steel and as white pigment in paint and rubber and has a wide variety of other uses, including photo engraving, lithographic printing, automobile components, and rain-water gutters and pipes (Moore and Ramamoorthy, 1984a, p. 184–185). These uses indicate that zinc has a greater number of sources in the urban area than in the agricultural area. The absence of greater ground-water concentrations in the urban area indicates solubility or sorption controls. Moore and Ramamoorthy (1984a, p. 189) stated that iron-manganese oxides scavenge zinc from solution. Mean zinc concentrations in Fountain Creek primarily were increased by sewage effluent from about 15 µg/L at site SW1 to 40 µg/L at site SW2 and decreased steadily to about 8 µg/L at site SW5 (table 17). As with manganese, the potential recharge of zinc-enriched Fountain Creek water in the urban reach did not cause significantly greater concentrations of zinc in ground water beneath the urban area because of geochemical mechanisms that limit zinc concentrations.

Infrequently Detected Trace Elements

Table 5 lists the results of contingency-table tests comparing detection frequencies of infrequently detected trace elements in samples collected during July and August 1988 from basic-network wells in the urban land-use area with detection frequencies in samples collected in the agricultural land-use area. The probabilities of detecting arsenic, mercury, molybdenum, and silver were not significantly different between land-use areas. Arsenic concentrations did not exceed 1 µg/L in any sample, although they generally were 2 to 4 µg/L in Fountain Creek samples (table 17). Adsorption by hydrous iron oxides (Pierce and Moore, 1980) or other oxide complexes associated with clay, silt, and sand (Huang and Liaw, 1978) probably limit arsenic concentrations in the ground-water environment.

Mercury concentrations generally did not exceed 0.2 µg/L in either Fountain Creek or ground-water samples (table 17). Because mercury is used in industrial processes (Moore and Ramamoorthy, 1984a, p. 127–128), concentrations would be expected to be greater in ground water beneath the urban area than in ground water beneath the agricultural area if it were not for sorption controls. Moore and Ramamoorthy (1984a, p. 131) concluded that suspended solids of all types in the 0.45- to 20-µm size range sorb mercury concentrations to about 1×10^5 times the equilibrium concentrations dissolved in the surrounding water. Sorption limits equilibrium mercury concentrations in the ground-water system and is much more important than any potential source effect on the subsurface distribution of mercury.

Molybdenum concentrations did not exceed 20 µg/L in Fountain Creek samples. Small concentrations of molybdenum in Fountain Creek and in ground water and the high geochemical mobility of molybdenum under most conditions (Hem, 1985, p. 140) indicate that molybdenum was not abundant in the study area.

Silver was detected at concentrations that ranged from 1 to 3 µg/L in samples from eight wells in the urban area and nine wells in the agricultural area (tables 5 and 17), but was not detected in Fountain Creek samples. The small silver concentrations in ground-water samples probably represent background levels that were limited by either availability from aquifer materials, the solubility of silver metal (Hem, 1985, p. 141), or adsorption on iron and manganese oxides (Levinson, 1980, p. 882). Calculations with WATEQ4F indicate that oversaturation with respect to silver metal occurred at less than 1×10^{-3} of the detection level (1 µg/L) and that dissolved silver existed as $AgCl^0$ and Ag^+ in about 2 to 1 ratios. Leaching of the soil zone in the agricultural area by chloride in irrigation water possibly mobilized sorbed silver, which remained in solution in ground

Table 5. Summary of contingency-table tests comparing detection frequencies of infrequently detected trace elements and volatile organic compounds in samples collected from basic-network wells in the urban land-use area with those detection frequencies from the agricultural land-use area, July and August 1988

[Tests were made with a two-tailed significance level of 0.10 and a null hypothesis (H_0) defined as no significant difference in probability of detecting variable in samples from urban and agricultural land-use areas and an alternative hypothesis (H_1) defined as a significant difference between probability of detection; μg/L, micrograms per liter; N, total number of samples (in parentheses) for given land use; *p*-value, significance level; A, agricultural land-use area; >, greater than; U, urban land-use area; <, less than; VOC's, volatile organic compounds]

Test variable	Detection level (μg/L)	Number of urban detections (N)		Number of agricultural detections (N)		Test results	Test *p*-value
				Trace elements			
Arsenic	1	3	(22)	3	(19)	H_0	0.984
Cadmium	1	1	(22)	5	(20)	H_1: A>U	.058
Lead	10	1	(22)	5	(20)	H_1: A>U	.058
Mercury	.1	2	(21)	3	(20)	H_0	.576
Molybdenum	10	2	(22)	5	(20)	H_0	.166
Silver	1	8	(22)	9	(20)	H_0	.568
				Volatile organic compounds			
Benzene	.2	2	(22)	2	(20)	H_0	.992
Chloroform	.2	11	(22)	1	(20)	H_1: U>A	<.001
Dichlorobromomethane	.2	4	(22)	0	(20)	H_1: U>A	.046
Tetrachloroethylene	.2	6	(22)	0	(20)	H_1: U>A	.012
1,1,1-Trichloroethane	.2	4	(22)	0	(20)	H_1: U>A	.046
Combined VOC's[1]	.2	8	(22)	3	(20)	H_0	.125

[1] One or more detections at a well counted as only one detection; compounds that were detected in urban surface-water samples were excluded.

water because of slow rates of metallic silver precipitation. This hypothesis could explain why silver was not detected at a significantly greater frequency in the urban area where more industrial sources occur, especially from electroplating and chemical processing.

Cadmium was detected (at a detection level of 1 μg/L) with a significantly greater frequency in samples from the agricultural area than in samples from the urban area (table 5). Concentrations in both land-use areas, however, were in the 1- to 3-μg/L range, and cadmium was detected in only two Fountain Creek samples at 2 μg/L (table 17). Cadmium is used in electroplating, pigments for ceramics, paints and coatings, plastic stabilizers, and batteries (Moore and Ramamoorthy, 1984a, p. 30). Therefore, more sources of cadmium probably occur in the urban area. The more frequent detections of cadmium in the agricultural land-use area probably resulted from greater concentrations of chloride ions, which are capable of forming highly mobile complexes with cadmium (Moore and Ramamoorthy, 1984a, p. 31–32). This and other complexing and ionic-strength effects (Drever, 1982, p. 22–24) probably enabled cadmium to undergo evaporative concentration in a manner similar to major ions, although at much smaller concentrations.

Lead was detected (at a detection level of 10 μg/L) with a significantly greater frequency in ground-water samples collected from the agricultural area than in samples collected from the urban area (table 5). Concentrations detected in samples from the agricultural area ranged from 10 to 40 μg/L (five detections); the one detection in samples from the urban area was 10 μg/L (table 17). Fountain Creek samples had no lead detections, which indicates that recharge of water from Fountain Creek was not an important source of lead in ground water. Lead flushed into Fountain Creek probably was precipitated as the extremely insoluble lead phosphate phase $Pb_3(PO_4)_2$ (Moore and Ramamoorthy, 1984a, p. 105) because of the large concentrations of phosphorus supplied by sewage effluent.

The more frequent detection of lead in ground-water samples from the agricultural area than in samples collected from the urban area indicates that geochemical controls are more important than sources. More sources of lead probably occur in the urban area. Moore and Ramamoorthy (1984a, p. 101–102) listed a wide variety of lead uses, including in electric batteries, solder, paint pigments, sound-attenuation material, antivibration pads for buildings and heavy equipment, and automobile wheel weights and as an additive to leaded gasoline. Hem (1985, p. 144) reported that rain and snow may contain lead concentrations in excess of 100 µg/L in areas subject to air pollution. Automobile emissions and other pollution sources probably cause greater quantities of lead to accumulate on the land surface of the urban area than the agricultural area, although the agricultural land-use area is close enough to Colorado Springs and Pueblo to receive some lead from those sources. Moore and Ramamoorthy (1984a, p. 105) gave stability constants indicating that in the pH range of the surface and ground water in the study area, the soluble $PbOH^+$ ion should dominate over the Pb^{++} ion, which dominates at pH values less than 6. The soluble $PbOH^+$ ion probably enables lead to build up by the process of evaporative concentration and to be leached from the soil by irrigation water in the agricultural area during the summer. Lead entering the ground with precipitation in the urban land-use area probably exists mainly as the Pb^{++} ion (because of the slightly acidic nature of precipitation) and is sorbed strongly by clays, iron-manganese oxides, and humic substances in the soil and unsaturated zone.

Volatile Organic Compounds

Five VOC's were detected (at a detection level of 0.2 µg/L) frequently enough in samples collected from basic-network wells during July and August 1988 to be tested by contingency-table tests (table 5). Benzene was not detected with a significantly different frequency between land-use areas. Chloroform; dichlorobromomethane; tetrachloroethylene; and 1,1,1-trichloroethane were detected with significantly greater frequencies in ground water beneath the urban area than in ground water beneath the agricultural area. However, combined VOC's were not detected with significantly greater frequencies in the urban area. No VOC's were detected with a significantly greater frequency in the agricultural area.

Chloroform was detected in one-half (11) of the samples from the urban area and in only one sample from the agricultural area during July and August 1988 (tables 5 and 18). Chloroform was detected in samples collected at site SW2 during all sampling periods, but was not detected in samples collected at any other site on Fountain Creek. Chloroform, the most abundant halogenated methane in treated drinking water, is produced by the reaction of hydrolysis products of chlorine gas with DOC (Thurman, 1985, p. 226–227). Wastewater discharges also are chlorinated to destroy bacteria (Clark and others, 1977, p. 452). Otson and others (1981) reported that chlorine dosages and demands determined concentrations of chloroform discharged from three Canadian wastewater-treatment plants. The recharge of surface water into the alluvial aquifer potentially is a source of chloroform in the ground water of the urban land-use area. Industrial activities and pesticide spraying, however, also probably contributed chloroform to the ground water. Verschueren (1983) listed these uses of chloroform—as a chemical solvent; as a fumigant; and in the manufacturing of refrigerants, propellants, plastics, anesthetics, and pharmaceuticals. Both basic-network-well samples with pesticide and VOC detections during July and August 1988 (U03 and U19) had chloroform detections, a finding that indicates that pesticide applications probably account for some of the chloroform in ground water beneath the urban area. Because chloroform does not persist in detectable concentrations to site SW3 at Fountain and because chloroform is highly volatile and escapes with time from the alluvial aquifer, this compound was not detected in ground water at Fountain, which is less industrialized than the upgradient urban areas. The single detection of chloroform in ground water from the agricultural area indicates that very few sources of chloroform exist in that area.

Dichlorobromomethane is another chlorinated methane that was detected with a significantly greater frequency in samples from the urban area (table 5). This compound is another common trihalomethane that results from the oxidation of bromide ions during chlorination of water (Thurman, 1985, p. 226–227). This compound was not detected in any surface-water sample and can, therefore, probably be attributed to land-use sources.

Tetrachloroethylene was detected in six ground-water samples from the urban area, but in none of the samples from the agricultural area (tables 5 and 18). These findings result in a statistically significant difference. Tetrachloroethylene also was detected in the storm samples from Fountain Creek at sites SW1 and SW5 and in samples collected at site SW2 during all three sampling periods. This compound is used in dry-cleaning processes, for degreasing metal, in solvents for a wide variety of substances, and in paint removers (Verschueren, 1983). These uses probably account for its presence in Fountain Creek and in ground water. The presence of tetrachloroethylene in ground water probably was the combined result of land-use practices and surface-water recharge.

The compound 1,1,1-trichloroethane was detected with a significantly greater frequency in samples from wells in the urban area than in samples from the agricultural area (table 5). The only detection in Fountain Creek water was at site SW1 during the storm sampling (table 18). Three of the four urban detections occurred in samples from wells located in the vicinity of industrial parks (wells U03, U04, and U05). The U.S. Environmental Protection Agency (written commun., 1983) listed the following industrial applications of 1,1,1-trichloroethane—laundering, battery manufacturing, manufacturing of electrical and electronic components, metal finishing, manufacturing of photographic equipment and supplies, paint and ink formulation, and milling of paper products and textiles. These applications imply that this compound was present in ground water in the urban area as a result of land-use practices.

Combined VOC's were not detected with significantly greater frequencies in samples from the urban area than in samples from the agricultural area, although they were detected more than twice as frequently in the urban area (table 5). When counting detections for this group, compounds detected in samples from urban sites on Fountain Creek were excluded, and multiple detections at a single well were counted as only one detection.

Smith and others (1988, p. 52) concluded that, in surface-water systems, the primary environmental fate of chlorinated aliphatic and monocyclic aromatic compounds (groups that include almost all of both combined VOC groups in table 5) is volatilization into the atmosphere and photolytic degradation. Dilling and others (1975) determined that the volatilization rates of chloroform; 1,1,1-trichloroethane; trichloroethylene; and tetrachloroethylene were not significantly affected by the presence of a variety of inorganic and organic substances and, thus, sorptive effects were minor. Volatilization is an important process, however, affecting the environmental fate of chlorinated benzenes (Moore and Ramamoorthy, 1984b, p. 49; Smith and others, 1988, p. 53). Because the organic-matter content of the aquifer is small, volatilization probably is more important than sorption for removal of chlorinated aliphatic and chlorinated monocyclic aromatic compounds introduced to the ground water of the study area. Other mechanisms that may be important for the removal of VOC's from ground water are hydrolysis, oxidation, and biodegradation. The importance of these mechanisms in the ground-water system of Fountain Creek is not known.

The significantly greater VOC detection frequency in samples from the urban area than in samples from the agricultural area was the result of the presence of VOC sources in the urban area, removal of VOC's as ground water flows downgradient to and through the agricultural area, and lack of sources in the agricultural area. Rapid volatilization of VOC's from surface water in the urban area prevents transference of VOC's by seepage into ground water beneath the agricultural area. The general lack of VOC detections in samples from wells U20, U21, and U22 (table 18) at Fountain indicates the effectiveness of removal processes over the 3-mi distance downgradient from wells U17, U18, and U19 at Widefield, all of which yielded samples with detections. Dilution probably is not important because no notable inflow of tributary ground water occurs along this distance, and recharge of Fountain Creek water probably is minor because of the limited ground-water pumpage.

Differences in Quality of Ground Water Beneath Urban and Agricultural Land-Use Areas, January Through Early March 1989

The same hypothesis tests that were used to compare ground-water data collected during July and August 1988 were used to compare ground-water data collected from the urban and agricultural land-use areas during January through early March 1989. Wilcoxon-Mann-Whitney rank-sum tests were used to compare values of onsite measurements and concentrations of major constituents, nutrients, frequently detected trace elements, and DOC. Contingency-table tests were used to compare detection frequencies of infrequently detected trace elements and VOC's.

Onsite Measurements, Major Constituents, Nutrients, Frequently Detected Trace Elements, and Dissolved Organic Carbon

Table 6 lists the results of Wilcoxon-Mann-Whitney rank-sum tests comparing values of onsite measurements and concentrations of major constituents, nutrients, frequently detected trace elements, and DOC from samples collected from January through early March 1989 from basic-network wells in the urban area with onsite measurements and concentrations from samples collected from basic-network wells in the agricultural area. Side-by-side boxplots illustrating the distribution of pH and concentrations of selected constituents in ground water beneath the urban and agricultural land-use areas are shown in figure 9. A comparison of results in table 6 with corresponding test results for data collected during July and August 1988 (table 4) indicates few differences between the two sampling periods. Depth to water again was significantly greater in the urban area. During January through early March 1989, pH (fig. 9) was significantly greater in samples from the agricultural area (7.17) compared to samples from the urban area (7.09), but a smaller difference was not significant during July and August 1988 (fig. 8). The change in difference may have been caused by the relatively greater winter increase in dissolved-oxygen concentrations in the urban area, an increase that favored greater oxidation of DOC and decreased pH values by production of dissolved carbon dioxide (Drever, 1982, p. 35–38). The generally greater pH values of ground water in the agricultural area probably resulted from dissolution of aquifer minerals by ground water and unsaturated-zone minerals by irrigation water.

Dissolved-oxygen concentrations were significantly greater in ground-water samples from the urban area than in samples from the agricultural area from January through early March 1989 (fig. 9, table 6), although they had not been during July and August 1988 (fig. 8, table 4); however, the urban median concentration (4.4 mg/L) also was greater than the agricultural median concentration (3.5 mg/L) in samples collected during July and August 1988. In general, dissolved-oxygen concentrations were greater in the urban area than in the agricultural land-use area because the mean depth of water over well screens was 4.2 ft greater in the agricultural area, favoring slower reaeration at sampling depths and because more intensive pumpage in the urban area caused greater overturn and consequent reaeration of the water column.

Table 6. Summary of Wilcoxon-Mann-Whitney rank-sum tests comparing physical properties of water and constituent concentrations in samples collected from basic-network wells in the urban land-use area with those properties and concentrations from the agricultural land-use area, January through early March 1989

[Tests were made with a two-tailed significance level of 0.10 and a null hypothesis (H_0) defined as no significant difference between distributions of values or concentrations in samples from urban and agricultural land-use areas and an alternative hypothesis (H_1) defined as a significant difference between values or concentrations; ft, feet; *N*, total number of samples for given land use; *p*-value, significance level; U, urban land-use area; >, greater than; A, agricultural land-use area; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; <, less than; mg/L, milligrams per liter; µg/L, micrograms per liter]

Test variable	Unit	Urban		Agricultural		Test result	Test *p*-value
		Median	*N*	Median	*N*		
Depth to water	ft	32.1	21	10.8	20	H_1: U>A	0.001
Specific conductance	µS/cm	964	21	1,645	20	H_1: A>U	<.001
pH	Standard units	7.09	21	7.17	20	H_1: A>U	.025
Temperature	°C	12.0	21	11.0	20	H_0	.206
Dissolved oxygen	mg/L	5.0	21	3.5	20	H_1: U>A	.055
Alkalinity	mg/L as $CaCO_3$	223	21	252	20	H_1: A>U	.039
Dissolved solids, sum of constituents	mg/L	648	21	1,232	20	H_1: A>U	<.001
Calcium	mg/L as Ca	100	21	155	20	H_1: A>U	<.001
Magnesium	mg/L as Mg	28	21	44	20	H_1: A>U	<.001
Sodium	mg/L as Na	61	21	170	20	H_1: A>U	<.001
Potassium	mg/L as K	3.4	21	4.1	20	H_0	.564
Sulfate	mg/L as SO_4	210	21	595	20	H_1: A>U	<.001
Chloride	mg/L as Cl	36	21	56	20	H_1: A>U	<.001
Fluoride	mg/L as F	1.5	21	2.0	20	H_1: A>U	<.001
Silica	mg/L as SiO_2	20	21	16	20	H_1: U>A	<.001
Nitrite plus nitrate	mg/L as N	6.5	21	2.3	20	H_1: U>A	.002
Ammonium	mg/L as N	.02	21	.04	20	H_1: A>U	<.001
Phosphorus	mg/L as P	.03	21	.01	20	H_1: U>A	<.001
Barium	µg/L as Ba	61	21	23	20	H_1: U>A	<.001
Boron	µg/L as B	140	21	260	20	H_1: A>U	<.001
Iron	µg/L as Fe	10	21	9	20	H_0	.719
Lithium	µg/L as Li	45	21	65	20	H_1: A>U	<.001
Manganese	µg/L as Mn	2	21	2	20	H_0	.560
Selenium	µg/L as Se	3	21	10	20	H_1: A>U	.002
Strontium	µg/L as Sr	610	21	1,000	20	H_1: A>U	<.001
Zinc	µg/L as Zn	6	21	6	20	H_0	.634
Dissolved organic carbon	mg/L as C	2.0	21	2.0	20	H_0	.929

Specific conductance and concentrations of alkalinity, dissolved solids (fig. 9), major ions (except potassium), fluoride, ammonium (fig. 9), boron, lithium, selenium, and strontium were significantly greater in samples from the agricultural area than from the urban area from January through early March 1989, as was the case during July and August 1988. Concentrations of silica, nitrite plus nitrate (fig. 9), phosphorus (fig. 9), and barium were significantly greater in samples from the urban area than from the agricultural area during January through early March 1989, as was the case during July and August 1988. Temperature and concentrations of potassium (fig. 9), iron (fig. 9), manganese, zinc, and DOC (fig. 9) were not significantly different between land-use areas from January through early March 1989, as was the case during July and August 1988.

The general agreement of the results of hypothesis tests for July and August 1988 and January through early March 1989 indicates that the large-scale hydrologic and geochemical processes that determined these properties and constituents generally changed little between seasons. Land-use and water-use practices vary moderately between summer and winter in the urban land-use area, but vary greatly in the agricultural land-use area. Furthermore, sea-

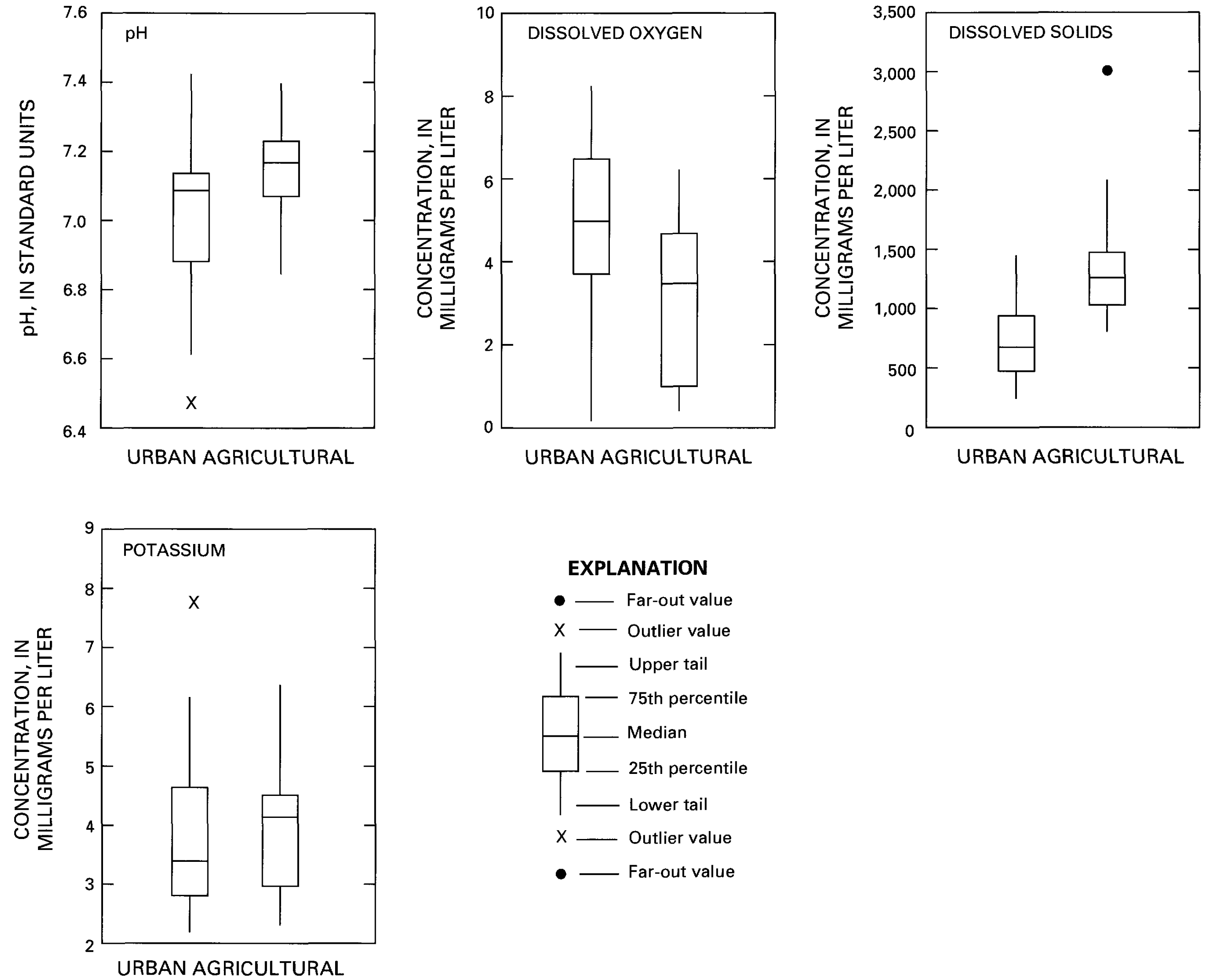


Figure 9. Values of pH and concentrations of selected water-quality constituents for samples collected from basic-network wells in the urban and agricultural land-use areas, January through early March 1989.

sonal differences in processes that may have occurred did not substantially affect ground-water quality because of the short distances (0.5 to 1 mi) that ground water flows downgradient between seasons relative to the length of land-use areas (causing areal interspersing of water recharged to the aquifer during summers and winters) and the semiaridity of the local climate. The small quantities of aquifer recharge from precipitation do not cause a detectable seasonal dilution of water-quality constituents.

Infrequently Detected Trace Elements

The results of contingency-table tests for infrequently detected trace elements in samples collected from basic-network wells from January through early March 1989 are listed in table 7. During this period, the probabilities of detecting cadmium, mercury, and molybdenum were not significantly different between land-use areas. Arsenic, cadmium, lead, molybdenum, and silver decreased in the number of detections in samples collected from the agricultural area from January through early March 1989 compared with July and August 1988 (table 5). A decrease in cadmium detections, which had a significantly greater frequency in samples from the agricultural area than from the urban area during July and August 1988, caused a null-hypothesis conclusion for samples collected from January through early March 1989. Silver, which was not significantly different in the number of detections between land-use areas during July and August 1988, had a significantly greater detection frequency in samples from the urban area than from the agricultural area from January

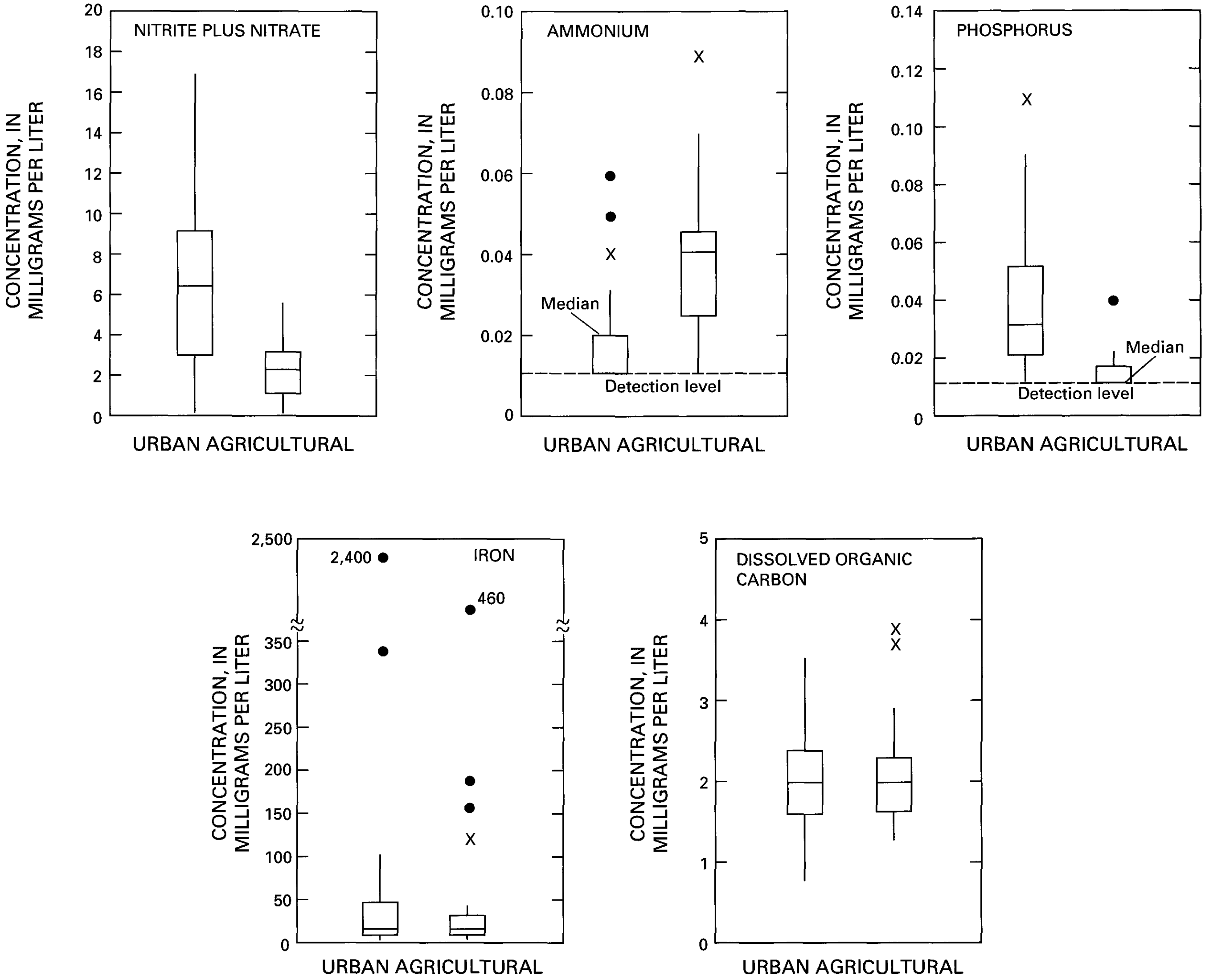


Figure 9. Values of pH and concentrations of selected water-quality constituents for samples collected from basic-network wells in the urban and agricultural land-use areas, January through early March 1989—Continued.

through early March 1989. A decrease in lead detections in samples from the agricultural area from January through early March 1989 as compared with July and August 1988 (table 5) prevented statistical testing, although lead was detected with a significantly greater frequency in samples from the agricultural area than from the urban area during July and August 1988. A decrease in arsenic detections in samples from both land-use areas from January through early March 1989 also prevented statistical testing. Decreases in detection frequencies of cadmium, lead, and silver in samples from the agricultural area from January through early March 1989 compared to July and August 1988 seem to indicate that evaporative concentration of irrigation water and flushing of the soil and unsaturated zone were important summer processes that temporarily increased concentrations of these metals in ground water. Following summer, dilution by deeper ground water and geochemical processes, such as sorption and precipitation, probably decreased concentrations of these elements. As during July and August 1988, mercury was not significantly associated with ground water beneath either land-use area from January through early March 1989 because of the strong interaction of this metal with sediment.

Volatile Organic Compounds

The results of contingency-table tests for VOC's detected in samples collected from basic-network wells from January through early March 1989 (table 7) are very similar to the results for those samples collected during July and August 1988 (table 5). Chloroform; dichlorobromomethane; tetrachloroethylene; toluene; 1,1,1-trichloroethane; and trichloroethylene were detected with a significantly greater frequency in samples from the urban

Table 7. Summary of contingency-table tests comparing detection frequencies of infrequently detected trace elements and volatile organic compounds in samples collected from basic-network wells in the urban land-use area with those detection frequencies from the agricultural land-use area, January through early March 1989

[Tests were made with a two-tailed significance level of 0.10 and a null hypothesis (H_0) defined as no significant difference in probability of detecting variable in samples from urban and agricultural land-use areas and an alternative hypothesis (H_1) defined as a significant difference between probability of detection; µg/L, micrograms per liter; *N*, total number of samples (in parentheses) for given land use; U, urban land-use area; >, greater than; *p*-value, significance level; A, agricultural land-use area; <, less than; VOC's, volatile organic compounds]

Test variable	Detection level (µg/L)	Number of urban detections (*N*)		Number of agricultural detections (*N*)		Test results	Test *p*-value
			Trace elements				
Cadmium	1	1	(21)	2	(20)	H_0	0.520
Mercury	.1	1	(20)	3	(18)	H_0	.242
Molybdenum	10	3	(21)	3	(20)	H_0	.948
Silver	1	9	(21)	0	(20)	H_1: U>A	<.001
			Volatile organic compounds				
Benzene	.2	3	(21)	1	(20)	H_0	.316
Chloroform	.2	14	(21)	2	(20)	H_1: U>A	<.001
Dichlorobromomethane	.2	4	(21)	0	(20)	H_1: U>A	.040
Tetrachloroethylene	.2	10	(21)	0	(20)	H_1: U>A	<.001
Toluene	.2	3	(21)	0	(20)	H_1: U>A	.080
1,1,1-Trichloroethane	.2	4	(21)	0	(20)	H_1: U>A	.040
Trichloroethylene	.2	3	(21)	0	(20)	H_1: U>A	.080
Combined VOC's[1]	.2	9	(21)	1	(20)	H_1: U>A	.005
Combined chlorinated ethanes and ethylenes[1]	.2	3	(21)	0	(20)	H_1: U>A	.080

[1] One or more detections at a well counted as only one detection; compounds that were detected in urban surface-water samples were excluded.

area than from the agricultural area during January through early March 1989. All of these compounds (except toluene and trichloroethylene, which were not tested) showed the same results for July and August 1988. Toluene was not tested for samples collected during July and August 1988 because of blank contamination. Trichloroethylene had too few detections to test. Benzene was not detected with a significantly different frequency between land-use areas during either sampling period.

In addition, combined VOC's and combined chlorinated ethanes and ethylenes were detected with a significantly greater frequency in samples from the urban area than from the agricultural area during January through early March 1989. In July and August 1988, combined VOC's were not detected with a significantly greater frequency in samples from the urban area than from the agricultural area, although they were detected more than twice as frequently in the urban area (p-value equals 0.125). During July and August 1988, combined chlorinated ethanes and ethylenes had too few detections to test. The increased significance for the test for combined VOC's in samples collected during January through early March 1989 largely resulted from a decline in the number of detections of VOC's in samples from the agricultural area during that period. This decline probably was the result of dispersal of VOC's in the agricultural area during winter months when agricultural land use was minimal.

Toluene was detected with a significantly greater frequency in samples collected from January through early March 1989 from the urban area than from the agricultural area (table 7). Toluene is used as a reagent to manufacture chemicals (especially benzene), as a paint solvent, and as a gasoline additive (Moore and Ramamoorthy, 1984a, p. 45). Toluene was detected at concentrations near the detection level in samples from Fountain Creek at site SW2 (table 18). The generally greater concentrations of toluene in ground water in the urban area than at site SW2 and the substantial distances between Fountain Creek and wells where toluene was detected indicate land-use sources of that compound. Trichloroethylene occasionally is used as a dry-cleaning agent, but its main use is as a metal degreaser. Production of this chemical gradually has slowed since 1970 (Moore and Ramamoorthy, 1984a, p. 17–19), and nonindustrial quantities are difficult to purchase. The absence of detectable trichloroethylene in all urban-reach samples from Fountain Creek indicates that the presence of trichloroethylene in ground water results from land-use practices. Detections of chloroform and tetrachloroethylene in samples from the urban area during January through early March 1989 (as during July and August 1988) cannot confidently be attributed to land-use sources because of the possibility that these compounds entered the aquifer by recharge of sewage-contaminated water from Fountain Creek or Canal No. 4. As discussed in the "Differences in Quality of Ground Water Beneath Urban and Agricultural Land-Use Areas, July and August 1988" section, these compounds have common uses in urban areas and, therefore, probably entered the alluvial aquifer in response to land-use practices and surface-water recharge. Detections of dichlorobromomethane; 1,1,1-trichloroethane; combined VOC's; and combined chlorinated ethanes and ethylenes in samples collected from January through early March 1989 are attributed to land-use practices because of the absence of detectable concentrations of these compounds in urban-reach samples from Fountain Creek (except for 1,1,1-trichloroethylane at site SW1 during the summer storm).

Seasonal Differences in Quality of Ground Water Beneath the Urban Land-Use Area, July and August 1988 and January Through Early March 1989

A comparison of paired data collected from basic-network wells in the urban land-use area during July and August 1988 and January through early March 1989 was accomplished by the use of Wilcoxon signed-ranks tests and contingency-table tests. Wilcoxon signed-ranks tests were used to compare values of onsite measurements and concentrations of major constituents, nutrients, frequently detected trace elements, and DOC. Contingency-table tests were used to compare detection frequencies of infrequently detected trace elements and VOC's. Because well U07 could not be resampled from January through early March 1989, data collected during July and August 1988 for that well were not used in these comparisons.

Onsite Measurements, Major Constituents, Nutrients, Frequently Detected Trace Elements, and Dissolved Organic Carbon

Table 8 lists the results of Wilcoxon signed-ranks (matched-pair) tests comparing values of onsite measurements and concentrations of major constituents, nutrients, frequently detected trace elements, and DOC in samples collected from basic-network wells in the urban land-use area during July and August 1988 to onsite measurements and concentrations in samples collected from January through early March 1989. Boxplots of matched-pair differences in values of selected onsite measurements and concentrations of selected water-quality constituents are shown in figure 10. Few significant changes in water quality occurred between the two periods. Depth to water (water level) and concentrations of fluoride and selenium were significantly greater during July and August 1988 than from January through early March 1989 (fig. 10). Potassium concentrations were significantly greater during winter (fig. 10). The smaller depths to water during the winter indicate recovery of water levels in the alluvial aquifer in the urban area in response to a postsummer decrease in withdrawal rates. The slightly greater concentrations of fluoride and selenium during the summer are difficult to understand given that concentrations of most major ions and commonly detected trace elements were similar in samples collected during both seasons. These trends possibly resulted from soil leaching by recharge from summer rainfall and lawn watering. Edelmann and Cain (1985, p. 22) reported that most recharge to the alluvial aquifer from land-surface sources occurs during April through September. The significantly greater potassium concentrations during the winter indicate the effects of plant decay and dormancy. Hem (1985, p. 104) stated that potassium ions are released from decaying plant material during the dormant season and are available for leaching to ground water. Most potassium released from the decay of plant material during summer is assimilated by active plants, whereas potassium released during the winter is not. Although local seasonal variations in water quality were detected in the urban area, the similarity of the water chemistry between seasons resulted, in general, from (1) the short distances (0.5 to 1 mi) that ground water flowed between seasons relative to the length of the land-use area, causing water recharged from surface-water sources during summers and winters to be areally interspersed in the urban land-use area; (2) inadequate quantities of seasonal recharge from precipitation and lawn irrigation to significantly affect the general water quality of either season; and (3) the small saturated thickness and large ground-water withdrawals, both of which were conducive to mixing of water that may have reflected seasonal differences.

Infrequently Detected Trace Elements

Table 9 lists the results of contingency-table tests comparing detection frequencies of infrequently detected trace elements in samples collected from basic-network wells in the urban land-use area during July and August 1988 to detection frequencies for samples collected from January through early March 1989. Arsenic, lead, mercury, molybdenum, and silver were detected frequently enough to test, but none of these trace elements were detected with a significantly different frequency between July and August 1988 and January through early March 1989. These similar detection frequencies support the conclusion that water recharging during summer and winter was areally interspersed and mixed in the aquifer and indicate that geochemical processes that control the mobility of these trace elements were not strongly affected by seasonal fluctuations.

Table 8. Summary of Wilcoxon signed-ranks (matched-pair) tests comparing physical properties of water and constituent concentrations in samples collected from basic-network wells in the urban land-use area during July and August 1988 with those properties and concentrations during January through early March 1989

[Tests were made with a two-tailed significance level of 0.10 and a null hypothesis (H_0) defined as no significant difference between distributions of values or concentrations in samples collected during July and August 1988 and from January through early March 1989, and an alternative hypothesis (H_1) defined as a significant difference between distributions of values or concentrations; summer 1988 results for well U07 were not used in tests because this well was not sampled during winter 1989; N, total number of samples for given period; *p*-value, significance level; ft, feet; S, summer 1988; >, greater than; W, winter 1989; <, less than; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter]

Test variable	Unit	Summer		Winter		Test result	Test *p*-value
		Median	*N*	Median	*N*		
Depth to water	ft	32.3	21	32.1	21	H_1: S>W	<0.001
Specific conductance	µS/cm	895	21	964	21	H_0	.920
pH	Standard units	7.07	21	7.09	21	H_0	.578
Dissolved oxygen	mg/L	4.6	21	5.0	21	H_0	.614
Alkalinity	mg/L as $CaCO_3$	215	21	223	21	H_0	.687
Dissolved solids, sum of constituents	mg/L	582	21	648	21	H_0	.907
Calcium	mg/L as Ca	92	21	100	21	H_0	.973
Magnesium	mg/L as Mg	23	21	28	21	H_0	.638
Sodium	mg/L as Na	61	21	61	21	H_0	.406
Potassium	mg/L as K	3.0	21	3.4	21	H_1: W>S	.009
Sulfate	mg/L as SO_4	180	21	210	21	H_0	.906
Chloride	mg/L as Cl	36	21	36	21	H_0	.867
Fluoride	mg/L as F	1.6	21	1.5	21	H_1: S>W	.003
Silica	mg/L as SiO_2	19	21	20	21	H_0	.153
Nitrite plus nitrate	mg/L as N	6.5	21	6.5	21	H_0	.801
Ammonium	mg/L as N	<.01	21	.02	21	H_0	.800
Phosphorus	mg/L as P	.03	21	.03	21	H_0	.693
Barium	µg/L as Ba	56	21	61	21	H_0	.332
Boron	µg/L as B	140	21	140	21	H_0	.812
Iron	µg/L as Fe	9	21	10	21	H_0	.626
Lithium	µg/L as Li	43	21	45	21	H_0	.369
Manganese	µg/L as Mn	3	21	2	21	H_0	.316
Selenium	µg/L as Se	3	21	3	21	H_1: S>W	.003
Strontium	µg/L as Sr	570	21	610	21	H_0	.342
Zinc	µg/L as Zn	7	21	6	21	H_0	.814
Dissolved organic carbon	mg/L as C	2.2	21	2.0	21	H_0	.193

Volatile Organic Compounds

The results of contingency-table tests comparing VOC detection frequencies in samples collected from basic-network wells in the urban land-use area during July and August 1988 to VOC detection frequencies in samples collected from January through early March 1989 are listed in table 9. Neither individual VOC's, combined VOC's, nor combined chlorinated ethanes and ethylenes were detected with a significantly different frequency between samples collected during July and August 1988 and from January through early March 1989. These results indicate that short-term differences between winter and summer in quantities of VOC's infiltrating into the aquifer underlying the urban area generally were not significant. Furthermore, short-term seasonal fluctuations in environmental conditions, notably temperature, did not significantly affect the concentrations of VOC's present.

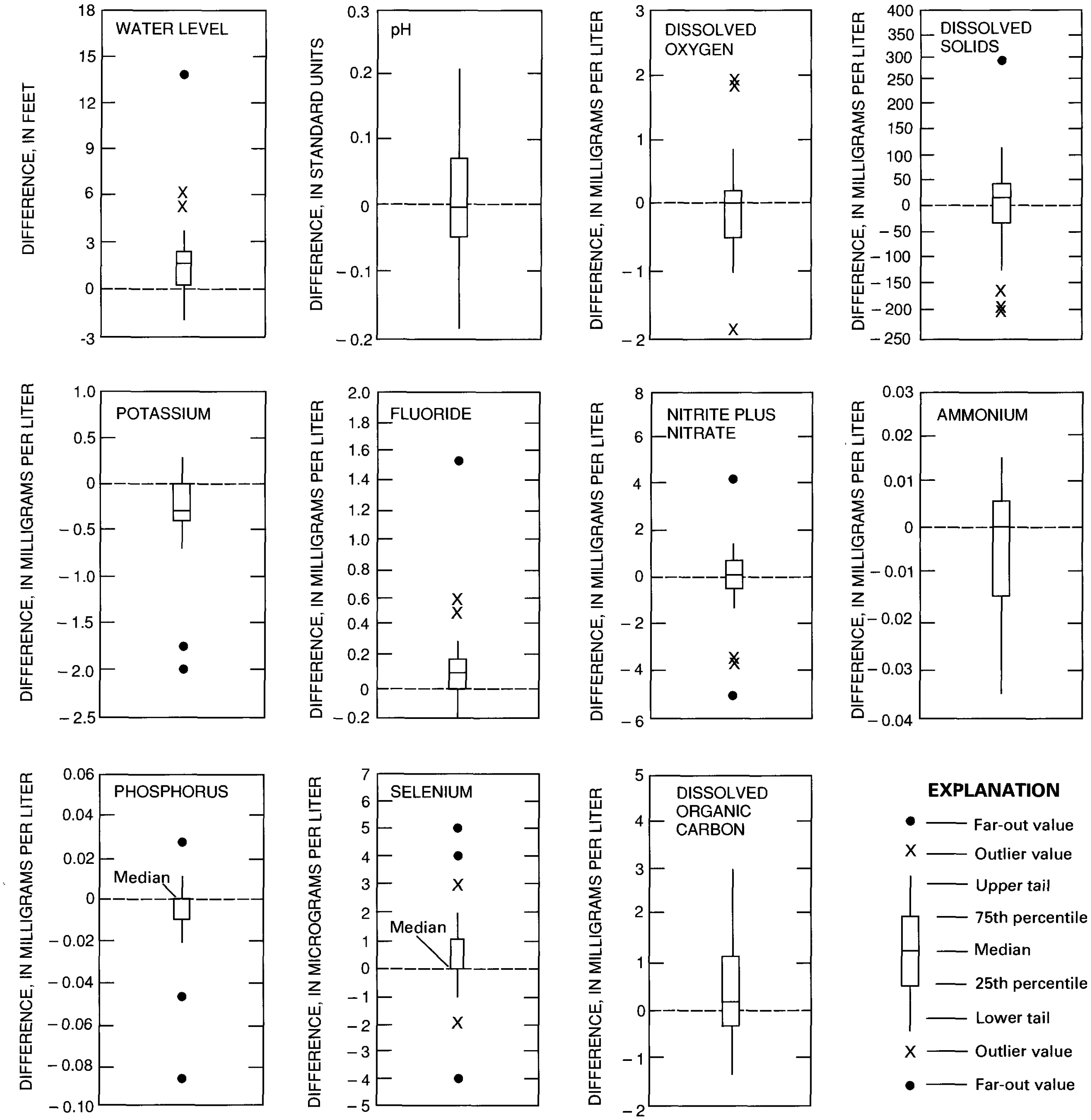


Figure 10. Matched-pair differences in values of selected onsite measurements and concentrations of selected water-quality constituents between samples collected from basic-network wells in the urban land-use area during July and August 1988 and January through early March 1989. Dashed line indicates zero difference, positive values indicate greater values during July and August 1988, and negative values indicate smaller values from January through early March 1989.

Seasonal Differences in Quality of Ground Water Beneath the Agricultural Land-Use Area, July and August 1988 and January Through Early March 1989

A comparison of paired data collected from basic-network wells in the agricultural land-use area during July and August 1988 and from January through early March 1989 was accomplished by the use of the same tests used to compare July and August 1988 with January through early March 1989 data collected from basic-network wells in the urban area. Wilcoxon signed-ranks tests were used to compare values of onsite measurements and concentrations of major constituents, nutrients, frequently detected trace elements, and DOC. Contingency-table tests were used to compare seasonal detection frequencies of infrequently detected trace elements and VOC's.

Table 9. Summary of contingency-table tests comparing detection frequencies of infrequently detected trace elements and volatile organic compounds in samples collected from basic-network wells in the urban land-use area during July and August 1988 with those detection frequencies during January through early March 1989

[Tests were made with a two-tailed significance level of 0.10 and a null hypothesis (H_0) defined as no significant difference in probability of detecting variable in samples collected during summer and winter and an alternative hypothesis (H_1) defined as a significant difference between probability of detection; summer 1988 results for well U07 were not used in tests because this well was not sampled during winter 1989; μg/L, micrograms per liter; *N*, total number of samples (in parentheses) for given season; *p*-value, significance level; VOC's, volatile organic compounds]

Test variable	Detection level (μg/L)	Number of summer 1988 detections (*N*)		Number of winter 1989 detections (*N*)		Test results	Test *p*-value
		Trace elements					
Arsenic	1	2	(21)	1	(21)	H_0	0.548
Lead	10	1	(21)	2	(21)	H_0	.548
Mercury	.1	2	(20)	1	(20)	H_0	.695
Molybdenum	10	2	(21)	3	(21)	H_0	.634
Silver	1	7	(21)	9	(21)	H_0	.526
		Volatile organic compounds					
Benzene	.2	2	(21)	3	(21)	H_0	.632
Chlorodibromomethane	.2	1	(21)	2	(21)	H_0	.552
Chloroform	.2	11	(21)	14	(21)	H_0	.342
Dichlorobromomethane	.2	4	(21)	4	(21)	H_0	1.000
1,1-Dichloroethane	.2	1	(21)	2	(21)	H_0	.552
Tetrachloroethylene	.2	6	(21)	10	(21)	H_0	.204
1,1,1-Trichloroethane	.2	4	(21)	4	(21)	H_0	1.000
Trichloroethylene	.2	1	(21)	3	(21)	H_0	.294
Combined VOC's[1]	.2	8	(21)	9	(21)	H_0	.754
Combined chlorinated ethanes and ethylenes[1]	.2	2	(21)	3	(21)	H_0	.634

[1] One or more detections at a well counted as only one detection; compounds that were detected in urban surface-water samples were excluded.

Onsite Measurements, Major Constituents, Nutrients, Frequently Detected Trace Elements, and Dissolved Organic Carbon

Table 10 lists the results of Wilcoxon signed-ranks (matched-pair) tests comparing values of onsite measurements and concentrations of major constituents, nutrients, frequently detected trace elements, and DOC in samples collected from basic-network wells in the agricultural land-use area during July and August 1988 to onsite measurements and concentrations from samples collected from January through early March 1989. Boxplots of matched-pair differences in values of selected onsite measurements and concentrations of selected water-quality constituents are shown in figure 11. Depths to water (water level in fig. 11), most major constituents (for example, dissolved solids in fig. 11), and concentrations of frequently detected trace elements did not change significantly between seasons (table 10). Values for pH and potassium concentrations were significantly greater in samples collected from January through early March 1989 (fig. 11). Concentrations of fluoride, phosphorus, and DOC (fig. 11) were significantly greater in samples collected during July and August 1988. The slightly greater pH values during winter probably resulted from the smaller concentrations of DOC; more DOC oxidizes during the summer and produces a greater partial pressure of carbon dioxide gas, a condition that decreases pH values. The greater DOC concentrations during the summer resulted from irrigation with sewage-contaminated water from Fountain Creek and leaching of decaying plant material in the soil horizon. The smaller summer concentrations for potassium probably indicate plant uptake during the summer growing season and release during the winter dormant period, as was described for the urban area.

The significantly greater concentrations of fluoride in samples collected from the agricultural area during July and August 1988 than from January through early March 1989 are problematic. As previously discussed, fluoride concentrations were significantly greater in samples from the agricultural area than in samples from the urban area during July and August 1988 and from January through early March 1989, probably because of evaporative concentration

Table 10. Summary of Wilcoxon signed-ranks (matched-pair) tests comparing physical properties of water and constituent concentrations in samples collected from basic-network wells in the agricultural land-use area during July and August 1988 with those properties and concentrations during January through early March 1989

[Tests were made with a two-tailed significance level of 0.10 and a null hypothesis (H_0) defined as no significant difference between distributions of values or concentrations in samples collected during July and August 1988 and from January through early March 1989, and an alternative hypothesis (H_1) defined as a significant difference between distributions of values or concentrations; summer 1988 results for well U07 were not used in tests because this well was not sampled during winter 1989; *N*, total number of samples for given period; *p*-value, significance level; ft, feet; S, summer 1988; >, greater than; W, winter 1989; <, less than; μS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; μg/L, micrograms per liter]

Test variable	Unit	Summer		Winter		Test result	Test *p*-value
		Median	*N*	Median	*N*		
Depth to water	ft	10.8	20	10.8	20	H_0	0.886
Specific conductance	μS/cm	1,505	20	1,645	20	H_0	.665
pH	Standard units	7.11	20	7.17	20	H_1: W>S	.040
Dissolved oxygen	mg/L	3.5	20	3.5	20	H_0	.943
Alkalinity	mg/L as $CaCO_3$	259	20	252	20	H_0	.900
Dissolved solids, sum of constituents	mg/L	1,152	20	1,232	20	H_0	.227
Calcium	mg/L as Ca	150	20	155	20	H_0	.728
Magnesium	mg/L as Mg	44	20	44	20	H_0	.423
Sodium	mg/L as Na	160	20	170	20	H_0	.913
Potassium	mg/L as K	3.9	20	4.1	20	H_1: W>S	.029
Sulfate	mg/L as SO_4	560	20	595	20	H_0	.814
Chloride	mg/L as Cl	56	20	56	20	H_0	.334
Fluoride	mg/L as F	2.3	20	2.0	20	H_1: S>W	.083
Silica	mg/L as SiO_2	16	20	16	20	H_0	.828
Nitrite plus nitrate	mg/L as N	2.2	20	2.3	20	H_0	.692
Ammonium	mg/L as N	.03	20	.04	20	H_0	.704
Phosphorus	mg/L as P	.02	20	.01	20	H_1: S>W	.025
Barium	μg/L as Ba	22	20	23	20	H_0	.480
Boron	μg/L as B	250	20	260	20	H_0	.771
Iron	μg/L as Fe	12	20	9	20	H_0	.563
Lithium	μg/L as Li	64	20	65	20	H_0	.651
Manganese	μg/L as Mn	2	20	2	20	H_0	.732
Selenium	μg/L as Se	11	20	10	20	H_0	.352
Strontium	μg/L as Sr	990	20	1,000	20	H_0	.248
Zinc	μg/L as Zn	7	20	6	20	H_0	.705
Dissolved organic carbon	mg/L as C	2.4	20	2.0	20	H_1: S>W	.015

in the agricultural area during the summer. The significantly smaller concentrations of fluoride from January through early March 1989 may result from postsummer precipitation of fluorite (CaF_2), which was supersaturated during summer irrigation in water from some wells, according to WATEQ4F calculations. This hypothesis is supported by the fact that four of the eight decreases in fluoride concentration from January through early March 1989 occurred in samples from wells where fluorite was oversaturated during July and August 1988, but became less oversaturated or slightly undersaturated from January through early March 1989, according to the calculations. At another well (A20), the smaller fluoride concentration from January through early March 1989 resulted from the arrival of water with a considerably greater concentration of calcium. The infusion caused greater supersaturation of fluorite.

In ground water beneath the agricultural area, phosphorus concentrations were significantly greater during July and August 1988 than from January through early March 1989 (table 10, fig. 9). The major cause for this trend was irrigation during summer with Fountain Creek water that had 50 to 100 times as much phosphorus as did ground water. After the irrigation season, phosphorus concentrations were decreased by mixing with alluvial water that was unaffected by irrigation and by sorption by iron and manganese oxyhydroxides, a process described by Hem (1985,

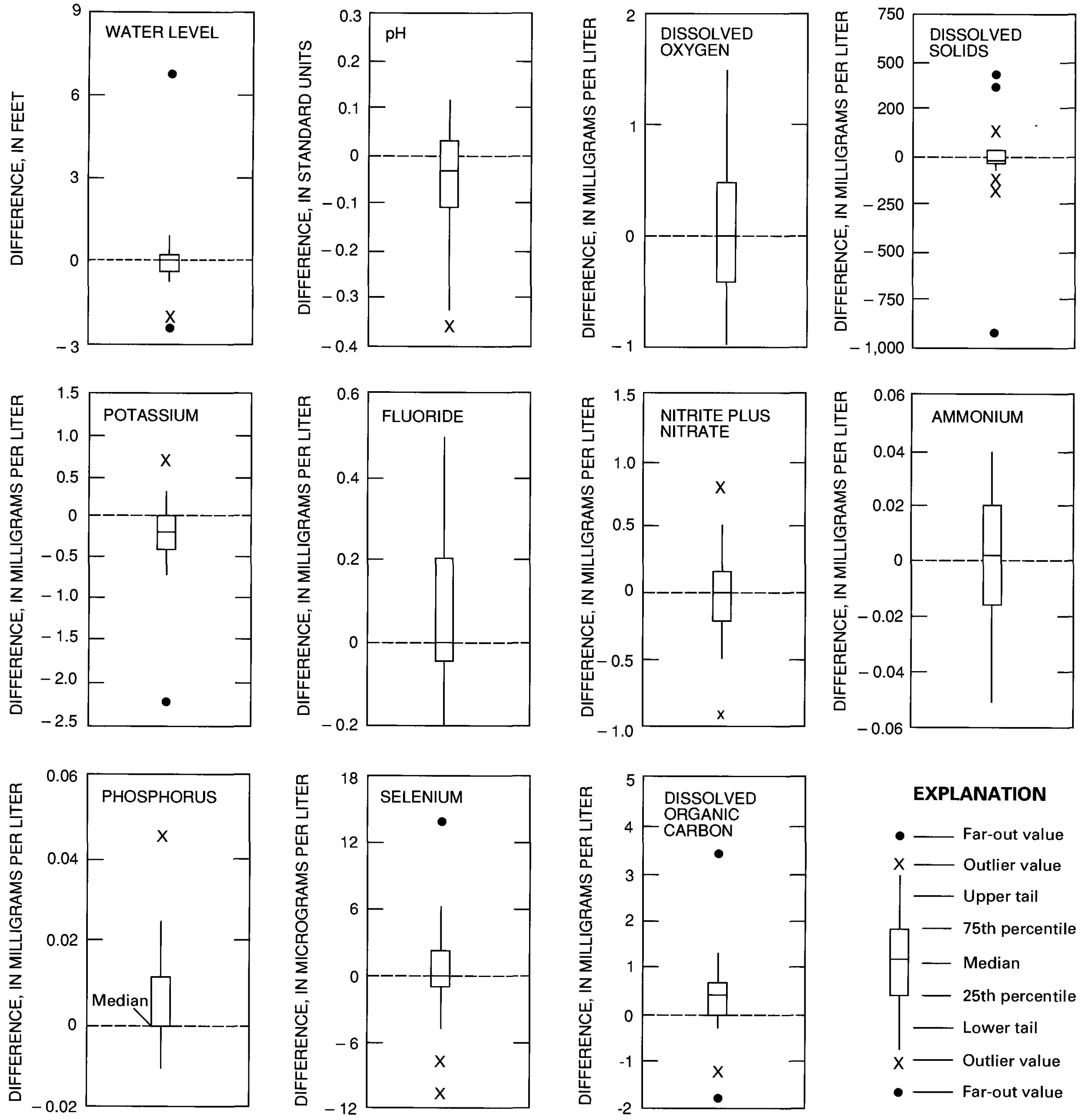


Figure 11. Matched-pair differences in values of selected onsite measurements and concentrations of selected water-quality constituents between samples collected from basic-network wells in the agricultural land-use area during July and August 1988 and January through early March 1989. Dashed line indicates zero difference, positive values indicate greater values during July and August 1988, and negative values indicate greater values from January through early March 1989.

p. 128). During the growing season, plant uptake removed some phosphorus from irrigation water, but not enough to prevent significantly greater concentrations in the ground water during July and August 1988.

The similarity of concentrations of most water-quality constituents listed in table 10 during July and August 1988 and January through early March 1989 indicates that most of the effects of land and water use on water quality during the summer in the agricultural area were not removed by geochemical or hydrologic processes during fall and winter. This continuity exists probably because of the minor quantities of recharge water that flowed into the aquifer during the nongrowing season and because the chemical stratification of ground water that resulted from evaporative concentration during the summer (described in "Differences in Quality of Ground Water from Shallow and Deep Matched-Pair

Wells Completed in the Agricultural Land-Use Area, July and August 1988" section) was not eliminated by the mixing effects of either ground-water withdrawals or downgradient flow between summer and winter. In addition, evaporative concentration during the summer did not cause sufficient supersaturation with respect to minerals consisting of major water-quality constituents to favor precipitation of those constituents following the cessation of irrigation and substantial summer evapotranspiration. For example, although calculations using WATEQ4F indicate that calcite was saturated or slightly supersaturated in much of the ground water of the agricultural area during July and August 1988, the capacity to precipitate calcite was too small to decrease calcium and alkalinity concentrations significantly before January through early March 1989.

Infrequently Detected Trace Elements

Table 11 lists the results of contingency-table tests comparing detection frequencies of infrequently detected trace elements in samples collected from basic-network wells in the agricultural land-use area during July and August 1988 with detection frequencies for samples collected from January through early March 1989. Although arsenic, cadmium, and molybdenum were detected more frequently in samples collected during July and August 1988 than from January through early March 1989 (and those higher concentrations may indicate some evapotranspirative concentration), the detection frequencies were not significantly smaller in samples collected from January through early March 1989, and that stability indicates that hydrologic and geochemical controls for those elements did not change significantly between seasons. Lead and silver, however, had significantly greater detection frequencies in samples collected during July and August 1988. This trend for lead indicates that lead may have been leached from the soil and unsaturated zone by irrigation water during summer and subsequently decreased in concentration by sorption or mineral precipitation following the cessation of irrigation. A similar cycle apparently affected silver concentrations. Mercury was detected with almost equal frequencies in samples collected during both sampling periods, a finding that indicates insignificant seasonal fluctuations in dissolved concentrations, probably because of the strong tendency of this metal to sorb onto sediments.

Volatile Organic Compounds

Table 11 also lists the results of contingency-table tests comparing VOC detection frequencies in samples collected from basic-network wells in the agricultural land-use area during July and August 1988 to VOC detection frequencies in samples collected from January through early March 1989. Neither chloroform nor combined VOC's were detected with a significantly different frequency between seasons. This similarity also was observed in the urban area. This fact and the small number of detections indicate minimal usage of VOC's in the agricultural area throughout the year.

Table 11. Summary of contingency-table tests comparing detection frequencies of infrequently detected trace elements and volatile organic compounds in samples collected from basic-network wells in the agricultural land-use area during July and August 1988 with those detection frequencies during January through early March 1989

[Tests were made with a two-tailed significance level of 0.10 and a null hypothesis (H_0) defined as no significant difference in probability of detecting variable in samples collected during summer and winter and an alternative hypothesis (H_1) defined as a significant difference between probability of detection; μg/L, micrograms per liter; *N*, total number of samples (in parentheses) for given season; *p*-value, significance level; S, summer 1988; >, greater than; W, winter 1989; <, less than; VOC's, volatile organic compounds]

Test variable	Detection level (μg/L)	Number of summer 1988 detections (*N*)		Number of winter 1989 detections (*N*)		Test results	Test *p*-value
			Trace elements				
Arsenic	1	3	(19)	1	(20)	H_0	0.268
Cadmium	1	5	(20)	2	(20)	H_0	.212
Lead	10	5	(20)	0	(20)	H_1: S>W	.016
Mercury	.1	3	(20)	3	(18)	H_0	.888
Molybdenum	10	5	(20)	3	(20)	H_0	.430
Silver	1	9	(20)	0	(20)	H_1: S>W	<.001
			Volatile organic compounds				
Chloroform	.2	1	(20)	2	(20)	H_0	.548
Combined VOC's[1]	.2	3	(20)	2	(20)	H_0	.806

[1] One or more detections at a well counted as only one detection; compounds that were detected in agricultural surface-water samples were excluded.

Differences in Quality of Ground Water from Shallow and Deep Matched-Pair Wells Completed in the Urban Land-Use Area, July and August 1988

A comparison of data collected from shallow and deep matched-pair wells in the urban land-use area during July and August 1988 was accomplished by using Wilcoxon signed-ranks tests and contingency-table tests. Wilcoxon signed-ranks tests were used to compare values of onsite measurements and concentrations of major constituents, nutrients, frequently detected trace elements, and DOC. Contingency-table tests were used to compare detection frequencies of infrequently detected trace elements and VOC's.

Onsite Measurements, Major Constituents, Nutrients, Frequently Detected Trace Elements, and Dissolved Organic Carbon

Table 12 lists the results of Wilcoxon signed-ranks tests comparing values of onsite measurements and concentrations of major constituents, nutrients, frequently detected trace elements, and DOC in samples collected from shallow and deep matched-pair wells in the urban land-use area during July and August 1988. Boxplots of matched-pair differences in concentrations of selected water-quality constituents are shown in figure 12. Of the measurements and constituents listed in table 12, only temperature and concentrations of dissolved oxygen, fluoride, and DOC were significantly different in samples between well sets,

Table 12. Summary of Wilcoxon signed-ranks (matched-pair) tests comparing physical properties of water and constituent concentrations in samples collected from depth-paired shallow wells in the urban land-use area with those properties and concentrations from depth-paired deep wells, July and August 1988

[Tests were made with a two-tailed significance level of 0.10 and a null hypothesis (H_0) defined as no significant difference between distributions of values or concentrations in samples from shallow and deep wells and an alternative hypothesis (H_1) defined as a significant difference between distributions of values or concentrations; *N*, total number of samples for given well type; *p*-value, significance level; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; S, shallow matched-pair wells; >, greater than; D, deep matched-pair wells; <, less than; mg/L, milligrams per liter; µg/L, micrograms per liter]

Test variable	Unit	Shallow well		Deep well		Test result	Test *p*-value
		Median	*N*	Median	*N*		
Specific conductance	µS/cm	758	10	735	10	H_0	0.814
pH	Standard units	7.07	10	7.09	10	H_0	.309
Temperature	°C	14.8	10	13.3	10	H_1: S>D	<.001
Dissolved oxygen	mg/L	5.0	10	1.6	10	H_1: S>D	.007
Alkalinity	mg/L as $CaCO_3$	169	10	156	10	H_0	.415
Dissolved solids, sum of constituents	mg/L	470	10	478	10	H_0	.474
Calcium	mg/L as Ca	80	10	69	10	H_0	.536
Magnesium	mg/L as Mg	20	10	20	10	H_0	.636
Sodium	mg/L as Na	52	10	55	10	H_0	.414
Potassium	mg/L as K	2.8	10	3.6	10	H_0	.925
Sulfate	mg/L as SO_4	135	10	145	10	H_0	.670
Chloride	mg/L as Cl	31	10	31	10	H_0	.341
Fluoride	mg/L as F	1.3	10	1.1	10	H_1: S>D	.050
Silica	mg/L as SiO_2	21	10	22	10	H_0	.242
Nitrite plus nitrate	mg/L as N	6.5	9	6.7	9	H_0	.871
Ammonium	mg/L as N	<.01	9	.01	9	H_0	.956
Phosphorus	mg/L as P	.03	10	.03	10	H_0	.776
Barium	µg/L as Ba	57	10	70	10	H_0	.218
Boron	µg/L as B	105	10	100	10	H_0	.253
Iron	µg/L as Fe	10	10	9	10	H_0	.740
Lithium	µg/L as Li	35	10	38	10	H_0	.668
Manganese	µg/L as Mn	3	10	2	10	H_0	.669
Selenium	µg/L as Se	3	10	3	10	H_0	.211
Strontium	µg/L as Sr	405	10	430	10	H_0	.536
Zinc	µg/L as Zn	7	10	5	10	H_0	.386
Dissolved organic carbon	mg/L as C	2.0	10	1.7	10	H_1: S>D	.070

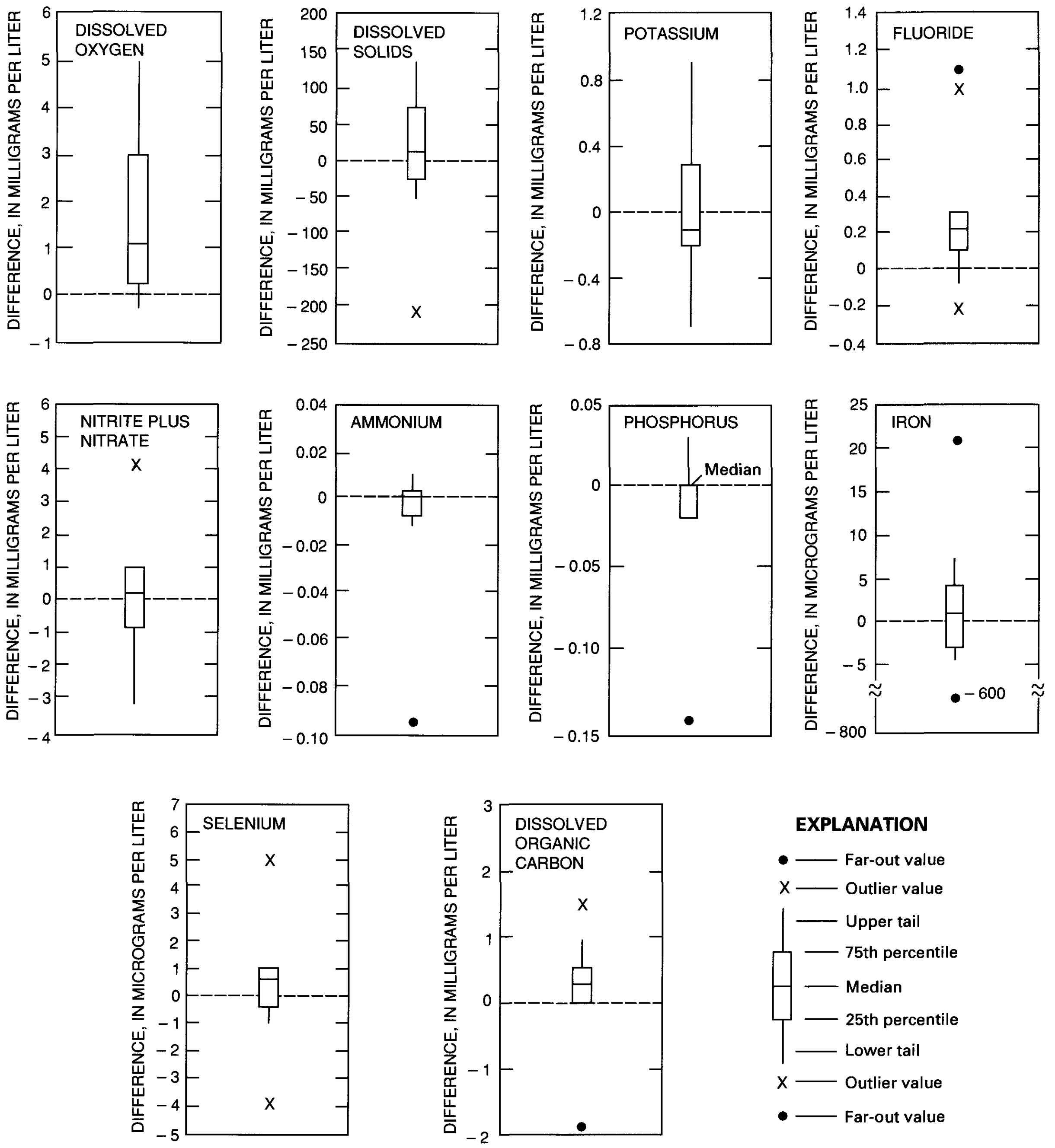


Figure 12. Differences in concentrations of selected water-quality constituents between samples collected from matched-pair shallow and deep wells in the urban land-use area, July and August 1988. Dashed line indicates zero difference, positive values indicate greater values in shallow wells, and negative values indicate greater values in deeper wells.

and they were greater in samples from shallow wells than from deep wells (boxplots, except for temperature, are shown in fig. 12). Values of temperature and concentrations of dissolved oxygen were significantly greater in samples from shallow wells than in samples from deep wells because the water had more contact with the warmer soil atmosphere. The significantly greater concentrations of fluoride in samples from shallow wells than in samples from deep wells probably was the result of soil leaching by summer recharge from summer rainfall and lawn irrigation and fluorapatite [$Ca_5(PO_4)_3F$] precipitation in some of the deeper ground water. WATEQ4F calculations indicate that five samples from deep matched-pair wells were saturated or supersaturated with respect to this mineral, as opposed to only one sample from shallow matched-pair wells. The significantly greater DOC concentrations in samples from shallow wells than in samples from deep wells probably were caused by leaching of decaying organic matter on the land surface and in the soil zone by (1) precipitation and lawn watering during summer and (2) dilution by mixing and removal by oxidation following summer. The general lack of depth-related trends with major water-quality constituents in the urban land-use area indicates that stratification did not develop. Hydrologic stresses associated with ground-water pumpage and tributary inflows probably prevented land-use practices or infiltration of precipitation from causing major stratification effects. Some processes, however—such as those accounting for vertical differences for temperature, dissolved oxygen, fluoride, and DOC—are rapid enough, in general, to cause vertical differences in the water column.

Infrequently Detected Trace Elements

The results of contingency-table tests comparing detection frequencies of infrequently detected trace elements between samples collected from shallow and deep matched-pair wells in the urban land-use area during July and August 1988 are listed in table 13. Only arsenic, molybdenum, and silver were detected frequently enough to test, and none of these elements were detected with a significantly different frequency between well sets. These relations indicate that possible contributions of these elements by infiltration from the land surface were obscured by relatively rapid vertical mixing of the ground water beneath the urban area.

Volatile Organic Compounds

The results of contingency-table tests comparing VOC detection frequencies between samples collected from shallow and deep matched-pair wells in the urban land-use area during July and August 1988 are listed in table 13. Only chloroform and tetrachloroethylene were detected frequently enough to enable testing, and neither compound was detected with a significantly different frequency between well sets. Chloroform was detected in five shallow wells and five deep wells, a finding that supports the conclusion that most of this compound in the alluvial aquifer probably originated from recharge of sewage effluent from Fountain Creek and Canal No. 4. Relatively large concentrations ensured an equal detection probability in deep-well samples because of relatively thorough mixing by hydrologic stresses. Tetrachloroethylene, however, was detected more frequently (with a *p*-value of 0.122) in shallow wells. Thus, tetrachloroethylene, although detected in all surface-water samples at site SW2 (table 18), also infiltrated into ground water in the urban land-use area as a result of land-use practices. The rate of infiltration was sufficient to preserve evidence of stratification despite hydrologic mixing. Combined VOC's that were not detected in samples from Fountain Creek were not detected with a significantly different frequency between well sets. That similarity indicates that infiltration from land-use sources was obscured by hydrologic mixing in the urban area.

Table 13. Summary of contingency-table tests comparing detection frequencies of infrequently detected trace elements and volatile organic compounds in samples collected from depth-paired shallow wells in the urban land-use area with those detection frequencies for depth-paired deep wells, July and August 1988

[Tests were made with a two-tailed significance level of 0.10 and a null hypothesis (H_0) defined as no significant difference in probability of detecting variable in samples from shallow and deep wells and an alternative hypothesis (H_1) defined as a significant difference between probability of detection; µg/L, micrograms per liter; *N*, total number of samples (in parentheses) for given well type; *p*-value, significance level; VOC's, volatile organic compounds]

Test variable	Detection level (µg/L)	Number of shallow-well detections	(*N*)	Number of deep-well detections	(*N*)	Test results	Test *p*-value
		Trace elements					
Arsenic	1	2	(10)	2	(10)	H_0	1.000
Molybdenum	10	1	(10)	2	(10)	H_0	.530
Silver	1	4	(10)	7	(10)	H_0	.178
		Volatile organic compounds					
Chloroform	.2	5	(10)	5	(10)	H_0	1.000
Tetrachloroethylene	.2	4	(10)	1	(10)	H_0	.122
Combined VOC's[1]	.2	1	(10)	3	(10)	H_0	.125

[1] One or more detections at a well counted as only one detection; compounds that were detected in urban surface-water samples were excluded.

Differences in Quality of Ground Water from Shallow and Deep Matched-Pair Wells Completed in the Agricultural Land-Use Area, July and August 1988

A comparison of the data collected from shallow and deep matched-pair wells in the agricultural land-use area during July and August 1988 was accomplished by using the same tests used to compare the data collected from shallow and deep matched-pair wells in the urban land-use area. Wilcoxon signed-ranks tests were used to compare values of onsite measurements and concentrations of major constituents, nutrients, frequently detected trace elements, and DOC. Contingency-table tests were used to compare detection frequencies of infrequently detected trace elements and VOC's.

Onsite Measurements, Major Constituents, Nutrients, Frequently Detected Trace Elements, and Dissolved Organic Carbon

Table 14 lists the results of Wilcoxon signed-ranks tests comparing values of onsite measurements and concentrations of major constituents, nutrients, frequently detected trace elements, and DOC in samples collected from shallow and deep matched-pair wells in the agricultural land-use area during July and August 1988. Boxplots of matched-pair differences in concentrations of selected water-quality constituents are shown in figure 13. Most water-quality constituents had concentrations that were significantly greater in samples from shallow wells than in samples from deep wells. That difference indicates that ground water in the agricultural land-use area generally was stratified with respect to water quality. Mean values of pH and temperature, however, were not significantly different between well types.

Mean values for shallow-well samples were significantly greater than mean values for deep-well samples from the agricultural land-use area by the indicated percentages for the following measurements or constituents: specific conductance (5.5), dissolved oxygen (100), alkalinity (7.3), dissolved solids (7.8), calcium (5.9), magnesium (7.5), sodium (9.6), sulfate (6.1), chloride (17), silica (2.5), phosphorus (23), lithium (5.1), selenium (50), strontium (14), and DOC (14). The enrichment of these constituents in shallow-well samples primarily resulted from evapotranspiration of irrigation water diverted from Fountain Creek or pumped from the aquifer. The salt load of this water was increased by evaporation at the land surface and by plant uptake of water from the unsaturated zone and water table.

The large relative enrichment of selenium in samples from shallow matched-pair wells (50 percent) compared with most of the constituents listed above indicates that concentration by evapotranspiration was not the only mechanism causing selenium concentrations. Leaching of selenium from the soil probably was the main cause of selenium enrichment in the shallow ground water. Fujii and Deverel (1989) concluded that soil leaching can contribute substantial quantities of selenium to ground water in the San Joaquin Valley of California.

Phosphorus and DOC had significantly greater concentrations in samples from shallow matched-pair wells than from deep matched-pair wells in the agricultural area table 14, fig. 13). The significantly greater concentrations of phosphorus and DOC in samples from shallow matched-pair wells probably resulted from direct recharge from Fountain Creek and from irrigation with water diverted from Fountain Creek, which had relatively large concentrations of these constituents. Additional DOC probably was leached from decaying plants in the soil horizon.

Mean concentration of nitrite plus nitrate (table 14, fig. 13) was significantly greater (by 28 percent) in samples from deep wells than in samples from shallow wells. Mean concentrations of nitrite plus nitrate in Fountain Creek in the agricultural reach exceeded the mean concentration in shallow wells. This relation supports the conclusion that plant uptake of nitrate from irrigation water and from the water table probably depleted nitrite and nitrate in the shallower ground water during summer. Deeper water in the aquifer retained greater nitrite-plus-nitrate concentrations acquired by downgradient ground-water flow from the urban area and recharged by seepage from Fountain Creek, especially between summers.

Ammonium concentrations (table 14, fig. 13) were not significantly greater in samples from shallow wells than in samples from deep wells, although Fountain Creek water diverted for irrigation was enriched in ammonium. This lack of statistical significance was caused by plant uptake, sorption into the soil and aquifer materials, and oxidation of ammonium to nitrate with subsequent plant uptake.

Boron had a greater mean concentration in shallow wells than in deep wells (*p*-value equals 0.102 in table 14), which indicates evaporative concentration of that element. Boron forms boron salts in closed-basin deposits in California (Hem, 1985, p. 129). Small quantities of this element are needed for plant growth, and that natural use probably caused a smaller degree of concentration in shallow-well samples (4.2 percent) than most of the constituents listed above. Further evidence of evaporative concentration of boron is indicated by the moderately strong correlation of boron with specific conductance (correlation coefficient, R^2=0.795) for samples collected from the basic-network wells in the agricultural area during July and August 1988.

Concentrations of potassium (fig. 13), fluoride (fig. 13), barium, iron (fig. 13), manganese, and zinc were not significantly different between shallow and deep wells in the agricultural area (table 14). Potassium is probably the least conservative of dissolved major ions because of the tendency of that ion to be incorporated into solid weathering products (especially clays) and plants (Hem, 1985, p. 104).

Table 14. Summary of Wilcoxon signed-ranks (matched-pair) tests comparing values of onsite measurements and concentrations of major constituents, nutrients, frequently detected trace elements, and dissolved organic carbon in samples collected from depth-paired shallow wells in the agricultural land-use area with those properties and concentrations from depth-paired deep wells, July and August 1988

[Tests were made with a two-tailed significance level of 0.10 and a null hypothesis (H_0) defined as no significant difference between distributions of values or concentrations in samples from shallow and deep wells and an alternative hypothesis (H_1) defined as a significant difference between distributions of values or concentrations; *N*, total number of samples for given well type; *p*-value, significance level; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; S, shallow matched-pair wells; >, greater than; D, deep matched-pair wells; mg/L, milligrams per liter; µg/L, micrograms per liter]

Test variable	Unit	Shallow well		Deep well		Test result	Test *p*-value
		Median	*N*	Median	*N*		
Specific conductance	µS/cm	1,495	10	1,430	10	H_1: S>D	0.012
pH	Standard units	7.14	10	7.19	10	H_0	.360
Temperature	°C	13.5	10	12.7	10	H_0	.179
Dissolved oxygen	mg/L	3.3	10	1.0	10	H_1: S>D	.053
Alkalinity	mg/L as $CaCO_3$	253	10	235	10	H_1: S>D	.004
Dissolved solids, sum of constituents	mg/L	1,087	10	1,023	10	H_1: S>D	.018
Calcium	mg/L as Ca	145	10	135	10	H_1: S>D	.013
Magnesium	mg/L as Mg	42	10	39	10	H_1: S>D	.011
Sodium	mg/L as Na	150	10	130	10	H_1: S>D	.023
Potassium	mg/L as K	3.8	10	3.7	10	H_0	.963
Sulfate	mg/L as SO_4	520	10	490	10	H_1: S>D	.045
Chloride	mg/L as Cl	53	10	48	10	H_1: S>D	.004
Fluoride	mg/L as F	2.5	10	2.2	10	H_0	.354
Silica	mg/L as SiO_2	16	10	15	10	H_1: S>D	.028
Nitrite plus nitrate	mg/L as N	1.6	10	2.5	10	H_1: D>S	.027
Ammonium	mg/L as N	.03	10	.03	10	H_0	.144
Phosphorus	mg/L as P	.02	10	.01	10	H_1: S>D	<.001
Barium	µg/L as Ba	23	10	21	10	H_0	.146
Boron	µg/L as B	245	10	240	10	H_0	.102
Iron	µg/L as Fe	10	10	8	10	H_0	.634
Lithium	µg/L as Li	61	10	58	10	H_1: S>D	.004
Manganese	µg/L as Mn	1	10	1	10	H_0	.280
Selenium	µg/L as Se	11	10	8	10	H_1: S>D	.052
Strontium	µg/L as Sr	990	10	930	10	H_1: S>D	.038
Zinc	µg/L as Zn	6	10	3	10	H_0	.473
Dissolved organic carbon	mg/L as C	2.4	10	2.1	10	H_1: S>D	.032

These processes probably countered whatever increase in concentration that potassium may have undergone by evaporative concentration during irrigation. The lack of fluoride stratification probably was because (1) fluoride concentrations in irrigation water from Fountain Creek were smaller than in ground water in the agricultural area, and evaporative concentration of fluoride generally did not increase concentrations in the shallow ground water to values exceeding those in deep ground water; and (2) fluoride concentrations in samples from several shallow and deep wells were limited by the solubility of the mineral fluorite (CaF_2). WATEQ4F calculations indicate that samples from 4 of the 10 shallow wells yielded water saturated or supersaturated with fluorite, whereas only 2 of 10 samples from deep wells did so. Barium concentrations were constrained by precipitation of barite ($BaSO_4$) in the agricultural area. That constraint prevented substantial buildup of barium in recharging irrigation water. Calculations with WATEQ4F indicate that all of the samples of both well types were supersaturated with respect to this mineral, but that most of

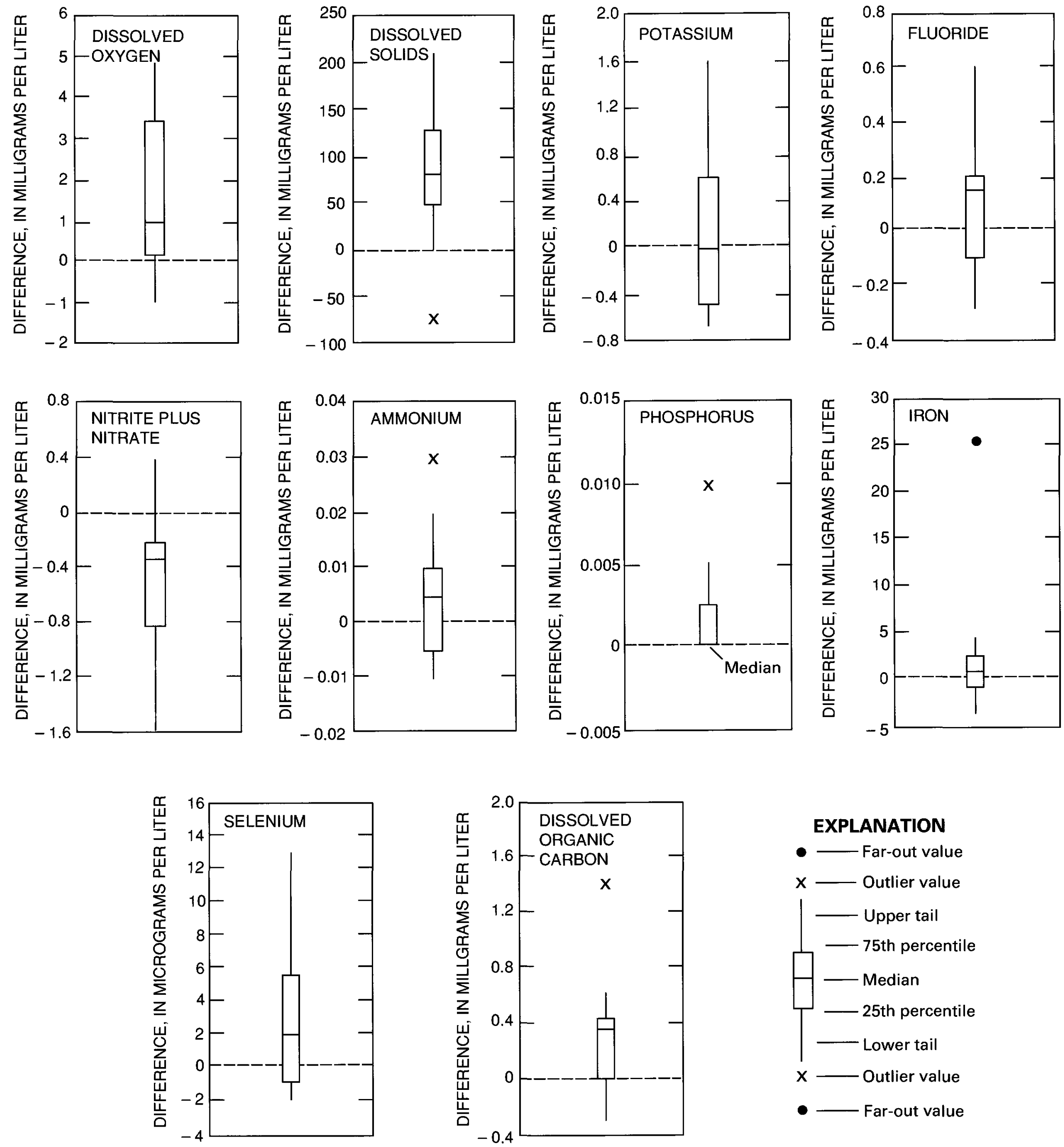


Figure 13. Differences in concentrations of selected water-quality constituents between samples collected from matched-pair shallow and deep wells in the agricultural land-use area, July and August 1988. Dashed line indicates zero difference, positive values indicate greater values in shallow wells, and negative values indicate greater values in deeper wells.

the samples from shallow wells were more supersaturated than samples from matching deep wells. Greater concentrations of sulfate in shallower ground water decreased barium concentrations by precipitation of barite. Precipitation of oxyhydroxides and sorption onto sediments accounted for similar distributions of iron, manganese, and zinc concentrations between shallow and deep sample sets.

Infrequently Detected Trace Elements

The results of contingency-table tests comparing detection frequencies of infrequently detected trace elements between samples collected from shallow and deep matched-pair wells in the agricultural land-use area during July and August 1988 are listed in table 15. Of the trace elements detected frequently enough to enable testing, only

Table 15. Summary of contingency-table tests comparing detection frequencies of infrequently detected trace elements and volatile organic compounds in samples collected from depth-paired shallow wells in the agricultural land-use area with those detection frequencies for depth-paired deep wells, July and August 1988

[Tests were made with a two-tailed significance level of 0.10 and a null hypothesis (H_0) defined as no significant difference in probability of detecting variable in samples from shallow and deep wells and an alternative hypothesis (H_1) defined as a significant difference between probability of detection; µg/L, micrograms per liter; *N*, total number of samples (in parentheses) for given well type; *p*-value, significance level; S, shallow matched-pair wells; >, greater than; D, deep matched-pair wells; VOC's, volatile organic compounds]

Test variable	Detection level (µg/L)	Number of shallow-well detections (*N*)	Number of deep-well detections (*N*)	Test results	Test *p*-value
		Trace elements			
Arsenic	1	3 (10)	0 (10)	H_1: S>D	0.060
Molybdenum	10	4 (10)	1 (10)	H_0	.122
Silver	1	4 (10)	5 (10)	H_0	.654
		Volatile organic compounds			
Chloroform	.2	1 (10)	2 (10)	H_0	.532
Combined VOC's[1]	.2	2 (10)	3 (10)	H_0	.606

[1] One or more detections at a well counted as only one detection; none of these compounds were detected at agricultural surface-water sites.

arsenic was detected with a significantly greater frequency in samples from shallow wells than in samples from deep wells, whereas molybdenum and silver were not detected with significantly different frequencies between well sets.

A significantly greater detection frequency of arsenic in samples from shallow wells may indicate a slight enrichment by evapotranspiration. As previously discussed, a significant difference between detection frequencies of arsenic in ground water beneath the urban and agricultural areas did not occur during July and August 1988. Therefore, urban sources of arsenic probably offset this enrichment in the agricultural area. Adsorption by hydrous iron oxides probably hindered the downgradient movement of arsenic into the agricultural area, thereby preventing significantly greater detection frequencies there.

Molybdenum was detected in samples from four shallow wells and one deep well (tables 15 and 17). The *p*-value of the test (0.122) was not significant, however. During July and August 1988, molybdenum was not detected with a significantly different frequency between land-use areas (*p*-value equals 0.166 in table 5), although agricultural land-use concentrations generally were greater. Molybdenum concentrations, although small, probably were increased by land-use and water-use practices in the agricultural area even though tests indicate no significant differences. Accumulation of molybdenum in vegetation (Hem, 1985, p. 140) probably accounts for the weakness of the trend.

The similar frequencies of silver detections in samples from shallow and deep wells in the agricultural area seem to contradict the significantly greater detection frequency in samples collected during July and August 1988 than in samples collected from January through early March 1989 (table 11). The latter result was interpreted to indicate evaporative concentration, complexing, and leaching of silver by irrigation practices. These processes are conducive to greater silver concentrations in shallower ground water. The similar frequency of silver detections in samples from deeper ground water probably resulted from weathering of the Pierre Shale, which is within 1.5 to 2.5 ft of the slotted intervals of the deeper wells. Levinson (1980, p. 881) stated that shales are relatively enriched in silver.

Volatile Organic Compounds

The results of contingency-table tests comparing VOC detection frequencies between samples collected from shallow and deep matched-pair wells in the agricultural land-use area during July and August 1988 are listed in table 15. Neither chloroform nor combined VOC's were detected with a significantly different frequency between well sets. VOC's were not stratified in the aquifer beneath this land-use area because of limited land-use applications and the absence of VOC's in Fountain Creek water diverted for irrigation and recharged by seepage from the stream channel.

SUMMARY

The Toxic-Waste—Ground-Water Contamination Program of the U.S. Geological Survey was begun in 1984 to assess the effects of nonpoint and point sources on the quality of ground water in a variety of hydrologic settings. The Fountain Creek alluvial aquifer in east-central Colorado was selected for study because (1) it is a stream-aquifer system that could provide insights into chemical changes in ground water caused by surface-water recharge that contains sewage effluent; (2) water withdrawals from the aquifer are large locally and supply water for urban and agricultural needs; and (3) the stream-aquifer system is located in a semiarid setting where small area recharge from precipitation, large evapotranspiration, and irrigation practices can cause changes in ground-water quality that do not occur in a humid climate.

The northern one-third of the study area is predominately urban, consisting of mostly residential, but also commercial, industrial, and transportation areas. The southern two-thirds of the study area is mostly agricultural (irrigated land and rangeland), but includes about 30 percent undeveloped land.

Ground water was sampled to provide water-quality data for statistical comparisons between land-use areas, seasons, and relative depth in the water column. Ground water was sampled during July and August 1988 when ground-water withdrawals and surface-water diversions were at a seasonal maximum and from January through early March 1989 when water usage was at a seasonal minimum. To assess the possibility that the chemical composition of ground water was affected primarily by direct recharge of streamflow rather than by infiltration of runoff from a specific land-use area, Fountain Creek was sampled at five sites during three hydrologically distinct periods (summer 1988 storm runoff, summer 1988 low flow, and winter 1989 moderate stable flow).

Statistical hypothesis tests were used to test for significant differences in values of onsite measurements, concentrations of constituents, and detection frequencies of trace elements and VOC's between ground-water sample sets defined by land-use area, sampling season, or relative depth in the water column. All tests were nonparametric and were conducted with a two-tailed significance of 0.10.

The study was designed around the statistical assumption of random sample collection. Wells were randomly located in separate urban and agricultural land-use areas. A basic well network consisting of 22 wells in the urban area and 20 wells in the agricultural area was emplaced. In addition, at 10 sites in each land-use area, 10 depth-paired deep wells were installed as close as possible to bedrock (shale) and adjacent to basic-network (shallow) wells that had screens installed in the upper few feet of the water column.

Wilcoxon-Mann-Whitney rank-sum tests (with a two-tailed significance of 0.10) on data for samples collected from basic-network wells during July and August 1988 indicate many significant differences in water quality between the urban and agricultural land-use areas. Specific conductance was significantly greater in samples from the agricultural area, whereas pH, temperature, and dissolved-oxygen concentrations were not significantly different between areas. Alkalinity, dissolved solids, major ions (except potassium), fluoride, boron, lithium, selenium, and strontium had significantly greater concentrations in samples from the agricultural area. These differences largely resulted from evaporative concentration of irrigation water and the inflow of more mineralized ground water into the agricultural area from tributary alluvium. Chemical-speciation calculations indicate that supersaturation of common minerals did not limit concentrations of major ions in the agricultural area sufficiently to (1) cause insignificant differences in constituent concentrations (null hypotheses) or (2) result in significantly greater concentrations in the urban area.

Nitrite plus nitrate was significantly more concentrated in ground water beneath the urban area than in ground water beneath the agricultural area during July and August 1988, partly because of sewage-effluent recharge from Fountain Creek. Much of the nitrite plus nitrate in ground water originated from ammonium in sewage effluent, which was oxidized within short distances after seeping into the aquifer. Lawn and garden fertilizing probably contributed nitrite and nitrate to the ground water beneath the urban area. The downgradient decrease in concentrations of nitrite plus nitrate in ground water at Fountain and beneath the agricultural area probably was the result of plant uptake.

Ammonium concentrations were significantly greater in ground-water samples from the agricultural area than from the urban area during July and August 1988 because of organic-matter decomposition and infiltration of ammonium-enriched irrigation water. Phosphorus concentrations were significantly greater in ground water beneath the urban area during July and August 1988 because of sewage-effluent recharge. Plant uptake from recharge water and sorption onto mineral surfaces resulted in decreased phosphorus concentrations of 0.05 mg/L or less in ground water beneath the agricultural area.

Iron, manganese, and zinc concentrations were not significantly different between land-use areas during July and August 1988. Solubility controls prevented significantly greater concentrations of iron in ground water beneath the urban area where land-use sources of iron greatly exceeded sources in the agricultural land-use area. Solubility or sorption prevented potential recharge of Fountain Creek water having greater manganese and zinc concentrations in urban reaches from causing significant concentration differences between land-use areas.

Contingency-table tests (with a two-tailed significance of 0.10) indicate that arsenic, mercury, molybdenum, and silver were not detected with significantly different frequencies between urban and agricultural areas during July and August 1988. Lead was detected with a significantly greater frequency in the agricultural area despite the expectation that it would be distributed more abundantly on the land surface of the urban area because of air-pollution fallout, spillage or leakage of leaded gasoline, and leaching of various lead-containing materials. The more frequent occurrence of lead in ground water beneath the agricultural area probably was caused by evaporative concentration of, and leaching from, the soil by irrigation water.

Contingency-table tests were made for five VOC's that were detected in samples collected from basic-network wells during July and August 1988. Benzene was not detected with a significantly different frequency between land-use areas. Chloroform; dichlorobromomethane; tetrachloroethylene; and 1,1,1-trichloroethane were detected with significantly greater frequencies in samples from the urban area than from the agricultural area. Chloroform and tetrachloroethylene probably originated from surface-water recharge and urban land use. The compound 1,1,1-trichloroethane was detected with significantly greater frequencies in the urban area because of industrial uses.

The significantly greater VOC detection frequencies in ground water beneath the urban area resulted from greater urban land-use sources and removal of VOC's from ground water as it flowed downgradient into the agricultural area. Rapid volatilization from surface water in the urban area prevented movement of VOC's by seepage into ground water beneath the agricultural area.

Wilcoxon-Mann-Whitney rank-sum tests comparing data for sample sets collected from basic-network wells in the urban and agricultural land-use areas from January through early March 1989 indicate few differences when compared with corresponding tests for July and August 1988. The general agreement of these test results for July and August 1988 and January through early March 1989 indicates that large-scale hydrologic and geochemical processes that determined these properties and constituents generally changed little between seasons. Furthermore, seasonal differences in processes that may have occurred did not substantially affect ground-water quality because of the short distances (0.5 to 1 mi) that ground water flows downgradient between seasons relative to the length of land-use areas (causing areal interspersing of water recharged to the aquifer during summers and winters) and the semiaridity of the local climate. Small quantities of aquifer recharge from precipitation do not cause a detectable seasonal dilution of water-quality constituents.

Contingency-table tests indicate that the probabilities of detecting cadmium, mercury, and molybdenum were not significantly different for samples collected from either land-use area from January through early March 1989 and that silver was detected with a significantly greater frequency in the urban area. All of these trace elements, except mercury, were detected less frequently in samples collected from the agricultural area from January through early March 1989 compared with July and August 1988. Smaller detection frequencies for cadmium, lead, and silver in samples from the agricultural area from January through early March 1989 as compared with July and August 1988 seem to indicate that evaporative concentration of and flushing of the soil and unsaturated zone by irrigation water temporarily increased concentrations of these metals in ground water during summer. Following summer, dilution by deeper ground water and geochemical processes, such as sorption and mineral precipitation, probably decreased concentrations of these elements.

The results of contingency-table tests comparing VOC's detected in samples collected from wells in the urban and agricultural areas during January through early March 1989 are very similar to the results for July and August 1988. Toluene; trichloroethylene; dichlorobromomethane; 1,1,1-trichloroethane; combined VOC's; and combined chlorinated ethanes and ethylenes were present in ground water beneath the urban area because of land-use practices. Chloroform and tetrachloroethylene probably entered the aquifer in response to land-use practices and surface-water recharge.

Wilcoxon signed-ranks tests (with a two-tailed significance of 0.10) indicate that few changes in ground-water quality occurred in the urban area between July and August 1988 and January through early March 1989. Depth to water and concentrations of fluoride and selenium were significantly greater during July and August 1988, whereas potassium concentrations were significantly greater from January through early March 1989. The smaller depths to water during the winter indicate alluvial-aquifer water-level recovery in response to a postsummer decrease in withdrawal rates. Contingency-table tests indicate that arsenic, lead, mercury, molybdenum, and silver were not detected with significantly different frequencies in samples from the urban area between July and August 1988 and January through early March 1989. The general similarity of water chemistry in the urban area between seasons resulted from (1) short distances (0.5 to 1 mi) that water flows relative to the length of the land-use area, which causes areal interspersing of ground water recharged during summers and winters; (2) inadequate quantities of recharge from precipitation and lawn watering to affect water quality of either season significantly; and (3) the relatively small saturated thickness and large ground-water withdrawals, both of which favor mixing of water that might have reflected seasonal differences and prevent seasonal stratification of the water column.

Contingency-table tests indicated that neither individual VOC's, combined VOC's, nor combined chlorinated ethanes and ethylenes were detected with significantly different frequencies in samples from the urban area between July and August 1988 and January through early March 1989. These similarities indicate that short-term differences between winter and summer in amounts of VOC's infiltrating into the aquifer were not significant and that seasonal temperature fluctuations did not significantly affect VOC concentrations.

The results of Wilcoxon signed-ranks tests comparing analyses of basic-network samples collected in the agricultural area during July and August 1988 to samples collected from January through early March 1989 indicate few significant differences between the two sampling periods. Depths to water, major water chemistry, and concentrations of frequently detected trace elements did not change significantly between seasons. Values for pH and potassium concentrations were significantly greater in samples collected from January through early March 1989. Concentrations of fluoride, phosphorus, and DOC were significantly greater in samples collected during July and August 1988. The similarity of summer and winter concentrations of most water-quality constituents in samples from the agricultural area indicates that most of the effects of water use and land use on water quality in the agricultural area in the summer were not removed by geochemical or hydrologic processes during the fall and winter months. The continuity between seasons probably existed because of (1) minor quantities of fall and winter recharge to the aquifer (negligible dilution), (2) mixing forces that were insufficient to eliminate chemical stratification resulting from evaporative concentration during summer, and (3) quantitatively unimportant supersaturation during summer with respect to minerals containing major water-quality constituents.

Contingency-table tests indicated no significant differences in detection frequencies of arsenic, cadmium, and molybdenum between samples collected in the agricultural area during July and August 1988 and January through early March 1989. Lead and silver had significantly greater detection frequencies in samples collected during July and August 1988. That increase possibly indicates leaching of these elements from the soil and unsaturated zone by irrigation water during summer and sorption or mineral precipitation after seasonal irrigation ended.

Contingency-table tests indicated that neither chloroform nor combined VOC's were detected with significantly different frequencies between samples collected from the agricultural area during July and August 1988 and January through early March 1989. These relations and the small number of detections indicate minor usage of VOC's in the agricultural area throughout the year.

Wilcoxon signed-ranks tests indicate few significant differences for values of onsite measurements and concentrations of major constituents, nutrients, and frequently detected trace elements between sample sets collected from shallow and deep matched-pair well sets in the urban area during July and August 1988. The only significant differences were that temperature and concentrations of dissolved oxygen, fluoride, and DOC were significantly greater in shallow-well samples. Contingency-table tests indicated that neither arsenic, molybdenum, silver, chloroform, nor tetrachloroethylene was detected with significantly different frequencies between shallow and deep matched-pair wells in the urban area. The general lack of depth-related trends for major water-quality constituents in the urban area indicates that hydrologic stresses associated with ground-water pumpage and tributary inflows prevented major stratification effects that might have occurred from land-use practices or infiltration of precipitation. Some processes, however—such as those accounting for significantly greater concentrations of dissolved oxygen, fluoride, and DOC in shallow-well samples—are rapid enough, in general, to cause steady-state or transient vertical differences in the water column.

Wilcoxon signed-ranks tests indicate that most major and minor water-quality constituents in samples collected from matched-pair wells in the agricultural area during July and August 1988 were significantly more concentrated in samples from shallow wells than in samples from deep wells. Mean values in shallow-well samples were significantly greater than mean values in deep-well samples by the indicated percentages for the following measurements or constituents: specific conductance (5.5); dissolved oxygen (100); alkalinity (7.3); dissolved solids (7.8); calcium (5.9); magnesium (7.5); sodium (9.6); sulfate (6.1); chloride (17); silica (2.5); phosphorus (23); lithium (5.1); selenium (50); strontium (14); and DOC (14). The enrichment of these constituents in the shallow-well samples primarily resulted from evapotranspiration of irrigation water diverted from Fountain Creek or pumped from the aquifer. Mean concentrations of nitrite plus nitrate were significantly greater (by 28 percent) in deep-well samples, probably because of depletion of that constituent from recharging irrigation water and the water table by plant uptake during summer months. Ammonium concentrations were greater in shallow-well samples, but not significantly so, although Fountain Creek water diverted for irrigation was enriched in ammonium. Plant uptake, sorption onto soil and aquifer materials, and nitrification probably prevented a statistically significant result. Concentrations of boron, potassium, fluoride, barium, iron, manganese, and zinc were not significantly different between shallow-well and deep-well samples from the agricultural area.

Contingency-table tests indicate that neither chloroform nor combined VOC's were detected with significantly different frequencies between shallow and deep matched-pair wells in the agricultural area during July and August 1988. VOC's were not stratified in the aquifer beneath this land-use area because of limited land-use applications and the unavailability of VOC's in Fountain Creek water diverted for irrigation and recharged by seepage from the stream channel.

REFERENCES CITED

American Public Health Association, American Water Works Association, and Water Pollution Control Federation, 1980, Standard methods for the examination of water and wastewater (15th ed.): Washington, D.C., 1,134 p.

Ball, J.W., Nordstrom, D.K., and Zachmann, D.W., 1987, WATEQ4F—A personal computer Fortran translation of the geochemical model WATEQ2 with revised data base: U.S. Geological Survey Open-File Report 87–50, 108 p.

Cain, Doug, and Edelmann, Patrick, 1986, A reconnaissance water-quality appraisal of the Fountain Creek alluvial aquifer between Colorado Springs and Pueblo, Colorado, including trace elements and organic constituents: U.S. Geological Survey Water-Resources Investigations Report 86–4085, 45 p.

Cain, Doug, Helsel, D.R., and Ragone, S.E., 1989, Preliminary evaluation of regional ground-water quality in relation to land use: Ground Water, v. 27, no. 2, p. 230–244.

Clark, J.W., Viessman, Warren, Jr., and Hammer, M.J., 1977, Water supply and pollution control (3d ed): New York, Harper and Row, 857 p.

Deverel, S.J., and Fujii, Roger, 1988, Processes affecting the distribution of selenium in shallow ground water of agricultural areas, western San Joaquin Valley, California: Water Resources Research, v. 24, no. 4, p. 516–524.

Dilling, W.L., Tefertiller, N.B., and Kallos, G.J., 1975, Evaporation rates and reactivities of methylene chloride, 1,1,1-trichloroethane, trichloroethylene, tetrachloroethylene, and other chlorinated compounds in dilute aqueous solutions: Environmental Science and Technology, v. 9, no. 9, p. 833–838.

Donahue, R.L., Miller, R.W., and Shickluna, J.C., 1977, Soils—An introduction to soils and plant growth: Englewood Cliffs, N.J., Prentice-Hall, 626 p.

Drever, J.I., 1982, The geochemistry of natural waters: Englewood Cliffs, N.J., Prentice-Hall, 388 p.

Edelmann, Patrick, and Cain, Doug, 1985, Sources of water and nitrogen to the Widefield aquifer, southwestern El Paso County, Colorado: U.S. Geological Survey Water-Resources Investigations Report 85–4162, 81 p.

Edmond, J.M., 1970, High precision determination of titration alkalinity and total carbon dioxide content of sea water: Deep-Sea Research and Oceanographic Abstracts, v. 17, no. 14, p. 737–750.

Fishman, M.J., and Friedman, L.C., eds., 1989, Methods for determination of inorganic substances in water and fluvial sediment: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A1, 545 p.

Freeze, R.A., and Cherry, J.A., 1979, Groundwater: Englewood Cliffs, N.J., Prentice-Hall, 604 p.

Fujii, Roger, and Deverel, S.J., 1989, Mobility and distribution of selenium and salinity in ground water and soil of drained agricultural fields, western San Joaquin Valley of California, *in* Selenium in agriculture and the environment, Symposium, New Orleans, 1986 Proceedings: Madison, Wis., Soil Science Society of America Special Publication 23, p. 195–212.

Helsel, D.R., and Ragone, S.E., 1984, Evaluation of regional ground-water quality in relation to land use—U.S. Geological Survey Toxic-Waste—Ground-Water Contamination Program: U.S. Geological Survey Water-Resources Investigations Report 84-4217, 33 p.

Hem, J.D., 1978, Redox processes at surfaces of manganese oxide and their effects on aqueous metal ions: Chemical Geology, v. 21, no. 3–4, p. 199–218.

———1985, Study and interpretation of the chemical characteristics of natural water (3d ed.): U.S. Geological Survey Water-Supply Paper 2254, 263 p.

Hipel, K.W., 1988, Nonparametric approaches to environmental impact assessment: Water Resources Bulletin, v. 24, no. 3, p. 487–492.

Huang, P.M., and Liaw, W.K., 1978, Adsorption of arsenite by lake sediments: Internationale Revue der Gesamten Hydrobiologie, v. 64, no. 2, p. 263–271.

Iman, R.L., and Conover, W.J., 1983, A modern approach to statistics: New York, Wiley, 497 p.

Jenkins, E.D., 1964, Ground water in Fountain and Jimmy Camp Valleys, El Paso County, Colorado, *with a section on* Computations of drawdowns caused by the pumping of wells in Fountain Valley by R.E. Glover and E.D. Jenkins: U.S. Geological Survey Water-Supply Paper 1583, 66 p.

Klein, J.M., and Bingham, D.L., 1975, Water quality, Fountain and Jimmy Camp Valleys, Colorado, 1973: Denver, Colorado Water Conservation Board Water Resources Circular 26, 27 p.

Larsen, L.S., 1981, Soil survey of El Paso County area, Colorado: U.S. Department of Agriculture, Soil Conservation Service, 212 p.

Larsen, R.J., Wiggins, T.J., Holden, D.L., McCulloch, M.B., and Preator, R.E., 1979, Soil survey of Pueblo area, Colorado—parts of Pueblo and Custer Counties: U.S. Department of Agriculture, Soil Conservation Service, 90 p.

Levinson, A.A., 1980, Introduction to exploration geochemistry (2d ed.): Wilmette, Ill., Applied Publishing, 924 p.

Moore, J.W., and Ramamoorthy, S., 1984a, Heavy metals in natural waters—Applied monitoring and impact assessment: New York, Springer-Verlag, 268 p.

———1984b, Organic chemicals in natural waters—Applied monitoring and impact assessment: New York, Springer-Verlag, 289 p.

National Oceanic and Atmospheric Administration, 1986, Climatological data annual summary, Colorado: Asheville, N.C., National Climatic Data Center, v. 91, no. 13, 28 p.

Otson, Rein, Williams, D.T., Bothwell, P.D., and Quon, T.K., 1981, Comparison of trihalomethane levels and other water quality parameters for three treatment plants on the Ottawa River: Environmental Science and Technology, v. 15, no. 9, p. 1075–1080.

Pierce, M.L., and Moore, C.B., 1980, Adsorption of arsenite on amorphous iron hydroxide from dilute aqueous solution: Environmental Science and Technology, v. 14, no. 2, p. 214–216.

Ragone, S.E., 1984, U.S. Geological Survey Toxic-Waste—Ground-Water Contamination Program—Fiscal year 1983: U.S. Geological Survey Open-File Report 84–474, 80 p.

Smith, J.A., Witkowski, P.J., and Fusillo, T.V., 1988, Manmade organic compounds in the surface water of the United States— A review of current understanding: U.S. Geological Survey Circular 1007, 92 p.

Taylor, O.J., 1975, Artificial-recharge experiments in the alluvial aquifer south of Fountain, El Paso County, Colorado: Denver, Colorado Water Conservation Board Water-Resources Circular 31, 28 p.

Thurman, E.M., 1985, Organic geochemistry of natural waters: Dordrecht, The Netherlands, Martinus Nijhoff/Dr W. Junk Publishers, 497 p.

Verschueren, Karel, 1983, Handbook of environmental data on organic chemicals (2d ed.): New York, Van Nostrand Reinhold, 1,310 p.

Wershaw, R.L., Fishman, M.J., Grabbe, R.R., and Lowe, L.E., eds., 1983, Methods for the determination of organic substances in water and fluvial sediments, Chapter A3 of Book 5, Laboratory Analysis: U.S. Geological Survey Techniques of Water-Resources Investigations Open-File Report 82–1004, 173 p.

Wilson, W.W., 1965, Pumping tests in Colorado: Denver, Colorado Water Conservation Board Ground Water Circular 11, 361 p.

SUPPLEMENTAL DATA

Table 16. Data for Fountain Creek sites and observation wells

[See pl. 1 for locations of wells and sites; all measurements are in feet; all depths are measured from land surface; --, data not applicable]

Site or well number	Station number	Local identifier	Altitude of land surface, in feet above sea level	Total depth of well	Depth to top of sample interval	Depth to bottom of sample interval
SW1	07105500	Fountain Creek at Colorado Springs	--	--	--	--
SW2	07105530	Fountain Creek below Janitell Road	--	--	--	--
SW3	384137104423201	Fountain Creek above Fountain	--	--	--	--
SW4	07106000	Fountain Creek near Fountain	--	--	--	--
SW5	0710630	Fountain Creek near Pinon	--	--	--	--
U01	384856104491601	SC01406619DBC1	5,910	16.8	12.8	15.3
U01D	384856104491602	SC01406619DBC2	5,910	27.3	23.3	25.8
U02	384851104484901	SC01406619DDA1	5,890	19.4	15.4	17.9
U03	384743104474501	SC01406632AAA1	5,870	59.0	55.0	57.5
U04	384728104474201	SC01406632ADA1	5,860	28.0	24.0	26.51
U05	384718104465801	SC01406633DBB1	5,800	16.0	12.0	14.5
U06	384712104471301	SC01406633CAD1	5,825	24.8	20.8	23.3
U07	384652104465101	SC01506604ABA1	5,790	11.7	6.7	9.2
U08	384621104460901	SC01506603CAB2	5,770	16.0	12.0	14.5
U08D	384621104460902	SC01506603CAB3	5,770	28.5	24.5	27.0
U09	384604104451501	SC01506602CCC1	5,775	41.3	37.3	39.8
U09D	384604104451502	SC01506602CCC2	5,775	54.7	50.7	53.2
U10	384540104443801	SC01506611ACD1	5,775	57.2	53.2	55.7
U11	384534104450301	SC01506611BDC2	5,750	55.7	51.7	54.2
U11D	384534104450302	SC01506611BDC3	5,750	68.5	64.5	67.0
U12	384513104445301	SC01506611CDD1	5,730	45.5	41.5	44.0
U12D	384513104445302	SC01506611CDD2	5,730	58.2	54.2	56.7
U13	384439104442101	SC01506614DAA1	5,715	40.5	36.5	39.0
U14	384433104440701	SC01506613CBD1	5,700	47.0	43.0	45.5
U14D	384433104440702	SC01506613CBD2	5,700	73.1	69.1	71.6
U15	384420104432601	SC01506613DDC1	5,700	65.7	61.7	64.2
U16	384404104434101	SC01506624ABC1	5,680	51.5	47.5	50.0
U16D	384404104434102	SC01506624ABC2	5,680	70.4	66.4	68.9
U17	384357104431001	SC01506519BCB1	5,680	35.5	31.5	34.0
U18	384348104432301	SC01506624DAB2	5,660	43.0	39.0	41.5
U19	384339104433501	SC01506624DBD2	5,640	27.4	23.4	25.9
U19D	384339104433502	SC01506624DBD3	5,640	49.2	45.2	47.7
U20	384136104423001	SC01606506ABB1	5,550	16.0	12.0	14.5

Table 16. Data for Fountain Creek sites and observation wells—Continued

Site or well number	Station number	Local identifier	Altitude of land surface, in feet above sea level	Total depth of well	Depth to top of sample interval	Depth to bottom of sample interval
U20D	384136104423002	SC01606506ABB2	5,550	26.4	22.4	24.9
U21	384122104421401	SC01606506ADB1	5,560	38.9	34.9	37.4
U22	384109104421101	SC01606506DAB1	5,550	33.0	29.0	31.5
U22D	384109104421102	SC01606506DAB2	5,550	50.8	46.8	49.3
A01	383453104393901	SC01706510CBC1	5,310	27.3	23.3	25.8
A02	383439104382701	SC01706514BBA1	5,280	27.1	23.1	25.6
A03	383435104380001	SC01706514ABB1	5,280	28.4	24.4	26.9
A04	383400104385501	SC01706515DDB1	5,280	33.5	29.5	32.0
A04D	383400104385502	SC01706515DDB2	5,280	49.0	45.0	47.5
A05	383322104382801	SC01706523CBA1	5,245	21.2	17.2	19.7
A05D	383322104382802	SC01706523CBA2	5,245	40.7	36.6	39.1
A06	383303104374901	SC01706523DDC1	5,235	18.6	14.6	17.1
A06D	383303104374902	SC01706523DDC2	5,235	34.1	30.1	32.6
A07	383301104383201	SC01706523CCC1	5,245	28.7	24.7	27.2
A07D	383301104383202	SC01706523CCC2	5,245	47.9	43.9	46.4
A08	383253104381801	SC01706526BAB1	5,230	45.7	41.7	44.2
A09	383244104375401	SC01706526ABD2	5,280	34.1	30.1	32.6
A10	383159104375701	SC01706535ABA1	5,220	33.5	29.5	32.0
A10D	383159104375702	SC01706535ABA2	5,220	48.7	44.7	47.2
A11	383121104374601	SC01706535DDB1	5,200	28.4	24.6	27.1
A12	383119104370201	SC01706536CDA1	5,170	16.9	12.9	15.4
A12D	383119104370202	SC01706536CDA2	5,170	31.9	27.9	30.4
A13	383052104365901	SC01806501ACC1	5,150	16.0	12.0	14.5
A13D	383052104365902	SC01806501ACC2	5,150	38.5	34.5	37.0
A14	383040104362201	SC01806406CBA1	5,145	18.7	14.7	17.2
A14D	383040104362202	SC01806406CBA2	5,145	30.6	26.6	29.1
A15	383020104365701	SC01806501DCC2	5,140	20.0	16.0	18.5
A15D	383020104365702	SC01806501DCC3	5,140	54.0	50.0	52.5
A16	382954104363001	SC01806512ADD1	5,120	21.0	17.0	19.5
A16D	382954104363002	SC01806512ADD2	5,120	34.8	30.8	33.3
A17	382914104365401	SC01806513ACB1	5,090	21.2	17.2	19.7
A18	382842104361901	SC01806418CCA1	5,075	23.5	19.5	22.0
A19	382724104352901	SC01806430ADA1	5,045	30.7	26.7	29.2
A20	382457104353801	SC01906407ABD1	4,970	38.7	34.7	37.2

Table 17. Onsite measurements and concentrations of major and minor water-quality constituents and trace elements in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989

[ft, feet; μS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; mg/L, milligrams per liter; IT, incremental titration; μg/L, micrograms per liter; <, less than; --, data not available; see pl. 1 for locations of wells and sites]

Site or well number	Date sampled	Time	Water level, depth below land surface (ft)	Specific conductance (μS/cm)	pH (standard units)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Alkalinity, dissolved, onsite, IT (mg/L as $CaCO_3$)	Dissolved solids, sum of constituents (mg/L)
SW1	8-17-88	1425	--	570	8.05	19.0	6.5	131	372
	8-30-88	1000	--	770	8.19	17.0	7.3	162	490
	2-28-89	0945	--	559	8.24	0	10.2	121	338
SW2	8-17-88	1530	--	850	7.75	20.5	5.7	142	536
	8-30-88	1130	--	920	7.69	20.0	5.5	169	584
	2-28-89	1130	--	745	7.76	6.0	3.9	155	460
SW3	8-17-88	2240	--	870	7.37	18.0	5.2	138	568
	8-30-88	2015	--	965	7.54	19.5	4.7	190	643
	2-28-89	1815	--	885	7.97	3.0	8.5	163	533
SW4	8-18-88	0500	--	805	7.55	18.0	5.4	121	533
	8-31-88	0330	--	1,200	8.07	14.5	6.7	188	814
	2-28-89	2330	--	1,030	7.94	0	8.0	172	616
SW5	8-18-88	1515	--	865	7.65	26.0	5.4	134	578
	8-31-88	1800	--	1,240	8.31	21.5	6.3	214	860
	3-01-89	0900	--	1,090	8.22	.5	8.3	182	695
U01	7-18-88	1018	11.4	541	6.43	13.5	.2	90	323
	1-27-89	1355	11.3	441	6.48	10.0	.2	96	249
U01D	7-18-88	1247	12.4	808	6.63	12.0	.2	117	533
U02	7-08-88	0945	5.8	854	6.96	12.5	.6	201	546
	2-23-89	1215	6.5	883	6.87	12.0	.4	195	563
U03	7-21-88	1530	46.5	573	6.54	15.0	5.9	92	366
	2-13-89	0945	44.9	555	6.73	12.0	4.0	96	363
U04	7-15-88	1122	22.2	1,140	6.92	13.5	3.2	274	776
	1-09-89	1325	21.7	1,150	7.05	9.5	4.1	277	797
U05	7-06-88	1330	4.4	830	6.56	11.0	.2	181	530
	3-03-89	0920	3.2	863	6.69	7.5	.5	174	472
U06	8-11-88	0845	16.2	1,350	7.34	13.5	7.4	256	933
	1-23-89	1220	16.7	1,290	7.27	13.0	6.6	254	909
U07	8-09-88	1300	2.6	960	7.15	16.5	.2	210	614

Table 17. Onsite measurements and concentrations of major and minor water-quality constituents and trace elements in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Calcium, dis-solved (mg/L as Ca)	Magne-sium, dis-solved (mg/L as Mg)	Sodium, dis-solved (mg/L as Na)	Potas-sium, dis-solved (mg/L as K)	Bicar-bonate, dis-solved, onsite, IT (mg/L as HCO$_3$)	Sulfate, dis-solved (mg/L as SO$_4$)	Chloride, dis-solved (mg/L as Cl)	Fluoride, dis-solved (mg/L as F)	Silica, dis-solved (mg/L as SiO$_2$)
SW1	8-17-88	60	15	41	4.2	160	130	17	2.0	18
	8-30-88	80	22	55	4.6	197	180	21	1.9	18
	2-28-89	56	12	35	4.0	148	110	21	1.5	17
SW2	8-17-88	55	22	79	6.4	173	230	26	1.3	12
	8-30-88	57	23	97	8.2	206	220	40	1.4	15
	2-28-89	49	15	71	7.2	189	150	40	1.7	14
SW3	8-17-88	61	22	86	6.9	168	240	33	1.5	14
	8-30-88	67	24	99	7.6	232	240	48	1.5	15
	2-28-89	57	18	82	7.0	199	190	46	1.6	14
SW4	8-18-88	58	20	80	6.3	148	230	30	1.7	14
	8-31-88	98	33	120	6.5	229	360	48	1.6	16
	2-28-89	66	22	92	6.6	210	240	49	1.6	14
SW5	8-18-88	68	23	86	6.2	163	250	31	1.7	14
	8-31-88	110	34	130	6.1	261	380	49	2.2	15
	3-01-89	78	25	100	6.4	222	290	51	1.7	14
U01	7-18-88	41	12	47	2.8	110	99	46	3.2	15
	1-27-89	34	9.3	38	2.8	120	68	20	1.6	15
U01D	7-18-88	72	22	60	4.0	143	240	40	2.6	14
U02	7-08-88	88	23	61	6.1	245	180	44	2.2	18
	2-23-89	91	22	61	6.1	238	200	42	2.4	18
U03	7-21-88	53	13	43	5.1	110	120	28	2.8	18
	2-13-89	54	13	43	5.1	120	120	27	2.8	19
U04	7-15-88	120	41	82	1.7	334	290	40	1.6	22
	1-09-89	120	39	88	3.4	338	300	42	1.6	23
U05	7-06-88	90	21	58	4.5	221	170	36	3.0	20
	3-03-89	79	18	54	4.4	212	140	31	3.0	20
U06	8-11-88	120	38	130	2.6	312	440	26	1.5	19
	1-23-89	120	36	120	3.0	310	430	25	1.5	20
U07	8-09-88	98	24	70	6.0	256	230	40	2.7	17

Table 17. Onsite measurements and concentrations of major and minor water-quality constituents and trace elements in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)	Nitrogen, ammonium, dissolved (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Arsenic, dissolved (µg/L as As)	Barium, dissolved (µg/L as Ba)	Boron, dissolved (µg/L as B)	Beryllium, dissolved (µg/L as Be)	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)
SW1	8-17-88	1.5	0.04	0.09	4	44	80	<0.5	<1	<5
	8-30-88	2.4	.02	.07	3	53	110	<.5	2	<5
	2-28-89	1.9	.43	.20	1	41	50	<.5	<1	<5
SW2	8-17-88	2.8	4.9	1.7	2	71	140	<.5	<1	<5
	8-30-88	2.2	9.0	3.9	2	42	210	<.5	2	6
	2-28-89	1.4	9.8	3.5	1	32	160	<.5	<1	<5
SW3	8-17-88	3.9	3.0	1.9	4	43	160	<.5	<1	<5
	8-30-88	5.2	3.1	2.8	3	57	210	<.5	<1	<5
	2-28-89	2.2	7.7	3.0	2	35	170	<.5	<1	<5
SW4	8-18-88	4.3	1.3	2.2	4	65	160	<.5	<1	<5
	8-31-88	4.0	.11	1.5	3	43	220	<.5	<1	<5
	2-28-89	3.0	6.1	2.9	2	35	170	<.5	<1	<5
SW5	8-18-88	4.1	<.01	1.1	4	39	160	<.5	<1	<5
	8-31-88	1.1	.03	.68	4	48	230	<.5	<1	<5
	3-01-89	3.5	3.5	2.0	<1	33	180	<.5	<1	<5
U01	7-18-88	<.10	<.01	<.01	<1	35	50	<.5	<1	<5
	1-27-89	<.10	.02	<.01	<1	33	40	<.5	<1	<5
U01D	7-18-88	<.10	.10	<.01	1	130	70	<.5	<1	<5
U02	7-08-88	.60	<.01	.01	<1	99	170	<.5	<1	<5
	2-23-89	.73	<.01	.01	<1	94	170	<.5	<1	<5
U03	7-21-88	6.3	<.01	.02	<1	46	60	<.5	1	<5
	2-13-89	5.0	<.01	.03	<1	50	70	<.5	<1	<5
U04	7-15-88	2.9	.03	.06	<1	150	130	<.5	<1	<5
	1-09-89	3.0	.03	.06	<1	150	140	<.5	3	<5
U05	7-06-88	4.9	.02	.02	<1	120	80	<.5	<1	<5
	3-03-89	4.2	<.01	.02	<1	120	80	<.5	<1	<5
U06	8-11-88	.57	<.01	.10	<1	56	150	<.5	<1	<5
	1-23-89	.25	.03	.11	<1	56	180	<.5	<1	<5
U07	8-09-88	.11	.01	<.01	1	80	130	<.5	<1	<5

Table 17. Onsite measurements and concentrations of major and minor water-quality constituents and trace elements in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Cobalt, dissolved (µg/L as Co)	Copper, dissolved (µg/L as Cu)	Iron, dissolved (µg/L as Fe)	Lead, dissolved (µg/L as Pb)	Lithium, dissolved (µg/L as Li)	Manganese, dissolved (µg/L as Mn)	Mercury, dissolved (µg/L as Hg)	Molybdenum, dissolved (µg/L as Mo)
SW1	8-17-88	<3	<10	9	<10	36	44	<0.1	<10
	8-30-88	<3	<10	17	<10	50	61	<.1	<10
	2-28-89	<3	<10	18	<10	29	24	<.1	<10
SW2	8-17-88	<3	<10	74	<10	49	120	.2	<10
	8-30-88	<3	<10	48	<10	46	110	<.1	<20
	2-28-89	<3	<10	59	<10	29	95	<.1	<10
SW3	8-17-88	<3	<10	21	<10	47	95	.2	<10
	8-30-88	<3	<10	14	<10	47	230	<.1	10
	2-28-89	<3	<10	43	<10	32	83	<.1	<10
SW4	8-18-88	<3	<10	40	<10	45	35	<.1	<10
	8-31-88	<3	<10	8	<10	54	110	<.1	<10
	2-28-89	<3	<10	86	<10	36	66	<.1	<10
SW5	8-18-88	<3	<10	15	<10	44	4	<.1	<10
	8-31-88	<3	<10	7	<10	56	57	<.1	<10
	3-01-89	<3	<10	39	<10	40	25	.2	10
U01	7-18-88	<3	<10	2,400	<10	36	1,300	<.1	<10
	1-27-89	<3	<10	2,400	<10	32	750	<.1	<10
U01D	7-18-88	3	<10	3,000	10	48	5,500	<.1	<10
U02	7-08-88	<3	<10	93	<10	46	690	<.1	10
	2-23-89	<3	<10	52	<10	46	600	<.1	10
U03	7-21-88	<3	<10	7	10	37	<1	<.1	<10
	2-13-89	<3	<10	100	<10	36	9	<.1	<10
U04	7-15-88	<3	<10	6	<10	48	24	.1	<10
	1-09-89	<3	<10	43	<10	46	13	<.1	<10
U05	7-06-88	<3	<10	5	<10	44	24	<.1	<10
	3-03-89	<3	<10	11	<10	38	16	<.1	<10
U06	8-11-88	<3	<10	11	<10	46	<1	<.1	<10
	1-23-89	<3	<10	10	<10	49	1	<.1	<10
U07	8-09-88	<3	<10	8	<10	45	97	<.1	<10

Table 17. Onsite measurements and concentrations of major and minor water-quality constituents and trace elements in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Nickel, dissolved (µg/L as Ni)	Selenium, dissolved (µg/L as Se)	Silver, dissolved (µg/L as Ag)	Strontium, dissolved (µg/L as Sr)	Vanadium, dissolved (µg/L as V)	Zinc, dissolved (µg/L as Zn)	Carbon, organic, dissolved (mg/L as C)	Methylene blue active substance (mg/L)
SW1	8-17-88	<10	4	<1	410	<6	40	4.7	<0.10
	8-30-88	<10	7	<1	560	<6	5	2.5	<.10
	2-28-89	<10	4	<1	370	<6	<3	2.5	<.10
SW2	8-17-88	20	9	<1	460	<6	31	12	.30
	8-30-88	<10	8	<1	460	<6	47	6.7	.19
	2-28-89	<10	5	<1	360	<6	43	6.1	.35
SW3	8-17-88	<10	7	<1	470	<6	16	6.8	<.10
	8-30-88	<10	4	<1	490	<6	21	4.9	--
	2-28-89	<10	5	<1	420	<6	25	7.0	.14
SW4	8-18-88	<10	6	<1	430	<6	17	5.7	<.10
	8-31-88	<10	6	<1	650	<6	7	3.6	<.10
	2-28-89	<10	5	<1	470	<6	25	5.1	.15
SW5	8-18-88	<10	5	<1	490	<6	8	5.5	<.10
	8-31-88	<10	5	<1	720	<6	<3	2.8	<.10
	3-01-89	<10	5	<1	540	<6	14	3.3	<.10
U01	7-18-88	<10	<1	<1	250	<6	8	1.7	<.10
	1-27-89	<10	<1	2	200	<6	13	2.0	<.10
U01D	7-18-88	<10	<1	<1	450	<6	5	1.7	<.10
U02	7-08-88	<10	1	<1	650	<6	48	2.2	<.10
	2-23-89	<10	<1	2	630	<6	8	2.3	<.10
U03	7-21-88	<10	1	2	280	<6	<3	1.4	<.10
	2-13-89	<10	1	1	290	<6	4	1.5	<.10
U04	7-15-88	<10	5	<1	830	<6	6	2.4	<.10
	1-09-89	<10	4	<1	850	<6	<3	1.7	<.10
U05	7-06-88	<10	3	<1	470	<6	<3	2.2	<.10
	3-03-89	<10	1	<1	440	<6	<3	1.1	<.10
U06	8-11-88	<10	3	<1	740	<6	4	2.3	<.10
	1-23-89	<10	5	1	720	<6	6	1.8	<.10
U07	8-09-88	<10	2	2	520	<6	9	2.8	<.10

Table 17. Onsite measurements and concentrations of major and minor water-quality constituents and trace elements in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Time	Water level, depth below land surface (feet)	Specific conduct-ance (μS/cm)	pH (standard units)	Temper-ature, water (deg C)	Oxygen, dissolved (mg/L)	Alkalinity, dissolved, onsite, IT (mg/L as $CaCO_3$)	Dissolved solids, sum of constituents (mg/L)
U08	7-12-88	1301	7.1	995	7.01	15.5	2.0	183	772
	1-23-89	0950	6.2	1,040	7.04	11.5	1.5	198	729
U08D	7-12-88	0930	7.1	937	7.06	13.0	.9	175	653
U09	7-20-88	0950	35.6	463	7.10	14.5	6.9	117	284
	1-30-89	1000	34.0	461	7.09	12.0	6.8	111	297
U09D	7-20-88	1150	35.6	428	7.16	14.0	7.1	114	275
U10	8-10-88	1210	47.9	1,120	7.15	17.5	5.8	228	764
	1-31-89	0930	49.9	964	7.14	12.5	5.4	243	648
U11	8-05-88	1025	52.5	522	7.12	17.5	7.2	128	318
	2-24-89	1145	38.6	469	7.00	12.5	8.2	116	300
U11D	8-05-88	1225	52.5	480	7.23	15.5	6.1	124	317
U12	8-08-88	1145	41.3	570	6.97	14.0	6.9	142	363
	2-15-89	1155	35.3	715	6.89	10.0	6.8	223	492
U12D	8-08-88	1410	41.6	661	6.92	13.5	1.9	155	417
U13	7-19-88	1345	36.9	895	6.70	18.0	4.3	183	582
	1-17-89	1345	35.0	1,130	6.62	13.0	6.2	226	789
U14	8-09-88	1100	40.7	710	6.89	15.0	4.2	155	462
	2-23-89	1415	35.4	687	6.92	12.5	5.0	155	446
U14D	8-09-88	1305	39.9	655	6.87	13.0	1.2	156	421
U15	8-11-88	1120	60.0	2,180	7.37	17.0	6.5	331	1,658
	2-23-89	0930	56.5	1,800	7.43	12.5	7.0	305	1,346
U16	7-22-88	1045	40.0	805	7.07	16.0	5.8	215	516
	2-22-89	1140	37.1	768	7.18	12.5	5.7	208	496
U16D	7-22-88	1245	40.0	890	7.19	15.5	3.7	220	540
U17	8-10-88	0930	32.3	1,300	7.19	18.0	6.4	317	884
	2-22-89	1345	32.1	1,330	7.18	11.5	4.6	338	919
U18	7-19-88	0940	35.8	1,600	7.16	13.0	4.6	303	1,182
	1-27-89	1100	33.8	1,800	7.16	12.5	6.5	324	1,397
U19	7-21-88	1015	20.6	848	7.10	16.0	5.9	217	532
	1-31-89	1135	18.9	785	7.09	14.0	6.1	209	508

Table 17. Onsite measurements and concentrations of major and minor water-quality constituents and trace elements in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Calcium, dis-solved (mg/L as Ca)	Magne-sium, dis-solved (mg/L as Mg)	Sodium, dis-solved (mg/L as Na)	Potas-sium, dis-solved (mg/L as K)	Bicar-bonate, dis-solved, onsite, IT (mg/L as HCO_3)	Sulfate, dis-solved (mg/L as SO_4)	Chloride, dis-solved (mg/L as Cl)	Fluoride, dis-solved (mg/L as F)	Silica, dis-solved (mg/L as SiO_2)
U08	7-12-88	110	28	71	2.8	223	360	31	0.8	25
	1-23-89	110	28	76	3.1	241	290	39	.7	24
U08D	7-12-88	96	26	68	3.5	213	260	32	1.0	24
U09	7-20-88	54	9.3	28	1.9	143	62	9.3	.7	23
	1-30-89	53	9.1	28	2.2	135	61	11	.7	23
U09D	7-20-88	52	6.9	23	1.6	139	51	8.2	.4	24
U10	8-10-88	130	41	55	2.5	278	310	31	.4	21
	1-31-89	110	36	52	2.6	296	210	36	.4	21
U11	8-05-88	55	11	33	2.2	156	67	16	.8	13
	2-24-89	52	9.6	28	2.3	141	59	12	.7	24
U11D	8-05-88	53	9.9	31	2.0	151	64	13	.7	30
U12	8-08-88	54	13	40	4.6	173	77	17	1.7	22
	2-15-89	71	17	52	5.3	272	130	29	1.6	23
U12D	8-08-88	66	18	42	4.8	189	110	29	1.5	23
U13	7-19-88	92	22	63	5.7	223	170	42	1.8	23
	1-17-89	130	29	67	7.7	276	280	39	1.6	24
U14	8-09-88	70	17	53	4.5	189	150	24	2.3	20
	2-23-89	68	16	52	4.8	189	140	24	2.0	21
U14D	8-09-88	64	13	53	3.6	190	120	22	1.2	22
U15	8-11-88	170	110	170	3.0	404	900	39	.7	17
	2-23-89	150	92	140	2.8	372	680	36	.8	17
U16	7-22-88	90	23	51	2.6	262	130	30	.5	22
	2-22-89	85	21	48	2.6	254	130	26	.4	23
U16D	7-22-89	98	26	56	2.8	268	170	33	.4	22
U17	8-10-88	110	43	120	4.1	386	320	42	.8	18
	2-22-89	120	47	110	4.6	412	330	45	.9	18
U18	7-19-88	180	57	110	2.7	369	550	39	.9	19
	1-27-89	200	64	140	3.1	395	680	38	.3	19
U19	7-21-88	92	22	52	2.6	264	140	31	.8	21
	1-31-89	90	21	52	2.9	255	130	27	.7	22

Table 17. Onsite measurements and concentrations of major and minor water-quality constituents and trace elements in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)	Nitrogen, ammonium, dissolved (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Arsenic, dissolved (µg/L as As)	Barium, dissolved (µg/L as Ba)	Boron, dissolved (µg/L as B)	Beryllium, dissolved (µg/L as Be)	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)
U08	7-12-88	7.5	<0.01	0.03	1	66	270	<0.5	<1	<5
	1-23-89	8.8	.02	.02	<1	67	310	<.5	<1	<5
U08D	7-12-88	8.5	<.01	.17	1	84	260	<.5	<1	<5
U09	7-20-88	5.8	<.01	.05	<1	58	40	<.5	<1	<5
	1-30-89	9.7	<.01	.05	<1	61	40	<.5	<1	<5
U09D	7-20-88	9.0	<.01	.07	<1	58	30	<.5	<1	<5
U10	8-10-88	8.1	.02	<.01	<1	89	70	<.5	<1	<5
	1-31-89	7.6	.02	.09	<1	81	80	<.5	<1	<5
U11	8-05-88	9.8	.01	.05	<1	24	50	<.5	<1	<5
	2-24-89	9.7	<.01	.05	<1	72	40	<.5	<1	<5
U11D	8-05-88	8.9	<.01	.05	<1	71	50	<.5	<1	<5
U12	8-08-88	11	.03	.05	<1	81	110	<.5	<1	<5
	2-15-89	6.5	.02	.02	<1	100	110	<.5	<1	<5
U12D	8-08-88	6.7	.02	.02	<1	130	90	<.5	2	<5
U13	7-19-88	12	<.01	.03	<1	36	140	<.5	<1	<5
	1-17-89	14	.04	.03	1	52	140	<.5	<1	<5
U14	8-09-88	6.5	<.01	<.01	<1	35	140	<.5	<1	<5
	2-23-89	5.7	<.01	.02	<1	40	130	<.5	<1	<5
U14D	8-09-88	6.4	.01	<.01	<1	61	140	<.5	<1	<5
U15	8-11-88	11	.01	.04	<1	22	250	<.5	<1	<5
	2-23-89	10	<.01	.03	<1	19	220	<.5	<1	<5
U16	7-22-88	8.7	<.01	.03	<1	110	90	<.5	<1	<5
	2-22-89	8.1	<.01	.04	<1	110	100	<.5	<1	<5
U16D	7-22-88	--	--	.05	<1	110	110	<.5	<1	<5
U17	8-10-88	8.1	.02	<.01	<1	36	230	<.5	<1	<5
	2-22-89	9.2	<.01	.05	<1	39	230	<.5	<1	<5
U18	7-19-88	9.3	.03	.05	<1	42	190	<.5	<1	<5
	1-27-89	13	.06	.05	<1	35	210	<.5	<1	<5
U19	7-21-88	9.1	<.01	.03	<1	120	100	<.5	<1	<5
	1-31-89	8.4	.02	.03	<1	120	100	<.5	<1	<5

Table 17. Onsite measurements and concentrations of major and minor water-quality constituents and trace elements in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Cobalt, dissolved (μg/L as Co)	Copper, dissolved (μg/L as Cu)	Iron, dissolved (μg/L as Fe)	Lead, dissolved (μg/L as Pb)	Lithium, dissolved (μg/L as Li)	Manganese, dissolved (μg/L as Mn)	Mercury, dissolved (μg/L as Hg)	Molybdenum, dissolved (μg/L as Mo)
U08	7-12-88	<3	<10	5	<10	43	<1	<0.1	<10
	1-23-89	<3	<10	6	<10	45	1	<.1	10
U08D	7-12-88	<3	<10	9	<10	45	2	.4	<10
U09	7-20-88	<3	<10	7	<10	26	2	<.1	<10
	1-30-89	<3	<10	5	<10	26	1	--	<10
U09D	7-20-88	<3	<10	6	<10	25	1	<.1	<10
U10	8-10-88	<3	<10	11	<10	40	<1	<.1	<10
	1-31-89	<3	<10	44	<10	38	2	<.1	<10
U11	8-05-88	<3	<10	14	<10	<4	3	<.1	<10
	2-24-89	<3	<10	4	<10	22	<1	<.1	<10
U11D	8-05-88	<3	<10	10	<10	8	2	<.1	<10
U12	8-08-88	<3	<10	18	<10	33	3	<.1	<10
	2-15-89	<3	<10	340	<10	35	7	<.1	<10
U12D	8-08-88	<3	<10	11	<10	36	3	<.1	<10
U13	7-19-88	<3	<10	7	<10	34	4	<.1	<10
	1-17-89	<3	<10	44	<10	47	3	<.1	<10
U14	8-09-88	<3	<10	6	<10	41	40	.1	<10
	2-23-89	<3	<10	6	<10	40	12	<.1	<10
U14D	8-09-88	<3	<10	7	<10	40	2	<.1	<10
U15	8-11-88	<3	<10	9	<10	140	<1	<.1	<10
	2-23-89	<3	<10	5	10	120	1	<.1	<10
U16	7-22-88	<3	<10	9	<10	30	<1	<.1	<10
	2-22-89	<3	<10	9	<10	34	<1	.1	<10
U16D	7-22-88	<3	<10	8	<10	33	<1	<.1	<10
U17	8-10-88	<3	<10	12	<10	44	4	<.1	<10
	2-22-89	<3	<10	5	<10	50	2	<.1	<10
U18	7-19-88	<3	<10	9	<10	81	3	<.1	<10
	1-27-89	<3	<10	6	<10	96	1	<.1	<10
U19	7-21-88	<3	<10	9	<10	31	<1	<.1	<10
	1-31-89	<3	<10	23	<10	32	5	<.1	<10

Table 17. Onsite measurements and concentrations of major and minor water-quality constituents and trace elements in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Nickel, dissolved (μg/L as Ni)	Selenium, dissolved (μg/L as Se)	Silver, dissolved (μg/L as Ag)	Strontium, dissolved (μg/L as Sr)	Vanadium, dissolved (μg/L as V)	Zinc, dissolved (μg/L as Zn)	Carbon, organic, dissolved (mg/L as C)	Methylene blue active substance (mg/L)
U08	7-12-88	<10	6	<1	530	<6	<3	4.9	<0.10
	1-23-89	<10	4	<1	550	<6	8	1.9	<.10
U08D	7-12-88	10	5	1	510	<6	<3	6.8	<.10
U09	7-20-88	<10	2	<1	230	<6	8	1.1	<.10
	1-30-89	<10	2	<1	230	<6	<3	.8	<.10
U09D	7-20-88	<10	2	1	270	<6	<3	1.1	<.10
U10	8-10-88	10	5	<1	690	<6	9	3.0	.10
	1-31-89	<10	4	<1	610	<6	9	1.7	<.10
U11	8-05-88	<10	2	<1	100	<6	19	2.3	.10
	2-24-89	<10	2	<1	280	<6	<3	1.2	.10
U11D	8-05-88	<10	1	<1	310	<6	4	1.4	<.10
U12	8-08-88	<10	3	2	330	<6	12	3.6	.13
	2-15-89	<10	3	<1	430	<6	3	3.5	<.10
U12D	8-08-88	<10	4	<1	410	<6	7	2.1	<.10
U13	7-19-88	<10	7	<1	570	<6	8	1.8	.14
	1-17-89	<10	4	<1	820	<6	10	2.4	.14
U14	8-09-88	<10	3	1	360	<6	6	1.9	<.10
	2-23-89	<10	2	1	380	<6	4	3.3	<.10
U14D	8-09-88	10	3	2	350	<6	<3	1.6	<.10
U15	8-11-88	<10	13	<1	1,400	<6	8	2.7	.12
	2-23-89	<10	8	1	1,200	<6	11	3.3	<.10
U16	7-22-88	<10	3	<1	450	<6	7	1.6	<.10
	2-22-89	<10	2	<1	420	<6	5	1.3	.10
U16D	7-22-88	<10	2	2	490	<6	17	1.4	<.10
U17	8-10-88	<10	3	<1	730	<6	10	3.7	.10
	2-22-89	<10	2	<1	800	<6	5	2.4	.15
U18	7-19-88	<10	6	2	980	<6	6	1.7	.12
	1-27-89	<10	10	1	1,100	<6	9	2.0	<.10
U19	7-21-88	<10	3	<1	460	<6	<3	1.8	<.10
	1-31-89	<10	2	<1	450	<6	7	1.6	<.10

Table 17. Onsite measurements and concentrations of major and minor water-quality constituents and trace elements in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Time	Water level, depth below land surface (feet)	Specific conduct-ance (µS/cm)	pH (standard units)	Temper-ature, water (deg C)	Oxygen, dissolved (mg/L)	Alkalinity, dissolved, onsite, IT (mg/L as $CaCO_3$)	Dissolved solids, sum of constituents (mg/L)
U19D	7-21-88	1300	20.6	610	7.07	16.0	5.2	155	392
U20	7-13-88	1120	9.3	1,100	7.32	14.0	.3	290	710
	1-30-89	1340	9.0	1,290	7.11	7.0	.2	298	881
U20D	7-13-88	1438	9.0	1,030	7.11	11.0	.6	274	690
U21	7-21-88	0800	29.4	1,230	7.09	13.0	3.6	260	823
	2-22-89	0945	27.1	1,290	7.13	11.5	3.7	253	901
U22	8-04-88	0820	25.3	1,140	7.06	13.0	4.2	292	761
	2-13-89	1245	24.7	1,100	7.11	10.5	4.6	267	721
U22D	8-04-88	1000	25.3	1,060	7.19	12.0	.7	240	686
A01	7-22-88	1000	15.3	2,160	7.18	15.0	4.4	277	1,607
	2-01-89	1325	16.0	1,620	7.24	11.0	5.4	250	1,242
A02	8-03-88	1245	4.9	1,840	7.03	14.0	.3	270	1,294
	3-02-89	1115	4.7	1,770	7.07	10.5	.4	268	1,327
A03	7-15-88	1100	5.0	3,750	6.99	14.0	.4	437	3,025
	1-27-89	0933	7.4	3,650	7.11	10.5	.4	458	3,056
A04	8-10-88	1050	22.4	1,420	6.87	11.5	5.1	226	1,030
	2-13-89	0945	22.4	1,670	6.86	11.0	4.1	260	1,233
A04D	8-10-88	1245	22.7	1,270	7.11	12.5	.2	191	888
A05	8-11-88	1120	10.5	1,490	7.13	12.0	4.3	245	1,097
	2-13-89	1215	12.6	1,350	7.02	10.5	4.1	245	977
A05D	8-11-88	1250	10.2	1,350	7.17	12.5	.8	214	969
A06	7-14-88	1120	10.5	1,220	7.05	17.5	1.2	223	819
	1-10-89	1000	10.3	1,150	7.18	11.0	1.8	213	796
A06D	7-14-88	1045	10.3	1,140	7.28	12.5	.6	211	769
A07	7-20-88	1007	18.5	1,510	7.18	12.0	5.9	239	1,207
	1-31-89	1111	18.5	1,660	7.11	12.5	6.2	251	1,231
A07D	7-20-88	1220	18.0	1,490	7.20	13.0	3.0	221	1,076
A08	7-05-88	1200	10.7	1,370	6.77	14.5	3.4	213	951
	1-18-89	1335	10.8	1,380	6.85	12.0	2.6	218	984
A09	7-20-88	1512	10.9	1,390	7.17	12.5	1.2	227	1,024
	1-31-89	1410	10.8	1,510	7.09	13.0	1.6	243	1,056
A10	8-03-88	0735	27.9	2,000	7.03	16.5	4.7	261	1,452
	2-01-89	0915	27.5	1,900	7.40	9.0	5.6	253	1,426

Table 17. Onsite measurements and concentrations of major and minor water-quality constituents and trace elements in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Bicarbonate, dissolved, onsite, IT (mg/L as HCO_3)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)
U19D	7-21-88	64	15	43	2.6	189	93	21	0.9	22
U20	7-13-88	100	32	95	4.0	354	230	47	1.7	19
	1-30-89	130	41	100	3.9	363	350	54	1.2	18
U20D	7-13-88	100	31	91	3.6	334	220	47	1.5	20
U21	7-21-88	100	40	110	3.2	317	330	49	1.8	18
	2-22-89	120	43	110	3.6	308	380	55	1.5	19
U22	8-04-88	110	34	96	4.4	356	260	51	1.9	19
	2-13-89	100	32	96	4.1	326	250	48	1.8	19
U22D	8-04-88	96	29	90	4.6	292	250	48	1.6	18
A01	7-22-88	200	67	210	2.5	338	880	50	1.9	15
	2-01-89	170	53	150	2.5	305	640	45	2.0	15
A02	8-03-88	150	44	200	5.1	329	650	57	2.2	14
	3-02-89	160	45	200	5.2	327	670	57	2.4	17
A03	7-15-88	300	150	400	4.1	533	1,800	80	1.0	23
	1-27-89	300	150	430	4.3	558	1,800	76	1.0	17
A04	8-10-88	140	39	130	3.9	276	500	46	1.6	18
	2-13-89	150	43	180	4.5	317	610	55	1.5	19
A04D	8-10-88	120	33	110	4.6	233	430	40	1.7	18
A05	8-11-88	150	43	130	4.7	299	540	50	1.4	20
	2-13-89	140	38	120	4.7	299	450	45	1.4	20
A05D	8-11-88	130	37	120	4.7	261	470	47	1.7	18
A06	7-14-88	110	30	120	3.8	272	350	46	2.6	16
	1-10-89	100	29	120	3.9	260	350	42	2.6	16
A06D	7-14-88	100	29	110	4.0	257	330	45	2.4	15
A07	7-20-88	160	49	150	2.7	291	620	50	1.9	16
	1-31-89	170	49	150	3.0	306	620	53	1.7	17
A07D	7-20-88	150	44	130	2.8	269	540	46	2.0	15
A08	7-05-88	130	36	120	3.8	260	460	42	1.9	16
	1-18-89	140	38	120	4.3	266	470	45	1.9	18
A09	7-20-88	140	38	130	4.1	277	490	57	2.3	16
	1-31-89	150	40	140	4.3	296	490	56	2.0	17
A10	8-03-88	180	59	190	2.6	318	760	73	2.4	14
	2-01-89	180	59	190	2.9	308	740	69	1.9	16

Table 17. Onsite measurements and concentrations of major and minor water-quality constituents and trace elements in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)	Nitrogen, ammonium, dissolved (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Arsenic, dissolved (μg/L as As)	Barium, dissolved (μg/L as Ba)	Boron, dissolved (μg/L as B)	Beryllium, dissolved (μg/L as Be)	Cadmium, dissolved (μg/L as Cd)	Chromium, dissolved (μg/L as Cr)
U19D	7-21-88	8.5	<0.01	0.02	<1	68	80	<0.5	<1	<5
U20	7-13-88	1.4	.03	.02	1	56	250	<.5	<1	<5
	1-30-89	.67	.05	.02	<1	73	250	<.5	<1	<5
U20D	7-13-88	2.5	.04	.02	<1	56	230	<.5	<1	<5
U21	7-21-88	3.4	<.01	.07	<1	30	240	<.5	<1	<5
	2-22-89	3.9	<.01	.07	<1	33	260	<.5	<1	<5
U22	8-04-88	2.1	.03	.02	<1	37	250	<.5	<1	<5
	2-13-89	2.2	.02	.02	<1	37	230	<.5	<1	<5
U22D	8-04-88	1.2	.03	.03	<1	49	240	<.5	<1	<5
A01	7-22-88	3.1	.03	.02	<1	25	310	.7	<1	<5
	2-01-89	3.1	.04	<.01	<1	19	240	<.5	<1	<5
A02	8-03-88	2.2	.07	.05	<1	22	280	<.5	1	<5
	3-02-89	2.2	.04	<.01	<1	26	270	<.5	<1	<5
A03	7-15-88	.13	.12	.02	<1	22	540	<.5	<1	<5
	1-27-89	<.10	.09	.02	<1	9	530	<.5	<1	<5
A04	8-10-88	3.4	.02	<.01	<1	23	220	<.5	<1	<5
	2-13-89	3.1	.04	.01	<1	25	290	<.5	<1	<5
A04D	8-10-88	3.7	.03	<.01	<1	21	190	<.5	<1	<5
A05	8-11-88	2.4	.01	.02	1	24	240	<.5	<1	<5
	2-13-89	2.5	.04	.01	<1	21	240	<.5	<1	<5
A05D	8-11-88	2.6	<.01	.02	<1	23	210	<.5	<1	<5
A06	7-14-88	1.4	.05	.02	<1	20	200	<.5	<1	<5
	1-10-89	1.1	.03	.01	<1	21	220	<.5	3	<5
A06D	7-14-88	1.7	.03	.02	<1	20	190	<.5	<1	<5
A07	7-20-88	3.0	.04	.01	<1	22	230	<.5	<1	<5
	1-31-89	3.5	.03	<.01	<1	25	240	<.5	<1	<5
A07D	7-20-88	2.9	.01	.01	<1	21	240	<.5	<1	<5
A08	7-05-88	3.0	.02	.02	<1	20	230	<.5	3	<5
	1-18-89	3.5	.03	.02	<1	25	230	<.5	<1	<5
A09	7-20-88	2.3	.06	.01	<1	24	240	<.5	<1	<5
	1-31-89	2.3	.04	.01	<1	28	240	<.5	<1	<5
A10	8-03-88	3.1	.06	.03	<1	17	250	<.5	1	<5
	2-01-89	3.3	.05	.01	<1	17	250	<.5	<1	<5

Table 17. Onsite measurements and concentrations of major and minor water-quality constituents and trace elements in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Cobalt, dissolved (μg/L as Co)	Copper, dissolved (μg/L as Cu)	Iron, dissolved (μg/L as Fe)	Lead, dissolved (μg/L as Pb)	Lithium, dissolved (μg/L as Li)	Manganese, dissolved (μg/L as Mn)	Mercury, dissolved (μg/L as Hg)	Molybdenum, dissolved (μg/L as Mo)
U19D	7-21-88	<3	<10	8	<10	28	<1	<0.1	<10
U20	7-13-88	<3	<10	28	<10	53	810	--	10
	1-30-89	<3	<10	10	<10	57	860	<.1	<10
U20D	7-13-88	<3	<10	7	<10	50	55	<.1	10
U21	7-21-88	<3	<10	6	<10	56	<1	<.1	<10
	2-22-89	<3	<10	4	<10	64	<1	<.1	<10
U22	8-04-88	<3	<10	11	<10	55	1	<.1	<10
	2-13-89	<3	<10	14	10	49	1	<.1	10
U22D	8-04-88	<3	<10	14	<10	50	1,200	<.1	10
A01	7-22-88	<3	<10	9	10	69	1	<.1	<10
	2-01-89	<3	<10	7	<10	58	<1	--	<10
A02	8-03-88	<3	<10	19	<10	71	9	<.1	<10
	3-02-89	<3	<10	6	<10	75	2	.2	<10
A03	7-15-88	<3	<10	1,100	10	170	84	.1	<10
	1-27-89	<3	<10	10	<10	170	42	.2	<10
A04	8-10-88	<3	<10	6	20	56	1	<.1	<10
	2-13-89	<3	<10	5	<10	65	<1	<.1	<10
A04D	8-10-88	<3	<10	5	<10	53	2	<.1	<10
A05	8-11-88	<3	<10	7	<10	71	1	<.1	10
	2-13-89	<3	<10	6	<10	63	<1	.2	10
A05D	8-11-88	<3	<10	7	<10	62	<1	<.1	<10
A06	7-14-88	<3	<10	29	<10	59	1	<.1	<10
	1-10-89	<3	<10	9	<10	58	2	<.1	<10
A06D	7-14-88	<3	<10	3	<10	54	<1	<.1	<10
A07	7-20-88	<3	<10	6	<10	60	<1	<.1	<10
	1-31-89	<3	<10	27	<10	64	1	<.1	<10
A07D	7-20-88	<3	<10	4	<10	61	1	<.1	<10
A08	7-05-88	<3	<10	15	<10	61	4	.2	<10
	1-18-89	<3	<10	190	<10	63	23	<.1	<10
A09	7-20-88	<3	<10	8	<10	61	1	.2	<10
	1-31-89	<3	<10	160	<10	65	7	<.1	<10
A10	8-03-88	<3	<10	18	<10	61	2	<.1	<10
	2-01-89	<3	<10	40	<10	66	5	<.1	<10

Table 17. Onsite measurements and concentrations of major and minor water-quality constituents and trace elements in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Nickel, dissolved (μg/L as Ni)	Selenium, dissolved (μg/L as Se)	Silver, dissolved (μg/L as Ag)	Strontium, dissolved (μg/L as Sr)	Vanadium, dissolved (μg/L as V)	Zinc, dissolved (μg/L as Zn)	Carbon, organic, dissolved (mg/L as C)	Methylene blue active substance (mg/L)
U19D	7-21-88	<10	2	1	340	<6	8	1.2	<0.10
U20	7-13-88	<10	5	2	700	<6	<3	4.2	<.10
	1-30-89	<10	4	2	920	<6	8	2.8	<.10
U20D	7-13-88	<10	9	2	670	<6	5	3.7	<.10
U21	7-21-88	<10	17	2	820	<6	3	2.2	<.10
	2-22-89	<10	16	<1	900	<6	9	2.2	<.10
U22	8-04-88	<10	8	2	670	<6	9	2.1	<.10
	2-13-89	<10	4	1	660	<6	5	2.9	<.10
U22D	8-04-88	<10	3	1	560	<6	<3	2.1	<.10
A01	7-22-88	<10	47	2	1,600	<6	6	2.2	<.10
	2-01-89	<10	33	<1	1,300	<6	6	1.7	<.10
A02	8-03-88	<10	4	<1	860	<6	11	2.1	<.10
	3-02-89	<10	4	<1	900	<6	9	1.3	<.10
A03	7-15-88	<10	<1	2	3,800	<6	18	3.3	<.10
	1-27-89	<10	<1	<1	3,900	<6	7	2.9	<.10
A04	8-10-88	<10	12	3	1,000	<6	4	2.3	<.10
	2-13-89	<10	18	<1	1,100	<6	3	2.3	<.10
A04D	8-10-88	<10	10	2	770	<6	<3	2.1	<.10
A05	8-11-88	<10	10	<1	980	<6	3	2.6	<.10
	2-13-89	<10	9	<1	890	<6	5	2.1	<.10
A05D	8-11-88	<10	10	<1	860	<6	<3	2.2	<.10
A06	7-14-88	<10	4	<1	640	<6	22	2.0	<.10
	1-10-89	<10	4	<1	610	<6	3	3.9	<.10
A06D	7-14-88	<10	2	2	64	<6	<3	2.0	<.10
A07	7-20-88	<10	26	<1	1,300	<6	3	3.0	<.10
	1-31-89	<10	20	<1	1,300	<6	33	1.7	<.10
A07D	7-20-88	<10	19	<1	1,100	<6	5	1.6	<.10
A08	7-05-88	<10	12	1	890	<6	14	5.0	<.10
	1-18-89	<10	12	<1	970	<6	8	1.6	<.10
A09	7-20-88	<10	13	<1	840	<6	11	2.1	<.10
	1-31-89	<10	12	<1	890	<6	52	1.7	<.10
A10	8-03-88	<10	28	<1	1,500	<6	10	1.6	<.10
	2-01-89	<10	30	<1	1,500	<6	5	1.3	<.10

Table 17. Onsite measurements and concentrations of major and minor water-quality constituents and trace elements in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Time	Water level, depth below land surface (feet)	Specific conduct-ance (µS/cm)	pH (standard units)	Temper-ature, water (deg C)	Oxygen, dissolved (mg/L)	Alkalinity, dissolved, onsite, IT (mg/L as $CaCO_3$)	Dissolved solids, sum of constituents (mg/L)
A10D	8-03-88	0950	27.9	1,720	7.06	14.5	3.3	248	1,243
A11	7-19-88	0900	17.1	2,570	7.07	12.0	5.6	257	2,037
	1-27-89	1220	10.3	2,550	7.38	13.0	5.6	260	2,055
A12	8-09-88	0800	6.0	1,460	7.09	12.5	.5	289	1,000
	2-24-89	1440	6.1	1,440	7.20	9.5	.4	279	994
A12D	8-09-88	0950	6.0	1,370	7.33	12.0	.3	257	912
A13	7-21-88	1000	5.0	1,500	7.15	12.5	2.0	286	1,076
	1-23-89	1450	6.5	1,560	7.18	12.0	1.0	271	1,122
A13D	7-21-88	1155	4.9	1,500	7.26	12.5	3.0	256	1,078
A14	7-11-88	1120	9.7	1,180	7.40	14.5	.6	217	784
	3-02-89	1300	9.7	1,170	7.26	10.0	1.1	218	794
A14D	7-11-88	1500	10.0	1,140	7.33	13.0	.2	197	723
A15	7-18-88	1010	6.4	1,820	7.14	17.0	2.4	318	1,295
	1-10-89	1245	8.3	1,900	7.17	11.0	2.8	307	1,430
A15D	7-18-88	1240	6.4	1,870	6.95	14.0	3.2	319	1,374
A16	8-08-88	0925	11.2	1,770	7.24	15.0	4.8	331	1,260
	2-15-89	1355	11.3	1,700	7.27	10.0	4.5	305	1,238
A16D	8-08-88	1130	11.3	1,700	7.14	14.5	1.1	332	1,196
A17	7-19-88	1400	16.4	2,290	6.92	13.5	5.2	365	1,718
	1-18-89	0940	15.7	2,220	7.01	11.0	4.6	363	1,734
A18	8-05-88	1200	8.5	1,840	7.03	14.0	1.9	269	1,366
	2-15-89	1045	8.4	1,310	7.16	11.0	.4	212	923
A19	7-07-88	1200	19.3	1,470	7.26	16.0	3.6	239	1,017
	2-24-89	0900	19.1	1,540	7.23	11.5	4.6	250	1,084
A20	8-04-88	1130	25.5	1,140	7.24	14.0	4.3	197	771
	2-14-89	1235	24.6	2,170	7.21	12.5	4.2	231	1,729

Table 17. Onsite measurements and concentrations of major and minor water-quality constituents and trace elements in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Bicarbonate, dissolved, onsite, IT (mg/L as HCO_3)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)
A10D	8-03-88	160	50	160	2.6	302	640	53	2.2	14
A11	7-19-88	220	95	250	2.8	313	1200	73	1.7	15
	1-27-89	220	97	270	3.0	317	1200	65	1.8	16
A12	8-09-88	130	36	150	4.1	352	430	55	2.8	15
	2-24-89	130	37	150	3.8	340	430	56	2.7	14
A12D	8-09-88	120	32	130	3.5	313	400	49	2.5	15
A13	7-21-88	130	41	160	4.4	349	490	55	2.5	16
	1-23-89	140	40	160	4.5	330	540	51	2.2	16
A13D	7-21-88	140	40	150	2.8	312	510	52	2.3	16
A14	7-11-88	97	29	120	3.6	264	340	44	2.6	14
	3-02-89	100	30	120	3.4	266	340	49	2.8	13
A14D	7-11-88	97	28	110	4.1	240	330	8.2	2.5	14
A15	7-18-88	180	55	160	3.0	388	620	59	2.4	17
	1-10-89	180	60	190	3.7	374	720	62	2.2	16
A15D	7-18-88	180	57	180	3.6	389	670	62	2.6	16
A16	8-08-88	160	47	180	4.5	404	580	68	2.7	15
	2-15-89	160	45	180	4.4	372	580	65	2.7	14
A16D	8-08-88	160	46	160	3.8	405	540	63	2.1	16
A17	7-19-88	220	78	210	2.1	445	900	57	1.8	18
	1-18-89	230	81	220	2.3	442	930	52	1.8	19
A18	8-05-88	170	57	170	5.2	328	680	70	2.4	16
	2-15-89	110	35	140	4.5	258	430	50	2.5	14
A19	7-07-88	110	37	160	2.3	291	480	57	2.2	15
	2-24-89	120	39	180	2.8	305	510	59	2.2	15
A20	8-04-88	95	27	120	4.1	240	340	42	2.5	13
	2-14-89	240	71	200	6.3	282	960	83	2.0	16

Table 17. Onsite measurements and concentrations of major and minor water-quality constituents and trace elements in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)	Nitrogen, ammonium, dissolved (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Arsenic, dissolved (µg/L as As)	Barium, dissolved (µg/L as Ba)	Boron, dissolved (µg/L as B)	Beryllium, dissolved (µg/L as Be)	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)
A10D	8-03-88	2.7	0.05	0.03	<1	17	240	<0.5	<1	<5
A11	7-19-88	5.4	.03	.01	<1	16	290	<.5	<1	<5
	1-27-89	5.6	.04	.01	<1	20	280	<.5	<1	<5
A12	8-09-88	.50	.03	<.01	<1	28	260	<.5	<1	<5
	2-24-89	.33	.01	.01	<1	28	260	<.5	<1	<5
A12D	8-09-88	1.3	.03	<.01	<1	31	250	<.5	<1	<5
A13	7-21-88	1.1	<.01	.01	<1	21	270	<.5	<1	<5
	1-23-89	1.2	.03	.01	<1	25	300	<.5	<1	<5
A13D	7-21-88	2.4	<.01	<.01	<1	17	280	<.5	<1	<5
A14	7-11-88	.90	.01	<.01	<1	20	210	<.5	1	<5
	3-02-89	1.1	.02	<.01	<1	21	200	<.5	<1	<5
A14D	7-11-88	2.5	<.01	<.01	<1	23	190	<.5	1	<5
A15	7-18-88	1.7	.05	.02	1	41	260	<.5	<1	<5
	1-10-89	2.6	.05	.02	<1	41	260	<.5	5	<5
A15D	7-18-88	2.3	.04	.01	<1	20	270	<.5	<1	<5
A16	8-08-88	.86	.05	.03	1	37	280	<.5	<1	<5
	2-15-89	.85	.02	.04	1	32	280	<.5	<1	<5
A16D	8-08-88	1.2	.06	.02	<1	24	270	<.5	1	<5
A17	7-19-88	2.4	.03	.01	<1	13	380	<.5	1	<5
	1-18-89	2.3	.05	.01	<1	14	380	<.5	<1	<5
A18	8-05-88	2.6	.05	.03	<1	32	230	<.5	<1	<5
	2-15-89	2.1	.01	<.01	<1	20	220	<.5	<1	<5
A19	7-07-88	2.1	.01	.01	--	14	240	<.5	<1	<5
	2-24-89	1.3	<.01	.02	<1	17	280	<.5	<1	<5
A20	8-04-88	2.1	.02	.03	<1	20	250	<.5	<1	<5
	2-14-89	2.5	.07	<.01	<1	67	310	<.5	<1	<5

Table 17. Onsite measurements and concentrations of major and minor water-quality constituents and trace elements in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Cobalt, dissolved (μg/L as Co)	Copper, dissolved (μg/L as Cu)	Iron, dissolved (μg/L as Fe)	Lead, dissolved (μg/L as Pb)	Lithium, dissolved (μg/L as Li)	Manganese, dissolved (μg/L as Mn)	Mercury, dissolved (μg/L as Hg)	Molybdenum, dissolved (μg/L as Mo)
A10D	8-03-88	<3	<10	19	<10	57	1	<0.1	<10
A11	7-19-88	<3	<10	12	<10	79	2	<.1	<10
	1-27-89	<3	<10	11	<10	79	2	<.1	<10
A12	8-09-88	<3	<10	12	<10	59	1,200	<.1	<10
	2-24-89	<3	<10	9	<10	60	1,200	--	10
A12D	8-09-88	<3	<10	11	20	57	11	<.1	<10
A13	7-21-88	<3	<10	6	<10	62	<1	<.1	10
	1-23-89	<3	<10	5	<10	66	<1	<.1	<10
A13D	7-21-88	<3	<10	9	<10	59	3	<.1	<10
A14	7-11-88	<3	<10	3	<10	54	8	<.1	10
	3-02-89	<3	<10	5	<10	50	4	<.1	<10
A14D	7-11-88	<3	<10	4	<10	50	3	.3	20
A15	7-18-88	<3	<10	16	<10	71	1	<.1	<10
	1-10-89	<3	<10	<3	<10	74	<1	<.1	<10
A15D	7-18-88	<3	<10	20	20	68	<1	<.1	<10
A16	8-08-88	<3	<10	13	<10	71	2	<.1	10
	2-15-89	<3	<10	18	<10	74	3	<.1	<10
A16D	8-08-88	<3	<10	9	<10	72	1	<.1	<10
A17	7-19-88	<3	<10	25	40	99	3	<.1	10
	1-18-89	<3	<10	54	<10	100	3	<.1	<10
A18	8-05-88	<3	<10	5	<10	75	2	<.1	<10
	2-15-89	<3	<10	6	<10	56	2	<.1	20
A19	7-07-88	<3	<10	5	<10	65	2	<.1	<10
	2-24-89	<3	<10	5	<10	66	<1	<.1	<10
A20	8-04-88	<3	<10	18	10	54	3	<.1	<10
	2-14-89	<3	<10	280	<10	63	9	<.1	<10

Table 17. Onsite measurements and concentrations of major and minor water-quality constituents and trace elements in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Nickel, dissolved (μg/L as Ni)	Selenium, dissolved (μg/L as Se)	Silver, dissolved (μg/L as Ag)	Strontium, dissolved (μg/L as Sr)	Vanadium, dissolved (μg/L as V)	Zinc, dissolved (μg/L as Zn)	Carbon, organic, dissolved (mg/L as C)	Methylene blue active substance (mg/L)
A10D	8-03-88	<10	20	<1	1,300	<6	7	1.9	<0.10
A11	7-19-88	<10	45	<1	2,100	<6	9	2.0	<.10
	1-27-89	<10	42	<1	2,000	<6	6	1.9	<.10
A12	8-09-88	<10	<1	2	750	<6	7	2.5	<.10
	2-24-89	<10	<1	<1	760	<6	<3	2.0	<.10
A12D	8-09-88	<10	2	3	680	<6	<3	2.2	<.10
A13	7-21-88	<10	11	1	960	<6	6	1.9	<.10
	1-23-89	<10	7	<1	1,000	<6	9	2.1	<.10
A13D	7-21-88	<10	12	<1	1,000	<6	<3	1.6	<.10
A14	7-11-88	<10	1	2	590	<6	<3	2.3	<.10
	3-02-89	<10	<1	<1	620	<6	3	1.3	<.10
A14D	7-11-88	<10	2	1	580	<6	6	2.5	<.10
A15	7-18-88	<10	14	<1	1,300	<6	9	2.6	<.10
	1-10-89	<10	19	<1	1,400	<6	4	2.0	<.10
A15D	7-18-88	<10	<1	1	1,400	<6	12	2.2	<.10
A16	8-08-88	<10	10	<1	1,000	<6	7	3.0	<.10
	2-15-89	<10	9	<1	1,000	<6	4	2.2	<.10
A16D	8-08-88	<10	6	<1	1,000	<6	11	2.4	<.10
A17	7-19-88	<10	22	<1	2,200	<6	8	2.6	<.10
	1-18-89	<10	30	<1	2,300	<6	15	2.3	<.10
A18	8-05-88	<10	12	<1	1,300	<6	7	2.8	<.10
	2-15-89	<10	9	<1	800	<6	6	2.9	<.10
A19	7-07-88	<10	3	3	950	<6	3	2.0	<.10
	2-24-89	<10	3	<1	1,000	<6	6	1.5	<.10
A20	8-04-88	<10	5	2	600	<6	<3	2.5	<.10
	2-14-89	<10	16	<1	1,600	<1	26	3.7	<.10

Table 18. Concentrations of volatile organic compounds in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989

[<, less than; all values are expressed in micrograms per liter; --, data not available; all methylene chloride concentrations are reported as maximum because of laboratory contamination; see pl. 1 for locations of wells and sites]

Site or well number	Date sampled	Time	Benzene	Bromoform	Carbon tetrachloride	Chlorobenzene	Chlorodibromomethane	Chloroethane	2-Chloroethylvinylether	Chloroform	1,2,-Dibromoethane
SW1	8-17-88	1425	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
	8-30-88	1000	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-28-89	0945	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
SW2	8-17-88	1530	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.4	<.2
	8-30-88	1130	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.7	<.2
	2-28-89	1130	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.9	<.2
SW3	8-17-88	2240	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	8-30-88	2015	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-28-89	1815	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
SW4	8-18-88	0500	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	8-31-88	0330	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-28-89	2330	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
SW5	8-18-88	1515	<.2	<.2	<.2	3.2	<.2	<.2	<.2	<.2	<.2
	8-31-88	1800	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	3-01-89	0900	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U01	7-18-88	1018	.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--
	1-27-89	1355	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U01D	7-18-88	1247	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--
U02	7-08-88	0945	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--
	2-23-89	1215	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U03	7-21-88	1530	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.3	<.2
	2-13-89	0945	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.3	<.2
U04	7-15-88	1122	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.3	--
	1-09-89	1325	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.4	<.2
U05	7-06-88	1330	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--
	3-09-89	1120	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U06	8-11-88	0845	.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-23-89	1220	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U07	8-09-88	1300	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table 18. Concentrations of volatile organic compounds in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	1,2-Dichlorobenzene	1,3-Dichlorobenzene	1,4-Dichlorobenzene	Dichlorobromomethane	Dichlorodifluoromethane	1,2-Dichloroethane	1,1-Dichloroethane	1,1-Dichloroethylene	1,2-Dichloro-propane
SW1	8-17-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
	8-30-88	<.2	<.2	<.2	<.2	<.2	.2	<.2	<.2	<.2
	2-28-89	<.2	<.2	<.2	<.2	<.2	.2	<.2	<.2	<.2
SW2	8-17-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	8-30-88	<.2	.4	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-28-89	<.2	<.2	.3	<.2	<.2	<.2	<.2	<.2	<.2
SW3	8-17-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	8-30-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-28-89	<.2	<.2	<.2	<.2	<.2	.2	<.2	<.2	<.2
SW4	8-18-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	8-31-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-28-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
SW5	8-18-88	<.2	<.2	.4	<.2	<.2	<.2	<.2	<.2	<.2
	8-31-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	3-01-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U01	7-18-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-27-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U01D	7-18-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U02	7-08-88	<.2	<.2	<.2	<.2	<.2	<.2	.6	<.2	<.2
	2-23-89	<.2	<.2	<.2	<.2	<.2	<.2	.6	<.2	<.2
U03	7-21-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-13-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U04	7-15-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.4	<.2
	1-09-89	<.2	<.2	<.2	<.2	<.2	<.2	.2	.6	<.2
U05	7-06-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	3-09-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U06	8-11-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-23-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U07	8-09-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table 18. Concentrations of volatile organic compounds in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	1,3-Dichloropropene	Cis-1,3-dichloropropene	Trans-1,3-dichloropropene	Ethylbenzene	Methylbromide	Methylchloride	Methylene chloride	Styrene	1,1,2,2-Tetrachloroethane
SW1	8-17-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
	8-30-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-28-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
SW2	8-17-88	<.2	<.2	<.2	<.2	<.2	<.2	<.4	<.2	<.2
	8-30-88	<.2	<.2	<.2	<.2	<.2	<.2	<.7	<.2	<.2
	2-28-89	<.2	<.2	<.2	<.2	<.2	<.2	<1.7	<.2	<.2
SW3	8-17-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	8-30-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-28-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
SW4	8-18-88	<.2	<.2	<.2	<.2	<.2	.3	<.2	<.2	<.2
	8-31-88	<.2	<.2	<.2	<.2	<.2	<.2	<.3	<.2	<.2
	2-28-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
SW5	8-18-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	8-31-88	<.2	<.2	<.2	<.2	<.2	<.2	<.3	<.2	<.2
	3-01-89	<.2	<.2	<.2	<.2	<.2	<.2	<.3	<.2	<.2
U01	7-18-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-27-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U01D	7-18-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U02	7-08-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-23-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U03	7-21-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-13-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U04	7-15-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-09-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U05	7-06-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	3-09-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U06	8-11-88	<.2	<.2	<.2	<.2	<.2	<.4	<.2	<.2	<.2
	1-23-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U07	8-09-88	<.2	<.2	<.2	<.2	<.2	<.2	<.9	<.2	<.2

Table 18. Concentrations of volatile organic compounds in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Tetra-chloro-ethylene	Toluene	1,2-Trans-dichloro-ethene	1,1,1-Tri-chloro-ethane	1,1,2-Tri-chloro-ethane	Trichloro-ethylene	Trichloro-fluoro-methane	Vinyl chloride	Xylene
SW1	8-17-88	0.3	<0.2	<0.2	0.3	<0.2	<0.2	<0.2	<0.2	0.3
	8-30-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-28-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
SW2	8-17-88	3.4	.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	8-30-88	.2	.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-28-89	.2	.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
SW3	8-17-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	8-30-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-28-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
SW4	8-18-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	8-31-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-28-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
SW5	8-18-88	.6	<.2	<.2	<.2	<.2	.2	<.2	<.2	<.2
	8-31-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	3-01-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U01	7-18-88	<.2	<.6	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-27-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U01D	7-18-88	<.2	<.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U02	7-08-88	<.2	<.5	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-23-89	<.2	<.2	<.2	<.2	<.2	.2	<.2	<.2	<.2
U03	7-21-88	3.0	<.2	<.2	.4	<.2	<.2	<.2	<.2	<.2
	2-13-89	2.5	<.2	<.2	.3	<.2	<.2	<.2	<.2	<.2
U04	7-15-88	<.2	<.2	<.2	23	<.2	2.7	<.2	<.2	<.2
	1-09-89	<.2	<.2	<.2	19	<.2	3.9	<.2	<.2	<.2
U05	7-06-88	1.5	<.3	<.2	.5	<.2	<.2	<.2	<.2	<.2
	3-09-89	1.6	<.2	<.2	.4	<.2	<.2	<.2	<.2	<.2
U06	8-11-88	<.2	<.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-23-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U07	8-09-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table 18. Concentrations of volatile organic compounds in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Time	Benzene	Bromoform	Carbon tetrachloride	Chlorobenzene	Chlorodibromomethane	Chloroethane	2-Chloroethylvinylether	Chloroform	1,2,-Dibromoethane
U08	7-12-88	1301	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.4	--
	1-23-89	0950	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.3	<0.2
U08D	7-12-88	0930	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.5	--
U09	7-20-88	0950	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.3	<.2
	1-30-89	1000	.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U09D	7-20-88	1150	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.3	<.2
U10	8-10-88	1210	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.9	<.2
	1-31-89	0930	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.3	<.2
U11	8-05-88	1025	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.3	<.2
	2-24-89	1145	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.4	<.2
U11D	8-05-88	1225	.3	<.2	<.2	<.2	<.2	<.2	<.2	.3	<.2
U12	8-08-88	1145	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-15-89	1155	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.3	<.2
U12D	8-08-88	1410	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.5	<.2
U13	7-19-88	1345	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.7	--
	1-17-89	1345	<.2	<.2	<.2	<.2	.7	<.2	<.2	.2	<.2
U14	8-09-88	1100	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-23-89	1415	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U14D	8-09-88	1305	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U15	8-11-88	1120	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-23-89	0930	.4	<.2	<.2	<.2	.3	<.2	<.2	2.5	<.2
U16	7-22-88	1045	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.3	<.2
	2-22-89	1140	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.4	<.2
U16D	7-22-88	1245	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.6	<.2
U17	8-10-88	0930	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.3	<.2
	2-22-89	1345	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.4	<.2
U18	7-19-88	0940	<.2	<.2	<.2	<.2	1.0	<.2	<.2	.2	--
	1-27-89	1100	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.6	<.2
U19	7-21-88	1015	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.3	<.2
	1-31-89	1135	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.8	<.2

Table 18. Concentrations of volatile organic compounds in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	1,2-Dichlorobenzene	1,3-Dichlorobenzene	1,4-Dichlorobenzene	Dichlorobromomethane	Dichlorodifluoromethane	1,2-Dichloroethane	1,1-Dichloroethane	1,1-Dichloroethylene	1,2-Dichloropropane
U08	7-12-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
	1-23-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U08D	7-12-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U09	7-20-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-30-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U09D	7-20-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U10	8-10-88	<.2	<.2	<.2	.3	<.2	<.2	<.2	<.2	<.2
	1-31-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U11	8-05-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-24-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U11D	8-05-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.3	<.2
U12	8-08-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-15-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U12D	8-08-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U13	7-19-88	<.2	<.2	<.2	.4	<.2	<.2	<.2	<.2	<.2
	1-17-89	<.2	<.2	<.2	.5	<.2	<.2	<.2	<.2	<.2
U14	8-09-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-23-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U14D	8-09-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U15	8-11-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-23-89	<.2	<.2	<.2	1.1	<.2	<.2	<.2	<.2	<.2
U16	7-22-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-22-89	<.2	<.2	<.2	.2	<.2	<.2	<.2	<.2	<.2
U16D	7-22-88	<.2	<.2	<.2	.2	<.2	<.2	<.2	<.2	<.2
U17	8-10-88	<.2	<.2	<.2	.3	<.2	<.2	<.2	<.2	<.2
	2-22-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U18	7-19-88	<.2	<.2	<.2	.6	<.2	<.2	<.2	<.2	<.2
	1-27-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U19	7-21-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-31-89	<.2	<.2	<.2	.3	<.2	<.2	<.2	<.2	<.2

Table 18. Concentrations of volatile organic compounds in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	1,3-Dichloro-propene	Cis-1,3-dichloro-propene	Trans-1,3-dichloro-propene	Ethyl-benzene	Methyl-bromide	Methyl-chloride	Meth-ylene chloride	Styrene	1,1,2,2-Tetra-chloro-ethane
U08	7-12-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
	1-23-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U08D	7-12-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U09	7-20-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-30-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U09D	7-20-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U10	8-10-88	<.2	<.2	<.2	<.2	<.2	<.6	<.6	<.2	<.2
	1-31-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U11	8-05-88	<.2	<.2	<.2	<.2	<.2	<.4	<.2	<.2	<.2
	2-24-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U11D	8-05-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U12	8-08-88	<.2	<.2	<.2	<.2	<.2	<.3	<.6	<.2	<.2
	2-15-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U12D	8-08-88	<.2	<.2	<.2	<.2	<.2	<2.2	<.2	<.2	<.2
U13	7-19-88	<.2	<.2	<.2	<.2	<.2	<.2	<19	<.2	<.2
	1-17-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U14	8-09-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-23-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U14D	8-09-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U15	8-11-88	<.2	<.2	<.2	<.2	<.2	<.2	<1.2	<.2	<.2
	2-23-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U16	7-22-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-22-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U16D	7-22-88	<.2	<.2	<.2	<.2	<.2	<.3	<.2	<.2	<.2
U17	8-10-88	<.2	<.2	<.2	.3	<.2	<.2	<1.7	<.2	<.2
	2-22-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U18	7-19-88	<.2	<.2	<.2	.6	<.2	<.2	<.7	<.2	<.2
	1-27-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U19	7-21-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-31-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table 18. Concentrations of volatile organic compounds in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Tetra-chloro-ethylene	Toluene	1,2-Trans-dichloro-ethene	1,1,1-Tri-chloro-ethane	1,1,2-Tri-chloro-ethane	Trichloro-ethylene	Trichloro-fluoro-methane	Vinyl chloride	Xylene
U08	7-12-88	0.3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
	1-23-89	.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U08D	7-12-88	<.2	<.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U09	7-20-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-30-89	.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U09D	7-20-88	<.2	<.2	<.2	<.2	<.2	.2	<.2	<.2	<.2
U10	8-10-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-31-89	.5	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U11	8-05-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-24-89	<.2	<.2	<.2	<.2	<.2	.3	<.2	<.2	<.2
U11D	8-05-88	<.2	<.3	<.2	<.2	<.2	.4	<.2	<.2	<.2
U12	8-08-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-15-89	<.2	.8	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U12D	8-08-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U13	7-19-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-17-89	.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U14	8-09-88	1.1	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-23-89	5.9	.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U14D	8-09-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U15	8-11-88	<.2	<.2	<.2	<.2	<.2	<.2	<1.2	<.2	<.2
	2-23-89	.3	.9	<.2	<.2	<.2	<.2	<.2	<.2	.3
U16	7-22-88	.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-22-89	.4	<.2	<.2	.2	<.2	<.2	<.2	<.2	<.2
U16D	7-22-88	.8	<.2	<.2	<.2	<.2	<.3	<.2	<.2	<.2
U17	8-10-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-22-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U18	7-19-88	<.2	<.2	<.2	.3	<.2	<.2	<.2	<.2	<.2
	1-27-89	.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U19	7-21-88	.5	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-31-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table 18. Concentrations of volatile organic compounds in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Time	Benzene	Bromoform	Carbon tetrachloride	Chlorobenzene	Chlorodibromomethane	Chloroethane	2-Chloroethylvinylether	Chloroform	1,2,-Dibromoethane
U19D	7-21-88	1300	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
U20	7-13-88	1120	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--
	1-30-89	1340	.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U20D	7-13-88	1438	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--
U21	7-21-88	0800	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-22-89	0945	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.2	<.2
U22	8-04-88	0820	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-13-89	1245	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.2	<.2
U22D	8-04-88	1000	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A01	7-22-88	1000	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-01-89	1325	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A02	8-25-88	1310	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	3-02-89	1115	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A03	7-15-88	1100	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--
	1-27-89	0933	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A04	8-10-88	1050	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.9	<.2
	2-13-89	0945	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.2	<.2
A04D	8-10-88	1245	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.8	<.2
A05	8-11-88	1120	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-13-89	1215	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A05D	8-11-88	1250	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.3	<.2
A06	7-14-88	1120	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--
	1-10-89	1000	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A06D	7-14-88	1045	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--
A07	7-20-88	1007	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-31-89	1111	.3	<.2	<.2	<.2	<.2	<.2	<.2	.4	<.2
A07D	7-20-88	1220	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A08	7-05-88	1200	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--
	1-18-89	1335	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A09	7-20-88	1512	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-31-89	1410	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A10	8-25-88	1155	.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-01-89	0915	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table 18. Concentrations of volatile organic compounds in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	1,2-Di-chloro-benzene	1,3-Di-chloro-benzene	1,4-Di-chloro-benzene	Dichloro-bromo-methane	Dichloro-difluoro-methane	1,2-Di-chloro-ethane	1,1-Dichloro-ethane	1,1-Dichloro-ethylene	1,2-Dichloro-propane
U19D	7-21-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
U20	7-13-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-30-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U20D	7-13-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U21	7-21-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-22-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U22	8-04-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-13-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U22D	8-04-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A01	7-22-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-01-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A02	8-25-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	3-02-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A03	7-15-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-27-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A04	8-10-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-13-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A04D	8-10-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A05	8-11-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-13-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A05D	8-11-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A06	7-14-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-10-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A06D	7-14-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A07	7-20-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-31-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A07D	7-20-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A08	7-05-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-18-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A09	7-20-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-31-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A10	8-25-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-01-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table 18. Concentrations of volatile organic compounds in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	1,3-Dichloropropene	Cis-1,3-dichloropropene	Trans-1,3-dichloropropene	Ethylbenzene	Methylbromide	Methylchloride	Methylene chloride	Styrene	1,1,2,2-Tetrachloroethane
U19D	7-21-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
U20	7-13-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-30-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U20D	7-13-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U21	7-21-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-22-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U22	8-04-88	<.2	<.2	<.2	<.2	<.2	<.2	<.4	<.2	<.2
	2-13-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U22D	8-04-88	<.2	<.2	<.2	<.2	<.2	<.2	<.4	<.2	<.2
A01	7-22-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-01-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A02	8-25-88	<.2	<.2	<.2	<.2	<.2	<.2	<.4	<.2	<.2
	3-02-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A03	7-15-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-27-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A04	8-10-88	<.2	<.2	<.2	<.2	<.2	<.2	<.3	<.2	<.2
	2-13-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A04D	8-10-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A05	8-11-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-13-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A05D	8-11-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A06	7-14-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-10-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A06D	7-14-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A07	7-20-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-31-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A07D	7-20-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A08	7-05-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-18-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A09	7-20-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-31-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A10	8-25-88	<.2	<.2	<.2	<.2	<.2	<.2	<.3	<.2	<.2
	2-01-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table 18. Concentrations of volatile organic compounds in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Tetra-chloro-ethylene	Toluene	1,2-Trans-dichloro-ethene	1,1,1-Tri-chloro-ethane	1,1,2-Tri-chloro-ethane	Trichloro-ethylene	Trichloro-fluoro-methane	Vinyl chloride	Xylene
U19D	7-21-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
U20	7-13-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-30-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U20D	7-13-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U21	7-21-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-22-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U22	8-04-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-13-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
U22D	8-04-88	<.2	.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A01	7-22-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-01-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A02	8-25-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	3-02-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A03	7-15-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-27-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A04	8-10-88	<.2	<.2	<.2	<.2	<.2	<.2	<.3	<.2	<.2
	2-13-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A04D	8-10-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A05	8-11-88	<.2	<.2	<.2	<.2	<.2	<.2	<19	<.2	<.2
	2-13-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A05D	8-11-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A06	7-14-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-10-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A06D	7-14-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A07	7-20-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-31-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A07D	7-20-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A08	7-05-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-18-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A09	7-20-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-31-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A10	8-25-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-01-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table 18. Concentrations of volatile organic compounds in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Time	Benzene	Bromoform	Carbon tetrachloride	Chlorobenzene	Chlorodibromomethane	Chloroethane	2-Chloroethylvinylether	Chloroform	1,2,-Dibromoethane
A10D	8-25-88	1335	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
A11	7-19-88	0900	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--
	1-27-89	1220	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A12	8-09-88	0800	<.2	<.2	<.2	1.9	<.2	<.2	<.2	<.2	<.2
	2-24-89	1440	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A12D	8-09-88	0950	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A13	7-21-88	1000	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-23-89	1450	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A13D	7-21-88	1155	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A14	7-11-88	1120	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--
	3-02-89	1300	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A14D	7-11-88	1500	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--
A15	7-18-88	1010	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--
	1-10-89	1245	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A15D	7-18-88	1240	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--
A16	8-08-88	0925	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-15-89	1355	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A16D	8-08-88	1130	.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A17	7-19-88	1400	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--
	1-18-89	0940	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A18	8-05-88	1200	.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-15-89	1045	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A19	7-07-88	1200	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--
	2-24-89	0900	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A20	8-04-88	1130	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-14-89	1235	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table 18. Concentrations of volatile organic compounds in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	1,2-Di-chloro-benzene	1,3-Di-chloro-benzene	1,4-Di-chloro-benzene	Dichloro-bromo-methane	Dichloro-difluoro-methane	1,2-Di-chloro-ethane	1,1-Dichloro-ethane	1,1-Dichloro-ethylene	1,2-Dichloro-propane
A10D	8-25-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
A11	7-19-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-27-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A12	8-09-88	<.2	<.2	.4	<.2	<.2	<.2	<.2	<.2	<.2
	2-24-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A12D	8-09-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A13	7-21-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-23-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A13D	7-21-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A14	7-11-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	3-02-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A14D	7-11-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A15	7-18-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-10-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A15D	7-18-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A16	8-08-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-15-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A16D	8-08-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A17	7-19-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-18-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A18	8-05-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-15-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A19	7-07-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-24-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A20	8-04-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-14-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table 18. Concentrations of volatile organic compounds in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	1,3-Dichloropropene	Cis-1,3-dichloropropene	Trans-1,3-dichloropropene	Ethylbenzene	Methylbromide	Methylchloride	Methylene chloride	Styrene	1,1,2,2-Tetrachloroethane
A10D	8-25-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
A11	7-19-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-27-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A12	8-09-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-24-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A12D	8-09-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A13	7-21-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-23-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A13D	7-21-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A14	7-11-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	3-02-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A14D	7-11-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A15	7-18-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-10-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A15D	7-18-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A16	8-08-88	<.2	<.2	<.2	<.2	<.2	<.2	<.3	<.2	<.2
	2-15-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A16D	8-08-88	<.2	<.2	<.2	<.2	<.2	<.2	<.4	<.2	<.2
A17	7-19-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-18-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A18	8-05-88	<.2	<.2	<.2	<.2	<.2	<.2	<.4	<.2	<.2
	2-15-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A19	7-07-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-24-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A20	8-04-88	<.2	<.2	<.2	<.2	<.2	<.2	<.5	<.2	<.2
	2-14-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table 18. Concentrations of volatile organic compounds in samples collected from Fountain Creek sites and wells, July and August 1988 and January through early March 1989—Continued

Site or well number	Date sampled	Tetra-chloro-ethylene	Toluene	1,2-Trans-dichloro-ethene	1,1,1-Tri-chloro-ethane	1,1,2-Tri-chloro-ethane	Trichloro-ethylene	Trichloro-fluoro-methane	Vinyl chloride	Xylene
A10D	8-25-88	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
A11	7-19-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-27-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A12	8-09-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-24-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A12D	8-09-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A13	7-21-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-23-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A13D	7-21-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A14	7-11-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	3-02-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A14D	7-11-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A15	7-18-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-10-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A15D	7-18-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A16	8-08-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-15-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A16D	8-08-88	<.2	<.5	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A17	7-19-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	1-18-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A18	8-05-88	<.2	<.5	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-15-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A19	7-07-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-24-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A20	8-04-88	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	2-14-89	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table 19. Concentrations of pesticides in samples collected from Fountain Creek sites and wells, July and August 1988

[<, less than; all values are expressed in micrograms per liter; --, data not available; all analyses are total recoverable, taken from unfiltered samples; see pl. 1 for locations of wells and sites]

Site or well number	Date sampled	Time	Chlorophenoxy-acid herbicides					Organochlorine insecticides			
			2,4-D	2,4-DP	Silvex	2,4,5-T	Aldrin	Chlordane	DDD	DDE	DDT
SW1	8-17-88	1425	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<0.01	<0.01	<0.01
	8-30-88	1000	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
SW2	8-17-88	1530	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
	8-30-88	1130	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
SW3	8-17-88	2240	<.09	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
	8-30-88	2015	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
SW4	8-18-88	0500	<.03	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
	8-31-88	0330	<.10	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
SW5	8-18-88	1515	<.03	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
	8-31-88	1800	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
U01	7-18-88	1018	<.05	<.05	<.01	<.01	<.01	<.1	<.01	<.01	<.01
U02	7-08-88	0945	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
U03	7-21-88	1530	<.05	<.05	<.01	<.01	<.01	<.1	<.01	<.01	<.01
U04	7-15-88	1122	<.05	<.05	<.01	<.01	<.01	<.1	<.01	<.01	<.01
U05	7-06-88	1330	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
U06	8-11-88	0845	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
U07	8-09-88	1300	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
U08	7-12-88	1301	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
U09	7-20-88	0950	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
U10	8-10-88	1210	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
U11	8-05-88	1025	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
U12	8-08-88	1145	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
U13	7-19-88	1345	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
U14	8-09-88	1100	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
U15	8-11-88	1120	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
U16	7-22-88	1045	<.05	<.05	<.01	<.01	<.01	<.1	<.01	<.01	<.01
U17	8-10-88	0930	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
U18	7-19-88	0940	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
U19	7-21-88	1015	<.05	<.05	<.01	<.01	<.01	<.1	<.01	<.01	<.01
U20	7-13-88	1120	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
U21	7-21-88	0800	<.05	<.05	<.01	<.01	<.01	<.1	<.01	<.01	<.01
U22	8-04-88	0820	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01

Table 19. Concentrations of pesticides in samples collected from Fountain Creek sites and wells, July and August 1988—Continued

Site or well number	Date sampled	Organochlorine pesticides									
		Dieldrin	Endo-sulfan	Endrin	Hepta-chlor	Hepta-chlor epoxide	Lin-dane	Methoxy-chlor	Mirex	Per-thane	Toxa-phene
SW1	8-17-88	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<1
	8-30-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
SW2	8-17-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
	8-30-88	<.01	<.01	<.01	<.01	<.01	.01	<.01	<.01	<.1	<1
SW3	8-17-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
	8-30-88	<.01	<.01	<.01	<.01	<.01	.01	<.01	<.01	<.1	<1
SW4	8-18-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
	8-31-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
SW5	8-18-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
	8-31-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
U01	7-18-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
U02	7-08-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
U03	7-21-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
U04	7-15-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
U05	7-06-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
U06	8-11-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
U07	8-09-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
U08	7-12-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
U09	7-20-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
U10	8-10-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
U11	8-05-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
U12	8-08-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
U13	7-19-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
U14	8-09-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
U15	8-11-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
U16	7-22-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
U17	8-10-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
U18	7-19-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
U19	7-21-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
U20	7-13-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
U21	7-21-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
U22	8-04-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1

Table 19. Concentrations of pesticides in samples collected from Fountain Creek sites and wells, July and August 1988—Continued

Site or well number	Date sampled	Biphenyls, polychlorinated	Naphthalenes, polychlorinated	Organophosphorus insecticides						
				Diazinon	Ethion	Malathion	Methyl parathion	Methyl trithion	Parathion	Trithion
SW1	8-17-88	<0.1	<0.1	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	8-30-88	<.1	<.1	.01	<.01	<.01	<.01	<.01	<.01	<.01
SW2	8-17-88	<.1	<.1	.09	<.01	.04	<.01	<.01	<.01	<.01
	8-30-88	<.1	<.1	.15	<.01	.01	<.01	<.01	<.01	<.01
SW3	8-17-88	<.1	<.1	.06	<.01	.10	<.01	<.01	<.01	<.01
	8-30-88	<.1	<.1	.10	<.01	<.01	<.01	<.01	<.01	<.01
SW4	8-18-88	<.1	<.1	.09	<.01	.03	<.01	<.01	<.01	<.01
	8-31-88	<.1	<.1	.04	<.01	<.01	<.01	<.01	<.01	<.01
SW5	8-18-88	<.1	<.1	.08	<.01	.03	<.01	<.01	<.01	<.01
	8-31-88	<.1	<.1	.01	<.01	<.01	<.01	<.01	<.01	<.01
U01	7-18-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
U02	7-08-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
U03	7-21-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
U04	7-15-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
U05	7-06-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
U06	8-11-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
U07	8-09-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
U08	7-12-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
U09	7-20-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
U10	8-10-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
U11	8-05-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
U12	8-08-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
U13	7-19-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
U14	8-09-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
U15	8-11-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
U16	7-22-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
U17	8-10-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
U18	7-19-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
U19	7-21-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
U20	7-13-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
U21	7-21-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
U22	8-04-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01

Table 19. Concentrations of pesticides in samples collected from Fountain Creek sites and wells, July and August 1988—Continued

Site or well number	Date sampled	Triazines and other nitrogen-containing herbicides									
		Alachlor	Ametryn	Atrazine	Cyanazine	Prometon	Prometryn	Propazine	Simazine	Simetryn	Trifluralin
SW1	8-17-88	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	<0.1	0.1	<0.1	<0.1
	8-30-88	<.1	<.1	<.1	<.1	.1	<.1	<.1	<.1	<.1	<.1
SW2	8-17-88	<.1	<.1	<.1	<.1	.5	<.1	<.1	.1	<.1	<.1
	8-30-88	<.1	<.1	<.1	<.1	.1	<.1	<.1	<.1	<.1	<.1
SW3	8-17-88	<.1	<.1	<.1	<.1	.3	<.1	<.1	.1	<.1	<.1
	8-30-88	<.1	<.1	<.1	<.1	.1	<.1	<.1	<.1	<.1	<.1
SW4	8-18-88	<.1	<.1	<.1	<.1	.2	<.1	<.1	.1	<.1	<.1
	8-31-88	<.1	<.1	<.1	<.1	.1	<.1	<.1	<.1	<.1	<.1
SW5	8-18-88	<.1	<.1	<.1	<.1	.3	<.1	<.1	<.1	<.1	<.1
	8-31-88	--	--	--	--	--	--	--	--	--	--
U01	7-18-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
U02	7-08-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
U03	7-21-88	<.1	<.1	<.1	.1	<.1	<.1	<.1	<.1	<.1	<.1
U04	7-15-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
U05	7-06-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
U06	8-11-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
U07	8-09-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
U08	7-12-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
U09	7-20-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
U10	8-10-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
U11	8-05-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
U12	8-08-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
U13	7-19-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
U14	8-09-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
U15	8-11-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
U16	7-22-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
U17	8-10-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
U18	7-19-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
U19	7-21-88	<.1	<.1	<.1	.2	<.1	<.1	<.1	<.1	<.1	<.1
U20	7-13-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
U21	7-21-88	<.1	<.1	<.1	.1	.2	<.1	<.1	<.1	<.1	<.1
U22	8-04-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1

Table 19. Concentrations of pesticides in samples collected from Fountain Creek sites and wells, July and August 1988—Continued

Site or well number	Date sampled	Time	Chlorophenoxy-acid herbicides					Organochlorine insecticides			
			2,4-D	2,4-DP	Silvex	2,4,5-T	Aldrin	Chlordane	DDD	DDE	DDT
A01	7-22-88	1000	<0.05	<0.05	<0.01	<0.01	<0.01	<0.1	<0.01	<0.01	<0.01
A02	8-03-88	1245	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
A03	7-15-88	1100	<.05	<.05	<.01	<.01	<.01	<.1	<.01	<.01	<.01
A04	8-10-88	1050	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
A05	8-11-88	1120	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
A06	7-14-88	1120	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
A07	7-20-88	1007	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
A08	7-05-88	1200	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
A09	7-20-88	1512	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
A10	8-03-88	0735	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
A11	7-19-88	0900	<.05	<.05	<.01	<.01	<.01	<.1	<.01	<.01	<.01
A12	8-09-88	0800	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
A13	7-21-88	1000	<.05	<.05	<.01	<.01	<.01	<.1	<.01	<.01	<.01
A14	7-11-88	1120	<.01	<.01	<.01	<.01	--	--	--	--	--
A15	7-18-88	1010	<.05	<.05	<.01	<.01	<.01	<.1	<.01	<.01	<.01
A16	8-08-88	0925	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
A17	7-19-88	1400	<.05	<.05	<.01	<.01	<.01	<.1	<.01	<.01	<.01
A18	8-05-88	1200	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
A19	7-07-88	1200	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01
A20	8-04-88	1130	<.01	<.01	<.01	<.01	<.01	<.1	<.01	<.01	<.01

Table 19. Concentrations of pesticides in samples collected from Fountain Creek sites and wells, July and August 1988—Continued

Site or well number	Date sampled	Organochlorine pesticides									
		Dieldrin	Endo-sulfan	Endrin	Hepta-chlor	Hepta-chlor epoxide	Lin-dane	Methoxy-chlor	Mirex	Per-thane	Toxa-phene
A01	7-22-88	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	<1
A02	8-03-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
A03	7-15-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
A04	8-10-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
A05	8-11-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
A06	7-14-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
A07	7-20-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
A08	7-05-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
A09	7-20-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
A10	8-03-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
A11	7-19-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
A12	8-09-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
A13	7-21-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
A14	7-11-88	--	--	--	--	--	--	--	--	--	--
A15	7-18-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
A16	8-08-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
A17	7-19-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
A18	8-05-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
A19	7-07-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1
A20	8-04-88	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.1	<1

Table 19. Concentrations of pesticides in samples collected from Fountain Creek sites and wells, July and August 1988—Continued

Site or well number	Date sampled	Biphenyls, polychlorinated	Naphthalenes, polychlorinated	Organophosphorus insecticides						
				Diazinon	Ethion	Malathion	Methyl parathion	Methyl trithion	Parathion	Trithion
A01	7-22-88	<0.1	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
A02	8-03-88	--	<.1	.10	<.01	<.01	<.01	<.01	<.01	<.01
A03	7-15-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
A04	8-10-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
A05	8-11-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
A06	7-14-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
A07	7-20-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
A08	7-05-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
A09	7-20-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
A10	8-03-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
A11	7-19-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
A12	8-09-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
A13	7-21-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
A14	7-11-88	--	--	--	--	--	--	--	--	--
A15	7-18-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
A16	8-08-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
A17	7-19-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
A18	8-05-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
A19	7-07-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01
A20	8-04-88	<.1	<.1	<.01	<.01	<.01	<.01	<.01	<.01	<.01

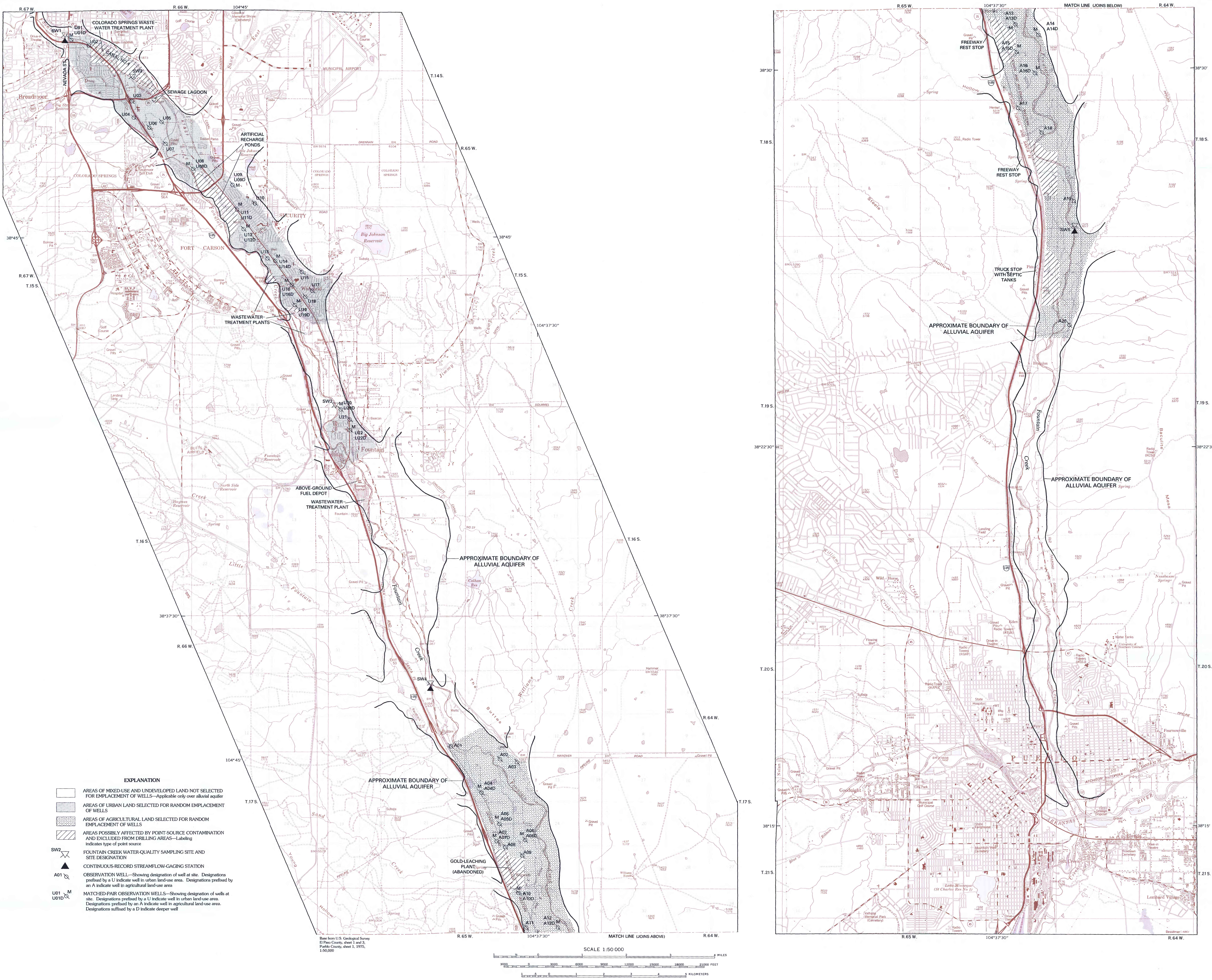
Table 19. Concentrations of pesticides in samples collected from Fountain Creek sites and wells, July and August 1988—Continued

Site or well number	Date sampled	Triazines and other nitrogen-containing herbicides									
		Alachlor	Ametryn	Atrazine	Cyanazine	Prometon	Prometryn	Propazine	Simazine	Simetryn	Trifluralin
A01	7-22-88	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
A02	8-03-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
A03	7-15-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
A04	8-10-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
A05	8-11-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
A06	7-14-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
A07	7-20-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
A08	7-05-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
A09	7-20-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
A10	8-03-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
A11	7-19-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
A12	8-09-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
A13	7-21-88	<.1	<.1	<.1	.1	<.1	<.1	<.1	<.1	<.1	<.1
A14	7-11-88	<.1	<.1	<.1	<.1	.1	<.1	<.1	<.1	<.1	<.1
A15	7-18-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
A16	8-08-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
A17	7-19-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
A18	8-05-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
A19	7-07-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
A20	8-04-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1

*U.S. GOVERNMENT PRINTING OFFICE 1997-0-774-216/40010

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

WATER-SUPPLY PAPER 2381-D
Fountain Creek Land-Use Effects—PLATE 1
Chafin, D.T., 1996, Effects of land use on water
quality of the Fountain Creek alluvial aquifer,
east-central Colorado



EXPLANATION

☐ AREAS OF MIXED-USE AND UNDEVELOPED LAND NOT SELECTED FOR EMPLACEMENT OF WELLS—Applicable only over alluvial aquifer

▒ AREAS OF URBAN LAND SELECTED FOR RANDOM EMPLACEMENT OF WELLS

▒ AREAS OF AGRICULTURAL LAND SELECTED FOR RANDOM EMPLACEMENT OF WELLS

▨ AREAS POSSIBLY AFFECTED BY POINT-SOURCE CONTAMINATION AND EXCLUDED FROM DRILLING AREAS—Labeling indicates type of point source

SW2 ▽ FOUNTAIN CREEK WATER-QUALITY SAMPLING SITE AND SITE DESIGNATION

▲ CONTINUOUS-RECORD STREAMFLOW-GAGING STATION

A01 ⌀ OBSERVATION WELL—Showing designation of well at site. Designations prefixed by a U indicate well in urban land-use area. Designations prefixed by an A indicate well in agricultural land-use area

U01 U01D M ⌀ MATCHED-PAIR OBSERVATION WELLS—Showing designation of wells at site. Designations prefixed by a U indicate well in urban land-use area. Designations prefixed by an A indicate well in agricultural land-use area. Designations suffixed by a D indicate deeper well

Base from U.S. Geological Survey
El Paso County, sheet 1 and 3,
Pueblo County, sheet 1, 1975,
1:50,000

MAP SHOWING FOUNTAIN CREEK ALLUVIAL AQUIFER IN EAST-CENTRAL COLORADO AND LOCATIONS OF FOUNTAIN CREEK SAMPLING SITES AND OBSERVATION WELLS

by

Daniel T. Chafin

1996

☆ U.S. GOVERNMENT PRINTING OFFICE 1997—774-068