Quality of Water in the Alluvial Aquifer and Tributary Alluvium of the Fountain Creek Valley, Southwestern El Paso County, Colorado, 1991-92

by Michael E. Lewis

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 94-4118

Prepared in cooperation with the
COLORADO SPRINGS UTILITIES,
WASTEWATER DEPARTMENT

Denver, Colorado
1995

Supersedes Interim Report Published in 1994

U.S. DEPARTMENT OF THE INTERIOR

BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY

Gordon P. Eaton, Director

For additional information write to:

District Chief
U.S. Geological Survey
Box 25046, MS 415
Denver Federal Center
Denver, CO 80225

Copies of this report can be purchased from:

U.S. Geological Survey
Earth Science Information Center
Open-File Reports Section
Box 25286, MS 517
Denver Federal Center
Denver, CO 80225

CONTENTS

Plate

[In-pocket]

FIGURES

TABLES

CONVERSION FACTORS, ABBREVIATED WATER-QUALITY TERMS, AND VERTICAL DATUM

Multiply	By	To obtain
acre-foot (acre-ft)	1,233	cubic meter
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
inch (in.)	25.4	centimeter
foot (ft)	0.3048	meter

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

$$°F = 9/5\ (°C) + 32.$$

The following terms and abbreviations also are used in this report:

microgram per liter (µg/L)

milligram (mg)

milligram per liter (mg/L)

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."

Quality of Water in the Alluvial Aquifer and Tributary Alluvium of the Fountain Creek Valley, Southwestern El Paso County, Colorado, 1991–92

By Michael E. Lewis

Abstract

The alluvial aquifer in the Fountain Creek Valley is the primary municipal water supply for the communities of Stratmoor Hills, Security, and Widefield and is a supplemental supply for Colorado Springs, Colorado. As such, about 5,000 to 6,000 acre-feet of the estimated 18,000 acre-feet of water stored in the aquifer are pumped annually. Therefore, the quality of water pumped from the aquifer is a major concern. Since 1981, concentrations of dissolved nitrite plus nitrate as nitrogen (nitrate) have exceeded the Federal drinking-water maximum contaminant level of 10 milligrams per liter in several areas of the aquifer. The source of increased nitrate concentrations in the aquifer was thought to be Fountain Creek. Water-quality data collected quarterly in 1991 and 1992 from a network of 63 wells were used to define the spatial and temporal variations in concentrations of dissolved oxygen, dissolved solids, major ions, and nitrogen in the aquifer.

Fountain Creek and the aquifer are hydraulically connected throughout much of the study area. The connection is present as discontinuous bedrock lows where the creek and the aquifer are in contact. In the areas where the creek and the aquifer are hydraulically connected, the hydraulic gradient controls the direction of flow between the creek and the aquifer. Ground-water flow generally was toward Fountain Creek during 1991 and 1992, although short-term increases in stream stage in Fountain Creek might have resulted in short-term flow from the creek to the aquifer.

Dissolved-oxygen concentrations in the aquifer ranged from 0.0 to 8.2 milligrams per liter. Concentrations of dissolved oxygen generally were smaller near the interface of Fountain Creek and the aquifer than in the main body of the aquifer. Dissolved-solids concentrations were generally larger near the creek than in the main body of the aquifer; calcium bicarbonate type water was the predominant water type in the main body of the aquifer. Tributary alluvium inflow and surface recharge from precipitation and lawn watering are the primary sources of recharge and the resulting small dissolved-solids concentrations in the main body of the aquifer.

Concentrations of dissolved nitrate in the aquifer ranged from less than 0.05 to 17 milligrams per liter. Considerable spatial variability occurred in nitrogen concentrations. Concentrations generally were smaller near Fountain Creek than in the main body of the aquifer. Denitrification near the interface of Fountain Creek and the aquifer was indicated to be the cause of the small nitrogen concentrations in ground water near the creek. Several sources of indirect evidence indicate that major sources of nitrogen in the ground water may include natural soil nitrogen, lawn fertilizers, and leakage from industrial-waste lagoons: (1) Relatively fresh, surface-derived water in the aquifer coincides with the area of larger dissolved nitrite-plus-nitrate concentrations; (2) ground water flows from the densely populated residential areas toward Fountain Creek; (3) a rapidly expanding residential population is increasing surface-derived recharge and associated nitrogen from lawn watering and fertilization; (4) median dissolved-oxygen concentrations in the lower- and upper-terrace-alluvium wells are 4.2 and 4.9 milligrams per liter, compared to a median concentration of 0.3 milligram per liter near Fountain Creek; (5) nitrogen-isotope ratios are 6.2 to 6.3 per mil in the main body of the

aquifer; and (6) concentrations of dissolved nitrate are as large as 475 milligrams per liter in ground water downgradient from leaking industrial-waste lagoons.

INTRODUCTION

The shallow, unconfined alluvial aquifer that is located adjacent to Fountain Creek in southwestern El Paso County between Colorado Springs and Widefield (pl. 1) is a primary source of drinking water for the communities of Stratmoor Hills, Security, and Widefield and is a supplemental source of water for Colorado Springs. Historically, water pumped from the aquifer primarily was used for agricultural irrigation until the mid- to late 1950's, when the demand for municipal and industrial water for the rapidly developing area increased. Currently (1992) about 5,000 to 6,000 acre-ft of the estimated 18,000 acre-ft of stored water are pumped annually for municipal usage (Edelmann and Cain, 1985); therefore, the quality of water available in the aquifer is very important.

A previous investigation (Edelmann and Cain, 1985) indicated that concentrations of dissolved nitrite plus nitrate as nitrogen in some parts of the aquifer exceeded the Federal drinking-water maximum contaminant level of 10 mg/L (U.S. Environmental Protection Agency, 1986). The primary source of nitrogen to the aquifer was indicated to be recharge from Fountain Creek (Edelmann and Cain, 1985). Treated sewage effluent is discharged to Fountain Creek by the Colorado Springs Wastewater Treatment Plant and was reported by Edelmann and Cain (1985) to be the primary source of nitrogen in the creek. The findings of Edelmann and Cain (1985) primarily were based on the results of analyses of water samples collected from a network of large-capacity production wells that are situated along the central northwest-to-southeast axis of the aquifer (pl. 1); very limited hydrogeologic or water-quality data were available for areas at the aquifer boundaries. The present study was undertaken in 1991 and 1992 by the U.S. Geological Survey, in cooperation with Colorado Springs Utilities, Wastewater Department, to determine the hydrogeologic characteristics of the alluvial aquifer and adjacent deposits of the Fountain Creek Valley and to determine the water quality of the water in the aquifer and in the tributary alluvium.

Purpose and Scope

This report describes the water quality of water in the alluvial aquifer, which includes the adjacent tributary alluvium, of the Fountain Creek Valley. The spatial distributions of dissolved oxygen, dissolved solids, major ions, and dissolved nitrite plus nitrate as nitrogen (hereinafter referred to as nitrate) for 63 wells in the alluvium of the Fountain Creek Valley and the distributions of dissolved solids and nitrate as a function of time, from 1981 through 1992 for five of the wells, are discussed. This report is the second report for the study; the first report (Radell and others, 1994) presented water-table, saturated-thickness, and bedrock-contour maps, in addition to geologic sections and a discussion of ground-water flow at the aquifer boundaries. Some of the hydrogeologic information from that first report are included in this report.

Water-quality samples were collected quarterly from July 1991 through October 1992. Water samples for analysis of concentrations of dissolved solids, major ions (including phosphorus, iron, and manganese), nitrogen, and phosphorus were collected in July or August 1991 and August 1992 from 46 2-in. monitoring wells, 12 large-capacity production wells, 3 irrigation wells, and 2 domestic-supply wells (pl. 1). Water samples for analysis of dissolved-nitrogen concentrations also were collected in November 1991 and February, May, and October 1992 from a subset of the larger network of 63 wells and included 29 2-in. monitoring wells, 7 large-capacity production wells, 1 irrigation well, and 2 domestic-supply wells. Onsite measurements of specific conductance, pH, and temperature were made at all wells, and onsite measurements of dissolved-oxygen concentration were made at all 2-in. monitoring wells. In February 1992, water samples collected from six monitoring wells, one municipal supply well, one irrigation well, and one surface-water station, 07105530, Fountain Creek below Janitell Road below Colorado Springs (hereinafter referred to as the Janitell Road station), were analyzed for nitrogen isotopes.

Water-Quality Sampling

The 2-in. monitoring wells were sampled using a PVC bladder pump that had a Teflon bladder and polypropylene tubing. Water was discharged from the tubing into a flow-through, air-exclusion sample chamber equipped with probes for measuring water temperature, dissolved oxygen, pH, and specific conductance. Samples were not collected until a minimum of three casing volumes were pumped from each well and measurements of water temperature, dissolved oxygen, pH, and specific conductance had stabilized. Samples were collected from the outflow of the flow-through chamber. Production wells, irrigation wells, and domestic-supply wells were sampled directly from their pump outflow after being pumped a minimum of 10 minutes and measurements of water temperature, pH, and specific conductance had stabilized. Analyses of samples for concentrations of water-quality constituents, except nitrogen isotopes, were done by the U.S. Geological Survey National Water Quality Laboratory in Arvada, Colorado, according to methods described in Fishman and Friedman (1989). Nitrogen-isotope analyses were made by Global Geochemistry in Canoga Park, California.

Acknowledgments

The following municipal representatives provided valuable information and facilitated access to production wells for water-quality sampling: Robert T. Schrader and Bobby G. Padgett with the Security Water and Sanitation District; Donald C. Lohrmeyer and Ken Roadcamp with Widefield Homes, Inc.; and Elmer J. Wahlborg with the Stratmoor Hills Water and Sanitation District.

Rex L. William with Eagle-Picher Industries, Inc.; John Willian with Schlage Lock Co.; William P. Johnsen, Wenck Associates, Inc.; and John McDermott with Capsule Environmental Engineering provided hydrogeologic and water-quality data. Gary B. Thompson with W.W. Wheeler and Associates, Inc., provided pumpage data for production wells in Stratmoor Hills, Security, and Widefield.

DESCRIPTION OF STUDY AREA

Physical and Hydrogeologic Setting

The study area consists of an alluvial valley and adjacent terraces and tributary valleys that extend from Colorado Springs to Widefield (pl. 1). The valley is drained by Fountain Creek and is bordered by the terraces that rise to more than 200 ft above the valley floor. Daily streamflow in Fountain Creek in the study area averaged about 95 ft^3/s at the Janitell Road station in 1991 and 1992. Considerable variation in daily streamflow occurs as a result of snowmelt runoff, intense summer rainstorms, and releases of treated wastewater effluent from the Colorado Springs Wastewater Treatment Plant. More detailed discussions of the physical and geologic setting of the Fountain Creek Valley have been presented by Jenkins (1964), Scott and Wobus (1973), Livingston and others (1976), Edelmann and Cain (1985), and Radell and others (1994).

The alluvial aquifer and the tributary alluvium of the Fountain Creek Valley are in eroded ancestral channels of Fountain Creek and its adjacent tributary valleys between Colorado Springs and Widefield (pl. 1). For the purposes of this report, the study area has been divided into three sections based on physiographic and hydrogeologic setting: (1) Creek bottom, (2) lower terrace, and (3) upper terrace (pl. 1). The creek-bottom section of the study area extends about 300 to 500 ft on either side of Fountain Creek (pl. 1). The creek bottom (or flood plain) is a flat, low-lying, undeveloped area that rises about 10 ft above the creek. On the east and west sides of the creek bottom is the lower terrace (pl. 1). The lower terrace rises about 10 to 60 ft above Fountain Creek. Extensive residential and commercial development exists throughout much of the lower terrace. The upper terrace rises about 60 to more than 200 ft above Fountain Creek and is located predominantly to the east of Fountain Creek (pl. 1). Land use in the upper terrace includes extensive residential and commercial development and limited industrial development.

The Fountain Creek Valley alluvial aquifer consists of alluvial sediments of the Quaternary age that range from fine sand to cobbles and include variable quantities of silt and clay. Pierre Shale, which is a thick marine shale of Cretaceous age, underlies the alluvium throughout the study area and is considered impermeable to ground-water flow. The shale bedrock surface has been eroded by Fountain Creek and generally follows the overall northwest to southeast trend of the aquifer. The main body of the aquifer is within a buried ancestral channel of Fountain Creek that is eroded into bedrock of the Pierre Shale. Aquifer material in the creek bottom is Piney Creek Alluvium, which is a firmly compacted clayey silt and sand that has low to medium permeability and is subject to seasonal flooding (Scott and Wobus, 1973). Aquifer material in the lower terrace east of Fountain Creek is mainly Broadway Alluvium, which is a very permeable, gravelly alluvium. Aquifer materials in the lower terrace west of Fountain Creek include the Piney Creek Alluvium and the Verdos Alluvium (Scott and Wobus, 1973). The Verdos Alluvium is a poorly sorted gravel containing lenses of sand, silt, and clay. The alluvium located in the lower terrace west of Fountain Creek generally is thinner than east of Fountain Creek and wedges out against bedrock of the Pierre Shale to the west. Aquifer material in the upper terrace includes

Piney Creek Alluvium adjacent to Sand Creek; areas of eolian sand overlie older, alluvial deposits, including the Broadway and the Verdos Alluvium to the south of Sand Creek (Scott and Wobus, 1973).

The thickness of the alluvium ranges from 0 to about 100 ft; the saturated thickness varies from 0 to about 45 ft (Radell and others, 1994). Areas of saturated alluvial fill are located in ancient, buried tributary channels in the shale. Unsaturated alluvium and eolian sand are on ridges or geographic highs of the bedrock and separate areas of saturated alluvial fill. Saturated thickness in the creek bottom generally ranges from 0 to about 20 ft, and water levels are subject to rapid, short-term fluctuations that correspond to changes in stream stage in Fountain Creek. Saturated thickness in the lower terrace ranges from about 10 to almost 40 ft. The largest saturated thickness is along the central longitudinal (northwest to southeast) axis of the aquifer and in the tributary valleys between Sand Creek and Windmill Gulch.

The direction of regional ground-water flow in the saturated alluvium in the study area is from the northwest to the southeast. Locally in the aquifer and tributary alluvium, water flow is toward Fountain Creek throughout most of the study area. Hydraulic connection between the creek and aquifer and differences in water levels between the creek and aquifer are the determining factors in whether water flows from the creek to the aquifer instead of from the aquifer to the creek. Recharge sources of the alluvial aquifer include inflow from tributary alluvium; recharge from the land surface, which includes precipitation and lawn watering; leakage from Fountain Creek, Sand Creek, and Canal No. 4; and very limited agricultural irrigation.

Hydraulic connection between Fountain Creek and the aquifer is dependent on the geometry of the bedrock of Pierre Shale underlying and adjacent to the creek. Cross sections of the creek and the aquifer (Edelmann and Cain, 1985; Radell and others, 1994) and a reconnaissance of the creek indicated that hydraulic connection is not continuous but rather exists as discontinuous bedrock lows in the shale where the creek and the aquifer are in contact. Hydraulic connection is prevented in areas where the creek bed is incised into the shale and where a shale bedrock high separates the creek from the aquifer.

In areas where hydraulic connection exists between the creek and the aquifer, the direction of flow between the creek and the aquifer is dependent on the difference in water levels between the two. During 1991 and 1992, water levels in the aquifer remained relatively high, thus, resulting in a hydraulic gradient toward Fountain Creek. The difference in water levels between the creek and the aquifer can vary daily, seasonally, and for longer periods of time, depending on climatic and hydrologic conditions. Increased stream stage resulting from wastewater-treatment-plant discharges, precipitation, or spring snowmelt runoff can cause a decrease in the rate of flow from the aquifer to the creek or can result in flow from the creek to the aquifer. The local ground-water gradient near the stream may be reversed if the stream stage increases above the water level in the aquifer. The flow from the stream to the aquifer results in bank storage; bank storage returns to the creek when the stream stage decreases. The length of time that bank storage stays in the aquifer is dependent on how long the stream stage remains high. A small amount of streamflow generally is lost to bank storage (Kuhn, 1988). The amount of water lost to permanent storage is dependent on the length of the time necessary for bank storage to return to the stream. Ground-water pumpage that results in the drawdown of the aquifer can result in more flow from the creek to the aquifer.

Climate

The climate of the study area is semiarid and is characterized by hot summers, cold winters, and mean annual precipitation of about 15.4 in. About 80 percent of the annual precipitation occurs between April and September. During 1949–92, annual precipitation at the Colorado Springs weather station, located at the Colorado Springs airport, ranged from 8.59 in. in 1964 to 25.43 in. in 1965 (fig. 1). The cumulative departure from the mean annual precipitation from 1949 to 1992, which indicates temporal trends in precipitation, also is shown in figure 1. There was a cumulative decrease in precipitation in 1949–56, 1958–64, and 1972–75. A cumulative increase in precipitation occurred from 1975–92.

Ground-Water Pumpage

Pumpage from the aquifer primarily was used for agricultural irrigation until the mid-1950's (fig. 2). As the demand for municipal water increased, total withdrawals increased from less than 2,000 acre-ft/yr in 1950 to more than 6,000 acre-ft/yr in the early 1960's. Withdrawals were largest during 1964–78; total withdrawals exceeded 7,000 acre-ft/yr in 12 of the 15 years. Since 1979, annual withdrawals have averaged about 6,000 acre-ft/yr. During 1991 and 1992, annual withdrawals were less than 5,000 acre-ft/yr; the smallest annual withdrawal in more than 30 years.

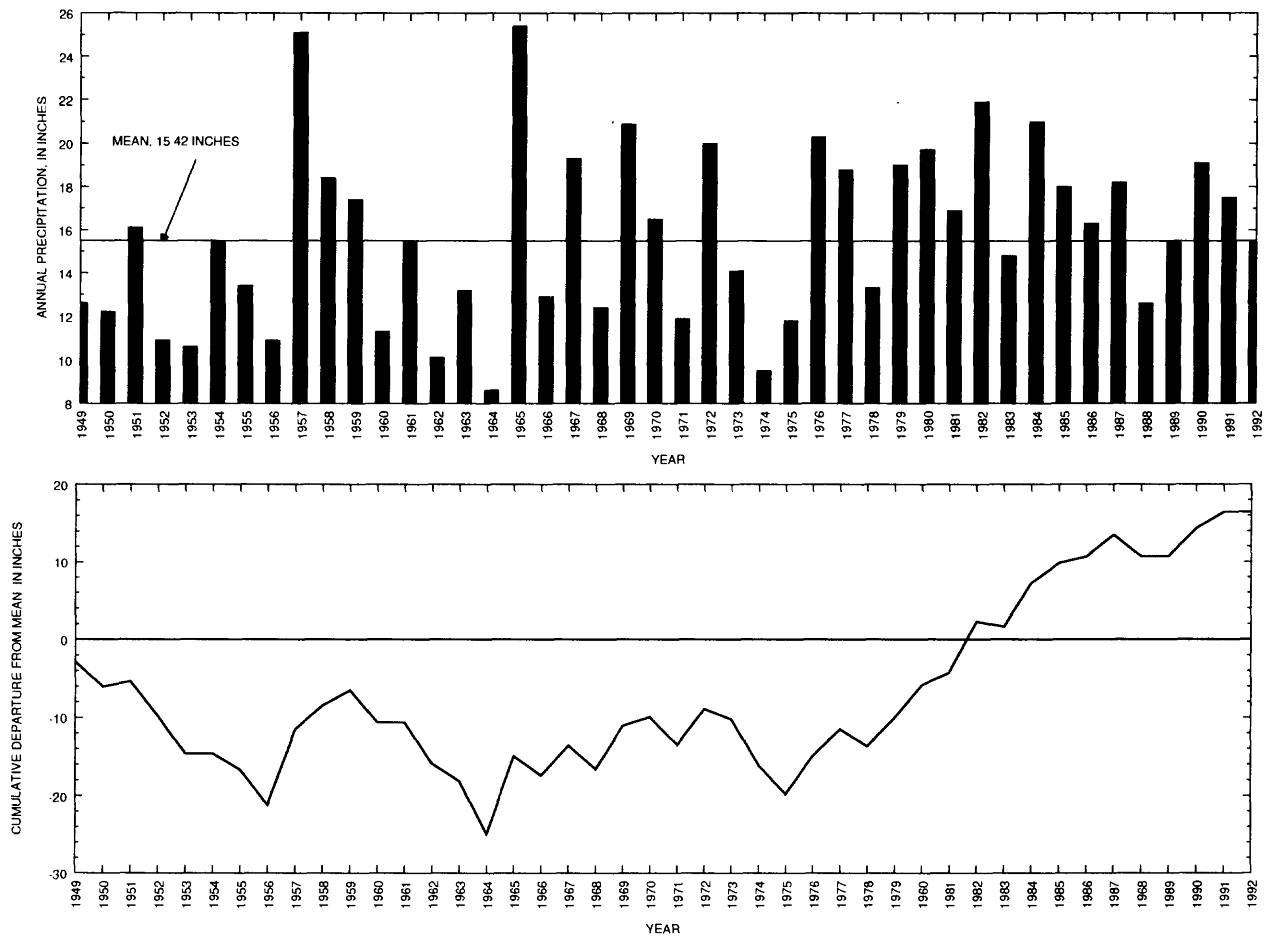

Figure 1. Annual precipitation and cumulative departure from mean (1949–92) at Colorado Springs.

Because of withdrawals for municipal water supplies, ground-water levels have been subject to drawdowns in the summer (June–August) when pumpage is largest. Drawdowns of 15 to 20 ft were common in the summers prior to 1979 (G.B. Thompson, W.W. Wheeler and Associates, written commun., 1992). The water levels generally recovered during the remainder of the year. In 1975, the water users of the aquifer entered into a water-use agreement that stipulates the timing and magnitude of pumping from the aquifer (G.B. Thompson, written commun., 1992). Ground-water-level declines have been much less severe since 1979 through the present (1992) because of better management of pumpage, increased recharge from larger than mean precipitation, and increased recharge from lawn irrigation. Residential development and the area subject to lawn watering have increased substantially since 1983. Between 1983 and 1992, the number of water customers served by the Security Water and Sanitation District increased about 50 percent and of the Widefield Homes, Inc., about 22 percent (R.T. Schrader, Security Water and Sanitation District, written commun., 1992; Ken Roadcamp, Widefield Homes, Inc., oral commun., 1992).

WATER QUALITY

Water quality in the aquifer is highly variable as a result of (1) numerous sources of aquifer recharge that have variable water-quality characteristics, (2) the extent to which different recharge sources mix within the aquifer, (3) the existence of numerous point and nonpoint sources of contamination, and (4) chemical and biological processes that affect water chemistry. Ground-water-quality data collected for this study are presented in tables 3–5 in the "Supplemental Data" section at the back of this report.

Dissolved Oxygen

Dissolved-oxygen (DO) concentrations in the aquifer ranged from completely anoxic in the creek bottom to 8.2 mg/L in the terraces (tables 3, 4, and 5). The DO concentration of water from various wells was a function of the source of water recharging a particular area and the biochemical processes occurring in the sediment through which water passed. DO concentrations were smallest in the creek-bottom wells; the

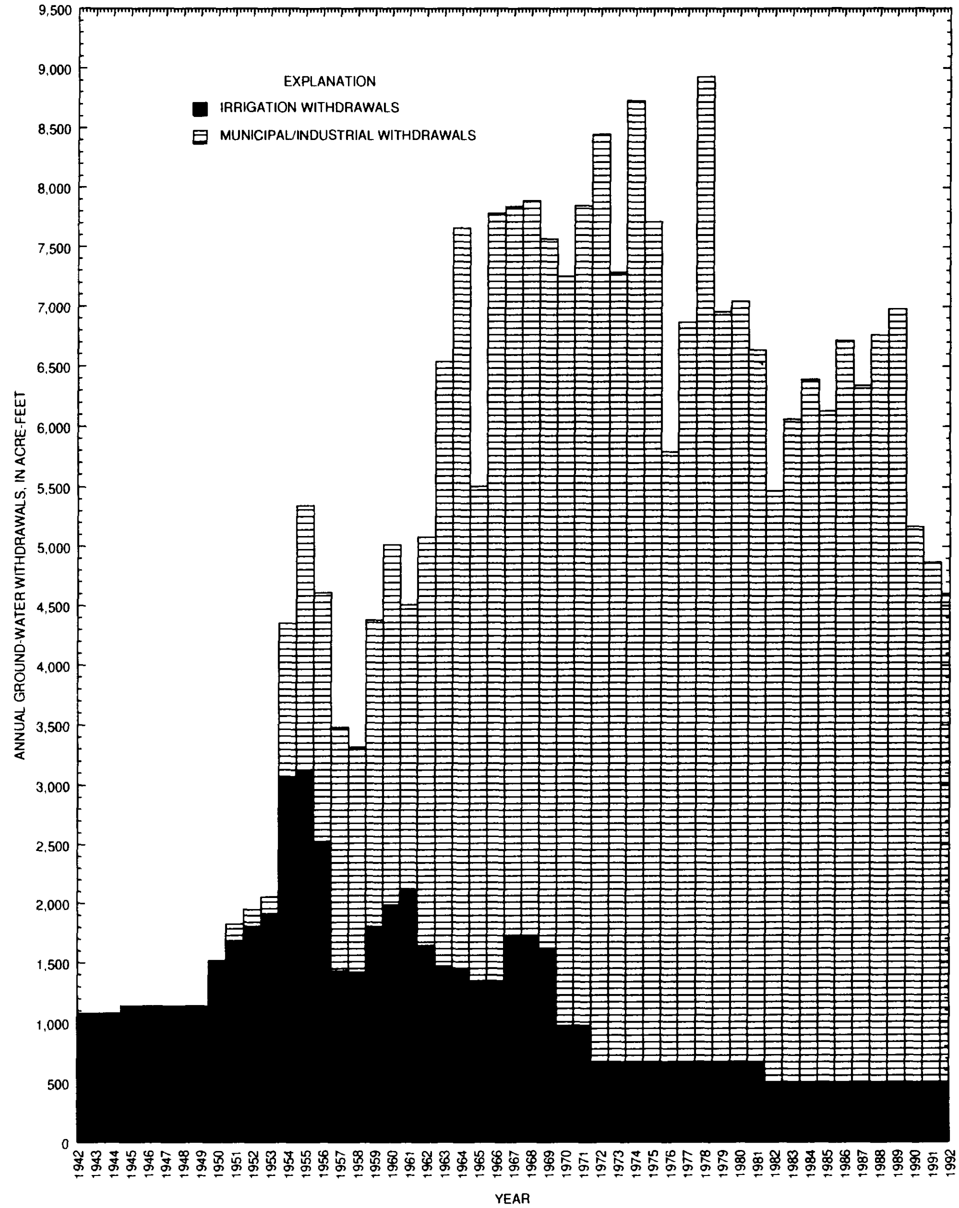

Figure 2. Ground-water withdrawals from the alluvial aquifer of the Fountain Creek Valley, 1942–92.

median concentration was 0.3 mg/L. DO concentrations in many of these creek-bottom wells seem to have been depleted by microbiological activity at the interface between Fountain Creek and the aquifer. The wells with small DO concentrations were located within about 25 to 300 ft of the creek. The microbiological decomposition of organic material in the creek sediments probably resulted in some decrease of DO concentrations in creek water that entered the aquifer (Bourg and Bertin, 1993) as short- or long-term bank storage. DO probably also was consumed by nitrification of ammonia to nitrate. Ground water in the lower and upper terraces generally was well oxygenated; the median DO concentration for wells in the lower terrace was 4.2 mg/L and for wells in the upper terrace was 4.9 mg/L. DO concentrations in most wells generally did not vary substantially during 1991 and 1992.

Dissolved Solids and Major Ions

Dissolved-solids concentration is a measure of the dissolved mineral content of water and is indicative of the inorganic quality of water. Ground-water samples collected in July or August 1991 and August 1992 were analyzed for dissolved-solids and major-ion concentrations (tables 3–5). Samples collected during the other quarterly sampling periods were analyzed for specific conductance, which can be used to estimate dissolved-solids concentrations. Specific conductance is the ability of water to conduct an electrical current and varies directly with the ionic strength of a solution; as the concentration of ions or dissolved solids increases, specific conductance increases. Dissolved-solids concentrations in all wells sampled in November 1991 and February, May, and October 1992 were estimated using a linear regression of dissolved-solids concentration and specific conductance, which was produced with dissolved-solids and specific-conductance data from the July and August 1991 and August 1992 water samples. The regression equation

$$DS = -105 + 0.764 \times SC,$$

where

DS = dissolved-solids concentration, in milligrams per liter; and

SC = specific conductance, in microsiemens per centimeter at 25 degrees Celsius.

The regression equation had an r^2 (coefficient of determination) of 0.99 and a standard error of 7.0 percent. The distribution of median concentrations of measured and calculated dissolved solids is shown on plate 2.

Dissolved-solids concentrations in the aquifer generally decreased with increasing distance from Fountain Creek (pl. 2). The median concentration for water from the creek-bottom wells was 674 mg/L, for the lower-terrace wells was 447 mg/L, and for the upper-terrace wells was 370 mg/L. The decrease in dissolved solids with distance from the creek primarily is a function of the different sources of water recharging the aquifer. The larger dissolved-solids concentrations in the wells closest to the creek probably are caused by recharge from Fountain Creek, concentration of dissolved solids by phreatophyte transpiration, and underflow from the thinly saturated alluvium to the west of Fountain Creek. The smaller dissolved-solids concentrations in the lower-terrace wells than in the creek-bottom wells mostly were a result of some degree of mixing between creek-bottom ground water and fresher water from the upper terrace and tributary alluvium. The smallest dissolved-solids concentrations in the aquifer were measured in the main tributary valley to the southeast of Sand Creek and were indicative of relatively fresh, unmineralized water from surface recharge. The area of small dissolved-solids concentrations extended into the main body of the aquifer in the lower terrace, where most of the municipal wells are located (pl. 2).

The median daily dissolved-solids concentration for the Janitell Road station (pl. 1) was 498 mg/L during the study period. Dissolved-solids concentrations of Fountain Creek were determined using a linear-regression equation of dissolved-solids concentration and daily mean specific conductance. The equation had an r^2 value of 0.97 and a standard error of 4.7 percent. Large phreatophytes, such as the cottonwood trees that grow along Fountain Creek, consume large quantities of water from the very shallow saturated alluvium in the creek bottom. Through the process of evapotranspiration, large quantities of minerals can remain in the ground water, thus, concentrating the dissolved solids. Larger dissolved-solids concentrations to the west of Fountain Creek, as compared to east of Fountain Creek, might be a function of less permeable alluvium and less saturated thickness, thus, allowing for more contact time between the ground water and the Pierre Shale, more dissolution of the shale minerals, and less dilution of the minerals in the ground water.

Major-ion chemistry can be used as a general indicator of water quality and as a method of indicating water-composition differences and similarities. This information also can be used to help identify ground-water-recharge sources. Hydrochemical facies or water types were determined for each well using a classification system based on percentage of equivalents per million as described by Hem (1985). For a water type to be classified by a single cation or anion, that cation or anion must represent at least 50 percent of the total cation or anion equivalents per million. If there is no dominant cation or anion, the water is classified as a mixed type. The distribution of water types in the alluvial aquifer and the tributary alluvium for 1991 is shown on plate 3.

In the creek-bottom wells, ground water from 12 of the 16 wells was a mixed water type. The mixed water types in the creek-bottom wells are representative of recharge from Fountain Creek and some degree of mixing between other recharge sources. A review of miscellaneous analyses of the Janitell Road site from 1980 through 1992 indicates water in the creek is a mixed or mixed-cation sulfate water type.

In the lower terrace, the most common water type (from 16 of 34 wells) was calcium bicarbonate; ground water at 5 of the 34 wells in the lower terrace was a mixed-cation sulfate water type; ground water at the remaining wells was various mixed water types. In the upper terrace, ground water from 9 of the 14 wells was a calcium bicarbonate water type; ground water collected from the remaining wells had various mixed water types.

Chebotarev (1955) reported that the dominant anion in ground water tends to evolve from bicarbonate in relatively fresh recharge water to sulfate and finally chloride in older ground water that has had time to dissolve sulfate- and chloride-containing minerals in the aquifer. The area in the upper and lower terraces, which has relatively fresh water containing small dissolved-solids concentrations (pl. 2), coincides with the area having a calcium bicarbonate water type. These results indicate that surface recharge probably is a major source of recharge in these areas. Water samples from a few wells in the upper terrace had substantially larger dissolved-solids concentrations than samples from other nearby wells. Sulfate was the dominant anion in ground water from these wells. These water-quality anomalies can be caused by dissolution of shale minerals, irrigation canal leakage, water reuse, leaking sewers, or other localized sources of water-quality degradation.

Nitrogen

Nitrogen is present in the hydrologic environment in several forms, which may be stable or reactive depending on environmental conditions. Almost all of the nitrogen in the water samples collected from the monitoring-network wells was in the form of dissolved nitrate. Dissolved-nitrite concentrations generally were less than 0.02 mg/L as nitrogen (tables 3–5). As a result, nitrite is considered a negligible component of the analysis of nitrite plus nitrate. Dissolved-ammonia concentrations generally were less than 0.05 mg/L as nitrogen (tables 3, 4, and 5). No monitoring wells are located completely upgradient from all anthropogenic nitrogen sources; therefore, naturally occurring nitrate concentrations in ground water could not be estimated. Nitrate concentrations varied substantially within the study area (pl. 4), although nitrate concentrations in any given well generally did not vary substantially during 1991 and 1992. Potential sources of nitrogen in the aquifer include natural soil nitrogen; turf-grass fertilizers; leakage from industrial-waste lagoons; wastewater effluent discharged to Fountain Creek, Sand Creek, and Canal No. 4; exfiltration from sewers and septic systems; animal wastes; and atmospheric deposition.

Nitrate concentrations generally were smallest in water from the creek-bottom wells (pl. 4), where the corresponding dissolved-oxygen concentrations also were small. Nitrate concentrations in 24 of the 26 water samples collected from 6 of the 13 creek-bottom wells (TH5, TH7, TH29, TH49, TH50, and U07) that are located downstream from the Colorado Springs Wastewater Treatment Plant, which has been mentioned by previous investigators (Edelmann and Cain, 1985) as the major source of nitrogen in the creek, were less than 1 mg/L; concentrations from several of these wells were less than 0.05 mg/L. Nitrate concentrations in the other seven creek-bottom wells ranged from 2.5 to 12 mg/L; the median concentration was 7.0 mg/L. Similar geochemical composition and hydraulic contact between areas of the alluvial aquifer and Fountain Creek indicate that Fountain Creek is a source of recharge and, subsequently, of nitrogen to areas of the aquifer immediately adjacent to the creek.

The smaller nitrate concentrations in creek-bottom wells, as compared to lower- and upper-terrace wells, seem to be caused by denitrification. Denitrification is the bacterial reduction of nitrate to nitrous oxide or nitrogen gas and has been documented to occur in ground-water systems (Smith and Duff, 1988; Fustec and others, 1991). Denitrification was indicated in 6 of the 13 creek-bottom wells. This conclusion is supported by indirect evidence that included anoxic dissolved-oxygen concentrations; elevated concentrations of dissolved manganese and iron, as compared to dissolved manganese and iron concentrations in the well-oxygenated lower- and upper-terrace ground water; and smaller inorganic nitrogen concentrations than in the creek or any upgradient wells. Anoxic or almost anoxic conditions need to be present for denitrification to proceed. The median dissolved-oxygen concentration in the six suspected denitrifying wells was

0.2 mg/L. Dissolved-oxygen concentrations in water recharging the aquifer from Fountain Creek seem to be decreased or depleted by the nitrification of dissolved ammonia to nitrate. This process requires 3.7 mg of oxygen for every 1 mg of ammonia that is oxidized. Inorganic nitrogen concentrations in Fountain Creek in the study area generally are about 12 mg/L. Ammonia concentrations generally represent about 5 to 10 mg/L of the inorganic nitrogen concentration. Nitrification of the 5 to 10 mg/L of ammonia in Fountain Creek as it enters the creek-bottom part of the aquifer would deplete the 4 to 12 mg/L of dissolved oxygen that typically is present in the creek.

Large concentrations of dissolved manganese and dissolved iron can be used as indicators of a reducing environment because they essentially are insoluble in well-oxygenated environments and are soluble in anoxic, reducing environments. In the suspected denitrifying wells, the median concentration of dissolved manganese was 155 μg/L and dissolved iron was 124 μg/L; in wells in which denitrification was not suspected, the median dissolved-manganese concentration was 1 μg/L and dissolved-iron concentration was 7 μg/L. The elevated manganese and iron concentrations in the six suspected denitrifying creek-bottom wells emphasize the existence of reducing conditions, which have been shown to support the denitrification process (Champ and others, 1979). Four other creek-bottom wells had dissolved-oxygen concentrations less than 0.5 mg/L, a median dissolved-manganese concentration of 275 μg/L, and a median dissolved-iron concentration of 7.5 ug/L, indicating the presence of slight reducing conditions in these areas. The median nitrate concentration in these wells was 10 mg/L. Why some areas of the aquifer in the creek bottom undergo denitrification and others do not is not yet understood.

Nitrate concentrations in the lower- and upper-terrace wells ranged from 0.21 to 17 mg/L (tables 4 and 5); the median concentration for the lower-terrace wells was 7.9 mg/L and for the upper-terrace wells was 7.4 mg/L. As previously discussed in the "Dissolved Solids and Major Ions" section, relatively fresh surface recharge and inflow from the tributary alluvium seem to be the major sources of recharge to the terrace alluvium and the main body of the aquifer. Accordingly, nitrate concentrations in this area might be from sources in the terrace and tributary alluvium. These sources might include Sand Creek, Canal No. 4, animal wastes, septic systems and sewers, natural soil nitrogen, lawn fertilizers, and leakage from industrial-waste lagoons.

Sand Creek is an ephemeral tributary to Fountain Creek and has streamflows that generally are less than 1 ft^3/s, except during periods of rainfall runoff. Sand Creek had dissolved-solids concentrations that ranged from 489 to 580 mg/L and nitrate concentrations that ranged from 4.6 to 8.1 mg/L in six grab samples collected from the creek during 1991 and 1992. The small streamflow available for ground-water recharge and the large dissolved-solids concentrations in Sand Creek compared to the main body of the aquifer indicate that it is unlikely that Sand Creek contributes a substantial amount of water or nitrate to the alluvial aquifer.

Canal No. 4 is an irrigation canal that diverts water from Fountain Creek just downstream from the Colorado Springs Wastewater Treatment Plant (pl. 1). Edelmann and Cain (1985) estimated that about 57 percent of the flow in the canal is contributed by the treatment plant. Dissolved-solids concentrations generally were between 400 and 500 mg/L. Additionally, Edelmann and Cain (1985) reported that total inorganic nitrogen concentrations in the canal generally were larger than 10 mg/L; most of the inorganic nitrogen was ammonia. Based on the dissimilarities between water quality in the canal and in the main body of the aquifer and in wells immediately adjacent to the canal, leakage from the canal is unlikely to be a substantial source of water or nitrogen to the alluvial aquifer.

There are very few livestock operations in the study area; therefore, the contribution to the overall nitrate budget of the aquifer from animal wastes probably is not substantial. Nitrate concentrations could be elevated in very limited, localized areas where livestock are raised.

Edelmann and Cain (1985) reported that septic systems serve about 20 people in the study area and, thus, do not represent a substantial source of nitrate, except in very limited, localized areas where they are used. Contributions of nitrate to ground water from leaking sewers are not believed to be substantial, except possibly in some localized instances where elevated nitrate concentrations were observed.

Evidence indicating that natural soil nitrogen, lawn fertilizers, and leakage from industrial-waste lagoons might be substantial sources of nitrate in the terrace- and tributary-alluvium ground water includes: (1) Ground-water flow generally from the terrace alluvium toward Fountain Creek, (2) relatively large dissolved-oxygen concentrations in the terrace- and tributary-alluvium ground water, (3) a rapidly expanding residential area and associated increases in lawn watering and fertilization, (4) documented leakage from industrial-waste lagoons that have very large nitrate concentrations (Callaway Environmental

Consultants, 1992), and (5) nitrogen-isotope ratios ($\delta^{15}N$) in the main body of the aquifer of 6.2 to 6.3 per mil.

Naturally occurring soil nitrogen has been reported to be a major source of nitrate in ground water (Feth, 1966; Kreitler and Jones, 1975; Boyce and others, 1976). Because much of the study area was uncultivated, nonirrigated, semiarid grasslands prior to the residential growth that began in the 1960's, it is unlikely that substantial amounts of natural soil nitrogen were leached to the ground water prior to the 1960's. Increased residential development and associated lawn watering might have resulted in a corresponding increase in the leaching of natural soil nitrogen to the ground water. Edelmann and Cain (1985) reported that nitrate concentrations in the alluvial aquifer were less than 1 mg/L prior to the mid-1960's. By 1974, nitrate concentrations in ground water had increased more than five fold in parts of the study area. Increased lawn watering and leaching of soil nitrate might have contributed to the increase.

Dissolved-oxygen concentrations in the ground water of the lower- and upper-terrace alluvium generally ranged from about 4.5 to 7.0 mg/L. As previously mentioned in the "Dissolved Oxygen" section, dissolved-oxygen concentrations in the alluvium recharged by Fountain Creek generally were less than 1.0 mg/L; thus, if Fountain Creek or Canal No. 4 were a substantial source of recharge or nitrate to the entire aquifer, dissolved-oxygen concentrations would be expected to be substantially smaller than the measured concentrations.

Leakage of industrial wastes from surface impoundments that contained large concentrations of nitrate (Callaway Environmental Consultants, 1992) might have contributed to increased nitrate concentrations in the tributary alluvium near Little Johnson Reservoir. The surface impoundments are located just east of Little Johnson Reservoir (pl. 1) and have received industrial wastes since 1969 (Callaway Environmental Consultants, 1992). Leakage from the lagoons was not detected until 1984, and the time that the leakage began is unknown. Wastes were removed from the lagoons between 1986 and 1988. Nitrate concentrations in the saturated alluvium beneath the lagoons were as large as 475 mg/L and decreased downgradient from the lagoons (Callaway Environmental Consultants, 1992). At present (1992), the percentage of nitrate in the aquifer that originates from the lagoons is unknown.

Nitrogen-isotope ratios of nitrate in ground water have been used to help identify nitrate sources (Kreitler, 1975, 1979; Kreitler and Jones, 1975; Kreitler and others, 1978). Three $\delta^{15}N$ ranges have been defined for nitrate from different sources: (1) The $\delta^{15}N$ values in unfertilized, cultivated fields (soil nitrogen) range from +2 to +8 per mil; (2) the $\delta^{15}N$ values of commercial fertilizer generally are less than 3.5 per mil, although volatilization of ammonia fertilizers can increase the $\delta^{15}N$ value substantially; and (3) the $\delta^{15}N$ values for nitrogen from animal wastes, including treated wastewater effluent, range from +10 to +20 per mil (Kreitler, 1975; Kreitler and Jones, 1975; T.B. Coplen, U.S. Geological Survey, written comm., 1991). If there are different sources of nitrogen that mix with one another, the source or sources of nitrogen might be very difficult to distinguish.

The results of $\delta^{15}N$ analyses of water samples collected from the Janitell Road site and from eight wells are listed in table 1. Sampling all wells in the network for $\delta^{15}N$ was cost prohibitive. The wells that were sampled for $\delta^{15}N$ were selected to provide an adequate spatial representation of $\delta^{15}N$ values in the entire study area. The $\delta^{15}N$ value for Fountain Creek was 13.2 per mil and for well TH–37, which is located about 100 ft from Fountain Creek, was 10.4 per mil. These values are within the range for animal-waste-derived nitrate (+10 to +20 per mil) and indicate treated wastewater effluent in Fountain Creek might be the source of nitrate in these samples and possibly in much of the creek-bottom area of the aquifer immediately adjacent to the creek.

Table 1. Nitrogen-isotope ratios ($\delta^{15}N$) in surface-water and ground-water samples

Sample site	[1]$\delta^{15}N$
Fountain Creek below Janitell Road below Colorado Springs	13.2
Well TH–37	10.4
Well CO259–26	10.0
Well TH–22	6.3
Well U–09	6.3
Well V–3	6.3
Well CO259–25	8.9
Well W–8	6.2
Well U–15	11.6

[1]Nitrogen-isotope ratio of water relative to air, in per mil.

Two samples collected from wells in the upper terrace (wells CO259–26 and U–15) had $\delta^{15}N$ values of 10.0 and 11.6 per mil (table 1), respectively, indicating that an animal-derived source of nitrate might have contributed to nitrate contamination in these areas. Both wells are located in densely developed residential areas and are immediately adjacent to large public buildings that are served by sanitary sewers, and the water-quality characteristics of these wells are anomalous to conditions in the areas surrounding the two wells. These results indicate nitrate in these wells probably is from a localized source that seems to be leakage from sanitary sewers.

Samples from five wells in the lower and upper terraces (wells TH–22, U–09, V–3, CO259–25, and W–8) had $\delta^{15}N$ values ranging from 6.2 to 8.9 per mil (table 1). Wells TH–22, U–09, and V–3, which had $\delta^{15}N$ values of 6.3 per mil, are located along the major flow path of the aquifer that coincides with the area of small dissolved-solids concentrations that originate in the tributary alluvium located to the southeast of Sand Creek (pls. 1 and 2). Accordingly, $\delta^{15}N$ values of water from these wells are representative of a substantial source of nitrogen to the entire aquifer. The $\delta^{15}N$ values for these wells were smaller than the range for nitrate derived from animal wastes and make it unlikely that animal-derived nitrogen is the major source of nitrogen to the main body of the aquifer.

The $\delta^{15}N$ value for wells TH–22, U–09, and V–3 are similar to the range of $\delta^{15}N$ values for natural soil nitrogen (+2 to +8 per mil) and isotopically heavier than nitrate derived solely from nitrogen fertilizer (–3 to +2 per mil). Kreitler and others (1978) reported similar results from a study of nitrate in ground water in New York. They suggested three possibilities for these results: (1) More soil nitrogen is being mineralized into nitrate than is being applied as fertilizer; (2) some nitrate fertilizers analyzed are isotopically heavier than the predominant range of –3 to +2 per mil, and these fertilizers could be used in the area; and (3) fertilizer nitrate has undergone denitrification, ammonia volatilization, or nutrient assimilation and, thus, has been made isotopically heavier. All three possibilities can be applicable to conditions observed in the study area.

The $\delta^{15}N$ values for the nitrate in the industrial-waste lagoons, which include nitric acid, nickel nitrate, and cadmium nitrate (Callaway Environmental Consultants, 1992) are not known. Based on the $\delta^{15}N$ values in the three terrace-alluvium wells and the previously discussed hydrogeologic and water-quality characteristics of the alluvial aquifer, nitrate in ground water in much of the aquifer is not derived from an animal-waste source but might be derived from natural soil nitrogen, turf-grass fertilizers, and possibly from industrial wastes.

Water-Quality Trends

Temporal trends in dissolved-solids and nitrate concentrations in the aquifer were evaluated using the seasonal Kendall trend test on long-term concentration data for water from four municipal-production wells (SH–4, S–14, S–2, and W–4) and one irrigation well (V–3) in the monitoring network (pl. 1). Quarterly time series of dissolved-solids and nitrate concentrations were analyzed for 1981 through 1992. Data collected prior to 1991 were collected for different studies but were collected and analyzed using the same techniques as this study.

The trend-test results include the p-value and the direction and slope of temporal trends. The p-value is the attained two-sided significance level of a given trend (Crawford and others, 1983). A trend was judged to be statistically significant if the p-value was less than or equal to 0.05. A temporal-trend slope is an estimate of the magnitude of a trend expressed as the median annual change in concentration. Crawford and others (1983) stressed that the seasonal Kendall test is exploratory in nature, and any indication of a trend does not imply that the trend will continue in the future. Additionally, although the magnitude of a known trend is expressed as a slope, a linear relation is not assumed.

Dissolved Solids

The results of temporal-trend tests on dissolved-solids concentrations indicate significantly increasing concentrations for well S–14 and significantly decreasing concentrations for wells V–3, S–2, and W–4 (table 2). Dissolved-solids concentrations in well S–14 have been increasing steadily since data collection began in 1981 (fig. 3). Well S–14 is located about 2,000 ft south and downgradient from a large sand-and-gravel mining operation (pl. 1). Dissolved-solids concentrations seem to be increased by the washing of sand and gravel and by the evaporative concentration and reuse of the wash water. In 1976, the sand company decreased its annual ground-water withdrawals from 420 to 55 acre-ft/yr after installing a holding tank and a pump to recycle the water used in the sand-washing process (Tony Venetucci, written commun., 1976).

The trend in decreasing concentrations of dissolved solids observed in wells S–2, W–4, and V–3 in the main body of the aquifer probably is the result of increased recharge to the alluvium from increased precipitation (fig. 3) and increased total volume of water applied to lawns as the residential areas expanded.

Table 2. Results of seasonal Kendall temporal-trend analyses of dissolved solids and dissolved nitrite plus nitrate as nitrogen in water from wells sampled quarterly, 1981–92

[(mg/L)/yr, milligrams per liter per year; --, temporal-trend slope not reported for trends that have p-values greater than 0.05]

Well name	p-value[1]	Temporal-trend slope[2] [(mg/L)/yr]
	Dissolved solids	
SH–4	0.37	--
S–14	.00	+8.9
S–2	.00	−6.8
W–4	.00	−8.6
V–3	.01	−1.8
	Dissolved nitrite plus nitrate as nitrogen	
SH–4	.94	--
S–14	.23	--
S–2	.00	+.17
W–4	.66	--
V–3	.49	--

[1]A trend is statistically significant if the p-value is equal to or less than 0.05.

[2]A positive trend slope denotes a trend of increasing concentrations with time; a negative trend slope denotes a trend of decreasing concentrations with time.

Decreasing dissolved-solids concentrations in the main body of the aquifer could change if water levels in the aquifer decrease, as might occur during drier years if pumpage increased and surface recharge decreased. The dissolved-solids time-series plots for wells S–2, W–4, and V–3 indicate that the decreasing trends in dissolved-solids concentrations have been interrupted by rapid, temporary increases in concentration (fig. 3). These rapid increases in dissolved-solids concentrations typically occurred in the summer when ground-water withdrawals were largest. The increases were first observed in well V–3, then in well S–2, and finally, in well W–4, which is the downgradient order of these wells. These short-term fluctuations may indicate that short-term conditions, such as increased pumpage during the summer, may result in: (1) A short-term change in the hydraulic gradient and increased recharge from Fountain Creek, and (2) larger dissolved-solids concentrations in the main body of the aquifer resulting from the increased inflow of creek water.

Nitrate

During 1981–92, significantly increasing nitrate concentrations were detected for well S–2, and no significant trends were detected for wells SH–4, S–14, W–4, or V–3 (table 2). However, the time-series plot for well S–2 (fig. 4) indicates that nitrate concentrations increased steadily from 1981 until 1991, at which time an apparent trend break occurred; concentrations decreased through 1992. A similar break from increasing nitrate concentrations occurred at well S–14 in 1986 and at well V–3 in 1988 (fig. 4). All three wells had increasing nitrate concentrations until the breaks occurred (fig. 4). These results indicate that nitrate concentrations were increasing in the main body of the alluvial aquifer until some time during 1986–91.

SUMMARY

The alluvial aquifer in the Fountain Creek Valley of southwestern El Paso County is the primary municipal water supply for the communities of Stratmoor Hills, Security, and Widefield and is a secondary supply for Colorado Springs. As such, about 5,000 to 6,000 acre-ft of the estimated 18,000 acre-ft of aquifer storage is pumped annually. Therefore, the quality of water pumped from the aquifer is a major concern. Increased nitrate concentrations in the aquifer had been reported to result from recharge from Fountain Creek. Hydrogeologic and water-quality data collected quarterly in 1991 and 1992 from a network of 63 wells were used to define the spatial and temporal variations of dissolved-oxygen, dissolved-solids, and nitrate concentrations in the aquifer. Aquifer water levels and ground-water flow directions, dissolved-solids concentrations, hydrochemical facies, dissolved-oxygen concentrations, nitrate concentrations, and nitrogen-isotope ratios were used to make a qualitative determination of the potential sources of water and nitrogen to the aquifer.

The climate of the study area is semiarid with an annual mean precipitation of about 15.4 in. A cumulative increase in the annual mean precipitation occurred during 1975–92.

The alluvial aquifer and tributary alluvium of the Fountain Creek Valley are in eroded ancestral channels of Fountain Creek and its adjacent tributary valleys. The aquifer consists of alluvial sediments from fine sand to cobbles with varying quantities of silt and clay. Pierre Shale underlies the alluvium throughout the study area and is impermeable to ground-water flow.

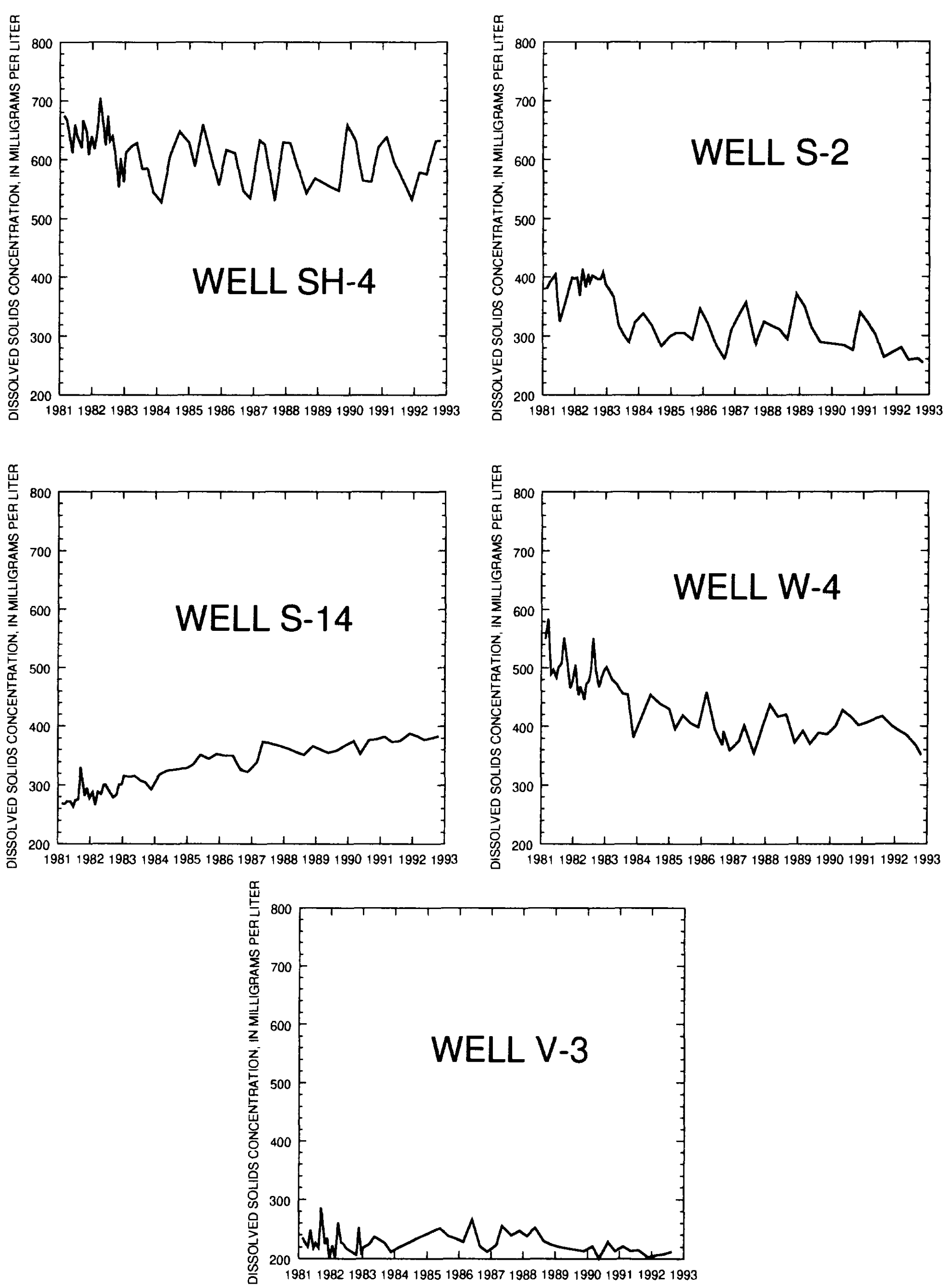

Figure 3. Long-term variations in dissolved-solids concentrations in ground water from selected wells in the alluvial aquifer of the Fountain Creek Valley, 1981–92.

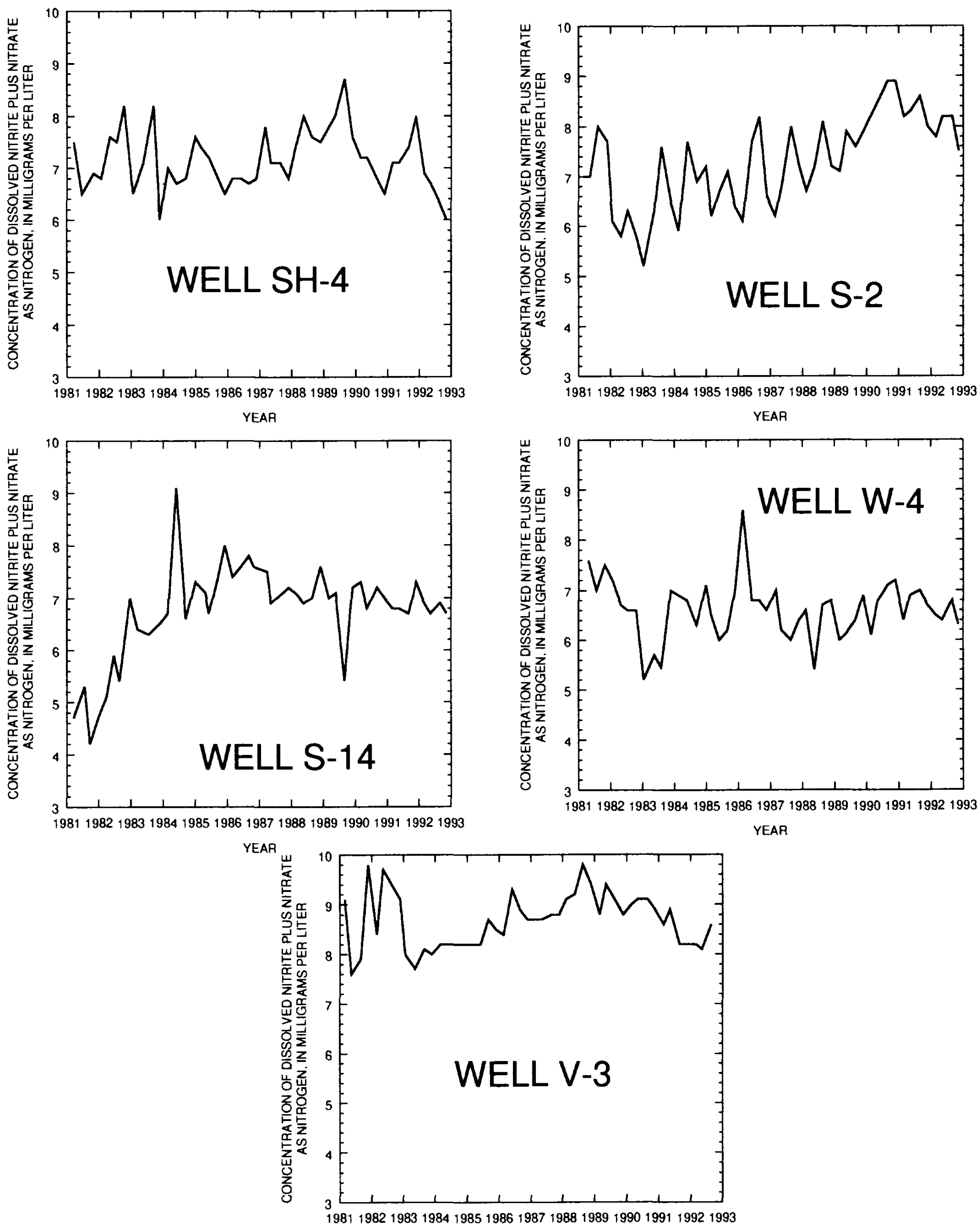

Figure 4. Long-term variations in concentrations of dissolved nitrite plus nitrate as nitrogen in ground water from selected wells in the alluvial aquifer of the Fountain Creek Valley, 1981–92.

Hydraulic connection between Fountain Creek and the aquifer exists throughout much of the study area as discontinuous bedrock lows where the creek and aquifer are in contact. Flow between the creek and the aquifer is a function of hydraulic connection and the hydraulic gradient between the creek and the aquifer. Ground-water flow generally was toward Fountain Creek during 1991 and 1992, although short-term increases in stream stage in Fountain Creek might have increased flow from the creek to the aquifer.

Dissolved-oxygen concentrations in the aquifer ranged from 0.0 to 8.2 mg/L. Concentrations generally were smaller near the interface of Fountain Creek and the aquifer than in the main body of the aquifer. The smaller dissolved-solids concentrations near the creek seem to be caused by the microbiological decomposition of organic matter in the creek sediments and the nitrification of ammonia to nitrate as water from the creek recharges parts of the aquifer. The water in the terrace deposits and in the main body of the aquifer was well oxygenated.

Dissolved-solids concentrations generally were larger near the creek than in the main body of the aquifer. Water from Fountain Creek and the creek bottom part of the aquifer generally was a mixed water type. The dominant water type in the terraces and in the main body of the aquifer was calcium bicarbonate. Relatively fresh recharge that contained small dissolved-solids concentrations is the primary source of recharge to the aquifer. Sources of recharge with smaller dissolved-solids concentrations include the tributary alluvium to the southeast of Sand Creek and surface recharge from precipitation and lawn watering.

Nitrate concentrations in the aquifer ranged from less than 0.05 to 17 mg/L. Considerable spatial variability occurred in nitrate concentrations. Concentrations generally were smaller near Fountain Creek and larger in the main body of the aquifer. Denitrification near the interface of Fountain Creek and the aquifer was indicated to be the cause of the small nitrate concentrations near the creek. Several sources of indirect evidence indicate that substantial sources of nitrate in the ground water may include natural soil nitrogen, lawn fertilizers, and leakage from industrial-waste lagoons. This evidence is supported by (1) small concentrations of dissolved solids in ground water with relatively large nitrate concentrations; (2) ground-water flow in the aquifer from the eastern tributary valleys toward Fountain Creek; (3) a rapidly expanding residential population, which has increased surface-derived recharge, and associated nitrate concentrations from lawn watering and fertilization; (4) dissolved-oxygen concentrations in water from the lower- and upper-terrace-alluvium wells that were significantly less than those near Fountain Creek; (5) nitrogen-isotope ratios of 6.2 to 6.3 in the main body of the aquifer; and (6) nitrate concentrations as large as 475 mg/L in the ground water beneath leaking industrial-waste lagoons.

Trends in long-term time series (1981–92) of dissolved-solids and nitrate concentrations in water from five wells were evaluated with the seasonal Kendall test. Significant decreases in dissolved-solids concentration were measured in three wells; a significant increase was detected in one well. An increase in surface recharge and inflow from tributary alluvium seems to be the cause of decreasing dissolved-solids concentrations in some areas of the aquifer. The one significant increase in dissolved-solids concentration seems to be caused by the reuse of ground water by a sand-and-gravel mining operation. A significant increase was detected in nitrate concentration for only one well. Nitrate concentrations seemed to be increasing in some areas of the aquifer until 1986, at which time a break in the trends occurred and concentrations began to decrease.

REFERENCES CITED

Bourg, A.C.M., and Bertin, Clotilde, 1993, Biogeochemical processes during the infiltration of river water into an alluvial aquifer: Environmental Science and Technology, v. 27, no. 4, p. 661–666.

Boyce, J.S., Muir, John, Edwards, A.P., Seim, E.C., and Olson, R.A., 1976, Geologic nitrogen in Pleistocene loess of Nebraska: Journal of Environmental Quality, v. 5, no. 1, p. 93–96.

Calloway Environmental Consultants, 1992, Groundwater quality assessment for 1991: Colorado Springs, Eagle-Picher Industries, Inc., p. 22.

Champ, D.R., Gulens, J., and Jackson, R.E., 1979, Oxidation-reduction sequences in ground water flow systems: Canadian Journal of Earth Science, v. 16, no. 1, p. 12–23.

Chebotarev, I.I., 1955, Metamorphism of natural water in the crust of weathering: Geochim. Cosmochim. Acta: v. 8, p. 22–48, 137–170, 198–212.

Crawford, C.G., Slack, J.R., and Hirsch, R.M., 1983, Nonparametric tests for trends in water quality data using the statistical analysis system: U.S. Geological Survey Open-File Report 83–550, 102 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.

Feth, J.H., 1966, Nitrogen compounds in natural water—A review: Water Resources Research, v. 2, no. 1, p. 41–58.

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

Fustec, E., Mariotti, A., Grillo, X., and Sajus, J., 1991, Nitrate removal by denitrification in alluvial ground water—Role of a former channel: Journal of Hydrology, v. 123, no. 3/4, p. 337–354.

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

Kreitler, C.W., 1975, Determining the source of nitrate in ground water by nitrogen isotope studies: University of Texas at Austin, Bureau of Economic Geology, Report of Investigations 83, 62 p.

_____1979, Nitrogen-isotope ratio studies of soils and ground water nitrate from alluvial fan aquifers in Texas: Journal of Hydrology, v. 42, no. 1/2, p. 147–170.

Kreitler, C.W., and Jones, D.C., 1975, Natural soil nitrate—The cause of the nitrate contamination of ground water in Runnels County, Texas: Ground Water, v. 13, no. 1, p. 53–62.

Kreitler, C.W., Ragone, S.E., and Katz, B.G., 1978, N15/N14 ratios of ground-water nitrate, Long Island, New York: Ground Water, v. 16, no. 6, p. 404–409.

Kuhn, Gerhard, 1988, Methods to determine transit losses for return flows of transmountain water in Fountain Creek between Colorado Springs and the Arkansas River, Colorado: U.S. Geological Survey Water-Resources Investigations Report 87–4119, 183 p.

Livingston, R.K., Klein, J.M., and Bingham, D.L., 1976, Water resources of El Paso County, Colorado: Colorado Water Resources Circular 32, 85 p.

Radell, M.J., Lewis, M.E., and Watts, K.R., 1994, Hydrogeologic characteristics of the alluvial aquifer and adjacent deposits of the Fountain Creek Valley, El Paso County, Colorado: U.S. Geological Survey Water-Resources Investigations Report 94–4129, map (4 sheets).

Scott, G.R., and Wobus, R.A., 1973, Reconnaissance geologic map of Colorado Springs and vicinity, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–482, 2 sheets, scale 1:62,500.

Smith, R.L., and Duff, J.H., 1988, Denitrification in a sand and gravel aquifer: Applied and Environmental Microbiology, v. 54, no. 5, p. 1071–1078.

U.S. Environmental Protection Agency, 1986, Quality criteria for water 1986: U.S. Environmental Protection Agency Report EPA–440/5–86–001, 501 p.

SUPPLEMENTAL DATA

Table 3. Ground-water-quality data for creek-bottom wells

[deg C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; µg/L, micrograms per liter; <, less than; --, no data; $CaCO_3$, calcium carbonate]

DATE	TEMPER-ATURE WATER (deg C)	OXYGEN, DIS-SOLVED (mg/L)	pH WATER WHOLE FIELD (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (µS/cm)	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)	ALKA-LINITY LAB (mg/L as $CaCO_3$)	SULFATE DIS-SOLVED (mg/L as SO_4)
Site 384503104451601; well SC01506614BBA TH-5 (LAT 45 03N LONG 104 45 16W)										
AUG 1991										
01...	18.5	0.2	7.1	980	84	21	56	5.8	229	150
NOV										
14...	11.5	0.1	7.0	854	--	--	--	--	--	--
FEB 1992										
20...	9.0	0.2	7.1	864	--	--	--	--	--	--
MAY										
05...	10.0	0.3	7.6	861	--	--	--	--	--	--
AUG										
19...	14.0	0.1	7.0	838	85	22	59	5.5	236	160
OCT										
19...	13.5	0.1	6.9	756	--	--	--	--	--	--
Site 384540104453601; well SC01506610ADB2 TH-46 (LAT 38 45 40N LONG 104 45 36W)										
AUG 1991										
01...	14.0	0.3	7.0	1100	98	27	66	7.3	150	260
NOV										
12...	14.0	0.6	6.9	833	--	--	--	--	--	--
FEB 1992										
20...	9.0	0.6	7.0	811	--	--	--	--	--	--
MAY										
04...	11.0	0.3	7.4	845	--	--	--	--	--	--
AUG										
17...	15.0	0.2	6.8	720	71	19	49	6.0	181	--
OCT										
19...	15.0	0	6.9	702	--	--	--	--	--	--
Site 384540104453801; well SC01506610ADB1 TH-7 (LAT 38 45 40N LONG 104 45 38W)										
JUL 1991										
31...	18.5	0.1	7.3	585	36	9.1	38	4.6	116	130
NOV										
11...	13.0	0.3	7.5	824	--	--	--	--	--	--
FEB 1992										
20...	11.5	0.2	6.9	793	--	--	--	--	--	--
MAY										
04...	11.5	0.1	7.3	849	--	--	--	--	--	--
AUG										
17...	16.0	0.1	6.9	1130	120	32	78	7.4	221	310
OCT										
19...	15.5	0	6.9	1040	--	--	--	--	--	--

DATE	CHLO-RIDE, DIS-SOLVED (mg/L as Cl)	FLUO-RIDE, DIS-SOLVED (mg/L as F)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (mg/L)	NITRO-GEN, AMMONIA DIS-SOLVED (mg/L as N)	NITRO-GEN, NITRITE DIS-SOLVED (mg/L as N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DIS-SOLVED (µg/L as Fe)	MANGA-NESE, DIS-SOLVED (µg/L as Mn)
Site 384503104451601; well SC01506614BBA TH-5 (LAT 38 45 03N LONG 104 45 16W)--Continued									
AUG 1991									
01...	26	2.7	498	--	--	--	--	4	130
NOV									
14...	--	--	--	0.020	0.020	0.240	--	--	--
FEB 1992									
20...	--	--	--	<0.010	<0.010	0.880	--	--	--
MAY									
05...	--	--	--	<0.010	<0.010	0.780	--	--	--
AUG									
19...	38	2.7	533	0.020	<0.010	<0.050	--	6	120
OCT									
19...	--	--	--	0.030	<0.010	<0.050	--	--	--

Table 3. Ground-water-quality data for creek-bottom wells--Continued

DATE	TEMPERATURE WATER (deg C)	OXYGEN, DISSOLVED (mg/L)	pH WATER WHOLE FIELD (STANDARD UNITS)	SPECIFIC CONDUCTANCE (µS/cm)	CALCIUM DISSOLVED (mg/L as Ca)	MAGNESIUM, DISSOLVED (mg/L as Mg)	SODIUM, DISSOLVED (mg/L as Na)	POTASSIUM, DISSOLVED (mg/L as K)	ALKALINITY LAB (mg/L as $CaCO_3$)	SULFATE DISSOLVED (mg/L as SO_4)
Site 384651104464701; well SC01506604AAB TH-49 (LAT 38 46 51N LONG 104 46 47W)										
AUG 1991										
06...	18.0	0.7	7.1	880	100	25	78	6.9	213	240
NOV										
14...	12.5	0.3	7.1	941	--	--	--	--	--	--
FEB 1992										
19...	8.0	0.5	7.2	918	--	--	--	--	--	--
MAY										
05...	10.5	0.7	7.1	1040	--	--	--	--	--	--
AUG										
19...	16.0	0.4	7.0	1010	100	25	77	6.1	228	240
OCT										
20...	13.0	0.3	7.1	961	--	--	--	--	--	--

DATE	CHLORIDE, DISSOLVED (mg/L as Cl)	FLUORIDE, DISSOLVED (mg/L as F)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (mg/L)	NITROGEN, AMMONIA DISSOLVED (mg/L as N)	NITROGEN, NITRITE DISSOLVED (mg/L as N)	NITROGEN, NO2+NO3 DISSOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DISSOLVED (µg/L as Fe)	MANGANESE, DISSOLVED (µg/L as Mn)
Site 384558104460001; well SC01506610BAA TH-1 (LAT 38 45 58N LONG 104 46 00W)--Continued									
AUG 1991									
01...	32	1.9	805	--	--	--	--	8	220
NOV									
11...	--	--	--	<0.010	0.010	6.50	--	--	--
FEB 1992									
19...	--	--	--	<0.010	<0.010	6.90	--	--	--
MAY									
04...	--	--	--	<0.010	<0.010	7.10	--	--	--
AUG									
19...	70	1.9	1830	0.060	<0.010	12.0	--	10	320
Site 384621104460902; well SC01506603CAB3 U-08 (LAT 38 46 21N LONG 104 46 09W)--Continued									
AUG 1991									
07...	45	0.80	649	--	--	--	--	<3	<1
AUG 1992									
28...	54	0.80	755	0.010	<0.010	7.40	--	6	1
Site 384636104465401; well SC01506604ACA TH-52 (LAT 38 46 36N LONG 104 46 54W)--Continued									
AUG 1991									
06...	83	1.5	1270	--	--	--	--	4	4
NOV									
13...	--	--	--	0.010	<0.010	4.30	--	--	--
FEB 1992									
26...	--	--	--	<0.010	<0.010	4.10	--	--	--
MAY									
05...	--	--	--	<0.010	<0.010	3.70	--	--	--
AUG									
21...	83	1.9	1210	0.020	<0.010	4.80	--	10	<1
OCT									
20...	--	--	--	0.010	<0.010	5.00	--	--	--
Site 384651104464701; well SC01506604AAB TH-49 (LAT 38 46 51N LONG 104 46 47W)--Continued									
AUG 1991									
06...	41	2.8	641	--	--	--	--	870	240
NOV									
14...	--	--	--	0.060	<0.010	<0.050	--	--	--
FEB 1992									
19...	--	--	--	0.030	<0.010	<0.050	--	--	--
MAY									
05...	--	--	--	0.040	<0.010	<0.050	--	--	--
AUG									
19...	50	3.2	658	0.050	<0.010	<0.050	--	1000	620
OCT									
20...	--	--	--	0.060	<0.010	<0.050	--	--	--

Table 3. Ground-water-quality data for creek-bottom wells--Continued

DATE	CHLORIDE, DISSOLVED (mg/L as Cl)	FLUORIDE, DISSOLVED (mg/L as F)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (mg/L)	NITROGEN, AMMONIA DISSOLVED (mg/L as N)	NITROGEN, NITRITE DISSOLVED (mg/L as N)	NITROGEN, NO2+NO3 DISSOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DISSOLVED (µg/L as Fe)	MANGANESE, DISSOLVED (µg/L as Mn)
Site 384540104453601; well SC01506610ADB2 TH-46 (LAT 38 45 40N LONG 104 45 36W)--Continued									
AUG 1991 01...	40	2.2	610	--	--	--	--	7	320
NOV 12...	--	--	--	0.010	0.020	6.40	--	--	--
FEB 1992 20...	--	--	--	<0.010	<0.010	7.60	--	--	--
MAY 04...	--	--	--	<0.010	<0.010	6.70	--	--	--
AUG 17...	--	--	--	0.010	<0.010	6.40	--	5	310
OCT 19...	--	--	--	0.010	0.010	7.00	--	--	--
Site 384540104453801; well SC01506610ADB1 TH-7 (LAT 38 45 40N LONG 104 45 38W)--Continued									
JUL 1991 31...	26	2.7	333	--	--	--	--	420	240
NOV 11...	--	--	--	0.170	0.030	6.20	--	--	--
FEB 1992 20...	--	--	--	<0.010	<0.010	7.20	--	--	--
MAY 04...	--	--	--	0.060	<0.010	0.400	--	--	--
AUG 17...	60	2.5	758	0.080	<0.010	<0.050	--	54	860
OCT 19...	--	--	--	0.130	<0.010	<0.050	--	--	--

DATE	TEMPERATURE WATER (deg C)	OXYGEN, DISSOLVED (mg/L)	pH WATER WHOLE FIELD (STANDARD UNITS)	SPECIFIC CONDUCTANCE (µS/cm)	CALCIUM DISSOLVED (mg/L as Ca)	MAGNESIUM, DISSOLVED (mg/L as Mg)	SODIUM, DISSOLVED (mg/L as Na)	POTASSIUM, DISSOLVED (mg/L as K)	ALKALINITY LAB (mg/L as $CaCO_3$)	SULFATE DISSOLVED (mg/L as SO_4)
Site 384558104460001; well SC01506610BAA TH-1 (LAT 38 45 58N LONG 104 46 00W)										
AUG 1991 01...	15.0	0.2	7.1	1420	110	37	110	6.2	152	400
NOV 11...	14.0	0.4	7.1	1600	--	--	--	--	--	--
FEB 1992 19...	9.5	0	7.1	921	--	--	--	--	--	--
MAY 04...	11.5	0	7.0	901	--	--	--	--	--	--
AUG 19...	15.5	0.2	6.9	2460	200	90	250	8.7	231	1000
Site 384621104460902; well SC01506603CAB3 U-08 (LAT 38 46 21N LONG 104 46 09W)										
AUG 1991 07...	12.5	0.7	6.9	1070	100	25	80	3.5	187	260
AUG 1992 28...	13.0	1.2	7.0	1110	110	28	93	3.6	197	290
Site 384636104465401; well SC01506604ACA TH-52 (LAT 38 46 36N LONG 104 46 54W)										
AUG 1991 06...	13.5	4.1	6.9	2010	180	61	140	7.6	278	610
NOV 13...	15.0	4.4	6.9	1670	--	--	--	--	--	--
FEB 1992 26...	9.5	4.8	7.0	1730	--	--	--	--	--	--
MAY 05...	12.0	5.2	7.1	1600	--	--	--	--	--	--
AUG 21...	13.0	4.7	6.9	1780	170	53	140	6.2	309	530
OCT 20...	14.5	4.4	6.9	1790	--	--	--	--	--	--

Table 3. Ground-water-quality data for creek-bottom wells--Continued

DATE	CHLORIDE, DISSOLVED (mg/L as Cl)	FLUORIDE, DISSOLVED (mg/L as F)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (mg/L)	NITROGEN, AMMONIA DISSOLVED (mg/L as N)	NITROGEN, NITRITE DISSOLVED (mg/L as N)	NITROGEN, NO2+NO3 DISSOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DISSOLVED (µg/L as Fe)	MANGANESE, DISSOLVED (µg/L as Mn)
Site 384712104464701; well SC01406633DAC2 TH-37 (LAT 38 47 12N LONG 104 46 47W)--Continued									
AUG 1991 05...	35	2.0	1080	--	--	--	--	14	140
NOV 11...	--	--	--	0.020	0.070	11.0	--	--	--
FEB 1992 25...	--	--	--	<0.010	0.020	12.0	10.40	--	--
MAY 08...	--	--	--	<0.010	0.040	11.0	--	--	--
AUG 19...	39	2.0	947	<0.010	0.080	12.0	--	<3	95
OCT 19...	--	--	--	0.010	0.060	10.0	--	--	--

DATE	TEMPERATURE WATER (deg C)	OXYGEN, DISSOLVED (mg/L)	pH WATER WHOLE FIELD (STANDARD UNITS)	SPECIFIC CONDUCTANCE (µS/cm)	CALCIUM DISSOLVED (mg/L as Ca)	MAGNESIUM, DISSOLVED (mg/L as Mg)	SODIUM, DISSOLVED (mg/L as Na)	POTASSIUM, DISSOLVED (mg/L as K)	ALKALINITY LAB (mg/L as $CaCO_3$)	SULFATE DISSOLVED (mg/L as SO_4)
Site 384712104464801; well SC01416633DAC1 TH-38 (LAT 38 47 12N LONG 104 46 48W)										
AUG 1991 05...	13.0	0.2	7.1	2080	210	60	140	7.6	323	670
NOV 11...	11.5	0.7	6.7	1600	--	--	--	--	--	--
FEB 1992 25...	7.0	0.4	7.1	1500	--	--	--	--	--	--
MAY 08...	11.0	0.2	7.2	1600	--	--	--	--	--	--
AUG 19...	13.5	--	--	--	150	46	110	6.1	310	400
OCT 19...	14.5	--	6.9	1320	--	--	--	--	--	--
Site 384811104474701; well SC01406629DAB TH-29 (LAT 38 48 11N LONG 104 47 47W)										
AUG 1991 05...	15.0	5.7	6.8	5100	230	68	710	9.8	172	150
Site 384837104481001; well SC01406629ABB TH-25 (LAT 38 48 37N LONG 104 48 10W)										
AUG 1991 05...	13.0	0.8	6.9	921	61	17	72	6.9	185	180
Site 384851104484901; well SC01406619DDA1 U-02 (LAT 38 48 51N LONG 104 48 49W)										
AUG 1991 14...	12.5	0.2	6.8	1050	110	27	71	6.1	218	250
Site 384856104491602; well SC01406619DBC2 U-01 (LAT 38 48 56N LONG 104 49 16W)										
AUG 1991 01...	--	--	--	--	120	38	110	6.5	200	360
NOV 12...	11.5	0.2	6.7	1270	--	--	--	--	--	--
FEB 1992 18...	12.0	0.3	6.7	1230	--	--	--	--	--	--
MAY 05...	12.0	0.2	7.0	1240	--	--	--	--	--	--
AUG 20...	11.5	0.1	6.8	1170	110	32	96	6.2	204	330
OCT 19...	11.5	0.1	6.8	1120	--	--	--	--	--	--

Table 3. Ground-water-quality data for creek-bottom wells--Continued

DATE	TEMPER-ATURE WATER (deg C)	OXYGEN, DIS-SOLVED (mg/L)	pH WATER WHOLE FIELD (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (µS/cm)	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)	ALKA-LINITY LAB (mg/L as $CaCO_3$)	SULFATE DIS-SOLVED (mg/L as SO_4)
Site 384651104464801: well SC01506604ABA2 TH-50 (LAT 38 46 51N LONG 104 46 48W)										
AUG 1991										
06...	16.5	0.3	7.1	1080	100	25	75	6.2	213	240
NOV										
14...	11.5	0.3	7.2	936	--	--	--	--	--	--
FEB 1992										
19...	7.0	0.5	7.2	906	--	--	--	--	--	--
MAY										
05...	10.5	0.3	7.1	1010	--	--	--	--	--	--
AUG										
19...	16.0	0.1	7.1	978	98	23	73	5.7	223	230
OCT										
20...	13.0	0.1	7.2	918	--	--	--	--	--	--
Site 384652104465101: well SC01506604ABA1 U-07 (LAT 38 46 52N LONG 104 46 51W)										
AUG 1991										
06...	14.0	0.2	7.1	988	91	23	74	6.2	199	240
NOV										
13...	12.0	0.1	7.1	912	--	--	--	--	--	--
FEB 1992										
19...	7.0	0.3	7.2	893	--	--	--	--	--	--
MAY										
05...	9.5	0.1	7.2	943	--	--	--	--	--	--
AUG										
19...	14.5	0	7.0	933	93	23	73	5.5	219	210
OCT										
20...	13.0	0	7.1	875	--	--	--	--	--	--
Site 384712104464701: well SC01406633DAC2 TH-37 (LAT 38 47 12N LONG 104 46 47W)										
AUG 1991										
05...	16.5	0.1	7.1	1670	170	52	110	7.2	294	510
NOV										
11...	12.0	0.4	6.8	1520	--	--	--	--	--	--
FEB 1992										
25...	6.0	0.1	7.1	1470	--	--	--	--	--	--
MAY										
08...	13.0	0.1	7.1	1470	--	--	--	--	--	--
AUG										
19...	--	--	--	--	140	46	99	6.4	305	360
OCT										
19...	14.5	--	7.0	1260	--	--	--	--	--	--

DATE	CHLO-RIDE, DIS-SOLVED (mg/L as Cl)	FLUO-RIDE, DIS-SOLVED (mg/L as F)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (mg/L)	NITRO-GEN, AMMONIA DIS-SOLVED (mg/L as N)	NITRO-GEN, NITRITE DIS-SOLVED (mg/L as N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DIS-SOLVED (µg/L as Fe)	MANGA-NESE, DIS-SOLVED (µg/L as Mn)
Site 384651104464801: well SC01506604ABA2 TH-50 (LAT 38 46 51N LONG 104 46 48W)--Continued									
AUG 1991									
06...	40	2.5	635	--	--	--	--	180	230
NOV									
14...	--	--	--	0.050	<0.010	<0.050	--	--	--
FEB 1992									
19...	--	--	--	0.020	<0.010	<0.050	--	--	--
MAY									
05...	--	--	--	0.040	<0.010	<0.050	--	--	--
AUG									
19...	46	3.1	631	0.050	<0.010	<0.050	--	780	310
OCT									
20...	--	--	--	0.060	<0.010	<0.050	--	--	--
Site 384652104465101: well SC01506604ABA1 U-07 (LAT 38 46 52N LONG 104 46 51W)--Continued									
AUG 1991									
06...	38	2.7	612	--	--	--	--	17	120
NOV									
13...	--	--	--	0.060	<0.010	<0.050	--	--	--
FEB 1992									
19...	--	--	--	<0.010	0.030	0.520	--	--	--
MAY									
05...	--	--	--	<0.010	0.020	0.064	--	--	--
AUG									
19...	45	3.2	602	0.020	<0.010	<0.050	--	61	120
OCT									
20...	--	--	--	0.030	<0.010	<0.050	--	--	--

Table 3. Ground-water-quality data for creek-bottom wells--Continued

DATE	CHLORIDE, DISSOLVED (mg/L as Cl)	FLUORIDE, DISSOLVED (mg/L as F)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (mg/L)	NITROGEN, AMMONIA DISSOLVED (mg/L as N)	NITROGEN, NITRITE DISSOLVED (mg/L as N)	NITROGEN, NO2+NO3 DISSOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DISSOLVED (μg/L as Fe)	MANGANESE, DISSOLVED (μg/L as Mn)
Site 384712104464801: well SC01416633DAC1 TH-38 (LAT 38 47 12N LONG 104 46 48W)--Continued									
AUG 1991									
05...	39	2.1	1340	--	--	--	--	6	500
NOV									
11...	--	--	--	0.020	0.050	11.0	--	--	--
FEB 1992									
25...	--	--	--	<0.010	0.020	12.0	--	--	--
MAY									
08...	--	--	--	<0.010	0.020	11.0	--	--	--
AUG									
19...	39	2.3	1010	0.010	0.060	11.0	--	19	240
OCT									
19...	--	--	--	0.010	0.040	11.0	--	--	--
Site 384811104474701: well SC01406629DAB TH-29 (LAT 38 48 11N LONG 104 47 47W)--Continued									
AUG 1991									
05...	1600	1.7	2890	--	--	--	--	10	50
Site 384837104481001: well SC01406629ABB TH-25 (LAT 38 48 37N LONG 104 48 10W)--Continued									
AUG 1991									
05...	50	2.2	522	--	--	--	--	21	<100
Site 384851104484901: well SC01406619DDA1 U-02 (LAT 38 48 51N LONG 104 48 49W)--Continued									
AUG 1991									
14...	52	3.0	667	--	--	--	--	30	740
Site 384856104491602: well SC01406619DBC2 U-01 (LAT 38 48 56N LONG 104 49 16W)--Continued									
AUG 1991									
01...	46	2.7	820	--	--	--	--	290	5700
NOV									
12...	--	--	--	0.020	0.020	0.290	--	--	--
FEB 1992									
18...	--	--	--	<0.010	0.010	0.460	--	--	--
MAY									
05...	--	--	--	0.010	0.010	0.550	--	--	--
AUG									
20...	45	3.3	764	0.020	0.020	0.660	--	15	4200
OCT									
19...	--	--	--	0.020	0.020	0.720	--	--	--

DATE	TEMPERATURE WATER (deg C)	OXYGEN, DISSOLVED (mg/L)	pH WATER WHOLE FIELD (STANDARD UNITS)	SPECIFIC CONDUCTANCE (μS/cm)	CALCIUM DISSOLVED (mg/L as Ca)	MAGNESIUM, DISSOLVED (mg/L as Mg)	SODIUM, DISSOLVED (mg/L as Na)	POTASSIUM, DISSOLVED (mg/L as K)	ALKALINITY LAB (mg/L as $CaCO_3$)	SULFATE DISSOLVED (mg/L as SO_4)
Site 384858104485501: well SC01406619DAB TH-24 (LAT 38 48 58N LONG 104 48 55W)										
AUG 1991										
07...	16.5	0.2	7.0	1270	120	37	86	5.8	267	330
AUG 1992										
27...	14.5	0.2	6.9	--	140	32	73	5.6	272	300

DATE	CHLORIDE, DISSOLVED (mg/L as Cl)	FLUORIDE, DISSOLVED (mg/L as F)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (mg/L)	NITROGEN, AMMONIA DISSOLVED (mg/L as N)	NITROGEN, NITRITE DISSOLVED (mg/L as N)	NITROGEN, NO2+NO3 DISSOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DISSOLVED (μg/L as Fe)	MANGANESE, DISSOLVED (μg/L as Mn)
Site 384858104485501: well SC01406619DAB TH-24 (LAT 38 48 58N LONG 104 48 55W)									
AUG 1991									
07...	51	0.90	810	--	--	--	--	7	230
AUG 1992									
27...	61	1.0	811	0.010	0.260	2.90	--	37	380

Table 4. Ground-water-quality data for lower-terrace wells

[deg C, degrees Celsius; mg/L, milligrams per liter; μS/cm, microsiemens per centimeter at 25 degrees Celsius; μg/L, micrograms per liter; <, less than; --, no data; $CaCO_3$, calcium carbonate]

DATE	TEMPER-ATURE WATER (deg C)	OXYGEN, DIS-SOLVED (mg/L)	pH WATER WHOLE FIELD (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (μS/cm)	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)	ALKA-LINITY LAB (mg/L as $CaCO_3$)	SULFATE DIS-SOLVED (mg/L as SO_4)
Site 384313104431801; well SC01506625AAD W-14 (LAT 38 43 13N LONG 104 43 18W)										
AUG 1991 09...	13.0	--	7.3	1160	100	39	86	2.5	273	270
NOV 26...	13.5	--	6.9	1240	--	--	--	--	--	--
FEB 1992 19...	13.5	--	7.0	1330	--	--	--	--	--	--
MAY 11...	13.5	--	7.4	1260	--	--	--	--	--	--
AUG 25...	13.5	--	7.3	1350	130	51	100	2.9	301	350
OCT 22...	13.0	--	7.3	1460	--	--	--	--	--	--
Site 384339104433501; well SC01506624DBD2 U-19 (LAT 38 43 39N LONG 104 43 35W)										
JUL 1991 30...	15.5	5.9	7.0	585	59	14	39	2.7	147	90
NOV 15...	12.5	5.4	7.1	477	--	--	--	--	--	--
FEB 1992 24...	13.0	4.5	7.1	565	--	--	--	--	--	--
MAY 06...	13.5	6.2	7.4	564	--	--	--	--	--	--
AUG 18...	13.5	6.0	7.0	577	60	13	37	3.1	144	84
OCT 20...	14.0	5.4	7.0	632	--	--	--	--	--	--
Site 384348104432301; well SC01506624DAB2 U-18 (LAT 38 43 48N LONG 104 43 23W)										
JUL 1991 25...	15.5	6.2	7.2	882	79	31	62	2.0	232	160
AUG 1992 18...	13.5	6.9	7.2	843	82	27	56	1.9	219	150
Site 384404104434102; well SC01506624ABC2 U-16 (LAT 38 44 04N LONG 104 43 41W)										
JUL 1991 30...	14.0	4.2	7.0	874	91	23	56	3.1	214	170
AUG 1992 18...	14.0	4.8	7.2	778	83	20	49	2.6	188	140

DATE	CHLO-RIDE, DIS-SOLVED (mg/L as Cl)	FLUO-RIDE, DIS-SOLVED (mg/L as F)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (mg/L)	NITRO-GEN, AMMONIA DIS-SOLVED (mg/L as N)	NITRO-GEN, NITRITE DIS-SOLVED (mg/L as N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DIS-SOLVED (μg/L as Fe)	MANGA-NESE, DIS-SOLVED (μg/L as Mn)
Site 384313104431801; well SC01506625AAD W-14 (LAT 38 43 13N LONG 104 43 18W)--Continued									
AUG 1991 09...	38	0.80	718	--	--	--	--	18	<1
NOV 26...	--	--	--	<0.010	<0.010	9.70	--	--	--
FEB 1992 19...	--	--	--	<0.010	<0.010	9.90	--	--	--
MAY 11...	--	--	--	0.020	<0.010	8.90	--	--	--
AUG 25...	43	0.90	924	0.020	<0.010	11.0	--	15	<1
OCT 22...	--	--	--	0.010	<0.010	9.70	--	--	--

Table 4. Ground-water-quality data for lower-terrace wells--Continued

DATE	CHLORIDE, DISSOLVED (mg/L as Cl)	FLUORIDE, DISSOLVED (mg/L as F)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (mg/L)	NITROGEN, AMMONIA DISSOLVED (mg/L as N)	NITROGEN, NITRITE DISSOLVED (mg/L as N)	NITROGEN, NO2+NO3 DISSOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DISSOLVED (µg/L as Fe)	MANGANESE, DISSOLVED (µg/L as Mn)
Site 384339104433501; well SC01506624DBD2 U-19 (LAT 38 43 39N LONG 104 43 35W)--Continued									
JUL 1991 30...	27	0.80	342	--	--	--	--	4	<1
NOV 15...	--	--	--	<0.010	<0.010	7.60	--	--	--
FEB 1992 24...	--	--	--	0.030	<0.010	9.30	--	--	--
MAY 06...	--	--	--	<0.010	<0.010	9.10	--	--	--
AUG 18...	24	1.0	372	<0.010	<0.010	9.70	--	5	<1
OCT 20...	--	--	--	0.020	<0.010	9.90	--	--	--
Site 384348104432301; well SC01506624DAB2 U-18 (LAT 38 43 48N LONG 104 43 23W)--Continued									
JUL 1991 25...	35	0.80	528	--	--	--	--	4	<1
AUG 1992 18...	36	0.70	545	<0.010	<0.010	9.30	--	9	<1
Site 384404104434102; well SC01506624ABC2 U-16 (LAT 38 44 04N LONG 104 43 41W)--Continued									
JUL 1991 30...	30	0.50	523	--	--	--	--	12	<1
AUG 1992 18...	30	0.70	512	0.010	<0.010	12.0	--	4	<1

DATE	TEMPERATURE WATER (deg C)	OXYGEN, DISSOLVED (mg/L)	pH WATER WHOLE FIELD (STANDARD UNITS)	SPECIFIC CONDUCTANCE (µS/cm)	CALCIUM DISSOLVED (mg/L as Ca)	MAGNESIUM, DISSOLVED (mg/L as Mg)	SODIUM, DISSOLVED (mg/L as Na)	POTASSIUM, DISSOLVED (mg/L as K)	ALKALINITY LAB (mg/L as $CaCO_3$)	SULFATE DISSOLVED (mg/L as SO_4)
Site 384407104434801; well SC01506624BAD1 W-4 (LAT 38 44 07N LONG 104 43 48W)										
AUG 1991 09...	13.5	--	7.1	696	70	15	48	4.1	162	130
NOV 26...	13.0	--	--	641	--	--	--	--	--	--
FEB 1992 21...	12.5	--	7.1	650	--	--	--	--	--	--
MAY 11...	13.0	--	7.3	647	--	--	--	--	--	--
AUG 26...	13.0	--	7.1	634	66	13	46	3.7	162	91
OCT 22...	13.5	--	7.1	597	--	--	--	--	--	--
Site 384408104424701; well SC01506519BAD1 NONUM-2 (LAT 38 44 08N LONG 104 42 47W)										
JUL 1991 30...	12.0	0.3	7.3	1320	100	46	120	1.8	309	370
AUG 1992 26...	12.0	0	7.4	1440	120	49	130	1.8	271	360
Site 384422104435201; well SC01506613CDA S-9 (LAT 38 44 22N LONG 104 43 52W)										
AUG 1991 08...	14.0	--	7.0	578	60	13	35	2.6	140	80
AUG 1992 25...	13.0	--	7.2	513	56	12	35	2.7	135	70
Site 384433104440702; well SC01506613CBD2 U-14 (LAT 38 44 33N LONG 104 44 07W)										
AUG 1991 14...	13.0	1.6	6.7	665	69	14	45	4.4	159	110
NOV 20...	12.5	1.6	6.9	621	--	--	--	--	--	--
FEB 1992 24...	12.5	1.5	6.9	622	--	--	--	--	--	--
MAY 06...	12.0	1.7	7.0	628	--	--	--	--	--	--
AUG 20...	13.5	1.6	6.9	614	62	13	44	4.0	162	87
OCT 22...	13.0	1.5	6.9	604	--	--	--	--	--	--

Table 4. Ground-water-quality data for lower-terrace wells--Continued

DATE	CHLORIDE, DISSOLVED (mg/L as Cl)	FLUORIDE, DISSOLVED (mg/L as F)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (mg/L)	NITROGEN, AMMONIA DISSOLVED (mg/L as N)	NITROGEN, NITRITE DISSOLVED (mg/L as N)	NITROGEN, NO2+NO3 DISSOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DISSOLVED (µg/L as Fe)	MANGANESE, DISSOLVED (µg/L as Mn)
Site 384407104434801: well SC01506624BAD1 W-4 (LAT 38 44 07N LONG 104 43 48W)--Continued									
AUG 1991 09...	30	1.4	418	--	--	--	--	14	2
NOV 26...	--	--	--	<0.010	<0.010	6.70	--	--	--
FEB 1992 21...	--	--	--	<0.010	<0.010	6.50	--	--	--
MAY 11...	--	--	--	0.010	<0.010	6.40	--	--	--
AUG 26...	27	1.5	396	0.020	<0.010	6.80	--	<3	<1
OCT 22...	--	--	--	0.020	<0.010	6.30	--	--	--
Site 384408104424701: well SC01506519BAD1 NONUM-2 (LAT 38 44 08N LONG 104 42 47W)--Contined									
JUL 1991 30...	46	1.2	886	--	--	--	--	5	87
AUG 1992 26...	51	1.1	896	0.020	<0.010	1.10	--	4	57
Site 384422104435201: well SC01506613CDA S-9 (LAT 38 44 22N LONG 104 43 52W)--Continued									
AUG 1991 08...	19	1.2	318	--	--	--	--	13	2
AUG 1992 25...	19	1.2	335	0.020	<0.010	8.50	--	3	<1
Site 384433104440702: well SC01506613CBD2 U-14 (LAT 38 44 33N LONG 104 44 07W)--Continued									
AUG 1991 14...	29	1.5	388	--	--	--	--	12	1
NOV 20...	--	--	--	0.010	<0.010	6.50	--	--	--
FEB 1992 24...	--	--	--	0.030	<0.010	6.50	--	--	--
MAY 06...	--	--	--	<0.010	<0.010	6.90	--	--	--
AUG 20...	24	1.6	381	0.020	<0.010	6.40	--	8	<1
OCT 22...	--	--	--	0.010	<0.010	5.80	--	--	--

DATE	TEMPERATURE WATER (deg C)	OXYGEN, DISSOLVED (mg/L)	pH WATER WHOLE FIELD (STANDARD UNITS)	SPECIFIC CONDUCTANCE (µS/cm)	CALCIUM DISSOLVED (mg/L as Ca)	MAGNESIUM, DISSOLVED (mg/L as Mg)	SODIUM, DISSOLVED (mg/L as Na)	POTASSIUM, DISSOLVED (mg/L as K)	ALKALINITY LAB (mg/L as $CaCO_3$)	SULFATE DISSOLVED (mg/L as SO_4)
Site 384439104442101: well SC01506614DAA1 U-13 (LAT 38 44 39N LONG 104 44 21W)										
JUL 1991 31...	15.0	4.6	7.1	1010	95	21	67	6.5	152	160
AUG 1992 28...	13.0	4.7	6.8	982	110	24	66	6.2	210	200
Site 384458104442601: well SC01506614AAD S-2 (LAT 38 44 58N LONG 104 44 26W)										
AUG 1991 08...	13.5	--	7.1	500	51	11	30	3.4	131	60
NOV 26...	13.0	--	6.9	477	--	--	--	--	--	--
FEB 1992 21...	13.5	--	7.1	503	--	--	--	--	--	--
MAY 11...	13.0	--	7.2	477	--	--	--	--	--	--
AUG 25...	13.0	--	7.2	476	54	12	28	3.8	126	63
OCT 22...	13.5	--	7.2	473	--	--	--	--	--	--

Table 4. Ground-water-quality data for lower-terrace wells--Continued

DATE	TEMPER-ATURE WATER (deg C)	OXYGEN, DIS-SOLVED (mg/L)	pH WATER WHOLE FIELD (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (µS/cm)	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)	ALKA-LINITY LAB (mg/L as $CaCO_3$)	SULFATE DIS-SOLVED (mg/L as SO_4)
Site 384513104445302; well SC01506611CDD2 U-12 (LAT 38 45 13N LONG 104 44 53W)										
AUG 1991 01...	13.0	1.7	7.0	708	58	15	44	5.1	169	88
NOV 15...	11.5	4.2	6.9	600	--	--	--	--	--	--
FEB 1992 24...	12.0	0	6.9	630	--	--	--	--	--	--
MAY 06...	12.0	2.4	7.0	625	--	--	--	--	--	--
AUG 19...	14.0	2.0	6.9	605	60	16	39	5.1	154	91
OCT 22...	14.0	3.8	6.9	523	--	--	--	--	--	--
Site 384524104445101; well SC01506611CaD S-4 (LAT 38 45 24N LONG 104 44 51W)										
AUG 1991 08...	13.5	--	7.1	459	51	8.6	23	1.9	116	49
AUG 1992 25...	13.0	--	7.3	427	53	8.9	24	2.0	114	55

DATE	CHLO-RIDE, DIS-SOLVED (mg/L as Cl)	FLUO-RIDE, DIS-SOLVED (mg/L as F)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (mg/L)	NITRO-GEN, AMMONIA DIS-SOLVED (mg/L as N)	NITRO-GEN, NITRITE DIS-SOLVED (mg/L as N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DIS-SOLVED (µg/L as Fe)	MANGA-NESE, DIS-SOLVED (µg/L as Mn)
Site 384439104442101; well SC01506614DAA1 U-13 (LAT 38 44 39N LONG 104 44 21W)--Continued									
JUL 1991 31...	80	2.2	542	--	--	--	--	12	<2
AUG 1992 28...	48	2.2	664	0.020	<0.010	14.0	--	7	<1
Site 384458104442601; well SC01506614AAD S-2 (LAT 38 44 58N LONG 104 44 26W)--Continued									
AUG 1991 08...	19	1.4	277	--	--	--	--	4	<1
NOV 26...	--	--	--	0.010	<0.010	8.00	--	--	--
FEB 1992 21...	--	--	--	<0.010	<0.010	7.80	--	--	--
MAY 11...	--	--	--	0.010	<0.010	8.20	--	--	--
AUG 25...	17	1.2	312	0.020	<0.010	8.20	--	<3	<1
OCT 22...	--	--	--	0.020	<0.010	7.50	--	--	--
Site 384513104445302; well SC01506611CDD2 U-12 (LAT 38 45 13N LONG 104 44 53W)--Continued									
AUG 1991 01...	26	1.4	360	--	--	--	--	4	<1
NOV 15...	--	--	--	0.020	<0.010	5.40	--	--	--
FEB 1992 24...	--	--	--	<0.010	<0.010	4.50	--	--	--
MAY 06...	--	--	--	<0.010	<0.010	5.70	--	--	--
AUG 19...	30	1.6	381	<0.010	<0.010	5.60	--	100	1
OCT 22...	--	--	--	<0.010	<0.010	5.90	--	--	--
Site 384524104445101; well SC01506611CaD S-4 (LAT 38 45 24N LONG 104 44 51W)--Continued									
AUG 1991 08...	14	0.70	239	--	--	--	--	3	<1
AUG 1992 25...	14	0.60	285	0.010	<0.010	8.20	--	4	<1

Table 4. Ground-water-quality data for lower-terrace wells--Continued

DATE	TEMPER-ATURE WATER (deg C)	OXYGEN, DIS-SOLVED (mg/L)	pH WATER WHOLE FIELD (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (µS/cm)	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)	ALKA-LINITY LAB (mg/L as $CaCO_3$)	SULFATE DIS-SOLVED (mg/L as SO_4)
	Site 384534104450302; well SC01506611BDC3 U-11(LAT 38 45 34N LONG 104 45 03W)									
AUG 1991										
02...	14.0	6.5	7.2	442	50	8.0	26	2.0	112	64
NOV										
15...	12.0	6.1	7.1	394	--	--	--	--	--	--
FEB 1992										
20...	13.5	5.9	7.2	396	--	--	--	--	--	--
MAY										
05...	15.0	5.9	7.9	401	--	--	--	--	--	--
AUG										
21...	14.5	5.5	7.1	427	49	7.9	26	1.7	111	57
OCT										
22...	13.5	5.9	7.2	393	--	--	--	--	--	--
	Site 384535104450801; well SC01506611BCD2 V-3(LAT 38 45 35N LONG 104 45 08W)									
AUG 1991										
06...	13.5	--	7.0	430	49	7.5	23	2.2	110	41
NOV										
26...	13.5	--	7.1	384	--	--	--	--	--	--
FEB 1992										
19...	13.5	--	6.8	396	--	--	--	--	--	--
MAY										
11...	13.5	--	7.2	410	--	--	--	--	--	--
AUG										
21...	13.5	--	6.9	409	50	7.3	22	1.7	110	48
	Site 384543104451801; well SC01506611BCB P-9 (LAT 38 45 43N LONG 104 45 18W)									
AUG 1991										
08...	14.0	--	7.3	449	53	8.1	21	1.9	121	51
	Site 384549104445101; well SC01506611ABC TH-47 (LAT 38 45 49N LONG 104 44 51W)									
AUG 1991										
02...	17.0	5.0	7.1	1080	120	32	60	4.6	187	310
NOV										
19...	11.5	7.1	7.0	1050	--	--	--	--	--	--
FEB 1992										
25...	12.0	5.6	6.9	1090	--	--	--	--	--	--
MAY										
07...	14.5	5.8	--	1100	--	--	--	--	--	--
AUG										
26...	13.5	6.2	6.9	1110	120	32	64	4.3	194	270
OCT										
21...	14.5	7.2	6.9	1070	--	--	--	--	--	--

DATE	CHLO-RIDE, DIS-SOLVED (mg/L as Cl)	FLUO-RIDE, DIS-SOLVED (mg/L as F)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (mg/L)	NITRO-GEN, AMMONIA DIS-SOLVED (mg/L as N)	NITRO-GEN, NITRITE DIS-SOLVED (mg/L as N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DIS-SOLVED (µg/L as Fe)	MANGA-NESE, DIS-SOLVED (µg/L as Mn)
	Site 384534104450302; well SC01506611BDC3 U-11(LAT 38 45 34N LONG 104 45 03W)--Continued								
AUG 1991									
02...	11	0.50	252	--	--	--	--	<3	<1
NOV									
15...	--	--	--	0.010	<0.010	5.40	--	--	--
FEB 1992									
20...	--	--	--	<0.010	<0.010	8.00	--	--	--
MAY									
05...	--	--	--	<0.010	<0.010	7.60	--	--	--
AUG									
21...	12	0.60	276	0.020	<0.010	7.50	--	5	2
OCT									
22...	--	--	--	<0.010	<0.010	7.30	--	--	--

Table 4. Ground-water-quality data for lower-terrace wells--Continued

DATE	CHLORIDE, DISSOLVED (mg/L as Cl)	FLUORIDE, DISSOLVED (mg/L as F)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (mg/L)	NITROGEN, AMMONIA DISSOLVED (mg/L as N)	NITROGEN, NITRITE DISSOLVED (mg/L as N)	NITROGEN, NO2+NO3 DISSOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DISSOLVED (µg/L as Fe)	MANGANESE, DISSOLVED (µg/L as Mn)
Site 384535104450801; well SC01506611BCD2 V-3 (LAT 38 45 35N LONG 104 45 08W)--Continued									
AUG 1991 06...	8.3	0.40	217	--	--	--	--	19	1
NOV 26...	--	--	--	<0.010	<0.010	8.20	--	--	--
FEB 1992 19...	--	--	--	<0.010	<0.010	8.20	6.30	--	--
MAY 11...	--	--	--	0.010	<0.010	8.10	--	--	--
AUG 21...	12	0.50	270	0.020	<0.010	8.60	--	<3	<1
Site 384543104451801; well SC01506611BCB P-9 (LAT 38 45 43N LONG 104 45 18W)--Continued									
AUG 1991 08...	17	0.40	252	--	--	--	--	9	<1
Site 384549104445101; well SC01506611ABC TH-47 (LAT 38 45 49N LONG 104 44 51W)--Continued									
AUG 1991 02...	36	0.80	697	--	--	--	--	4	<1
NOV 19...	--	--	--	0.020	<0.010	12.0	--	--	--
FEB 1992 25...	--	--	--	<0.010	<0.010	13.0	--	--	--
MAY 07...	--	--	--	0.010	<0.010	12.0	--	--	--
AUG 26...	41	1.0	727	0.020	<0.010	13.0	--	18	<1
OCT 21...	--	--	--	0.020	<0.010	11.0	--	--	--

DATE	TEMPERATURE WATER (deg C)	OXYGEN, DISSOLVED (mg/L)	pH WATER WHOLE FIELD (STANDARD UNITS)	SPECIFIC CONDUCTANCE (mS/cm)	CALCIUM DISSOLVED (mg/L as Ca)	MAGNESIUM, DISSOLVED (mg/L as Mg)	SODIUM, DISSOLVED (mg/L as Na)	POTASSIUM, DISSOLVED (mg/L as K)	ALKALINITY LAB (mg/L as $CaCO_3$)	SULFATE DISSOLVED (mg/L as SO_4)
Site 384553104451801; well SC01506611BBB2 S-11 (LAT 38 45 53N LONG 104 45 18W)										
AUG 1991 08...	14.5	--	7.2	442	50	7.5	23	1.8	117	55
AUG 1992 25...	13.0	--	7.4	390	48	7.2	24	1.8	107	53
Site 384558104453901; well SC01506610AAB2 P-10 (LAT 38 45 58N LONG 104 45 39W)										
AUG 1991 08...	13.5	--	7.5	642	75	13	32	2.3	175	92
AUG 1992 19...	15.5	--	7.1	580	71	11	34	2.2	150	83
Site 384604104451502; well SC01506602CCC2 U-09 (LAT 38 46 04N LONG 104 45 15W)										
AUG 1991 09...	13.5	6.4	7.2	412	48	6.4	24	1.8	107	56
NOV 19...	12.5	6.9	7.2	387	--	--	--	--	--	--
FEB 1992 18...	12.5	8.2	7.1	377	--	--	--	--	--	--
MAY 06...	13.0	7.1	7.3	446	--	--	--	--	--	--
AUG 21...	13.5	6.2	7.1	389	48	7.9	27	1.9	109	61
OCT 21...	14.0	6.2	7.1	434	--	--	--	--	--	--

Table 4. Ground-water-quality data for lower-terrace wells--Continued

DATE	TEMPERATURE WATER (deg C)	OXYGEN, DISSOLVED (mg/L)	pH WATER WHOLE FIELD (STANDARD UNITS)	SPECIFIC CONDUCTANCE (µS/cm)	CALCIUM DISSOLVED (mg/L as Ca)	MAGNESIUM, DISSOLVED (mg/L as Mg)	SODIUM, DISSOLVED (mg/L as Na)	POTASSIUM, DISSOLVED (mg/L as K)	ALKALINITY LAB (mg/L as $CaCO_3$)	SULFATE DISSOLVED (mg/L as SO_4)
Site 384610104453501; well SC01506603DDB S-14 (LAT 38 46 10N LONG 104 45 35W)										
AUG 1991										
08...	13.5	--	7.3	644	77	11	40	2.3	197	74
NOV										
26...	13.5	--	7.2	621	--	--	--	--	--	--
FEB 1992										
21...	13.5	--	7.4	633	--	--	--	--	--	--
MAY										
11...	13.0	--	7.5	638	--	--	--	--	--	--
AUG										
25...	12.5	--	7.6	620	81	11	38	2.1	194	77
OCT										
22...	13.0	--	7.4	644	--	--	--	--	--	--

DATE	CHLORIDE, DISSOLVED (mg/L as Cl)	FLUORIDE, DISSOLVED (mg/L as F)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (mg/L)	NITROGEN, AMMONIA DISSOLVED (mg/L as N)	NITROGEN, NITRITE DISSOLVED (mg/L as N)	NITROGEN, NO2+NO3 DISSOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DISSOLVED (µg/L as Fe)	MANGANESE, DISSOLVED (µg/L as Mn)
Site 384553104451801; well SC01506611BBB2 S-11 (LAT 38 45 53N LONG 104 45 18W)--Continued									
AUG 1991									
08...	11	0.50	243	--	--	--	--	5	<1
AUG 1992									
25...	10	0.50	263	0.020	<0.010	7.30	--	<3	<1
Site 384558104453901; well SC01506610AAB2 P-10 (LAT 38 45 58N LONG 104 45 39W)--Continued									
AUG 1991									
08...	23	0.50	365	--	--	--	--	4	<1
AUG 1992									
19...	30	0.50	374	0.010	<0.010	6.90	--	<3	<1
Site 384604104451502; well SC01506602CCC2 U-09 (LAT 38 46 04N LONG 104 45 15W)--Continued									
AUG 1991									
09...	11	0.50	237	--	--	--	-	<3	<1
NOV									
19...	--	--	--	0.010	<0.010	7.20	--	--	--
FEB 1992									
18...	--	--	--	<0.010	<0.010	7.50	6.30	--	--
MAY									
06...	--	--	--	<0.010	<0.010	7.50	--	--	--
AUG									
21...	11	0.70	277	0.020	<0.010	7.30	--	6	<1
OCT									
21...	--	--	--	0.010	<0.010	7.00	--	--	--
Site 384610104453501; well SC01506603DDB S-14 (LAT 38 46 10N LONG 104 45 35W)--Continued									
AUG 1991									
08...	25	0.30	372	--	--	--	--	8	<1
NOV									
26...	--	--	--	0.010	<0.010	7.30	--	--	--
FEB 1992									
21...	--	--	--	<0.010	<0.010	6.90	--	--	--
MAY									
11...	--	--	--	<0.010	<0.010	6.70	--	--	--
AUG									
25...	28	0.30	405	0.010	<0.010	6.90	--	3	<1
OCT									
22...	--	--	--	0.010	<0.010	6.70	--	--	--

Table 4. Ground-water-quality data for lower-terrace wells--Continued

DATE	TEMPER-ATURE WATER (deg C)	OXYGEN, DIS-SOLVED (mg/L)	pH WATER WHOLE FIELD (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (µS/cm)	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)	ALKA-LINITY LAB (mg/L as $CaCO_3$)	SULFATE DIS-SOLVED (mg/L as SO_4)
Site 384617104455901: well SC01506603CaD1 SH-4 (LAT 38 46 17N LONG 104 45 59W)										
AUG 1991 08...	13.0	--	6.9	887	100	19	49	2.1	250	120
NOV 26...	13.0	--	7.0	812	--	--	--	--	--	--
FEB 1992 21...	13.0	--	7.3	892	--	--	--	--	--	--
MAY 11...	13.0	--	7.3	898	--	--	--	--	--	--
AUG 24...	13.0	--	7.2	--	120	22	56	2.4	263	170
OCT 22...	13.5	--	7.1	972	--	--	--	--	--	--
Site 384639104461401: well SC01506603BAC1 MARS Gas(LAT 38 46 39N LONG 104 46 14W)										
AUG 1991 08...	13.0	--	6.9	1010	83	22	88	4.2	149	260
NOV 26...	12.0	--	7.0	1020	--	--	--	--	--	--
FEB 1992 19...	12.5	--	6.9	962	--	--	--	--	--	--
MAY 11...	12.5	--	7.2	999	--	--	--	--	--	--
AUG 25...	13.0	--	7.2	1040	92	23	97	3.9	156	240
OCT 22...	13.0	--	7.1	1040	--	--	--	--	--	--
Site 384640104463001: well SC01506603BBC TH-42 (LAT 38 46 40N LONG 104 46 30W)										
AUG 1991 07...	13.0	0.2	6.5	1030	93	20	80	5.3	141	240
AUG 1992 21...	12.5	0.2	6.9	1040	100	20	81	4.5	157	230
Site 384642104461001: well SC01506603BAC TH-56 (LAT 38 46 42N LONG 104 46 10W)										
AUG 1991 13...	12.5	1.2	7.1	1120	98	26	90	3.7	179	280
AUG 1992 20...	13.5	1.5	7.0	1090	100	25	92	3.8	176	220

DATE	CHLO-RIDE, DIS-SOLVED (mg/L as Cl)	FLUO-RIDE, DIS-SOLVED (mg/L as F)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (mg/L)	NITRO-GEN, AMMONIA DIS-SOLVED (mg/L as N)	NITRO-GEN, NITRITE DIS-SOLVED (mg/L as N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DIS-SOLVED (µg/L as Fe)	MANGA-NESE, DIS-SOLVED (µg/L as Mn)
Site 384617104455901: well SC01506603CaD1 SH-4 (LAT 38 46 17N LONG 104 45 59W)--Continued									
AUG 1991 08...	38	0.40	503	--	--	--	--	<3	<1
NOV 26...	--	--	--	0.010	<0.010	8.00	--	--	--
FEB 1992 21...	--	--	--	<0.010	<0.010	6.90	--	--	--
MAY 11...	--	--	--	0.010	<0.010	6.70	--	--	--
AUG 24...	51	0.40	629	0.020	<0.010	6.30	--	7	<1
OCT 22...	--	--	--	0.010	<0.010	6.00	--	--	--
Site 384639104461401: well SC01506603BAC1 MARS Gas(LAT 38 46 39N LONG 104 46 14W)--Continued									
AUG 1991 08...	50	1.3	622	--	--	--	--	110	1
NOV 26...	--	--	--	<0.010	<0.010	7.90	--	--	--
FEB 1992 19...	--	--	--	<0.010	<0.010	6.90	--	--	--
MAY 11...	--	--	--	0.020	<0.010	8.80	--	--	--
AUG 25...	65	1.3	683	0.020	<0.010	10.0	--	170	2
OCT 22...	--	--	--	0.020	<0.010	7.60	--	--	--

Table 4. Ground-water-quality data for lower-terrace wells--Continued

DATE	CHLORIDE, DISSOLVED (mg/L as Cl)	FLUORIDE, DISSOLVED (mg/L as F)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (mg/L)	NITROGEN, AMMONIA DISSOLVED (mg/L as N)	NITROGEN, NITRITE DISSOLVED (mg/L as N)	NITROGEN, NO2+NO3 DISSOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DISSOLVED (µg/L as Fe)	MANGANESE, DISSOLVED (µg/L as Mn)
Site 384640104463001; well SC01506603BBC TH-42 (LAT 38 46 40N LONG 104 46 30W)--Continued									
AUG 1991 07...	64	1.4	609	--	--	--	--	5	47
AUG 1992 21...	75	1.4	659	0.040	<0.010	7.50	--	240	190
Site 384642104461001; well SC01506603BAC TH-56 (LAT 38 46 42N LONG 104 46 10W)--Continued									
AUG 1991 13...	50	1.1	679	--	--	--	--	<3	3
AUG 1992 20...	55	0.90	672	0.020	<0.010	11.0	--	<3	1

DATE	TEMPERATURE WATER (deg C)	OXYGEN, DISSOLVED (mg/L)	pH WATER WHOLE FIELD (STANDARD UNITS)	SPECIFIC CONDUCTANCE (µS/cm)	CALCIUM DISSOLVED (mg/L as Ca)	MAGNESIUM, DISSOLVED (mg/L as Mg)	SODIUM, DISSOLVED (mg/L as Na)	POTASSIUM, DISSOLVED (mg/L as K)	ALKALINITY LAB (mg/L as $CaCO_3$)	SULFATE DISSOLVED (mg/L as SO_4)
Site 384653104463601; well SC01506604AAA TH-43(LAT 38 46 53N LONG 104 46 36W)										
AUG 1991 07...	17.5	1.9	6.8	705	69	13	49	4.3	160	140
AUG 1992 21...	14.5	0.2	7.0	903	75	15	90	4.4	149	210
Site 384659104461501; well SC01406634CCD TH-55 (LAT 38 46 59N LONG 104 46 15W)										
AUG 1991 13...	12.0	4.6	6.9	961	95	20	71	4.4	166	220
NOV 21...	13.0	3.1	6.8	--	--	--	--	--	--	--
FEB 1992 27...	13.5	4.2	6.9	892	--	--	--	--	--	--
MAY 08...	12.0	3.6	7.1	990	--	--	--	--	--	--
AUG 19...	11.0	3.1	6.9	941	89	18	78	4.7	163	220
OCT 22...	11.5	2.9	6.9	910	--	--	--	--	--	--
Site 384712104471301; well SC01406633CaD1 U-06 (LAT 38 47 12N LONG 104 47 13W)										
AUG 1991 09...	12.5	5.4	7.1	1220	110	32	110	2.4	254	370
NOV 13...	14.0	6.7	7.2	1150	--	--	--	--	--	--
FEB 1992 27...	12.5	5.6	7.3	1130	--	--	--	--	--	--
MAY 04...	13.5	6.4	7.5	1150	--	--	--	--	--	--
AUG 20...	13.5	5.7	7.2	1150	110	31	110	2.4	250	330
OCT 19...	14.0	6.2	7.1	1100	--	--	--	--	--	--
Site 384718104463701; well SC01406633DAA BARNES (LAT 38 47 18N LONG 104 46 37W)										
AUG 1991 08...	14.0	--	7.4	1340	130	44	75	3.9	309	340
NOV 26...	12.5	--	7.0	1380	--	--	--	--	--	--
FEB 1992 20...	13.0	--	7.2	1250	--	--	--	--	--	--
MAY 28...	13.0	--	7.3	1340	--	--	--	--	--	--
AUG 27...	13.5	--	7.2	1330	150	50	83	4.1	308	360
OCT 22...	13.5	--	7.1	1350	--	--	--	--	--	--

Table 4. Ground-water-quality data for lower-terrace wells--Continued

DATE	CHLORIDE, DISSOLVED (mg/L as Cl)	FLUORIDE, DISSOLVED (mg/L as F)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (mg/L)	NITROGEN, AMMONIA DISSOLVED (mg/L as N)	NITROGEN, NITRITE DISSOLVED (mg/L as N)	NITROGEN, NO2+NO3 DISSOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DISSOLVED (µg/L as Fe)	MANGANESE, DISSOLVED (µg/L as Mn)
Site 384653104463601; well SC01506604AAA TH-43 (LAT 38 46 53N LONG 104 46 36W)--Continued									
AUG 1991 07...	34	1.9	427	--	--	--	--	7	200
AUG 1992 21...	55	1.6	577	0.020	0.010	4.30	--	19	650
Site 384659104461501; well SC01406634CCD TH-55(LAT 38 46 59N LONG 104 46 15W)--Continued									
AUG 1991 13...	45	0.70	578	--	--	--	--	4	1
NOV 21...	--	--	--	0.030	<0.010	5.60	--	--	--
FEB 1992 27...	--	--	--	0.010	<0.010	5.80	--	--	--
MAY 08...	--	--	--	<0.010	<0.010	6.60	--	--	--
AUG 19...	56	0.90	611	<0.010	<0.010	5.60	--	9	1
OCT 22...	--	--	--	0.010	<0.010	5.20	--	--	--
Site 384712104471301; well SC01406633CaD1 U-06(LAT 38 47 12N LONG 104 47 13W)--Continued									
AUG 1991 09...	25	1.4	823	--	--	--	--	<3	<1
NOV 13...	--	--	--	<0.010	<0.010	0.200	--	--	--
FEB 1992 27...	--	--	--	<0.010	<0.010	0.180	--	--	--
MAY 04...	--	--	--	<0.010	<0.010	0.210	--	--	--
AUG 20...	31	1.5	787	0.020	<0.010	0.240	--	21	<1
OCT 19...	--	--	--	0.010	<0.010	0.220	--	--	--
Site 384718104463701; well SC01406633DAA BARNES (LAT 38 47 18N LONG 104 46 37W)--Continued									
AUG 1991 08...	36	1.0	839	--	--	--	--	6	<1
NOV 26...	--	--	--	<0.010	<0.010	15.0	--	--	--
FEB 1992 20...	--	--	--	<0.010	<0.010	12.0	--	--	--
MAY 28...	--	--	--	0.010	<0.010	12.0	--	--	--
AUG 27...	40	0.80	954	0.010	<0.010	13.0	--	10	<1
OCT 22...	--	--	--	0.020	<0.010	12.0	--	--	--

DATE	TEMPERATURE WATER (deg C)	OXYGEN, DISSOLVED (mg/L)	pH WATER WHOLE FIELD (STANDARD UNITS)	SPECIFIC CONDUCTANCE (µS/cm)	CALCIUM DISSOLVED (mg/L as Ca)	MAGNESIUM, DISSOLVED (mg/L as Mg)	SODIUM, DISSOLVED (mg/L as Na)	POTASSIUM, DISSOLVED (mg/L as K)	ALKALINITY LAB (mg/L as $CaCO_3$)	SULFATE DISSOLVED (mg/L as SO_4)
Site 384718104465801; well SC01406633DBB1 U-05 (LAT 38 47 18N LONG 104 46 58W)										
AUG 1991 14...	12.0	0.2	6.6	777	82	18	53	4.5	176	150
AUG 1992 20...	13.0	0.4	6.7	750	79	17	52	4.5	178	140
Site 384728104474201; well SC01406632ADA1 U-04 (LAT 38 47 28N LONG 104 47 41W)										
AUG 1991 21...	16.5	3.5	6.9	1170	110	36	91	2.9	293	270
NOV 12...	--	--	--	--	--	--	--	--	--	--
FEB 1992 18...	11.0	4.2	6.9	1110	--	--	--	--	--	--
MAY 04...	12.5	3.9	7.0	1140	--	--	--	--	--	--
AUG 20...	12.0	4.0	7.0	1120	110	32	91	2.9	222	230
OCT 19...	11.5	5.0	7.0	1090	--	--	--	--	--	--

Table 4. Ground-water-quality data for lower-terrace wells--Continued

DATE	TEMPER-ATURE WATER (deg C)	OXYGEN, DIS-SOLVED (mg/L)	pH WATER WHOLE FIELD (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (µS/cm)	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)	ALKA-LINITY LAB (mg/L as $CaCO_3$)	SULFATE DIS-SOLVED (mg/L as SO_4)
Site 384743104474501; well SC01406632AAA1 U-03 (LAT 38 47 43N LONG 104 47 45W)										
AUG 1991 13...	13.0	5.9	6.7	386	44	10	40	4.9	99	89
AUG 1992 20...	13.0	4.9	6.7	608	58	13	43	5.5	108	130
Site 384818104473201; well SC01406628BCC1 TH-26 (LAT 38 48 18N LONG 104 47 32W)										
AUG 1991 05...	12.0	4.5	7.2	1330	99	35	95	6.2	216	360
NOV 12...	12.5	2.5	7.1	1210	--	--	--	--	--	--
FEB 1992 18...	11.0	2.5	7.3	1210	--	--	--	--	--	--
MAY 04...	14.0	5.9	7.3	1420	--	--	--	--	--	--

DATE	CHLO-RIDE, DIS-SOLVED (mg/L as Cl)	FLUO-RIDE, DIS-SOLVED (mg/L as F)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (mg/L)	NITRO-GEN, AMMONIA DIS-SOLVED (mg/L as N)	NITRO-GEN, NITRITE DIS-SOLVED (mg/L as N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DIS-SOLVED (µg/L as Fe)	MANGA-NESE, DIS-SOLVED (µg/L as Mn)
Site 384718104465801; well SC01406633DBB1 U-05 (LAT 38 47 18N LONG 104 46 58W)--Continued									
AUG 1991 14...	34	3.0	469	--	--	--	--	5	18
AUG 1992 20...	38	3.0	477	0.100	<0.010	3.50	--	100	7
Site 384728104474201; well SC01406632ADA1 U-04 (LAT 38 47 28N LONG 104 47 41W)--Continued									
AUG 1991 21...	58	1.7	767	--	--	--	--	7	3
NOV 12...	--	--	--	0.010	0.010	2.80	--	--	--
FEB 1992 18...	--	--	--	<0.010	<0.010	2.80	--	--	--
MAY 04...	--	--	--	<0.010	<0.010	2.60	--	--	--
AUG 20...	57	1.6	692	0.020	<0.010	2.50	--	<3	2
OCT 19...	--	--	--	0.010	<0.010	2.40	--	--	--
Site 384743104474501; well SC01406632AAA1 U-03 (LAT 38 47 43N LONG 104 47 45W)--Continued									
AUG 1991 13...	25	3.2	292	--	--	--	--	13	2
AUG 1992 20...	33	3.2	390	0.010	<0.010	4.80	--	6	2
Site 384818104473201; well SC01406628BCC1 TH-26 (LAT 38 48 18N LONG 104 47 32W)--Continued									
AUG 1991 05...	39	1.1	779	--	--	--	--	5	<1
NOV 12...	--	--	--	<0.010	0.010	7.10	--	--	--
FEB 1992 18...	--	--	--	<0.010	<0.010	8.20	--	--	--
MAY 04...	--	--	--	<0.010	<0.010	9.20	--	--	--

Table 5. Ground-water-quality data for upper-terrace wells

[deg C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; µg/L, micrograms per liter; <, less than; --, no data; $CaCO_3$, calcium carbonate]

DATE	TEMPER-ATURE WATER (deg C)	OXYGEN, DIS-SOLVED (mg/L)	pH WATER WHOLE FIELD (STAND-ARD UNITS)	SPE-CIFIC CON-DUCT-ANCE (µS/cm)	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)	ALKA-LINITY LAB (mg/L as $CaCO_3$)	SULFATE DIS-SOLVED (mg/L as SO_4)
	Site 384420104432601: well SC01506613DDC1 U-15 (LAT 38 44 20N LONG 104 43 26W)									
NOV 1991 19...	11.5	6.4	7.5	1970	150	85	150	3.3	374	620
FEB 1992 24...	12.5	5.3	7.4	1900	--	--	--	--	--	--
MAY 07...	12.5	5.1	7.4	1690	--	--	--	--	--	--
AUG 18...	16.0	5.1	7.3	1950	160	91	150	3.2	382	640
OCT 20...	18.0	4.8	7.3	1940	--	--	--	--	--	--
	Site 384437104422601: well SC01506518DBA FVS (LAT 38 44 37N LONG 104 42 26W)									
AUG 1991 12...	16.0	--	7.4	1020	87	36	84	2.4	283	230
	Site 384441104431401: well SC01506613ADD CO259-27 (LAT 38 44 41N LONG 104 43 14W)									
NOV 1991 20...	12.5	1.3	7.4	2520	150	170	260	3.2	404	1000
FEB 1992 24...	--	--	--	--	--	--	--	--	--	--
OCT 20...	13.5	1.5	--	4700	--	--	--	--	--	--
	Site 384509104435901: well SC01506612CDC CO259-25 (LAT 38 45 09N LONG 104 43 59W)									
NOV 1991 18...	12.0	4.0	7.4	668	74	12	46	2.1	200	110
FEB 1992 26...	--	--	--	--	--	--	--	--	--	--
MAY 07...	14.0	2.9	7.6	688	--	--	--	--	--	--
AUG 21...	14.5	2.2	7.3	694	76	14	49	1.6	208	96
OCT 21...	14.5	2.1	7.3	688	--	--	--	--	--	--
	Site 384540104443801: well SC01506611ACD1 U-10 (LAT 38 45 40N LONG 104 44 38W)									
AUG 1991 02...	15.0	3.2	7.1	917	99	32	50	2.6	274	190
AUG 1992 26...	15.0	6.0	7.2	1000	110	35	53	2.4	232	220

DATE	CHLO-RIDE, DIS-SOLVED (mg/L as Cl)	FLUO-RIDE, DIS-SOLVED (mg/L as F)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (mg/L)	NITRO-GEN, AMMONIA DIS-SOLVED (mg/L as N)	NITRO-GEN, NITRITE DIS-SOLVED (mg/L as N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DIS-SOLVED (µg/L as Fe)	MANGA-NESE, DIS-SOLVED (µg/L as Mn)
	Site 384420104432601: well SC01506613DDC1 U-15 (LAT 38 44 20N LONG 104 43 26W)--Continued								
NOV 1991 19...	50	0.70	1350	<0.010	<0.010	11.0	--	<3	<1
FEB 1992 24...	--	--	--	<0.010	<0.010	10.0	11.60	--	--
MAY 07...	--	--	--	0.010	<0.010	8.90	--	--	--
AUG 18...	47	0.90	1380	0.010	<0.010	9.00	--	5	<1
OCT 20...	--	--	--	0.030	<0.010	8.90	--	--	--
	Site 384437104422601: well SC01506518DBA FVS (LAT 38 44 37N LONG 104 42 26W)--Continued								
AUG 1991 12...	36	0.60	665	--	--	--	--	38	4

Table 5. Ground-water-quality data for upper-terrace wells--Continued

DATE	CHLORIDE, DISSOLVED (mg/L as Cl)	FLUORIDE, DISSOLVED (mg/L as F)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (mg/L)	NITROGEN, AMMONIA DISSOLVED (mg/L as N)	NITROGEN, NITRITE DISSOLVED (mg/L as N)	NITROGEN, NO2+NO3 DISSOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DISSOLVED (µg/L as Fe)	MANGANESE, DISSOLVED (µg/L as Mn)
Site 384441104431401; well SC01506613ADD CO259-27 (LAT 38 44 41N LONG 104 43 14W)--Continued									
NOV 1991									
20...	47	0.60	1930	<0.010	<0.010	8.70	--	<10	50
FEB 1992									
24...	--	--	--	<0.010	<0.010	7.80	--	--	--
OCT									
20...	--	--	--	0.050	0.010	7.20	--	--	--
Site 384509104435901; well SC01506612CDC CO259-25 (LAT 38 45 09N LONG 104 43 59W)--Continued									
NOV 1991									
18...	23	0.50	453	0.020	<0.010	10.0	--	<3	7
FEB 1992									
26...	--	--	--	<0.010	<0.010	6.20	8.90	--	--
MAY									
07...	--	--	--	0.020	<0.010	6.90	--	--	--
AUG									
21...	22	0.70	431	0.020	<0.010	6.60	--	4	3
OCT									
21...	--	--	--	0.020	<0.010	6.00	--	--	--
Site 384540104443801; well SC01506611ACD1 U-10 (LAT 38 45 40N LONG 104 44 38W)--Continued									
AUG 1991									
02...	33	0.30	590	--	--	--	--	8	4
AUG 1992									
26...	33	0.40	643	0.020	<0.010	6.80	--	3	1

DATE	TEMPERATURE WATER (deg C)	OXYGEN, DISSOLVED (mg/L)	pH WATER WHOLE FIELD (STANDARD UNITS)	SPECIFIC CONDUCTANCE (µS/cm)	CALCIUM DISSOLVED (mg/L as Ca)	MAGNESIUM, DISSOLVED (mg/L as Mg)	SODIUM, DISSOLVED (mg/L as Na)	POTASSIUM, DISSOLVED (mg/L as K)	ALKALINITY LAB (mg/L as $CaCO_3$)	SULFATE DISSOLVED (mg/L as SO_4)
Site 384553104432901; well SC01506612ABA W-9 (LAT 38 45 53N LONG 104 43 29W)										
AUG 1991										
09...	13.0	--	7.5	492	56	7.8	26	1.8	159	63
Site 384610104432401; well SC01506601DDB W-8 (LAT 38 46 10N LONG 104 43 24W)										
AUG 1991										
09...	14.0	8010	7.4	491	59	7.7	26	1.6	148	71
NOV										
26...	14.0	--	7.2	462	--	--	--	--	--	--
FEB 1992										
21...	13.5	--	7.7	480	--	--	--	--	--	--
MAY										
11...	12.5	--	7.6	507	--	--	--	--	--	--
AUG										
26...	13.0	--	7.4	522	68	8.8	28	1.6	152	70
OCT										
22...	15.0	--	7.8	546	--	--	--	--	--	--
Site 384621104445401; well SCO1506602CaA TH-16 (LAT 38 46 21N LONG 104 44 54W)										
AUG 1991										
21...	14.0	--	7.0	877	83	17	71	6.9	206	150
NOV										
27...	11.0	5.1	7.1	853	--	--	--	--	--	--
MAY 1992										
08...	12.5	4.1	7.3	933	--	--	--	--	--	--
AUG										
27...	12.5	3.5	7.1	824	84	18	67	6.3	200	140
OCT										
21...	13.5	4.3	7.1	866	--	--	--	--	--	--

Table 5. Ground-water-quality data for upper-terrace wells--Continued

DATE	TEMPERATURE WATER (deg C)	OXYGEN, DISSOLVED (mg/L)	pH WATER WHOLE FIELD (STANDARD UNITS)	SPECIFIC CONDUCTANCE (µS/cm)	CALCIUM DISSOLVED (mg/L as Ca)	MAGNESIUM, DISSOLVED (mg/L as Mg)	SODIUM, DISSOLVED (mg/L as Na)	POTASSIUM, DISSOLVED (mg/L as K)	ALKALINITY LAB (mg/L as $CaCO_3$)	SULFATE DISSOLVED (mg/L as SO_4)
Site 384628104450801; well SC01506602BDC TH-23 (LAT 38 46 28N LONG 104 45 08W)										
AUG 1991 12...	14.5	6.3	7.0	606	76	9.8	42	2.6	130	120
NOV 21...	12.5	7.3	7.0	552	--	--	--	--	--	--
FEB 1992 27...	11.5	6.8	7.0	575	--	--	--	--	--	--
MAY 06...	14.5	6.4	7.2	571	--	--	--	--	--	--
AUG 27...	13.5	5.6	7.0	575	65	8.6	41	2.6	125	100
OCT 21...	15.0	6.1	7.0	657	--	--	--	--	--	--

DATE	CHLORIDE, DISSOLVED (mg/L as Cl)	FLUORIDE, DISSOLVED (mg/L as F)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (mg/L)	NITROGEN, AMMONIA DISSOLVED (mg/L as N)	NITROGEN, NITRITE DISSOLVED (mg/L as N)	NITROGEN, NO2+NO3 DISSOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DISSOLVED (µg/L as Fe)	MANGANESE, DISSOLVED (µg/L as Mn)
Site 384553104432901; well SC01506612ABA W-9 (LAT 38 45 53N LONG 104 43 29W)--Continued									
AUG 1991 09...	12	0.40	283	--	--	--	--	29	2
Site 384610104432401; well SC01506601DDB W-8(LAT 38 46 10N LONG 104 43 24W)--Continued									
AUG 1991 09...	8.8	0.40	287	--	--	--	--	13	2
NOV 26...	--	--	--	0.010	<0.010	7.00	--	--	--
FEB 1992 21...	--	--	--	<0.010	<0.010	6.70	6.20	--	--
MAY 11...	--	--	--	<0.010	<0.010	4.40	--	--	--
AUG 26...	7.4	0.30	335	0.020	<0.010	8.20	--	13	<1
OCT 22...	--	--	--	0.020	<0.010	7.20	--	--	--
Site 384621104445401; well SC01506602CaA TH-16(LAT 38 46 21N LONG 104 44 54W)--Continued									
AUG 1991 21...	37	1.1	507	--	--	--	--	7	46
NOV 27...	--	--	--	<0.010	<0.010	17.0	--	--	--
MAY 1992 08...	--	--	--	<0.010	<0.010	17.0	--	--	--
AUG 27...	29	1.0	554	0.010	<0.010	16.0	--	5	16
OCT 21...	--	--	--	0.020	<0.010	15.0	--	--	--
Site 384628104450801; well SC01506602BDC TH-23 (LAT 38 46 28N LONG 104 45 08W)--Continued									
AUG 1991 12...	27	0.60	379	--	--	--	--	10	4
NOV 21...	--	--	--	<0.010	<0.010	7.40	--	--	--
FEB 1992 27...	--	--	--	0.010	<0.010	8.60	--	--	--
MAY 06...	--	--	--	0.010	<0.010	7.70	--	--	--
AUG 27...	26	0.60	383	0.010	<0.010	9.10	--	9	1
OCT 21...	--	--	--	0.020	<0.010	9.00	--	--	--

Table 5. Ground-water-quality data for upper-terrace wells--Continued

DATE	TEMPER- ATURE WATER (deg C)	OXYGEN, DIS- SOLVED (mg/L)	pH WATER WHOLE FIELD (STAND- ARD UNITS)	SPE- CIFIC CON- DUCT- ANCE (µS/cm)	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)	ALKA- LINITY LAB (mg/L as $CaCO_3$)	SULFATE DIS- SOLVED (mg/L as SO_4)
Site 384639104452801; well SC01506603AAD TH-21(LAT 38 46 39N LONG 104 45 28W)										
AUG 1991 13...	13.5	4.7	7.4	673	83	12	39	2.4	196	89
Site 384642104440101; well SC01506601BBD TH-53(LAT 38 46 42N LONG 104 44 01W)										
AUG 1991 13...	13.5	7.2	7.8	481	40	9.9	47	1.3	171	54
NOV 20...	17.0	7.3	7.3	464	--	--	--	--	--	--
FEB 1992 25...	11.5	6.4	7.9	480	--	--	--	--	--	--
MAY 06...	16.5	6.5	7.9	489	--	--	--	--	--	--
AUG 26...	12.5	7.0	7.8	503	47	11	48	1.4	161	56
OCT 21...	11.5	7.0	7.7	495	--	--	--	--	--	--
Site 384648104454501; well SC01506603ABA TH-22(LAT 38 46 48N LONG 104 45 45W)										
AUG 1991 13...	14.0	6.3	7.4	580	71	10	27	1.8	158	85
NOV 20...	12.5	6.7	7.4	530	--	--	--	--	--	--
FEB 1992 26...	13.0	6.4	7.5	550	--	--	--	--	--	--
MAY 07...	14.0	6.0	7.6	561	--	--	--	--	--	--
AUG 20...	14.5	5.8	7.4	562	70	9.7	28	1.9	150	89
OCT 21...	13.5	6.1	7.3	554	--	--	--	--	--	--
Site 384653104451901; well SC01506602BBB TH-18 (LAT 38 46 53N LONG 104 45 19W)										
AUG 1991 12...	13.5	4.8	6.8	495	64	9.1	25	2.1	146	49
AUG 1992 28...	13.0	4.5	6.9	535	62	10	28	2.1	167	53

DATE	CHLO- RIDE, DIS- SOLVED (mg/L as CL)	FLUO- RIDE, DIS- SOLVED (mg/L as F)	SOLIDS, SUM OF CONSTI- TUENTS, DIS- SOLVED (mg/L)	NITRO- GEN, AMMONIA DIS- SOLVED (mg/L as N)	NITRO- GEN, NITRITE DIS- SOLVED (mg/L as N)	NITRO- GEN, NO2+NO3 DIS- SOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DIS- SOLVED (µg/L as Fe)	MANGA- NESE, DIS- SOLVED (µg/L as Mn)
Site 384639104452801; well SC01506603AAD TH-21 (LAT 38 46 39N LONG 104 45 28W)--Continued									
AUG 1991 13...	28	0.30	392	--	--	--	--	14	<1
Site 384642104440101; well SC01506601BBD TH-53(LAT 38 46 42N LONG 104 44 01W)--Continued									
AUG 1991 13...	9.5	0.60	280	--	--	--	--	<3	9
NOV 20...	--	--	--	<0.010	<0.010	3.40	--	--	--
FEB 1992 25...	--	--	--	<0.010	<0.010	3.50	--	--	--
MAY 06...	--	--	--	0.010	<0.010	3.70	--	--	--
AUG 26...	14	0.60	309	0.020	<0.010	4.30	--	<3	2
OCT 21...	--	--	--	0.020	<0.010	4.10	--	--	--

Table 5. Ground-water-quality data for upper-terrace wells--Continued

Site 384648104454501; well SC01506603ABA TH-22 (LAT 38 46 48N LONG 104 45 45W)--Continued

DATE	CHLORIDE, DISSOLVED (mg/L as CL)	FLUORIDE, DISSOLVED (mg/L as F)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (mg/L)	NITROGEN, AMMONIA DISSOLVED (mg/L as N)	NITROGEN, NITRITE DISSOLVED (mg/L as N)	NITROGEN, NO2+NO3 DISSOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DISSOLVED (µg/L as Fe)	MANGANESE, DISSOLVED (µg/L as Mn)
AUG 1991									
13...	18	0.20	331	--	--	--	--	32	1
NOV									
20...	--	--	--	<0.010	<0.010	5.90	--	--	--
FEB 1992									
26...	--	--	--	<0.010	<0.010	5.90	6.30	--	--
MAY									
07...	--	--	--	<0.010	<0.010	5.70	--	--	--
AUG									
20...	21	0.20	360	0.020	<0.010	5.50	--	<3	<1
OCT									
21...	--	--	--	0.020	<0.010	5.10	--	--	--

Site 384653104451901; well SC01506602BBB TH-18(LAT 38 46 53N LONG 104 45 19W)--Continued

DATE	CHLORIDE, DISSOLVED (mg/L as CL)	FLUORIDE, DISSOLVED (mg/L as F)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (mg/L)	NITROGEN, AMMONIA DISSOLVED (mg/L as N)	NITROGEN, NITRITE DISSOLVED (mg/L as N)	NITROGEN, NO2+NO3 DISSOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DISSOLVED (µg/L as Fe)	MANGANESE, DISSOLVED (µg/L as Mn)
AUG 1991									
12...	20	0.20	285	--	--	--	--	19	2
AUG 1992									
28...	25	0.20	345	0.010	<0.010	7.90	--	8	<1

Site 384717104455301; well SC01406634DBB2 CORMACK (LAT 38 47 17N LONG 104 45 53W)

DATE	TEMPERATURE WATER (deg C)	OXYGEN, DISSOLVED (mg/L)	pH WATER WHOLE FIELD (STANDARD UNITS)	SPECIFIC CONDUCTANCE (µS/cm)	CALCIUM DISSOLVED (mg/L as Ca)	MAGNESIUM, DISSOLVED (mg/L as Mg)	SODIUM, DISSOLVED (mg/L as Na)	POTASSIUM, DISSOLVED (mg/L as K)	ALKALINITY LAB (mg/L as $CaCO_3$)	SULFATE DISSOLVED (mg/L as SO_4)
NOV 1991										
20...	12.5	0.3	6.8	1090	140	26	55	5.7	387	120

Site 384719104444701; well SC01406635CaA CO259-26 (LAT 38 47 19N LONG 104 44 47W)

DATE	TEMPERATURE WATER (deg C)	OXYGEN, DISSOLVED (mg/L)	pH WATER WHOLE FIELD (STANDARD UNITS)	SPECIFIC CONDUCTANCE (µS/cm)	CALCIUM DISSOLVED (mg/L as Ca)	MAGNESIUM, DISSOLVED (mg/L as Mg)	SODIUM, DISSOLVED (mg/L as Na)	POTASSIUM, DISSOLVED (mg/L as K)	ALKALINITY LAB (mg/L as $CaCO_3$)	SULFATE DISSOLVED (mg/L as SO_4)
NOV 1991										
25...	12.5	3.8	6.7	508	67	9.9	26	2.2	157	56
25...	12.5	3.8	6.7	508	67	9.8	27	3.3	157	56
FEB 1992										
25...	--	--	--	--	--	--	--	--	--	--
25...	12.0	5.3	7.0	441	--	--	--	--	--	--
MAY										
07...	14.0	5.6	8.2	458	--	--	--	--	--	--
AUG										
26...	15.0	5.6	7.0	439	55	8.1	18	2.3	109	47
OCT										
21...	13.5	5.4	7.0	446	--	--	--	--	--	--

Site 384717104455301; well SC01406634DBB2 CORMACK (LAT 38 47 17N LONG 104 45 53W)--Continued

DATE	CHLORIDE, DISSOLVED (mg/L as CL)	FLUORIDE, DISSOLVED (mg/L as F)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (mg/L)	NITROGEN, AMMONIA DISSOLVED (mg/L as N)	NITROGEN, NITRITE DISSOLVED (mg/L as N)	NITROGEN, NO2+NO3 DISSOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DISSOLVED (µg/L as Fe)	MANGANESE, DISSOLVED (µg/L as Mn)
NOV 1991									
20...	61	0.20	675	1.30	0.010	1.50	--	640	5800

Site 384719104444701; well SC01406635CaA CO259-26 (LAT 38 47 19N LONG 104 44 47W)--Continued

DATE	CHLORIDE, DISSOLVED (mg/L as CL)	FLUORIDE, DISSOLVED (mg/L as F)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (mg/L)	NITROGEN, AMMONIA DISSOLVED (mg/L as N)	NITROGEN, NITRITE DISSOLVED (mg/L as N)	NITROGEN, NO2+NO3 DISSOLVED (mg/L as N)	N-15 / N-14 STABLE ISOTOPE RATIO PER MIL	IRON, DISSOLVED (µg/L as Fe)	MANGANESE, DISSOLVED (µg/L as Mn)
NOV 1991									
25...	21	0.30	340	<0.010	<0.010	8.60	--	<3	6
25...	21	0.20	341	<0.010	<0.010	8.40	--	5	6
FEB 1992									
25...	--	--	--	<0.010	<0.010	9.80	--	--	--
25...	--	--	--	<0.010	<0.010	10.0	6.90	--	--
MAY									
07...	--	--	--	<0.010	<0.010	11.0	--	--	--
AUG									
26...	19	0.20	284	0.020	<0.010	10.0	--	5	1
OCT									
21...	--	--	--	0.020	<0.010	9.90	--	--	--

☆ U.S. GOVERNMENT PRINTING OFFICE: 1995 - 673-211 / 00052 REGION NO. 8