SOURCES OF WATER AND NITROGEN TO THE WIDEFIELD AQUIFER, SOUTHWESTERN EL PASO COUNTY, COLORADO

By Patrick Edelmann and Doug Cain

U.S. GEOLOGICAL SURVEY

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METRIC CONVERSION FACTORS

Inch-pound units used in this report may be converted to International System of Units (SI) by using the following conversion factors:

Multiply inch-pound unit	*By*	*To obtain SI unit*
acre	4,047	square meter
acre-foot	1,233	cubic meter
acre-foot per year	1,233	cubic meter per annum
cubic foot per second	0.02832	cubic meter per second
cubic foot per day	0.02832	cubic meter per day
foot	0.3048	meter
foot per day	0.3048	meter per day
foot per mile	0.3048	meter per mile
inch	25.40	millimeter
gallon per minute	0.06308	liter per second
gallon per day	0.003785	cubic meter per day
mile	1.609	kilometer
mile per year	1.609	kilometer per annum
pound (avoirdupois)	453.6	gram
pound per acre	1.120	kilogram per hectare
square foot	0.09294	square meter
square foot per day	0.09294	square meter per day
square mile	2.590	square kilometer
ton	0.9072	megagram

Water-quality terms and abbreviations used in this report:

milligram per liter (mg/L)
milligram per liter as nitrogen (mg/L as N)
microsiemen per centimeter at 25° Celsius (μs/cm)
°Celsius (°C).

Fountain Creek downstream from the Colorado Springs Sewage Treatment Plant effluent.

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ABSTRACT

The Widefield aquifer, located south of Colorado Springs, Colorado, is a shallow, very permeable part of the Fountain Creek alluvial aquifer, which is underlain by Pierre Shale. During the past 20 to 30 years, available data suggest that nitrate concentrations have increased from 0.5 to 3.0 milligrams per liter as nitrogen in the Widefield aquifer to concentrations that often approach and occasionally exceed the drinking-water standard of 10 milligrams per liter as nitrogen. Because of the large nitrate concentrations detected in the Widefield aquifer, distribution and sources of nitrogen to the aquifer were evaluated during 1981 and 1982.

During the summer of 1982, the concentration of nitrite plus nitrate in water collected from wells completed in the Widefield aquifer ranged from 3.2 to 15 milligrams per liter as nitrogen with a mean concentration of 6.9 milligrams per liter. In general, the concentrations of nitrite plus nitrate are greatest near the north end of the Widefield aquifer probably as a result of streamflow losses from Fountain Creek. These large concentrations appear to be diluted by tributary inflows or recharge from land surface in other parts of the aquifer.

A water budget for the Widefield aquifer indicates that the major source of inflow is recharge from Fountain Creek, north of the Widefield aquifer. During 1982, an estimated 8,000 acre-feet, or 65 percent of the 12,200 acre-feet of water that recharged the aquifer, was from streamflow losses from Fountain Creek. Other inflows to the aquifer, in order of decreasing contribution, are: (1) Infiltration and percolation of precipitation and irrigation return flow; (2) underflow from tributary alluvium; (3) underflow from Fountain Creek alluvium north of the Widefield aquifer; (4) infiltration from artificial recharge ponds on the Pinello Ranch; and (5) infiltration from septic systems and sewage lagoons.

A large percentage of flow in Fountain Creek is from the Colorado Springs Sewage Treatment Plant. During 1982, an estimated 38 percent of the flow and 85 percent of the nitrogen in Fountain Creek, in the reach that provides recharge to the Widefield aquifer, was from the Colorado Springs Sewage Treatment Plant. An estimated 130 tons of the total 162 tons of nitrogen available to recharge the aquifer during 1982 was from Fountain Creek. These data indicate that flow from the Colorado Springs Sewage Treatment Plant is the primary source of nitrogen entering the aquifer. Nitrogen also enters the aquifer as a result of seepage from Canal No. 4, which traverses the eastern part of the alluvial aquifer, artificial recharge ponds, and irrigation at the Pinello Ranch. These sources resulted in an additional 20 tons of nitrogen available to the aquifer during 1982. Nitrogen applied to the land through irrigation and fertilization probably was consumed by various crops in the area. Most of the nitrogen leaves the aquifer as a result of ground-water pumpage, and, to a lesser extent, by ground-water flow to Fountain Creek, ground-water outflow to the south, and possibly through denitrification processes.

1.0 INTRODUCTION

The Widefield aquifer is located in the alluvium of Fountain Creek near Security, Colorado, about 5 miles south of Colorado Springs (fig. 1.0-1). The aquifer consists of alluvial-fill in a former channel of Fountain Creek. Approximately 30,000 people, currently (1983) living in the communities of Security, Stratmoor Hills, and Widefield, depend on the Widefield aquifer as their primary water supply. The aquifer is also used as a supplemental water supply for the city of Colorado Springs. Therefore, both the quantity and quality of ground water from the Widefield aquifer are important.

During 1981, analyses of water samples collected by the U.S. Geological Survey from wells tapping the Widefield aquifer indicated the ground water contained concentrations of nitrite plus nitrate between 5 and 10 mg/L as N (milligrams per liter as nitrogen). Because concentrations of nitrate in excess of 10 mg/L as N may cause methemoglobinemia in infants under three months of age, the U.S. Environmental Protection Agency (1976, p. 81) established a standard for nitrate in drinking water of 10 mg/L as N. As a result of the concentrations of nitrate found in 1981, the U.S. Geological Survey, in cooperation with the Colorado Springs Department of Public Utilities and the Lower Fountain Water Quality Management Association, expanded the study during 1982 and 1983 in an effort to determine: (1) Distribution and sources of nitrogen in the Widefield aquifer; and (2) quantity of water and nitrogen contributed to the aquifer by each source.

To meet these objectives, a 10-square-mile area (fig. 1.0-1), extending southward from Nevada Street in Colorado Springs to just south of Widefield was selected and intensively studied during 1982 and 1983. Within this reach, surface and ground water hydraulically connected to the Widefield aquifer were evaluated.

The scope of this investigation included: (1) Evaluating all existing hydrologic, geologic, and water-quality data for the study; (2) measuring flow and analyzing water samples collected from surface waters in the study area; (3) collecting and analyzing water samples from wells, tapping either the Widefield aquifer, Fountain Creek alluvium, or tributary alluvium to the Widefield aquifer; (4) evaluating hydraulic characteristics of the alluvial aquifer, using results from aquifer tests; (5) analyzing water samples collected from lagoons, ponds, and reservoirs overlying alluvium within the study area; and (6) installing and monitoring a nonrecording rain gage at Pinello Ranch (fig. 1.0-1). Much of the surface- and ground-water data used in this investigation was presented by Jenkins (1961, 1964), Bingham and Klein (1973), Livingston and others (1975), Klein and Bingham (1975), Livingston and others (1976a and 1976b), and Emmons (1977).

The authors wish to thank the many people who helped to make this study successful, including Gene Y. Michael, Gary Bostrom, Dennis T. Cafaro, Monte S. Fryt, William J. McCullough, and Max Grimes, with the Colorado Springs Department of Public Utilities; Robert T. Schrader, Bobby G. Padgett, and Richard L. Gilham with the Security Water and Sanitation District; Donald C. Lohrmeyer, Ronald Woolsey, and Chris Moffler with Widefield Homes Incorporated; Edmond W. Hakes and Elmer J. Wahlborg with the Stratmoor Hills Water and Sanitation District; F. Stuart Loosley with the Cherokee Water District; and Mary Barber with the U.S. Army.

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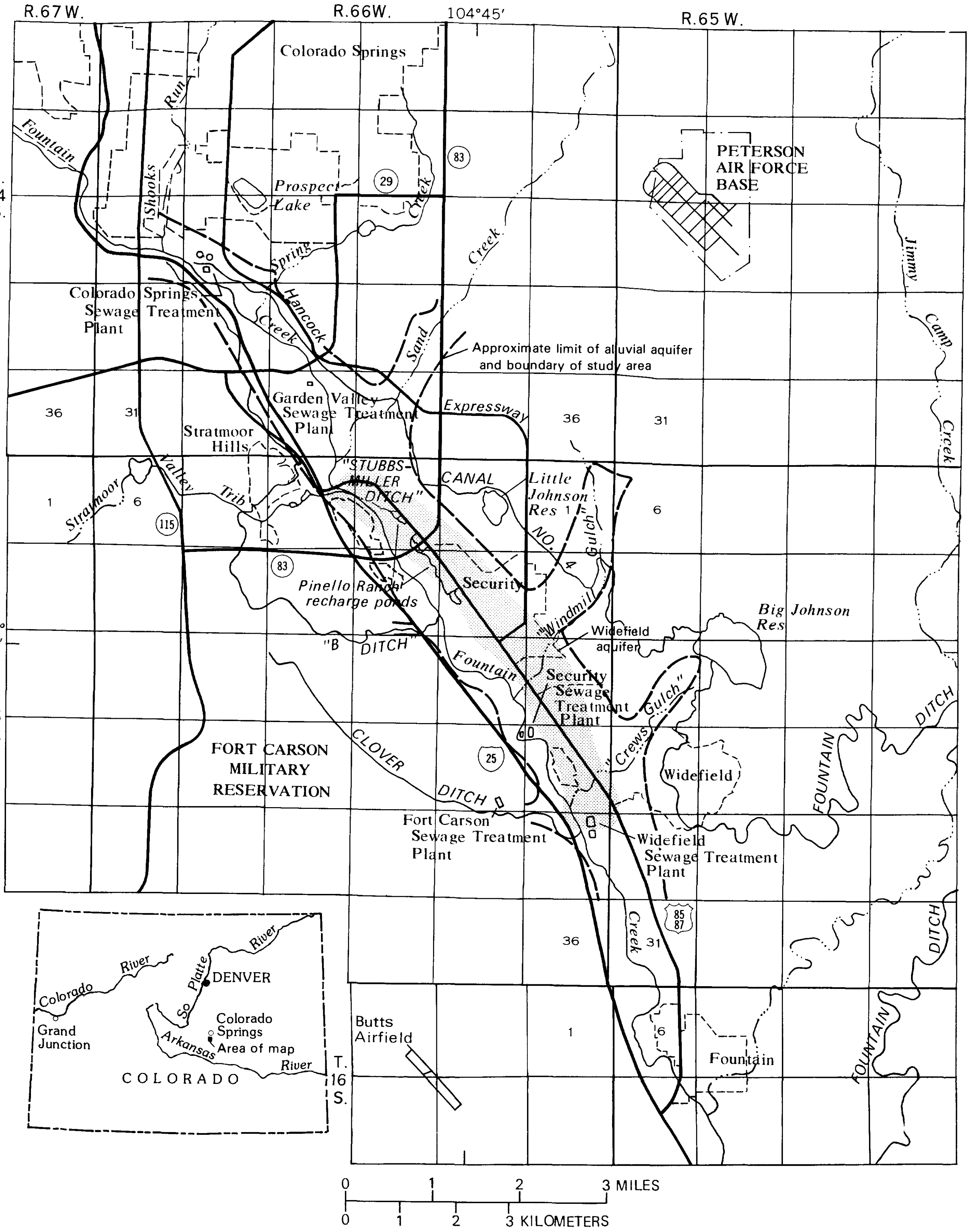

Figure 1.0-1.--Location of study area.

1.1 Physical and Geologic Setting

The 10-square-mile study area lies in the valley of Fountain Creek and has mixed land uses. Most of the area adjacent to the flood plain of Fountain Creek is urbanized, except to the southwest, where the study area borders on Fort Carson Military Reservation. The flood plain generally is used for agriculture, although some light industry and commercial buildings are present. Most of the area east of Canal No. 4 and south of Sand Creek is undeveloped land, but some residential development is occurring.

Total relief in the area is about 400 feet, and the gradient of Fountain Creek is about 30 feet per mile. The valley floor is underlain by alluvium deposited on top of the Cretaceous Pierre Shale, which is the bedrock throughout the area. The alluvium consists of sand and gravel, with minor amounts of silt and clay (Jenkins, 1964, p. 15). The sand and gravel range in size from fine sand to cobbles; thickness of the alluvium ranges from 0 to 100 feet (fig. 1.1-1). The greatest thickness is in the Widefield-Security area (Livingston and others, 1976b, pl. 1), where the alluvium is deposited in a former channel of Fountain Creek, which is deeply eroded into shale bedrock. As indicated by figure 1.1-1, the 3.5-square-mile area, locally known as the Widefield aquifer, contains coarse sands; this area has the largest transmissive properties in the alluvial aquifer, with reported well yields as large as 3,120 gallons per minute. Eolian sand overlies older alluvial deposits and the Pierre Shale east of the Widefield aquifer (Scott and Wobus, 1973).

Venetucci Ranch--one of the three agricultural areas still remaining in the area.

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1.2 Climate

A temperate climate generally is prevalent in the area, characterized by about 85 percent sunny days, an annual relative humidity of about 54 percent, large daily range in temperature, and fairly mild winters with little snow. The area is semiarid with a mean annual precipitation of about 15.5 inches. However, large variations in annual precipitation do occur.

Between 1949 and 1982, annual precipitation at the Colorado Springs weather station located at Peterson Air Force Base ranged from 8.59 inches in 1964 to 25.43 inches in 1965 (fig. 1.2-1). The mean annual precipitation for this period was 15.48 inches. The cumulative departure from the mean precipitation from 1949 to 1982, illustrating temporal trends in precipitation, also is shown in figure 1.2-1. Cumulative decreases in precipitation occurred during the periods 1949-56, 1959-64, and 1972-75. Cumulative increases in precipitation occurred during the periods 1956-59 and 1975-82. Variations in precipitation affect the overall hydrologic system. For example, during a wet year, such as 1982, the streams had more flow and ground-water withdrawals decreased as a result of less agricultural and lawn-irrigation demands.

Areal variations in precipitation also occur (fig. 1.2-2) as a result of localized summer thunderstorms. For example, during 1982, 21.9 inches of precipitation were recorded at Colorado Springs weather station, which is located at Peterson Air Force Base; about 28 inches of precipitation were measured at the Pinello Ranch rain gage; and 24.3 inches of precipitation were recorded at Fort Carson's Butts Airfield weather station. Because Pinello Ranch lies in the study area, the monthly precipitation measured there is used in calculations for this report.

Semiarid conditions result in high evapotranspiration, which generally exceeds precipitation. Potential evapotranspiration is evapotranspiration that occurs when adequate moisture is always available. Potential evapotranspiration was estimated to be 32.7 inches in 1982 using the modified Blaney-Criddle equation (U.S. Soil Conservation Service, 1967, p. 7). The modified Blaney-Criddle equation uses mean monthly air temperature, monthly percentage of daytime hours of the year, and an empirical monthly consumptive-use crop coefficient, which varies by crop. Because the study area primarily is urbanized, the monthly crop coefficients for turf grass, as estimated by CH2M Hill (1982, p. 3) for the Colorado Springs area, were used. Actual evapotranspiration was estimated to be 21.9 inches in 1982. Monthly actual evapotranspiration was approximated by multiplying the monthly potential evapotranspiration by 0.67. This factor was used for the Colorado Springs area by CH2M Hill (1982, p. 4) and was derived from a relationship between lawn quality and relative evapotranspiration, developed by Danielson and others (1981, p. 32). Relative evapotranspiration is defined as the ratio of actual evapotranspiration to potential evapotranspiration. Monthly potential and actual evapotranspiration for 1982 are shown in figure 1.2-2. Annual evaporation from natural water bodies in the area, such as lakes, ponds, and reservoirs, was about 60 inches (Hansen and others, 1978, p. 33).

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2.0 SURFACE WATER

Surface water in the study area is hydraulically connected to the alluvial aquifer (Livingston and others, 1976a) and is an important source of recharge that affects the quality of water in the Widefield aquifer. During 1982, flow and water-chemistry data were obtained at 23 surface-water sites (fig. 2.0-1 and table 2.0-1). Four sites were on Fountain Creek; stream gages are operated at two of these sites (1 and 19). At site 1, the contributing drainage area of Fountain Creek (394 square miles) is mostly foothills or mountains north and west of Colorado Springs. The flow at site 1 is affected by diversions, ground-water pumpage, storage reservoirs, and small upstream municipal-sewage effluents.

As Fountain Creek crosses the study area, it receives additional sewage effluent from the city of Colorado Springs (site 3), Garden Valley (site 11), Security (site 18), Fort Carson Sewage Treatment Plant via Clover Ditch Drain (site 21), and Widefield (site 22)(fig. 2.0-1).

Several tributaries enter Fountain Creek in the study area. Shooks Run and Spring Creek (sites 2 and 9) drain the Colorado Springs urban area. Sand Creek (sites 12 and 13), an ephemeral stream, drains a 62-square-mile, partially urbanized area to the east of Colorado Springs. Sand Creek receives flows from a sand-and-gravel operation downstream from Canal No. 4 and may receive some seepage from an abandoned landfill located about a mile upstream from the mouth (Schneider and Turk, 1983). A small tributary, called Stratmoor Valley tributary in this report (site 14), drains Stratmoor Hills and areas to the west. B Ditch (site 16) drains part of the Fort Carson cantonment area and may receive seepage from an abandoned landfill used between 1946 and 1956 for disposal of mixed sanitary wastes, construction wastes, and sludges (M.E. Halla, Fort Carson Environmental Program Director, written commun., 1981). A small tributary locally known as "Windmill Gulch" (site 17) drains a relatively undeveloped area east of Security. Another small tributary from the east, locally known as "Crews Gulch" (site 20), provides drainage for much of Widefield and receives outflow from a small recreation lake owned by Fountain Valley School in the south end of Section 18, Township 15 South, Range 65 West. Water is pumped into the lake from two wells in the Widefield aquifer. Crews Gulch also may receive seepage from Big Johnson Reservoir.

Two major canals divert water from Fountain Creek for use in, or transportation through, the study area. Canal No. 4, also known as the Fountain Mutual Ditch, diverts water from Fountain Creek just downstream from the outfall of the Colorado Springs Sewage Treatment Plant. The flow of Canal No. 4 is recorded daily at the headgate (site 4). Canal No. 4 parallels Fountain Creek, and its water is used for minor amounts of irrigation between the headgate and Big Johnson Reservoir. Several intermediate data-collection sites (5, 6, and 7) were established on the canal during 1982 (fig. 2.0-1 and table 2.0-1). Another canal, locally known as the "Stubbs-Miller Ditch" (site 15), diverts water from Fountain Creek for artificial recharge and irrigation on the Pinello Ranch.

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2.1 Fountain Creek

Flow in Fountain Creek is perennial in the study area. Records from stream gages at site 1, Fountain Creek at Colorado Springs, and site 19, Fountain Creek at Security (fig. 2.1-1), indicate that mean flows generally are low and fairly stable during the winter months, and quite variable during the irrigation season. These flow variations are caused by the amount of winter snowpack, and by the number and severity of summer thunderstorms.

Mean monthly flows at the gage at Security (site 19) are greater than at the upstream gage at Colorado Springs (site 1), because inflows between the gages are greater than diversions. Between 1976 and 1982, the mean flow of Fountain Creek at Security (site 19) was 33 ft^3/s (cubic feet per second) greater than the mean flow of Fountain Creek at Colorado Springs (site 1). During 1982, the mean flow of Fountain Creek at Security was 110 ft^3/s, and the mean flow of Fountain Creek at Colorado Springs was 54 ft^3/s. The 56-ft^3/s increase in flow in 1982 between site 1 and site 19 was the largest increase during the 1976-82 period. Fountain Creek flows in 1982 were among the highest for the period of record (fig. 2.1-2). Livingston and others (1976a) showed that Fountain Creek is hydraulically connected to the alluvial aquifer. In the reach just downstream from the confluence with Spring Creek to just downstream from the headgate of the Stubbs-Miller Ditch, the creek generally loses water to the ground-water system; from that point downstream to Security (site 19), it generally gains water from the ground-water system. This interconnection directly ties water-quality conditions in Fountain Creek to water-quality conditions in the alluvial aquifer.

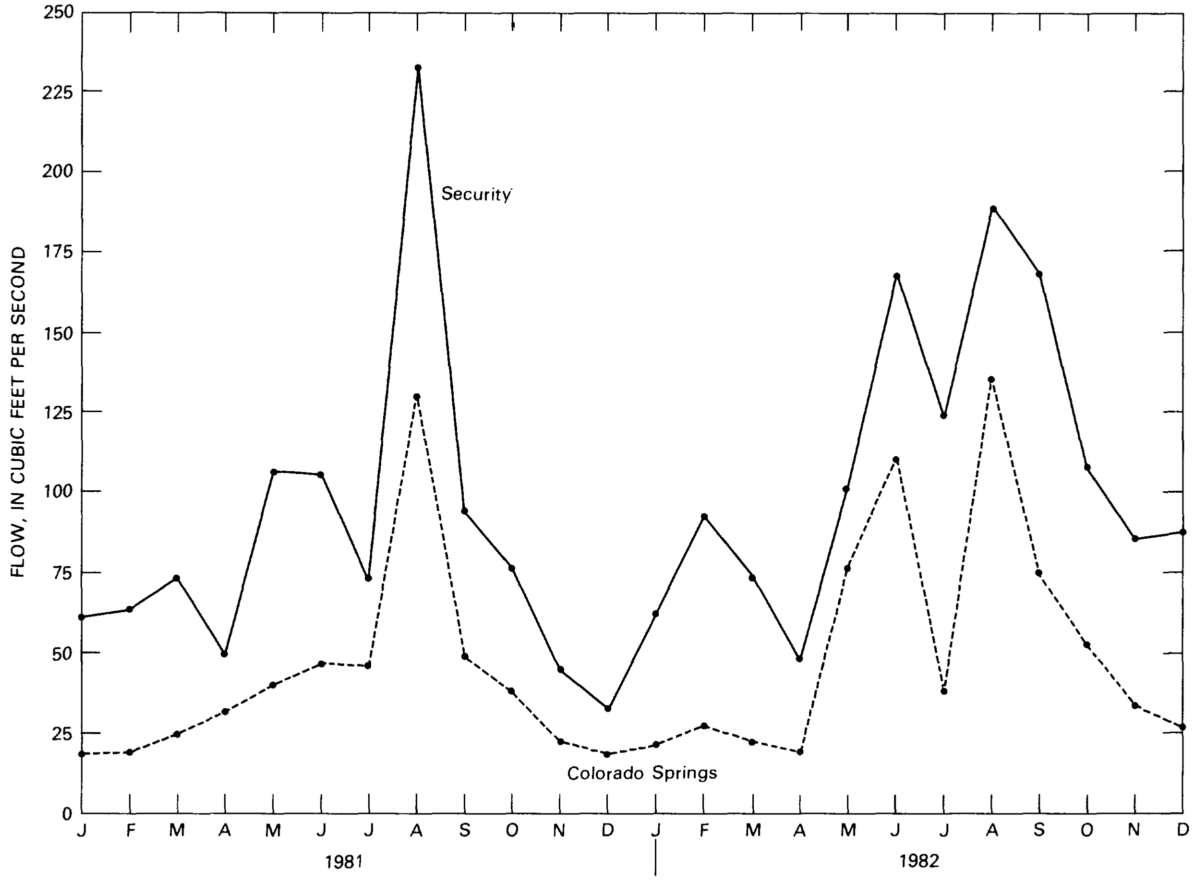

Figure 2.1-1.--Mean monthly flow at two sites on Fountain Creek during 1981 and 1982.

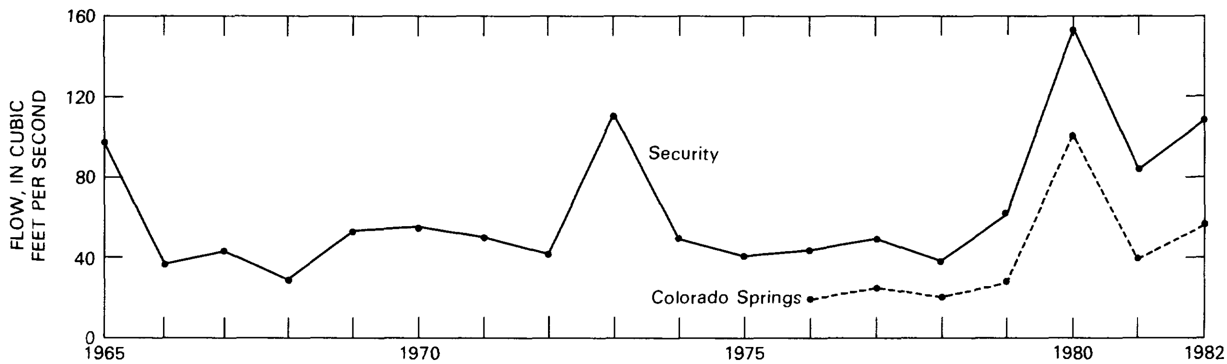

Figure 2.1-2.--Mean annual flow at two sites on Fountain Creek.

2.2 Inflows and Diversions

Water enters Fountain Creek from seven small tributaries and five sewage-treatment plants and is diverted by two major canals in the study area (fig. 2.0-1). These inflows and diversions affect both the quantity and quality of water in Fountain Creek and the quality of water in the Widefield aquifer.

Flow was measured quarterly during baseflow periods at six of the tributaries and continuously at B Ditch Drain near Security (site 16) during 1982 (table 2.0-1, fig. 2.2-1). Because the flow of B Ditch Drain was measured continuously, brief periods of heavy runoff that occurred during 11 days, that were not measured at the quarterly sites, are not included in the calculations of its mean. The mean flows shown in figure 2.2-1 provide a good representation of the flow on most days. As shown in figure 2.2-1, none of the tributaries contributed large quantities of flow to Fountain Creek.

Sewage-treatment plants contribute much more flow to Fountain Creek than tributaries (fig. 2.2-1). The largest amount of flow is contributed by the Colorado Springs Sewage Treatment Plant (site 3), near the upstream end of the study area (fig. 2.0-1). Increasingly smaller amounts are contributed by Fort Carson Sewage Treatment Plant, which flows into Clover Ditch Drain, and by the Security (site 18), Widefield (site 22), and Garden Valley (site 11) Sewage Treatment Plants. Flow from the Colorado Springs Sewage Treatment Plant varies somewhat from month to month (fig. 2.2-2), with flow slightly higher in the summer. Similar trends occur for other sewage-treatment plants in the area. Between 1965 and 1982, mean annual flow from the Colorado Springs Sewage Treatment Plant more than doubled, from about 18 ft^3/s (cubic feet per second) to greater than 40 ft^3/s (fig. 2.2-3). Long-term flow data from the other sewage-treatment plants are not available.

The amount and quality of flow in Canal No. 4 and Stubbs-Miller Ditch are important because both diversions provide water that recharges the Widefield aquifer. Canal No. 4 diverted a mean flow of 14.8 ft^3/s and the Stubbs-Miller Ditch diverted a mean flow of 1.56 ft^3/s from Fountain Creek during 1982 (fig. 2.2-1). The 1982 diversions were lower than the mean flows, probably because of the large amount of precipitation during the summer months (figs. 1.2-2 and 2.2-3). Mean monthly flows for both diversions during 1982 are shown in figure 2.2-2.

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2.3 Quantification of Sources of Water in Fountain Creek and Canal No. 4

Upstream from the study area, water in Fountain Creek originates from a variety of natural and man-affected sources. In this report, water in Fountain Creek at Colorado Springs (site 1 in fig. 2.3-1) plus the small flow of Shooks Run (site 2 in fig. 2.3-1) is considered as one upstream source of water. About one-fourth mile downstream from Shooks Run, the flow from the Colorado Springs Sewage Treatment Plant (site 3 in fig. 2.3-1) enters Fountain Creek. During 1982, the mean flow of the treatment plant was 40.1 ft^3/s (cubic feet per second), compared to 54.4 ft^3/s in Fountain Creek at Colorado Springs. The combined mean flow of 94.5 ft^3/s in Fountain Creek just downstream from the treatment plant comprised 42 percent of the flow from the Colorado Springs Sewage Treatment Plant (fig. 2.3-1). Between 1977 and 1982, this percentage varied between 26 and 62 percent.

The percentage of annual flow contributed by the sewage-treatment plant does not clearly explain the plant's effect on flows in Fountain Creek, because short periods of heavy runoff in Fountain Creek greatly contribute to its annual flow, while flow from the sewage-treatment plant is relatively constant. Duration curves shown in figure 2.3-2 show the amount of time that specified percentages of flow contributed by the Colorado Springs Sewage Treatment Plant were equaled or exceeded. During 1982, 42 percent or more of Fountain Creek flow was contributed by the Colorado Springs Sewage Treatment Plant 67 percent of the time. Because of relatively high flow in Fountain Creek during 1982 (fig. 2.1-2), the duration curve for 1982 is shifted downward in relation to the 1977-82 curve (also shown in fig. 2.3-2).

About one-eighth mile downstream from the Colorado Springs Sewage Treatment Plant outfall, Canal No. 4 diverts water from Fountain Creek on the same bank. Because of the short distance, complete mixing of the flow from the plant and Fountain Creek does not occur. As a result, Canal No. 4 generally receives a higher percentage of flow from the Colorado Springs Sewage Treatment Plant than if complete mixing occurs. An estimate of the lack of mixing was made using ammonia as a tracer. The ratio of observed ammonia concentrations based on total mixing and expected ammonia concentrations at the head-gate of Canal No. 4 was found to be directly proportional to the mean daily flow in Fountain Creek at Colorado Springs (fig. 2.3-3). The line shown in figure 2.3-3, which was developed by using the method of least-squares (correlation coefficient = 0.81), defines a mixing ratio with the equation:

$$\text{MIXING RATIO} = 0.0067Q + 1.01,$$

where Q = mean daily flow of Fountain Creek at Colorado Springs.

To estimate the actual percentage of flow in Canal No. 4 contributed by the Colorado Springs Sewage Treatment Plant, the mixing ratio is multiplied by the percentage of flow from the treatment plant effluent at the Canal No. 4 diversion point, assuming complete mixing.

The mixing ratio was tested in 1982 by using it to calculate expected ammonia concentrations in Fountain Creek below Janitell Road (site 10 in fig. 2.3-1) and comparing these to observed ammonia concentrations (fig. 2.3-4). Agreement between observed and expected ammonia concentrations was very good.

Using the mixing ratio and a mass balance, sources of flow in Fountain Creek and Canal No. 4 were calculated on a daily basis during 1982. Calculations were based on the mean daily flows at Fountain Creek at Colorado Springs, Colorado Springs Sewage Treatment Plant outfall, and Canal No. 4 headgate, and mean 1982 flows at Shooks Run and Spring Creek (fig. 2.2-1). Sources of flow are shown as annual mean percentages in figure 2.3-1, and as duration curves in figure 2.3-2. Sources of flow in Fountain Creek below Janitell Road (site 10 in fig. 2.3-1) are important because this is the upstream end of the losing reach of Fountain Creek that recharges the Widefield aquifer. Sources of flow throughout this reach will be similar because inflows are small (fig. 2.3-1).

During 1982, an estimated 38 percent of the flow of Fountain Creek in the reach that provides recharge to the Widefield aquifer and an estimated 57 percent of the flow in Canal No. 4 were contributed by the Colorado Springs Sewage Treatment Plant. During this same period, flow from this plant comprised more than one-half the flow in the losing reach of Fountain Creek about 50 percent of the time, and in Canal No. 4 about 60 percent of the time.

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3.0 GROUND WATER

The Widefield aquifer is a shallow, highly permeable alluvial aquifer in which the saturated thickness varies with time and location but averages 30 to 35 feet. A significant part of the approximately 18,000 acre-feet of water in storage is withdrawn by wells each year. Thirty-three of the 50 municipal wells and 8 irrigation wells in the area are currently in use (fig. 3.0-1).

Amount and type of water use has changed significantly in the last 40 years (fig. 3.0-2). Between 1942 and 1950, a mean of 1,160 acre-feet of water was withdrawn from the aquifer, primarily for irrigation purposes (Livingston and others, 1976b, p. 51). Development of the ground-water system for municipal and industrial use began in 1951; pumpage for these uses began increasing in 1954, as population in the area increased because of expansion of Fort Carson. Since 1960, population has increased at a mean rate of about 1,000 people per year. As the area has become increasingly urbanized, ground water primarily has been used for municipal purposes. During the past 10 years, annual mean pumpage has been about 7,100 acre-feet; only about 9 percent, or 640 acre-feet, has been for irrigation use. During 1982, only about 7 percent, or 400 acre-feet of the total 5,400 acre-feet withdrawn, was for irrigation use; about 1,100 acre-feet were exported to Colorado Springs. Decreases in total pumpage and in the amount used for irrigation that occurred during 1982 were the result of the large and relatively constant amount of precipitation that occurred during the summer of 1982 (fig. 1.2-2).

Ground water in the Widefield aquifer flows naturally to the southeast (fig. 3.0-1). However, during periods of intense pumpage, localized depressions in the water table may occur, resulting in some temporary northward movement. The mean rate of water movement through the Widefield aquifer is dependent on hydraulic conductivity, hydraulic gradient, and effective porosity. In the Widefield aquifer, hydraulic conductivity, which is a measure of the volume rate of flow through a unit cross-sectional area, ranges from 670 to 1,140 feet per day (Wilson, 1965, p. 75-78; R.A. Hogan, W.W. Wheeler and Associates, written commun., 1983). Based on available U.S. Geological Survey data, a mean hydraulic conductivity for the Widefield aquifer is 830 feet per day. Hydraulic gradient in an alluvial aquifer is the slope or change in altitude of the water table over some specified distance in a given direction; it is about 0.006 for the area. Effective porosity is the interconnected pore space; for the purposes of this report, effective porosity is assumed to approximate specific yield. Specific yield is the ratio of the volume of water that a water-saturated material will yield by gravity to its own volume. Jenkins (1964, p. 23) noted that specific yield varied from 20 to 30 percent in the alluvial aquifer; he selected a value of 25 percent for all computations using specific yield.

As hydraulic properties of the aquifer change, the rate of movement of water through the aquifer changes. The mean rate of movement of water through the Widefield aquifer is about 20 feet per day, or 1.4 miles per year, assuming a gradient of 0.006, a hydraulic conductivity of 830 feet per day, and an effective porosity of 25 percent. Actual rate of movement of water through the Widefield aquifer varies with time and location, and may range from 13 to 34 feet per day (0.9 to 2.4 miles per year).

Water moves into the Widefield aquifer from: (1) Fountain Creek; (2) underflow from Fountain Creek alluvium north of the Widefield aquifer; (3) underflow from tributary alluvium; and (4) deep percolation from precipitation, irrigation, ponds, and lagoons overlying the aquifer. Water moves out of the Widefield aquifer to: (1) Fountain Creek; (2) Fountain Creek alluvium south of the Widefield aquifer; and (3) various locations, by pumpage of wells completed in the Widefield aquifer.

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Fountain Creek traverses the alluvial aquifer throughout the study area, and crosses the north end of the Widefield aquifer between sites 1 and 2 (fig. 3.1.1-1). Livingston and others (1976a, p. 64 and 1976b, p. 57-60) determined that Fountain Creek recharged the aquifer in a 3-mile reach of Fountain Creek, extending downstream from the confluence with Spring Creek (site 1, fig. 3.1.1-1) to downstream from the headgate of the Stubbs-Miller Ditch (site 2, fig. 3.1.1-1). The cross section of the alluvial aquifer shown in figure 3.1.1-1 depicts the thickness of alluvium underlying Fountain Creek north of the Widefield aquifer, and typifies the relationship between a losing stream and the underlying aquifer.

Between 1973 and 1977, the quantity of water interchanged between Fountain Creek and the aquifer was determined by 14 gain-loss investigations. A gain-loss investigation is an accounting of all surface water entering or leaving specified reaches of a stream; the investigation ideally is conducted during periods of relatively stable streamflow conditions. Differences in flow that cannot be accounted for by tributary inflow or by diversions are attributed to an interchange between ground and surface water. During many of the 14 gain-loss investigations, significant diurnal variations in flow occurred in a 3-mile reach between sites 1 and 2, and in a 4.2-mile reach between sites 2 and 3 (fig. 3.1.1-1), as a result of fluctuations in flow from the Colorado Springs Sewage Treatment Plant. Because of these fluctuations, it was necessary to adjust the original data (U.S. Geological Survey, 1974, p. 389-393; and 1978, p. 378-382), using estimates of time of travel, time of instantaneous flow measurements, and continuous flow records at the Security gaging station (site 3, fig. 3.1.1-1). During 4 of the 14 gain-loss investigations, poor flow records at the Security gage, coupled with inappropriate timing of flow measurements in the 3-mile reach between sites 1 and 2, prevented an accurate adjustment of the data. Adjusted gain-loss data for the 3-mile reach, based on the 10 remaining gain-loss runs, are summarized in table 3.1.1-1. A mean loss of 11 ft^3/s (cubic feet per second), or about 8,000 acre-ft/yr (acre-feet per year), occurred between sites 1 and 2.

Table 3.1.1-1.--*Summary of gain-loss investigations for losing reach of Fountain Creek in the study area*

Date	Gain-loss[1] (cubic feet per second)	Date	Gain-loss[1] (cubic feet per second)
July 26, 1973	3.0	June 29, 1976	-21.2
September 6, 1973	-16.4	November 9, 1976	-15.4
October 31, 1973	-8.6	May 9, 1977	1.1
September 26, 1974	-14.8	July 18, 1977	-7.7
August 26, 1975	-24.8	September 27, 1977	-3.6

[1]Positive number indicates amount of water gained by the stream. Negative number indicates amount of water lost to ground water.

At any given time, the actual amount of interchange between the stream and the aquifer in this 3-mile reach may vary significantly from an average 11-ft^3/s loss. The actual amount of water lost to the aquifer is dependent on the hydraulic-head difference between the aquifer and the stream, and the hydraulic properties of the aquifer (Livingston and others, 1976a, p. 64). Emmons (1977, p. 38) noted that no significant long-term water-level changes occurred in the aquifer, although withdrawals from the aquifer had increased. He also stated that the stream-aquifer system was apparently in equilibrium. Since 1963, withdrawals have become more stable (fig. 3.0-1), and no changes in the hydrologic system that would have affected the stream-aquifer relationship in this reach have occurred. Because of this stability, the mean loss of 11 ft^3/s, based on adjusted gain-loss data for 1973 to 1977, should be a reasonable estimate of the stream-aquifer relationship; this mean is used to compute the amount of recharge from Fountain Creek in this report.

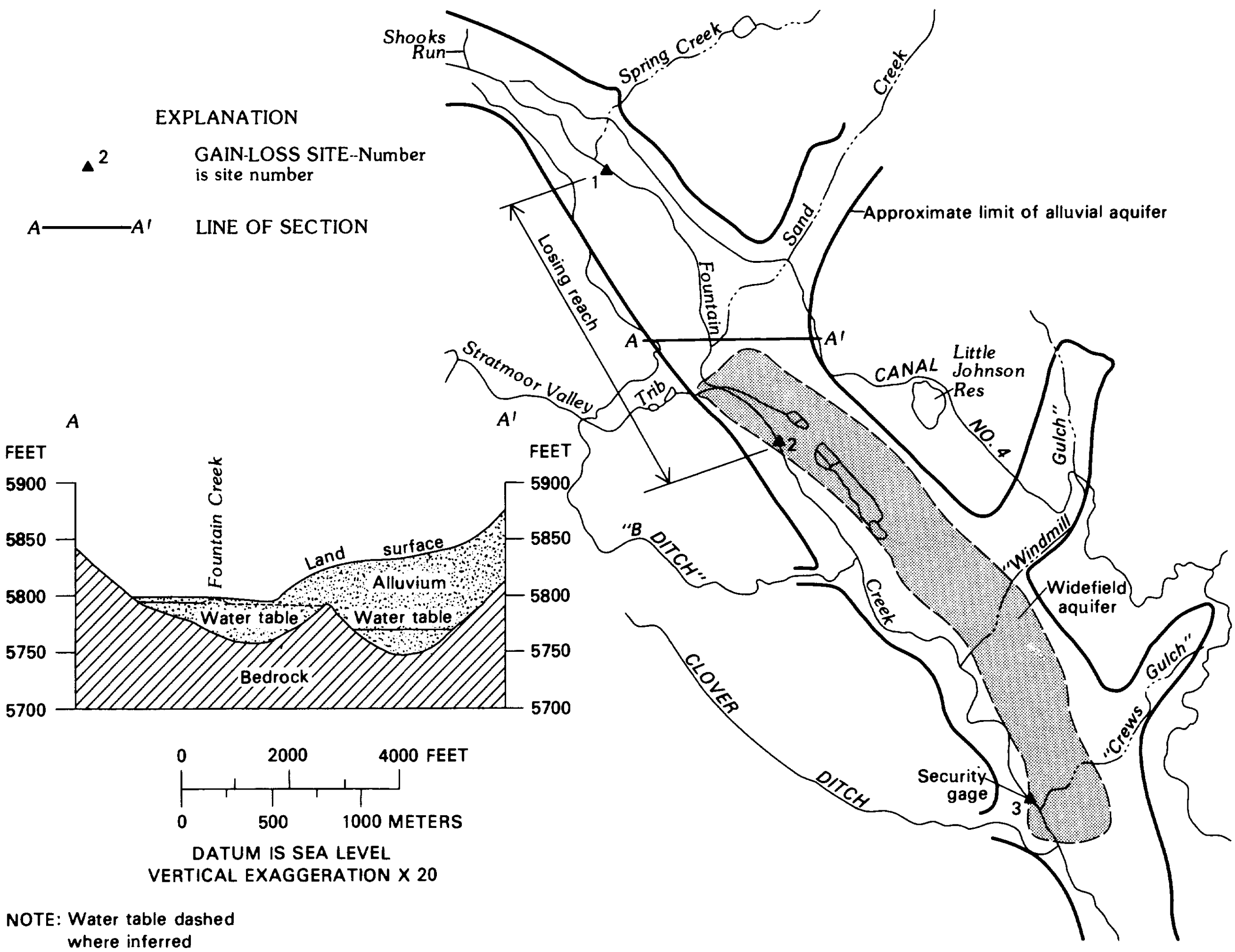

Figure 3.1.1-1.--Cross section of Fountain Creek alluvium showing altitude of the water table in the losing reach of Fountain Creek in the study area.

3.1.2 Underflow from Fountain Creek Alluvium and Tributary Alluvium

The Widefield aquifer receives ground-water inflow from Fountain Creek alluvium, north of the aquifer, and from tributary alluvium, east and west of the aquifer. Ground-water inflow or underflow may be approximated by using a modified form of Darcy's law, expressed as:

$$Q = KIA;$$

where Q = quantity of water passing through a cross section, in cubic feet per day;
K = hydraulic conductivity, in feet per day;
I = hydraulic gradient (dimensionless); and
A = cross-sectional area (width times saturated thickness), in feet squared.

Underflow from Fountain Creek alluvium enters the Widefield aquifer in the vicinity of the confluence of Sand Creek and Fountain Creek. In this area, ground water consists of surface-water losses from Fountain Creek, seepage from Canal No. 4, underflow from Sand Creek alluvium, and water originating in Fountain Creek alluvium north of Highway 29. For the purposes of this report, it was desirable to evaluate each inflow independently; the cross section selected for approximating underflow from Fountain Creek alluvium, exclusive of underflow from Sand Creek and water lost from Fountain Creek and Canal No. 4, is located north of Highway 29 (cross section A-A', fig. 3.1.2-1). Underflow at this point from Fountain Creek alluvium is about 84,000 ft^3/d (cubic feet per day), or 700 acre-ft/yr (acre-feet per year) (table 3.1.2-1).

Water enters the Widefield aquifer from the east as underflow from Sand Creek alluvium, Windmill Gulch alluvium, and Crews Gulch alluvium, and from saturated eolian deposits that are recharged by leakage from Canal No. 4. Underflows from tributary alluvium east of the Widefield aquifer are shown in figure 3.1.2-1 and table 3.1.2-1. Because only one well is completed in the Crews Gulch alluvium, underflow could not be calculated directly, so it was estimated from its similarity to Windmill Gulch. Calculation of Crews Gulch underflow assumed: (1) Width equals 1,500 feet (fig. 3.1.2-1); (2) mean saturated thickness equals 10 feet; (3) hydraulic gradient equals the land-surface gradient of 0.014 (hydraulic gradient on the Windmill Gulch area equals land-surface gradient); and (4) hydraulic conductivity is the same as hydraulic conductivity in the Windmill Gulch area, approximately 50 feet per day. These assumptions result in an estimated underflow of 90 acre-ft/yr from Crews Gulch. Most of the underflow to the Widefield aquifer from the east is from saturated eolian deposits, with an estimated underflow of 720 acre-ft/yr. Two gain-loss investigations that were conducted on Canal No. 4 during 1982 indicate that Canal No. 4 loses water to underlying material. The cumulative flow gains and losses along Canal No. 4 on September 29, 1982, are shown in figure 3.1.2-2. Assuming a 2-ft^3/s (cubic feet per second) loss of canal water on the 223 days the canal flowed during 1982, 880 acre-feet of water was lost from the canal to eolian deposits in the reach between Sand Creek and Windmill Gulch, indicating that canal seepage was the probable source of most recharge to ground water in eolian deposits.

A small amount of water enters the Widefield aquifer from the west as underflow from Stratmoor Valley tributary alluvium, B Ditch alluvium, and Clover Ditch alluvium (fig. 3.1.2-1, table 3.1.2-1). The remaining area west of the aquifer is Pierre Shale, which is considered to be impermeable. Underflow from Stratmoor Valley tributary is estimated to be about 5 acre-ft/yr, assuming a saturated area of 10,000 square feet, and hydraulic properties the same as B Ditch.

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3.1.3 Recharge from Land Surface

Recharge from land surface to the Widefield aquifer occurs through infiltration and percolation of precipitation and irrigation water, artificial recharge at the Pinello Ranch, and seepage from sewage lagoons and septic tanks.

Precipitation and lawn- and agricultural-irrigation water percolate downward and recharge the aquifer. The amount of recharge is dependent on: (1) Amount of precipitation and irrigation, (2) soil-moisture storage capacity, and (3) amount of evapotranspiration. Estimates of recharge were made separately for residential and agricultural areas and are shown in tables 3.1.3-1 and 3.1.3-2.

The amount of deep percolation from precipitation and lawn and agricultural irrigation that occurred monthly during 1982 was estimated from the following equation:

$$R = Rt - Re + I - Ir - Ru$$

where R = Recharge or deep percolation, in inches;
Rt = total precipitation measured at Pinello Ranch, in inches;
Re = effective precipitation, that is, the part of precipitation that remains in the soil profile and is available for consumptive use, in inches (U.S. Soil Conservation Service, 1967, p. 27);
I = irrigation, in inches;
Ir = irrigation or consumptive use requirement (which equals the differences between evapotranspiration and effective precipitation), in inches; and
Ru = runoff, in inches.

Each component in the equation is quantified in tables 3.1.3-1 and 3.1.3-2.

During 1982, an estimated 1,000 acre-feet of the approximately 2,000 acre-feet of precipitation and irrigation water applied to the 435 acres of lawns that overlie the aquifer percolated beneath the root zone and recharged the aquifer.

In addition to lawns overlying the aquifer, three agricultural areas exist, totaling approximately 286 acres. Alfalfa was grown on about 127 acres; corn was grown on most of the remaining 159 acres. The resulting amount of recharge to the aquifer from agricultural areas was estimated to be 1,200 acre-feet of the estimated 1,900 acre-feet of precipitation and irrigation water that was applied to the agricultural areas during 1982.

Pinello Ranch artificial-recharge ponds are a source of recharge to the aquifer. The Pinello Ranch is located at the north end of the Widefield aquifer. Water in the ponds is diverted from Fountain Creek via Stubbs-Miller Ditch. During 1982, the amount of recharge to the aquifer from the recharge ponds was estimated by using inflow records, observed changes in storage, and monthly evaporation. Monthly evaporation was estimated from an estimated annual evaporation of 60 inches (Hansen and others, 1978, p. 33), multiplied by ratios of monthly to total evaporation measured during 1982 at Pueblo Reservoir, which is about 5 miles west of Pueblo, Colo., and about 35 miles south of the study area (National Oceanic and Atmospheric Administration, 1982, p. 21). During 1982, an estimated 180 acre-feet of water from Pinello Ranch recharge ponds percolated to the water table.

Two sewage-treatment plants operate sewage lagoons that overlie the aquifer and are potential sources of recharge. Sewage lagoons at the Security Sewage Treatment Plant have clay liners that were reported to be intact (Richard Gilham, Security Wastewater Division, oral commun., 1982). Influent and effluent records are not accurate enough to estimate recharge to the aquifer from leakage through clay liners; however, the influent and effluent records suggest that, if leakage does occur, it is likely to be small. Sewage lagoons at the Widefield Sewage Treatment Plant are not lined; leakage is likely to occur. Insufficient data exist to accurately estimate the amount of water percolating to the water table. However, the amount may be greater than the 180 acre-feet that was estimated to recharge the aquifer from Pinello Ranch recharge ponds, because of greater surface area and volume of the Widefield lagoons.

Approximately 10 septic systems, servicing an estimated 20 people, exist in the area. Assuming a per capita flow of 40 gallons per day (Porter, 1980, p. 618), approximately 1 acre-ft/yr (acre-feet per year) of water from septic systems is available for recharge.

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3.2 *Outflows from the Widefield Aquifer*

3.2.1 Discharge to Fountain Creek

Fountain Creek crosses the Widefield aquifer only at its western and eastern ends (fig. 3.2.1-1). Jenkins (1964) indicated that a buried shale "ridge" separated Fountain Creek from the Widefield aquifer in the area where Fountain Creek parallels the aquifer. However, Livingston and others (1976a, p. 64; and 1976b, p. 57-60) indicated that the shale barrier was not as significant as previously thought. The cross sections in figure 3.2.1-1 illustrate that Fountain Creek and the thin alluvial deposits underlying Fountain Creek are hydraulically connected to the Widefield aquifer throughout most of the area. Overall, the 4.2-mile reach extending from the Stubbs-Miller Ditch to the Security gage is generally a gaining reach; that is, the stream gains water from the aquifer. However, at times, the stream may lose water to the aquifer, as indicated by cross section B-B' (fig. 3.2.1-1). Because the altitude of the stream and aquifer appears to be similar, small changes in the altitude of the stream or water table could alter the direction and amount of movement of water between the stream and aquifer.

The amount of water interchanged between Fountain Creek and the Widefield aquifer was determined by means of 14 gain-loss investigations performed between 1973 and 1977. Because of significant diurnal variations in flow that occurred during the gain-loss investigations, it was necessary to adjust the original data (U.S. Geological Survey, 1974, p. 389-393; and 1978, p. 378-382) using estimates of time of travel, time of instantaneous-flow measurements, and flow records at the Security gage (site 3, fig. 3.2.1-1). During 3 of the 14 gain-loss investigations, accurate adjustments could not be made, either because of the time of flow measurements in the 4.2-mile reach between sites 2 and 3, or because of the inadequate record at the Security gage. Adjusted gain-loss data for the 4.2-mile reach, based on the remaining 11 gain-loss runs, are summarized in table 3.2.1-1. A mean gain of 3.2 ft^3/s (cubic feet per second) occurred between sites 2 and 3. This mean gain is equivalent to a 2,300-acre-ft/yr (acre-feet per year) loss of water from the Widefield aquifer to Fountain Creek.

At any given time, the actual amount of interchange between Fountain Creek and the Widefield aquifer in this 4.2-mile reach may vary significantly from the mean 3.2-ft^3/s gain, primarily as a result of hydraulic-head difference between the aquifer and the stream. Because no long-term changes in the hydrologic system have occurred, the mean gain of 3.2 ft^3/s to Fountain Creek should be a reasonable estimate of the stream-aquifer relationship in this reach. However, because of the high water table that occurred during 1982, the amount of water that the stream gained from the aquifer was likely to have been greater than the mean 3.2 ft^3/s.

Table 3.2.1-1.--*Summary of gain-loss investigations for the gaining reach of Fountain Creek in the study area*

Date	Gain-loss[1] (cubic feet per second)	Date	Gain-loss[1] (cubic feet per second)
July 26, 1973---------	13.3	June 29, 1976---------	2.6
September 6, 1973-----	7.6	November 9, 1976------	3.3
October 31, 1973------	5.0	May 9, 1977-----------	-7.2
June 14, 1974---------	14.8	July 18, 1977---------	.1
September 26, 1974----	1.7	September 27, 1977----	-13.5
August 26, 1975-------	7.9		

[1]Positive number indicates amount of water gained by the stream. Negative number indicates amount of water lost to ground water.

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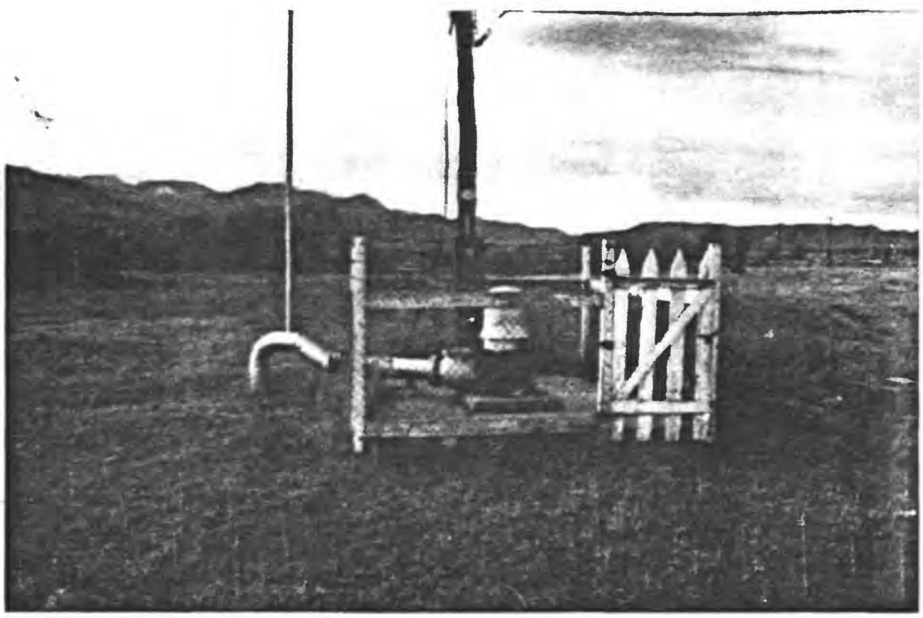
3.2.2 Underflow to Fountain Creek Alluvium and Ground-Water Withdrawals

Water in the aquifer moves generally southeastward through the alluvium, and water leaves the study area at the southeastern boundary at a rate of about 2,500 acre-ft/yr (acre-feet per year). The amount of underflow leaving the area was estimated by using a cross-sectional area of 90,000 square feet (fig. 3.2.2-1), a hydraulic gradient of 0.005, and a hydraulic conductivity of 670 feet per day (R.A. Hogan, W.W. Wheeler and Associates, written commun., 1983).

The largest outflow of water from the Widefield aquifer is through pumpage of wells. During the past 10 years, annual mean pumpage has been about 7,100 acre-feet; from 30 to 40 percent of the water in storage has been withdrawn each year. Yet, water levels throughout the aquifer indicate rapid recovery and no lasting effects (fig. 3.2.2-2). Jenkins (1964, p. 54) observed that the water table recovered more rapidly in the northern part of the aquifer than the southern part, presumably because of recharge from Fountain Creek as it crosses the north end of the aquifer. A comparison of the hydrographs in figure 3.2.2-2 illustrates the effects of pumpage on the water table in the northern, middle, and southern parts of the aquifer. Because of extensive pumpage in the middle of the aquifer, larger water-level fluctuations occur in the middle aquifer than in either the northern (Stratmoor Hills-5 well) or southern (U.S. Geological Survey observation well) parts of the aquifer as illustrated by wells Pinello-1 and Venetucci-8.

Because 1982 was a wet year, only 5,400 acre-feet of water were withdrawn from the aquifer. Due to smaller withdrawals, the water table was generally higher in 1982 than during previous years, resulting in an increase in the amount of ground-water storage. Between December 1981 and December 1982, the change in water levels observed at 26 sites ranged from a decrease of 2 feet to an increase of 7 feet. Mean water-level change in the aquifer was an increase of about 3 feet. Using an area-weighted mean water-level change of 2.7 feet, an aquifer area of 3.5 square miles, and a specific yield of 0.25, an estimated 1,500 acre-feet increase in ground-water storage occurred during 1982.



A municipal well located on the Pinello Ranch, which is used to export water to the city of Colorado Springs.

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Artificial recharge ponds located on the Pinello Ranch.

3.3 *Summary of Inflows and Outflows*

Inflows to the Widefield aquifer and outflows from the aquifer are summarized in table 3.3-1. A ground-water budget for 1982 was not computed because the data used to estimate inflows and outflows were from different time periods. However, the total of the inflows minus the actual change in storage is within 5 percent of the total of the outflows, which indicates that estimates for the inflows and outflows are reasonable.

INFLOWS: The major inflow to the Widefield aquifer is from Fountain Creek. Recharge from Fountain Creek to the aquifer was based on 10 gain-loss investigations performed between 1973 and 1977; recharge was estimated to be 8,000 acre-ft/yr (acre-feet per year). Underflow from Fountain Creek alluvium to the Widefield aquifer at a cross section located near Highway 29 was estimated to be 700 acre-ft/yr. Underflow from tributary alluvium to the Widefield aquifer was estimated to be 318 acre-ft/yr. An estimated 720 acre-ft/yr entered the aquifer as underflow from eolian deposits located east of the aquifer. Recharge to the ground water in this area was primarily from Canal No. 4. During 1982, approximately 2,200 acre-feet of water recharged the aquifer from precipitation, lawn irrigation, and agricultural irrigation. The Pinello Ranch recharge ponds contributed an estimated 180 acre-feet of water to the aquifer during 1982. Some seepage from sewage lagoons occurs in the area, but it was not possible to confidently estimate the amount. Because of a lack of clay liners, it is probable that there is more recharge from lagoons at the Widefield Sewage Treatment Plant than the Security Sewage Treatment Plant, which reportedly has clay-lined lagoons. Septic tanks in the area may contribute as much as 1 acre-ft/yr of water to the aquifer.

OUTFLOWS: A significant amount of ground water flows to Fountain Creek in the 4.2-mile reach where the stream flows adjacent to the aquifer. Based on 11 gain-loss investigations performed between 1973 and 1977, the Widefield aquifer loses an estimated 2,300 acre-ft/yr to Fountain Creek. An estimated 2,500 acre-ft/yr of ground water flows out of the study area to the southeast. The largest outflow is withdrawal of ground water by pumpage. During the past 10 years, annual mean pumpage has been about 7,100 acre-feet. However, because of larger than normal precipitation during 1982, annual pumpage was only 5,400 acre-feet.

Table 3.3-1.--*Summary of inflows and outflows, Widefield aquifer, 1982*[1]

Name of inflow	Inflow (acre-feet)	Name of outflow	Outflow (acre-feet)
Fountain Creek	8,000	Fountain Creek	2,300
Fountain Creek alluvium	700	Ground-water outflow	2,500
Sand Creek alluvium	28	Ground-water pumpage	5,400
Windmill Gulch alluvium	200		
Crews Gulch alluvium	90		
Eolian deposits	720		
Stratmoor Valley tributary	5		
B Ditch alluvium	3		
Clover Ditch alluvium	<1		
Precipitation and lawn irrigation	1,000		
Precipitation and agricultural irrigation	1,200		
Pinello Ranch recharge ponds	180		
Sewage lagoons	Unknown		
Septic tanks	1		
TOTAL[2]	12,100		10,200

[1]Estimated 1982 change in storage equals 1,500 acre-feet.
[2]Total rounded to nearest 100 acre-feet.

4.0 NITROGEN FORMS AND TRANSFORMATIONS

Nitrogen occurs in the hydrologic environment in several forms, which may be stable or reactive depending on the environmental conditions. Many of the reactions between nitrogen forms require specific bacteria which use the energy released in the reaction. Important nitrogen forms and potential nitrogen-transformation reactions are shown in figure 4.0-1.

During the study, nitrogen was analyzed using methods described in Skougstad and others (1979). Nitrogen analyses of surface water were made on whole (unfiltered) water samples and were expressed as total nitrogen, while ground-water samples were filtered through a 0.45-micron membrane filter before analysis, and were expressed as dissolved nitrogen. All samples were collected in opaque bottles, preserved by addition of mercuric chloride, and chilled to 4°C before shipment to the Denver Central Laboratory of the U.S. Geological Survey for analysis. The total or dissolved forms of nitrogen analyzed included: (1) Ammonia, which includes both ammonium (NH_4^+) and nonionized ammonia (NH_3); (2) Kjeldahl nitrogen, which includes both ammonia and organic nitrogen; (3) organic nitrogen, which is determined by subtracting ammonia from Kjeldahl nitrogen; (4) nitrite; (5) nitrite plus nitrate; (6) nitrate, which is determined by substracting nitrite from nitrite plus nitrate; and (7) total or dissolved nitrogen, which is determined by adding Kjeldahl nitrogen and nitrite plus nitrate. All nitrogen concentrations in this report are expressed as the equivalent amount of nitrogen.

Because of the municipal wastewater flow into Fountain Creek, ammonia (NH_3) and ammonium (NH_4^+), with which it is in equilibrium, are the most abundant nitrogen forms in Fountain Creek and canals which divert water from it. Ammonia may be lost from surface water by volatilization into the atmosphere and through uptake by aquatic plants. Ammonium may react to the unstable intermediate nitrite, and then to nitrate in surface water in a process called nitrification, since adequate dissolved oxygen is generally present. Nitrate and ammonia may be used by both floating and attached aquatic plants (Kittrell, 1969), but because of short residence time of surface water and the shifting sand channel in Fountain Creek and Canal No. 4, few plants are observed, and little nitrate or ammonia are likely to be consumed in this way. However, nitrate or ammonia uptake by aquatic plants may be important in the Pinello Ranch recharge ponds and in some streams tributary to Fountain Creek.

During the process of infiltration and percolation to ground water, nitrogen in the water of streams, canals, sewage lagoons, septic tanks, artificial recharge ponds, and applied irrigation water may undergo several transformations. Ammonia in percolating water may be reversibly adsorbed onto cation-exchange sites of clays in soil or alluvial deposits (Keeney, 1981, p. 261). Adsorbtion will retard the ammonia movement until available exchange sites are filled (Lance and Whistler, 1972). Ammonia in water applied to soils may also volatilize back to the atmosphere, the amount depending on the amount of calcium carbonate in the soil and soil pH (Ryden, 1981). If oxygen and nitrosomonas and nitrobacter bacteria are present, ammonia in water moving through soil may react to form nitrate through the process of nitrification. The reaction should be essentially complete during warm months in the top inch of soil (Lance, 1972; Bouwer and others, 1974). Nitrate is not subject to adsorbtion onto clays and generally will be stable in the unsaturated zone if oxygen is present. If oxygen is not present (anaerobic conditions), nitrate may undergo denitrification to nitrogen gas or nitrous-oxide gas or reduction to ammonium. Denitrification is believed to be preferred over reduction, except in organic-rich soils (Reddy and others, 1980). Denitrification requires the absence of oxygen and proceeds most rapidly at temperatures of 20° to 35°C (Broadbent and Clark, 1965) and at neutral to slightly alkaline pH (Focht and Verstraete, 1977). However, it is believed that nitrification and denitrification may occur simultaneously in close proximity, because nitrification may proceed at small oxygen concentrations that allow for micro-anaerobic zones where denitrification may take place (Broadbent and others, 1977). Additionally, both nitrate and ammonia, when present in the root zone, may be used by plants.

Once infiltrating water has reached the ground-water table, some of the same transformations that occur in the unsaturated zone may occur. Aerobic conditions will promote nitrification of any remaining ammonia to nitrate while anaerobic conditions will favor denitrification, and nitrate will be lost from the system as nitrogen gas or nitrous-oxide gas, or nitrate may be reduced to ammonium. Ammonium may be adsorbed onto clays under either aerobic or anaerobic conditions.

Nitrogen in ground water in the study area is generally present primarily as nitrate. Only small concentrations [less than 0.3 mg/L as N (milligrams per liter as nitrogen)] of ammonia and even smaller concentrations of nitrite generally are observed, suggesting that nitrification of ammonia in recharge water is mostly complete before the water enters the ground-water system. The amount of denitrification which occurs will be determined by: (1) The absence of dissolved oxygen, and (2) the availability of carbon.

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5.0 SURFACE-WATER QUALITY

5.1 Fountain Creek

The water in Fountain Creek changes in quality as a result of inflows from the study area. These observed changes are especially large for nitrogen forms as shown for three sites on Fountain Creek during 1982 in figure 5.1-1 and in table 11.0-1 (Supplemental Information section).

At site 1, Fountain Creek at Colorado Springs, mean total nitrogen in monthly samples was 2.4 mg/L as N (milligrams per liter as nitrogen) during 1982, similar to the mean value of 2.6 mg/L as N, based on 36 samples collected since 1975. About 60 percent of the total nitrogen during 1982 was present as total nitrite plus nitrate (1.4 mg/L as N), with most of the remainder total organic nitrogen. This nitrogen reflects upstream municipal wastewater flows and return flows. Seasonal variations during 1982 are related to higher streamflow in the summer months (fig. 2.1-1).

The next downstream site, Fountain Creek below Janitell Road (site 10), is downstream from two small tributaries and the Colorado Springs Sewage Treatment Plant. During 1982, the observed mean total nitrogen concentration was 12.5 mg/L as N, approximately five times the concentration at site 1, upstream. During the period since 1975, 40 samples analyzed for total nitrogen at this site gave a mean concentration of 15.5 mg/L as N. The smaller mean concentration during 1982 probably resulted from higher natural flows in Fountain Creek, which diluted nitrogen discharged by the Colorado Springs Sewage Treatment Plant. About two-thirds of the total nitrogen present at Fountain Creek below Janitell Road (site 10) was in the form of total ammonia during 1982, with most of the rest present as total organic nitrogen. Concentrations of total nitrite plus nitrate at this site were slightly smaller than at site 1, because water entering Fountain Creek from the Colorado Springs Sewage Treatment Plant generally contained less total nitrite plus nitrate than Fountain Creek. Large seasonal variations in total nitrogen concentrations at this site are the result of seasonal variations in the flow of Fountain Creek which was available to dilute relatively constant nitrogen inputs from the Colorado Springs Sewage Treatment Plant.

The quality of water in Fountain Creek below Janitell Road is important, because this is the upstream end of the reach that provides most recharge to the Widefield aquifer. The following comparison of total nitrogen concentrations in water collected from Fountain Creek below Janitell Road and at the Stubbs-Miller Ditch headgate near the downstream end of the recharging reach indicates that little change in total nitrogen concentrations occurs in this reach:

Site	Date	Concentration (milligrams per liter as nitrogen)			
		Total Kjeldahl nitrogen	Total ammonia	Total nitrite plus nitrate	Total nitrogen
Fountain Creek below Janitell Road.	3-24-82	17.0	13.0	0.94	18.0
	12-15-82	15.0	13.0	1.2	16.0
Stubbs-Miller Ditch at headgate.	3-24-82	16.9	12.0	1.1	17.0
	12-15-82	17.5	12.0	1.5	18.0

Fountain Creek below Widefield, site 23, is located at the downstream end of the study area. Water quality at this site is affected by inflows from additional small tributaries and outfalls from four smaller sewage treatment plants. In addition, flow from ground water to Fountain Creek in its gaining reach also may affect water quality. During 1982, the mean total nitrogen concentration of 11 mg/L as N observed at this site decreased from 12.5 mg/L as N at site 10 (Fountain Creek below Janitell Road). About one-half the total nitrogen concentration at this site during 1982 was ammonia, with approximately equal amounts of organic nitrogen and nitrite plus nitrate comprising the remainder. Changes in the relative proportion of the nitrogen forms and the decrease in total nitrogen concentration between sites 10 and 23 probably can be attributed primarily to a combination of nitrification of ammonia to nitrate, ammonia volatilization, and inflows of ground water with relatively large concentrations of total nitrite plus nitrate.

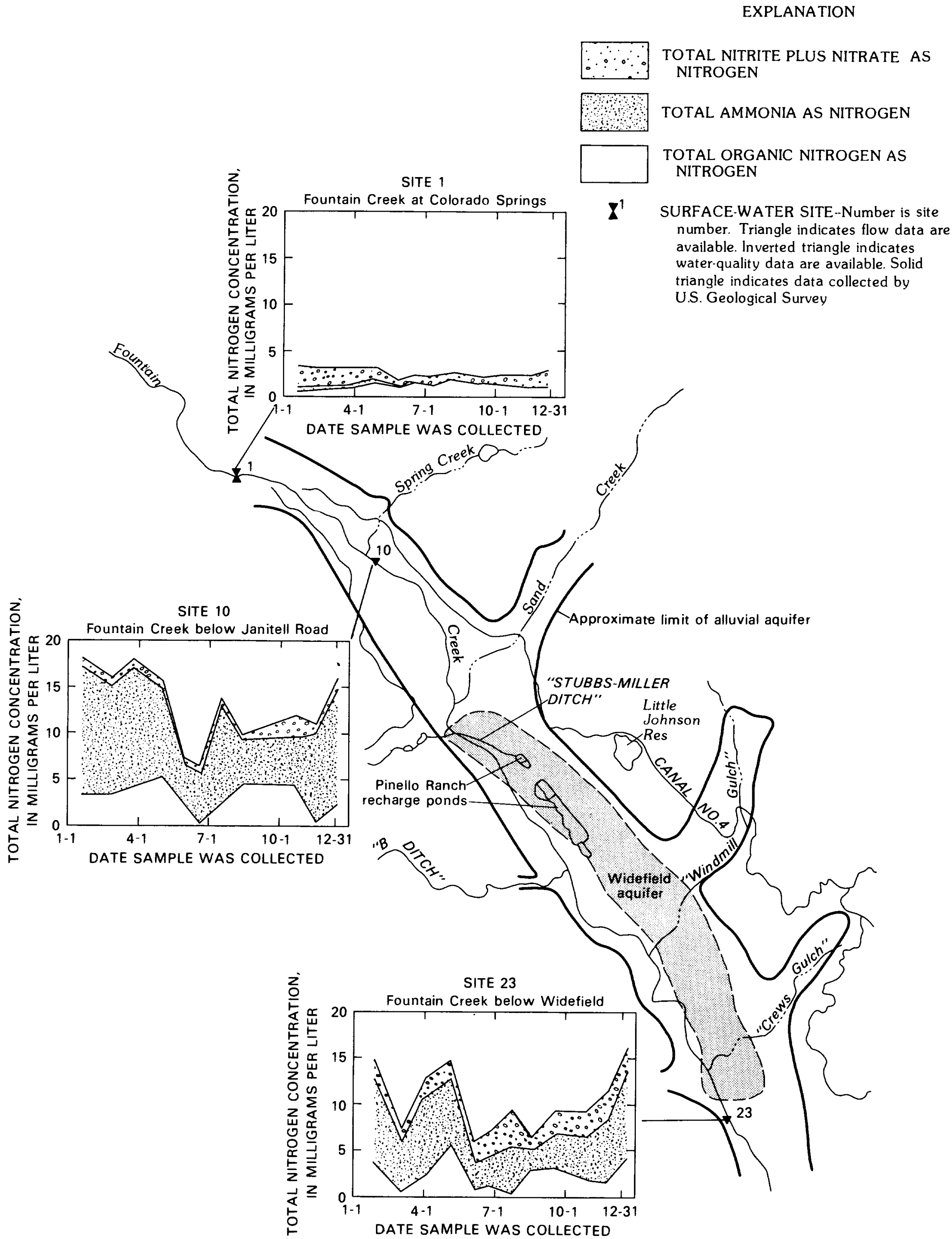


Figure 5.1-1.--Downstream and seasonal variations in total nitrogen concentrations of Fountain Creek, 1982.

5.2 *Inflows and Diversions*

Mean concentrations of various nitrogen forms in inflows and diversions in the study area during 1982 are shown in figure 5.2-1 and in table 11.0-1 (Supplemental Information section). Concentrations of total nitrogen in the inflows are the largest at sites 3 (Colorado Springs Sewage Treatment Plant outfall), 11 (Garden Valley Sewage Treatment Plant outfall), 18 (Security Sewage Treatment Plant outfall), 21 (Clover Ditch drain near Widefield), and 22 (Widefield Sewage Treatment Plant outfall). Concentrations of total organic nitrogen were not routinely measured at sites 3, 18, and 22, but they were estimated to be 15 percent of measured total ammonia nitrogen concentrations, based on analyses of 42 samples during 1980-83 from the Colorado Springs Sewage Treatment Plant (Max Grimes, Laboratory Manager, Wastewater Division, Colorado Springs Department of Public Utilities, oral commun., 1984). Ammonia nitrogen is the dominant nitrogen form in water at all of these sites, except site 11, Garden Valley Sewage Treatment Plant outfall, where nitrite plus nitrate dominates, indicating that during 1982 this plant was nitrifying most ammonia to nitrite plus nitrate prior to discharge to Fountain Creek.

Concentration of total nitrogen and distribution of different nitrogen forms varied widely in tributary inflows (fig. 5.2-1). At sites 2 (Shooks Run), 9 (Spring Creek), 13 (Sand Creek), 14 (Stratmoor Valley tributary), and 16 (B Ditch), mean total nitrogen concentrations ranged from about 5 to 12 mg/L as N (milligrams per liter as nitrogen) with nitrite plus nitrate the dominant nitrogen form. At sites 17 (Windmill Gulch) and 20 (Crews Gulch), mean total nitrogen concentrations were less than 3 mg/L as N, with organic nitrogen the dominant form. Nitrite plus nitrate in these small tributaries may be used by aquatic plants upstream from the sampling sites.

Concentration and distribution of nitrogen forms in the two diversions--Canal No. 4 (site 4) and Stubbs-Miller Ditch (site 15)--reflect the quality of water found in Fountain Creek at their respective diversion points. Water at both of these points is similar in quality to that found in Fountain Creek below Janitell Road.

Seasonal variations in concentration and distribution of nitrogen species occurred in all inflows and diversions during 1982. Because the flow is small at these sites with the exception of the Colorado Springs Sewage Treatment Plant, even large seasonal water-quality variations did not have a major effect on the quality of water in Fountain Creek. However, because the Colorado Springs Sewage Treatment Plant contributes such a large amount of flow to Fountain Creek, seasonal variations in the effluent quality are more important. These variations are shown in figure 5.2-2 and indicate that the concentrations and distribution of nitrogen forms were relatively stable during 1982. Total nitrogen concentrations decreased somewhat during September and October. During the same period, more nitrification occurred in the plant, resulting in more total nitrite plus nitrate nitrogen and less total ammonia nitrogen being discharged to Fountain Creek.

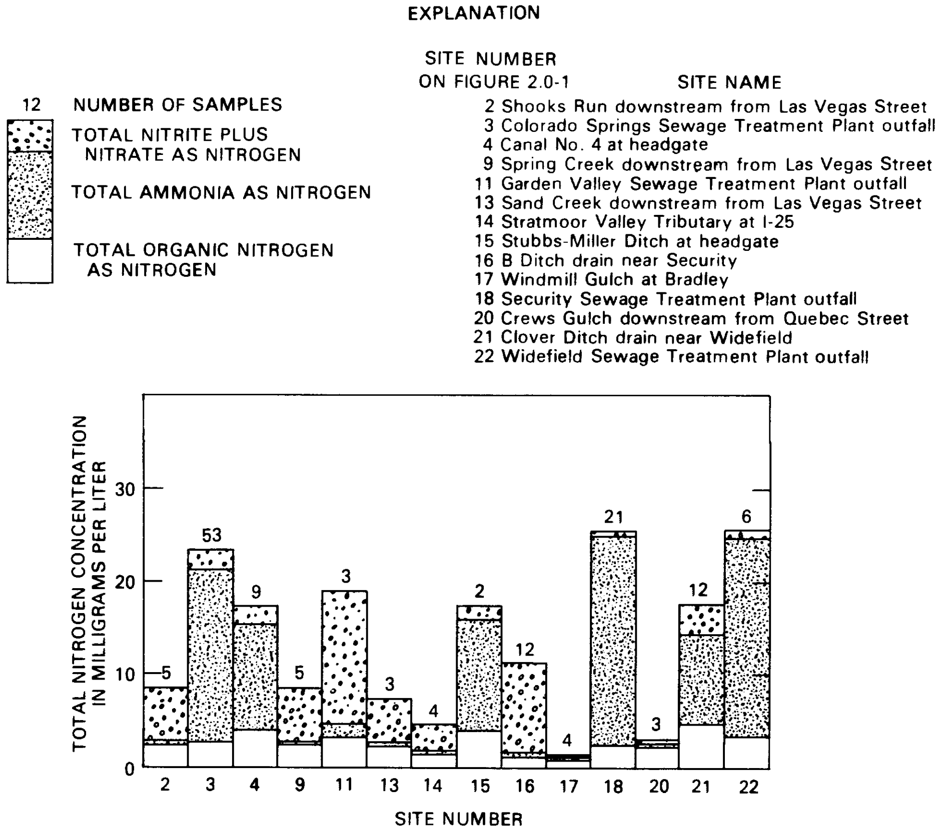


Figure 5.2-1.--Mean total nitrogen concentrations of inflows and diversions, 1982.

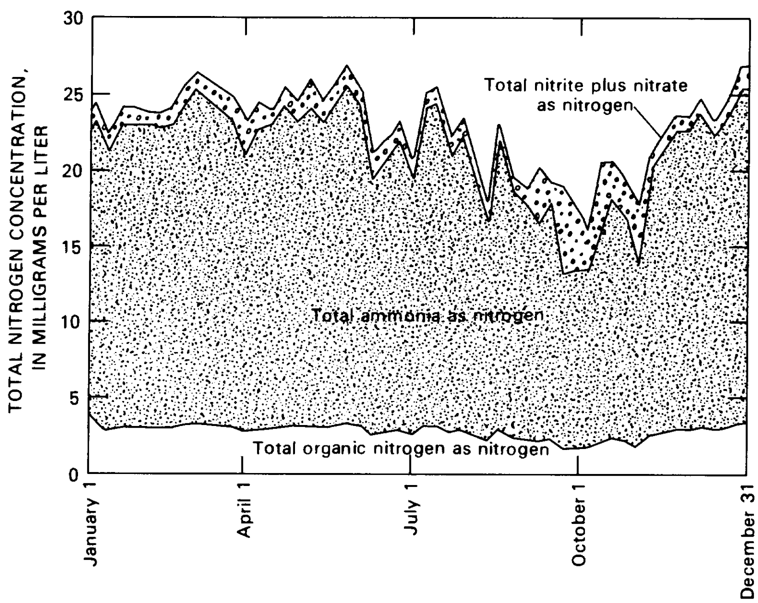


Figure 5.2-2.--Variations in total nitrogen concentrations in flow from the Colorado Springs Sewage Treatment Plant, 1982.

5.3 Quantification of Nitrogen Sources in Fountain Creek and Canal No. 4

Sources of water in Fountain Creek and Canal No. 4 during 1982 were estimated in an earlier section of this report. To extend this analysis to estimate sources of nitrogen at the same points, it was necessary to calculate predicted values of daily total nitrogen concentrations for Fountain Creek at Colorado Springs, Colorado Springs Sewage Treatment Plant outfall, Shooks Run, and Spring Creek.

Daily total nitrogen concentration for Fountain Creek at Colorado Springs can be predicted using a least-squares linear regression relationship between streamflow and total nitrogen load using 1982 data (table 11.0-1, Supplemental Information section). The regression relationship was significant at the 99-percent level, and the correlation coefficient was 0.95. The equation for predicting total nitrogen concentration from this relation is:

$$PREDNIT = 1.68 + 25.85/QCSPGS,$$

where PREDNIT = Predicted total nitrogen concentration of Fountain Creek at Colorado Springs, in milligrams per liter as nitrogen; and
QCSPGS = Daily flow of Fountain Creek at Colorado Springs.

Daily total nitrogen concentrations for the Colorado Springs Sewage Treatment Plant were predicted by a simple linear interpolation between weekly concentrations. A relation between daily flow and total nitrogen concentrations was statistically significant, but this relationship did not explain enough of the variation to be a useful predictor.

Daily total nitrogen concentrations for Shooks Run and Spring Creek were assumed to be equal to the mean concentration measured during 1982 at these sites. This method gave acceptable results, because the flow at these sites generally was small (fig. 2.1-2), and the coefficient of variation of total nitrogen concentration at both sites was 25 percent or less.

Results of the mass-balance calculations to estimate sources, loads, and concentrations of total nitrogen during 1982 are shown in figure 5.3-1. During 1982, an estimated 85 percent of the total nitrogen at Fountain Creek below Janitell Road (site 10) was contributed by the Colorado Springs Sewage Treatment Plant; about 13 percent was contributed from upstream sources, primarily Fountain Creek at Colorado Springs; the remaining 2 percent of the total nitrogen was contributed from Spring Creek. The estimated mean daily total nitrogen concentration at Fountain Creek below Janitell Road during 1982 was 12.1 mg/L as N (milligrams per liter as nitrogen).

An estimated 93 percent of the total nitrogen in Canal No. 4 was contributed by the Colorado Springs Sewage Treatment Plant during 1982; the remaining 7 percent was from upstream sources. The estimated mean daily total nitrogen concentration in Canal No. 4 during 1982 was 14.1 mg/L as N. Sampling at several locations along the canal during 1982 indicated that little change occurred in total nitrogen concentration between the headgate and Big Johnson Reservoir. The total nitrogen concentration at the headgate, then, was a reasonable estimate of concentrations that were available for potential recharge to the Widefield aquifer from canal leakage.

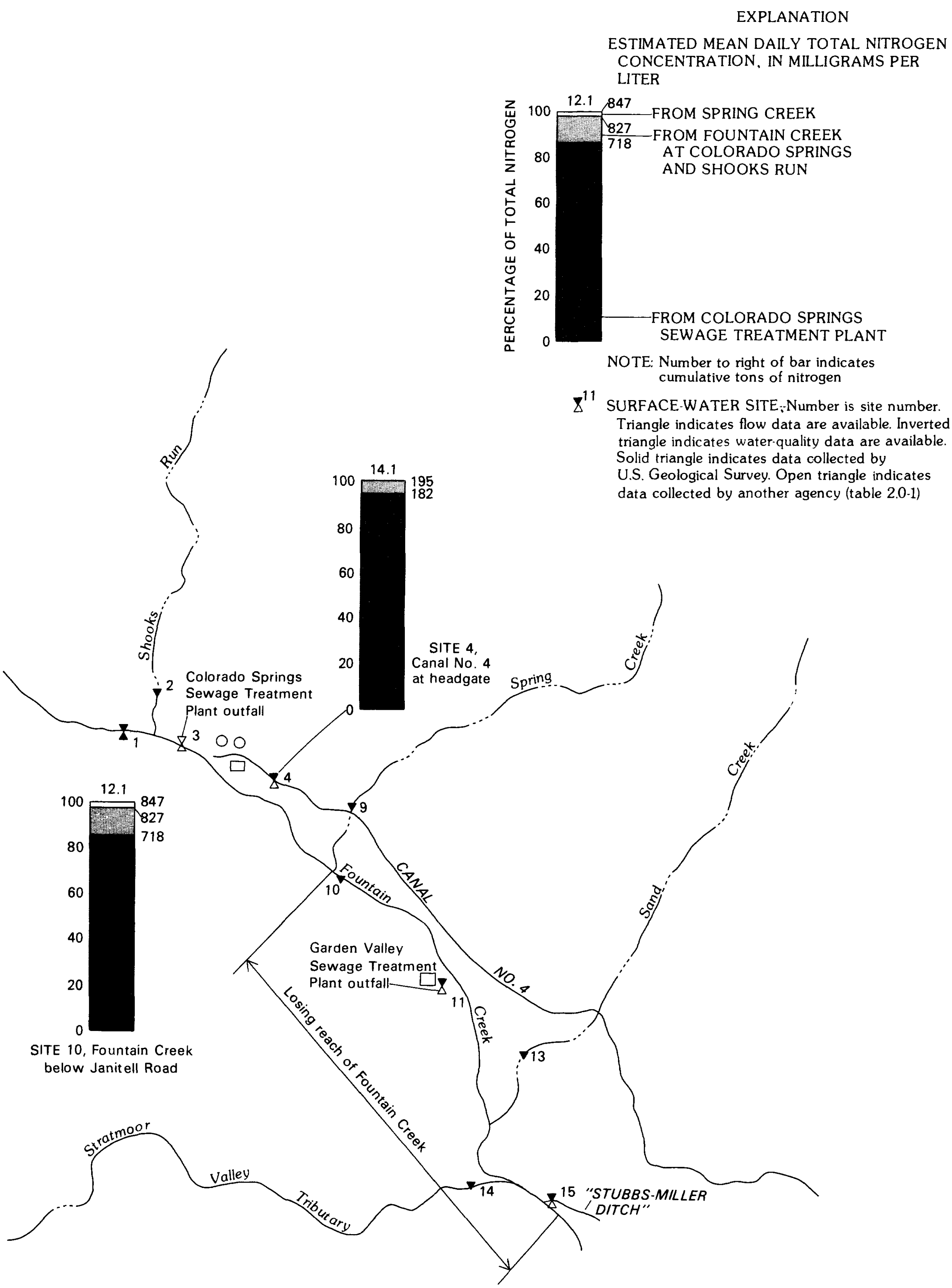


Figure 5.3-1.--Sources, estimated loads, and concentrations of total nitrogen in the upstream end of the study area.

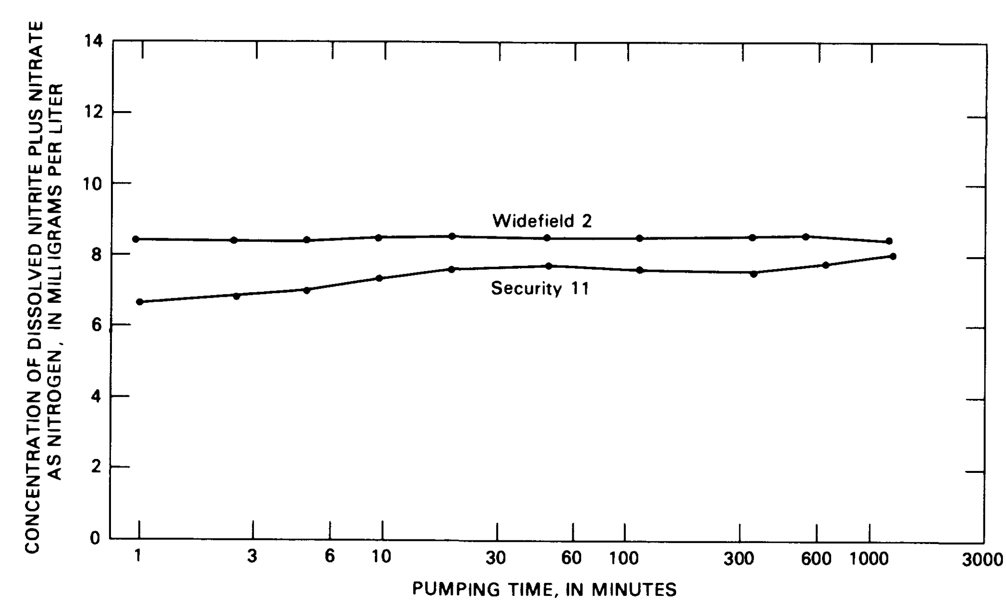
6.0 GROUND-WATER QUALITY

6.1 Nitrogen Variations in Pumping Wells and Sampling Methods

Studies of ground-water quality have shown that concentrations of chemical constituents, including nitrite plus nitrate, in water pumped from alluvial aquifers may be related to well construction and operation (Schmidt, 1977; Nightingale and Bianchi, 1980). In a given hydrologic environment, differences in well construction and operation may cause varying changes in nitrate concentration with pumping time. Such changes have been most evident for infrequently pumped, shallow wells near point or line sources of contamination (Schmidt, 1977). This type of concentration variation was minimized during the study by collecting most ground-water samples from similarly constructed and operated wells. All wells from which samples were collected in the Widefield aquifer, except one, were large capacity, municipal-supply or irrigation wells. These wells have similar construction, including large diameter casing (12 to 24 inches), perforations throughout most or all of the saturated thickness, gravelpack, and turbine pump with the intakes set below the level of drawdown. Most of these wells were in frequent use, especially during the summer months, when much of the sampling was done.

Two municipal-water-supply wells were sampled 10 times during a 24-hour period after the pump was turned on to determine dissolved nitrite plus nitrate concentration variations with time. Neither of the wells had been pumped for at least 2 days prior to the sampling. The results of the sampling (table 11.0-2 in the Supplemental Information section, fig. 6.1-1) show that only small concentration variations in dissolved nitrite plus nitrate occurred with pumping time. This indicates that dissolved nitrite plus nitrate data from large-capacity wells can be used to confidently evaluate temporal and areal trends. To help insure comparability of data between large capacity wells, samples were collected only after a pumping period of at least 10 minutes, and frequently, the pumping period was longer.

Many of the wells used to collect ground-water samples from tributary alluvium were small-capacity domestic wells or small-diameter wells without pumps. Because domestic wells are generally in continuous use, they were pumped long enough to flush the delivery system and deliver fresh water for samples. Some of these wells were equipped with pressure tanks, but no samples were collected after water had passed through water softeners. Wells without pumps were either bailed or pumped with a portable centrifugal pump or submersible pump; at least two well volumes of water, and usually more, were removed from the well before sampling.



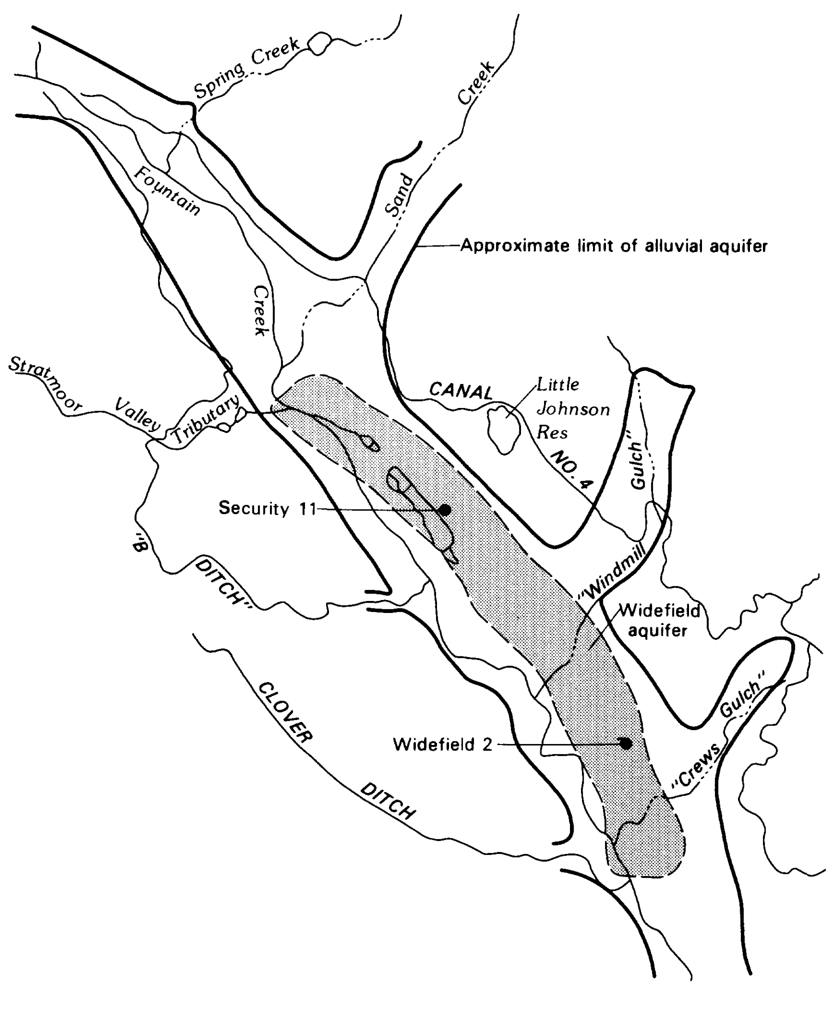


Figure 6.1-1.--Variations in concentrations of dissolved nitrite plus nitrate with pumping time in two wells.

6.2 Temporal Variations of Nitrogen

6.2.1 Long-Term Variations in Nitrogen Data

Water-quality data for dissolved nitrite plus nitrate (fig. 6.2.1-1) and other constituents have been collected by the city of Colorado Springs from well fields on the Venetucci and Pinello Ranches, since 1965. However, interpretation of these data is limited by the samples being collected from pipelines leaving each well field, rather than individual wells and by the use of four different analytical techniques for nitrate during the period. Approximate times that the four analytical techniques were used were obtained from Monte Fryt (Laboratory Director, Colorado Springs Department of Public Utilities, Water Division, oral commun., 1983) and are shown in figure 6.2.1-1. In general, concentrations of dissolved nitrite plus nitrate were less than 1 mg/L as N (milligram per liter as nitrogen) during 1965-67 when dissolved nitrite plus nitrate was analyzed using the phenyl-disulfonic-acid method. Dissolved nitrite-plus-nitrate concentrations increased rapidly during the late 1960's. During this time, samples were analyzed by both the phenyl-disulfonic-acid and Hach methods, with both methods giving similar small concentrations during 1967-68. The apparent concentration increase occurred first in the Pinello Ranch wells, which are nearer the area of recharge from Fountain Creek. Between 1970 and 1982, dissolved nitrite-plus-nitrate concentrations of water produced from both well fields were variable but have not shown a consistent trend in time.

Water-quality data have been collected previously by the U.S. Geological Survey during 1954-55, 1972, and 1977. Dissolved nitrite-plus-nitrate concentrations were determined before 1981 and again during 1981-82 on water from 17 wells in the study area, 13 in the Widefield aquifer and 4 in tributary alluvium (fig. 6.2.1-1). Only two samples were analyzed for dissolved nitrite plus nitrate during 1954-55; concentrations of dissolved nitrite plus nitrate during 1981-82 exhibited large increases since 1954-55.

Between 1972 and 1981-82, concentrations of dissolved nitrite plus nitrate increased in all five wells sampled in the Widefield aquifer. The increase in concentration from two wells in the northern one-third of the aquifer was much larger than three wells in the southern one-third. However, the increases in all five wells are similar in magnitude to seasonal variations observed on water from wells sampled monthly during 1981-82 and, as such, may not represent a long-term trend.

Concentrations of dissolved nitrite plus nitrate were measured during 1977 and 1981-82 on water produced from five wells located throughout the aquifer. Water from only one well in the north end of the aquifer increased in concentration by more than 1.2 mg/L as N. Other concentration changes during the 1977 to 1981-82 period were small.

Two additional wells, Widefield-4 and Venetucci-3, were sampled about 15 times during 1976-79 and again during 1981-82 (fig. 6.2.1-1). Sufficient samples are available to statistically evaluate time trend. Because dissolved nitrite-plus-nitrate concentrations were not normally distributed, and a data gap occurs between 1979 and 1981, the Wilcoxon rank-sum nonparametric test was chosen to evaluate the trend (SAS Institute, 1982). Results of the test and mean concentrations during both periods are shown here:

Site	Mean dissolved nitrite-plus-nitrate concentration (milligrams per liter as nitrogen)		Significant change (95-percent confidence level, two-tailed test)
	1976-79	1981-82	
Venetucci-3	7.75	8.39	yes
Widefield-4	6.97	6.91	no

Results of this test indicate that concentrations of dissolved nitrite plus nitrate have increased in well Venetucci-3, located in the northern one-half of the aquifer, while no statistically significant change was observed in well Widefield-4, located at the south end of the aquifer.

In spite of problems with changing analytical techniques, long-term data from the city of Colorado Springs and the U.S. Geological Survey indicate that concentrations of dissolved nitrate as nitrogen in water produced from the Widefield aquifer have increased. Twenty to thirty years ago, concentrations ranged from 0.5 to 3.0 mg/L as N to concentrations that approach, and occasionally exceeded, the drinking-water standard of 10 mg/L as N during 1981 and 1982. Data collected during the last 6 to 10 years also indicate that concentrations of dissolved nitrite plus nitrate may have increased more rapidly in water produced from some wells located in the northern part of the aquifer than in other places.

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6.2.2 Short-Term Variations in Nitrogen

Short-term variations in dissolved-nitrogen concentrations were evaluated using monthly data from six wells and annual data from 54 wells during 1981 and 1982 (table 11.0-2, Supplemental Information section).

Variations in concentrations of dissolved nitrogen in the six wells sampled monthly are shown in figure 6.2.2-1. Consistent seasonal trends are not evident during 1981 and 1982 at any of the sites, nor are seasonal concentration trends similar between adjacent sites. Nitrite plus nitrate is the major nitrogen form present at all sites, making up between 82 and 91 percent of the total. Organic nitrogen makes up most of the remainder, with smaller concentrations of ammonia.

Concentrations of dissolved nitrite plus nitrate at the five sites sampled monthly where at least 18 analyses were available during 1981-82 were evaluated for concentration trends with time. Trends were evaluated using the Kendall tau-b correlation coefficient (SAS Institute, 1982). Because the test used only 2 years of data, results should only be considered suggestive. Results of the test and related data are shown here:

Site name	Number of samples	Concentrations of dissolved nitrite plus nitrate (milligrams per liter as nitrogen): Mean	Standard deviation	Kendall tau-b time trend test results: Significant trend (confidence level in parenthesis)	Direction of trend
Stratmoor Hills-4	22	7.15	0.88	Yes (90 percent)	Increasing
Security-14------	22	5.70	1.02	Yes (90 percent)	Increasing
Venetucci-3------	20	8.38	.79	No (90 percent)	----------
Security-2-------	18	6.25	.86	Yes (95 percent)	Decreasing
Widefield-4------	23	6.91	.85	Yes (95 percent)	Decreasing

Short-term trends also were evaluated using data from 46 wells in the Widefield aquifer, and 8 wells in tributary alluvial aquifers, collected during the summers of 1981 and 1982. Mean dissolved nitrite-plus-nitrate concentrations of about 7 mg/L as N (milligrams per liter as nitrogen) in the Widefield aquifer and about 6 mg/L as N in tributary alluvium did not change significantly between 1981 and 1982. However, changes at individual wells were as large as 3.1 mg/L as N and some areal variation in these changes occurred in the Widefield aquifer as shown below:

Concentration change, 1981-82 (milligrams per liter as nitrogen)	Category	Northern part of aquifer: Number of wells	Percent	Southern part of aquifer: Number of wells	Percent
>1.6	Large increase-----	3	12	2	10
0.8 to 1.6	Moderate increase--	5	19	0	0
-.8 to .8	No change----------	11	42	8	40
-.8 to -1.6	Moderate decrease--	3	12	4	20
<-1.6	Large decrease-----	4	15	6	30

The aquifer was divided into southern and northern parts at the south end of the Venetucci Ranch well field. About 40 percent of wells in both areas were in the no-change category. Water from about as many wells showed moderate to large increases in concentration as moderate to large decreases in the northern part of the aquifer, while water from five times as many wells showed decreases as increases in the southern part of the aquifer. Water from 8 of 10 wells with concentration increases were in the northern area and about 60 percent of wells with decreases in concentration were in the southern part of the aquifer. While these data are too limited to be statistically significant, they indicate that future water-quality data needs to be examined carefully to evaluate these trends.

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6.3 Areal Variations of Nitrogen

Concentrations of dissolved nitrite plus nitrate as nitrogen in ground water in and adjacent to the Widefield aquifer during the summer of 1982 are shown in figure 6.3-1. These concentrations are shown rather than dissolved nitrogen because dissolved nitrite plus nitrate is of greater interest in drinking waters. The distribution of dissolved nitrogen, which is used in later sections to calculate nitrogen loads, is generally similar, but the actual concentrations are larger. The general pattern of concentration was similar in 1981. The largest concentrations occurred near the north end of the Widefield aquifer near the confluence with Sand Creek. These large concentrations are consistent with recharge from Fountain Creek as the source of nitrogen. Gain-loss studies have indicated that Fountain Creek recharges the Widefield aquifer in the reach between Janitell Road and the headgate of the Stubbs-Miller Ditch. Upstream from the recharge area, concentrations of dissolved nitrite plus nitrate in ground water from the Fountain Creek alluvium were in the range of 6 to 8 mg/L as N (milligrams per liter as nitrogen) or less.

Large concentrations appear to be diluted by tributary inflows or recharge from land surface to concentrations from 8 to 10 mg/L as N, in a narrow band extending as far south as the Venetucci Ranch. During the summer of 1982, concentrations of dissolved nitrite plus nitrate were less than 8 mg/L as N in the central part of the aquifer, with concentrations between 3 and 5 mg/L as N in water produced from several wells on the west side of the aquifer, which underlie or are just downgradient from agricultural areas.

A narrow band of concentrations greater than 8 mg/L as N also occurred in the southern end of the aquifer. Concentrations reached 10 mg/L as N in one well (Widefield-14), which is located adjacent to and may be affected by seepage from the Widefield Sewage Treatment Plant lagoons.

Because other data (section 6.2.1) indicated that concentrations of dissolved nitrite plus nitrate may have increased more rapidly in the northern part of the Widefield aquifer during the last 6 to 10 years, concentrations in 1982 were tested to determine if a difference existed between the northern and southern parts of the aquifer. The test was made using the Wilcoxon rank-sum nonparametric test, and indicated no statistically significant difference existed between the areas in the concentration of dissolved nitrite plus nitrate. This lack of difference suggests that time trends noted in sections 6.2.1 and 6.2.2 may be localized and are not affecting the entire aquifer.

Concentrations of dissolved nitrite plus nitrate were less than 4 mg/L as N in the upgradient reaches of tributary alluvium along Windmill and Crews Gulches, indicating that these inflows did not increase concentrations in the Widefield aquifer. The Widefield aquifer also received inflow from water in eolian deposits recharged by leakage from Canal No. 4 between Sand Creek and Windmill Gulch. Few wells exist in this area, but two that were sampled had concentrations of dissolved nitrite plus nitrate of 9.5 and 27 mg/L as N during 1982. Larger concentrations found in one well indicated possible contamination by some localized source, such as septic systems that are used in that area. Larger concentrations found in the area were not reflected in the concentrations downgradient in the Widefield aquifer, indicating either that they were not representative of the area, or that some process, such as dilution or denitrification, was reducing concentrations downgradient.

Areal variations in the concentration of dissolved organic nitrogen and dissolved nitrite were not significant, but larger concentrations of dissolved ammonia nitrogen occurred in Stratmoor Hills-4, located in the north end of the Widefield aquifer, than in four wells as shown:

Well	Number of samples: Total	Number of samples: With concentrations greater than limit of detection	Mean dissolved ammonia nitrogen concentration in samples with concentrations greater than limit of detection (milligram per liter as nitrogen)
Stratmoor Hills-4--	22	19	0.17
Security-14--------	22	13	.10
Venetucci-3--------	20	10	.10
Security-2---------	18	10	.09
Widefield-4--------	23	14	.09

This concentration difference was statistically significant at the 99-percent confidence level based on a Kruskal-Wallis nonparametric test and indicates that nitrification of ammonia nitrogen in water recharged from Fountain Creek was not always complete in the northern part of the aquifer.

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6.4 Vertical Variations of Nitrogen

Vertical variations in the concentration of dissolved nitrite plus nitrate in the Widefield aquifer were evaluated by sampling four municipal-supply or irrigation wells throughout the aquifer during 1982. These wells were perforated throughout the saturated thickness, but none of the wells was equipped with pumps at the time of sampling. Two of the wells had been unused for several years (Pinello-14 and Enfield-3), and the other two had the pumps pulled for repairs and had not been used for about 6 months. Sampling of all four wells was made by first measuring the total saturated thickness in the casing using a steel tape, dividing this total into five or six equal intervals, and collecting samples with a 1-foot-long thief sampler at the center of each interval. Samples were collected from the top down to minimize disturbance in the water column. Results of the sampling are shown in figure 6.4-1. Little vertical variation of dissolved nitrite-plus-nitrate concentrations occurred in any of these wells, which were located in all parts of the aquifer and are near various sources of recharge including Fountain Creek, agricultural, and residential areas.

Lack of apparent vertical variation in dissolved nitrite-plus-nitrate concentrations in the Widefield aquifer may have resulted from the fact that most of the recharge resulted from infiltration of recharge from Fountain Creek in the northern part of the aquifer, rather than percolation from land surface in the form of irrigation return flow, artificial recharge, septic systems, and seepage from sewage lagoons. As the water recharged from Fountain Creek moves south through the aquifer, it is subject to intense pumping, which results in more mixing and less vertical stratification than would occur in a less-pumped system.

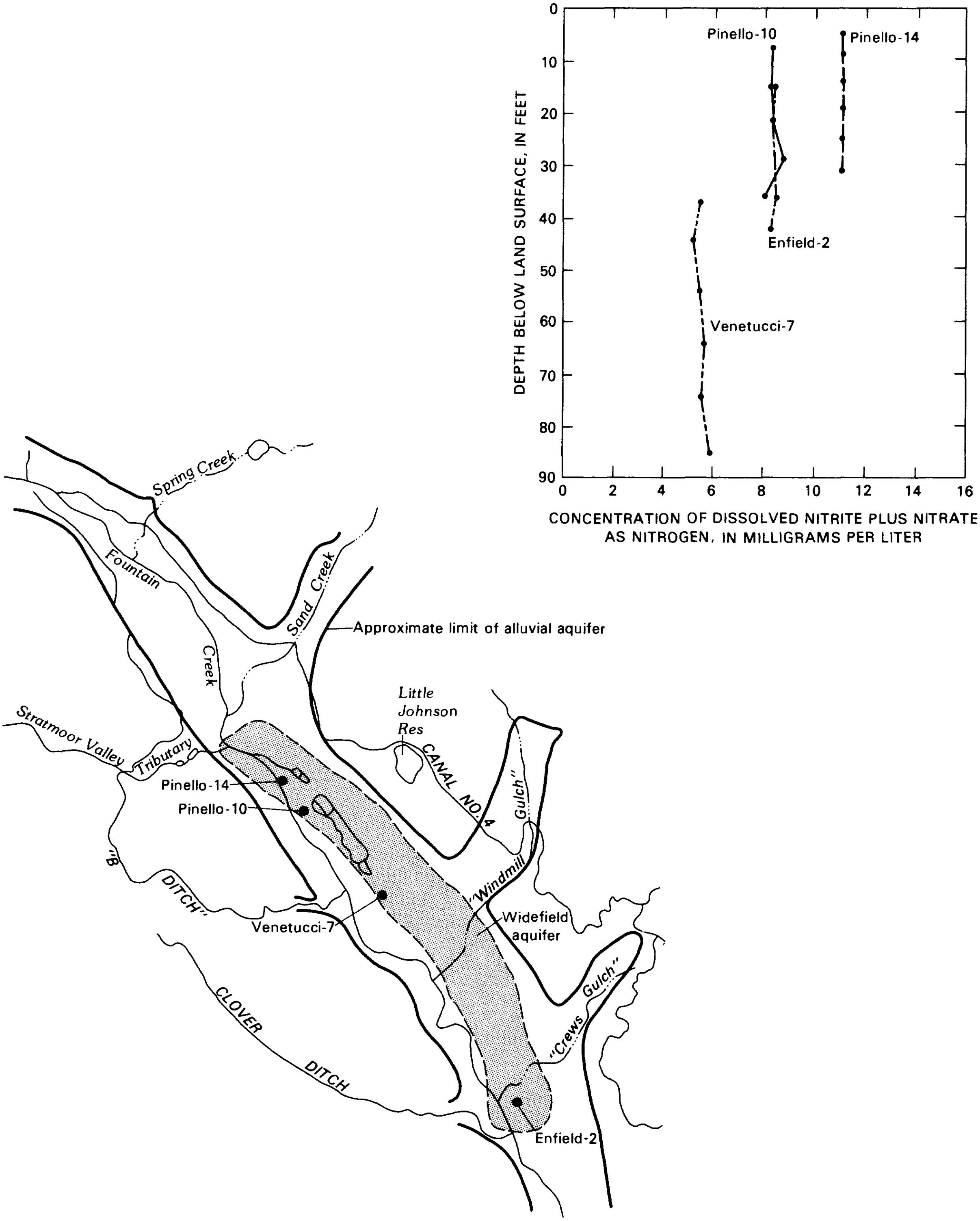

Figure 6.4-1.--Vertical variations in the concentration of dissolved nitrite plus nitrate as nitrogen in four wells.

7.0 NITROGEN SOURCES AND LOADS TO THE WIDEFIELD AQUIFER

Nitrogen may enter the Widefield aquifer from Fountain Creek, underflow from Fountain Creek alluvium and tributary alluvium, and recharge from land surface. For the purpose of estimating the amount of nitrogen entering the aquifer from various sources, nitrogen loads were calculated for each source, using dissolved or total nitrogen concentrations and the volume of water recharging the aquifer from each source. Load refers to the amount of nitrogen in solution or in transport; in this report, load is usually expressed in tons.

As previously discussed in section 4.0, given the right environmental conditions, nitrogen may undergo many different transformations in the unsaturated and saturated zones. Nitrogen transformations in the Widefield aquifer probably occur more readily in the unsaturated zone than in the saturated zone. The probable nitrogen pathways and transformation processes that occur in the Widefield aquifer are shown in figure 7.0-1. During infiltration and percolation, nitrogen may first be nitrified to nitrate, which then may be denitrified. Ammonium may, in addition, be reversibly adsorbed to aquifer materials, especially clays. Of these processes, only denitrification results in permanent nitrogen loss from the aquifer and, therefore, is the transformation process that may produce the greatest uncertainties in estimating nitrogen loads from various sources.

Due to the apparent presence of dissolved oxygen in most parts of the aquifer and the lack of adequate concentrations of a carbon source in the ground water in the Widefield aquifer, significant denitrification is unlikely to occur, and nitrogen in the ground water should be fairly stable. Therefore, nitrogen loads from underflows should be reasonable. The largest uncertainty in estimating nitrogen loads from underflows probably results from errors in estimating the volume of water recharging the aquifer from each source.

Because the potential exists for significant nitrogen losses in the unsaturated zone through denitrification, estimates of nitrogen loads to the aquifer from Fountain Creek, seepage from Canal No. 4, irrigation, and artificial recharge are most likely to have the greatest uncertainties. Due to the nonconservative nature of nitrogen, specifically in the unsaturated zone, and uncertainties in estimating the volume of water recharging the aquifer from various sources, it is not possible to confidently compute a nitrogen budget for the Widefield aquifer. The reader needs to be aware that nitrogen loads presented in this report may be considered only as estimates of the nitrogen contribution to the aquifer from each source.

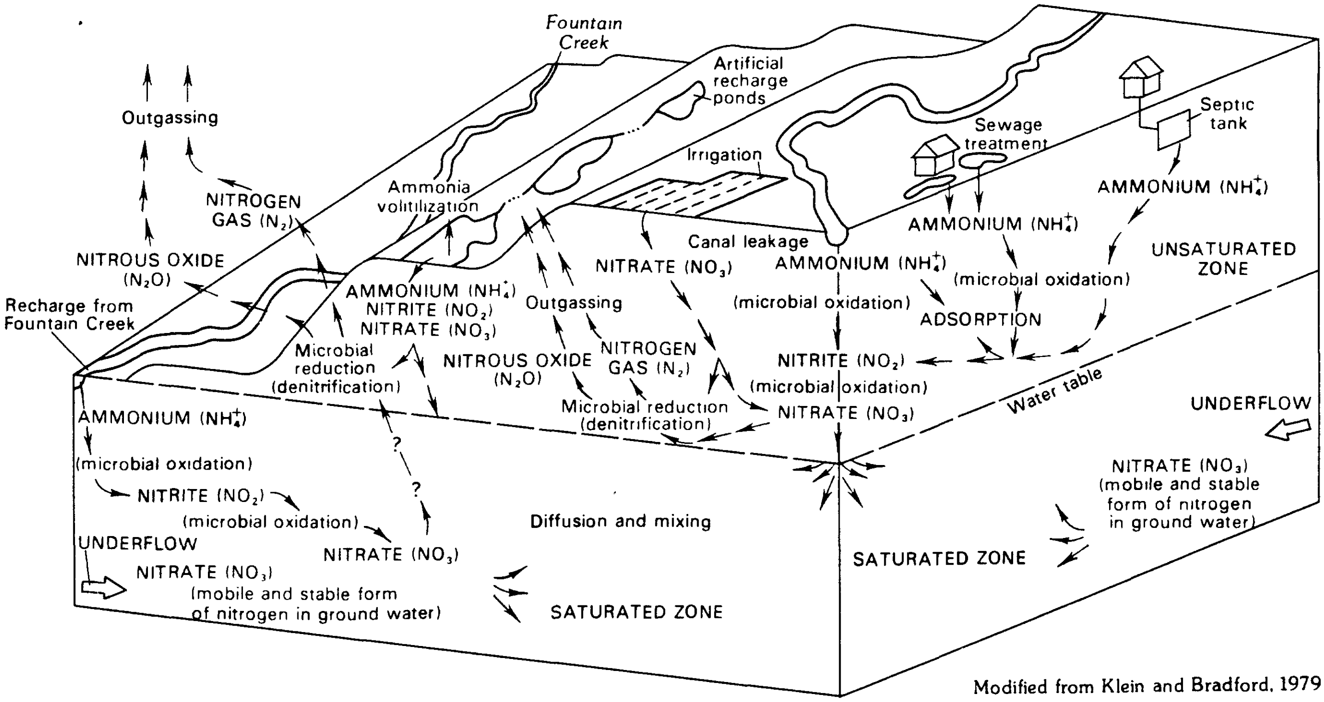

Figure 7.0-1.--Nitrogen pathways and transformation processes in the Widefield aquifer.

7.1 Fountain Creek and Fountain Creek Alluvium

Recharge from Fountain Creek and underflow from Fountain Creek alluvium are two sources of nitrogen to the Widefield aquifer. Nitrogen load in Fountain Creek below Janitell Road during 1982 was estimated to be 850 tons (fig. 5.3-1). The primary source of nitrogen in the losing reach of Fountain Creek (fig. 5.3-1) is the Colorado Springs Sewage Treatment Plant effluent, which made up 42 percent of the flow in Fountain Creek during 1982. During 1982, the Colorado Springs Sewage Treatment Plant contributed approximately 720 tons (fig. 5.3-1) of nitrogen to Fountain Creek. Spring Creek contributed 20 tons of nitrogen to Fountain Creek, and the nitrogen load in Fountain Creek upstream from the outfall from the Colorado Springs Sewage Treatment Plant was approximately 110 tons. Because little change in total nitrogen concentration occurred in the losing reach of Fountain Creek, the estimated mean daily total nitrogen concentration of 12.1 mg/L (milligrams per liter) (fig. 5.3-1) was used as the nitrogen concentration in water that was available to recharge the Widefield aquifer during 1982. An estimated 8,000 acre-ft/yr (acre-feet per year) of water from Fountain Creek recharged this reach of the aquifer. The resulting potential nitrogen load in water recharging the Widefield aquifer during 1982 was 130 tons (fig. 7.1-1) or about 15 percent of the nitrogen in the stream. This amount does not account for nitrogen losses through denitrification, which could reduce the concentration of nitrogen in water recharging the aquifer. If denitrification occurred during recharge, the actual amount of nitrogen from Fountain Creek recharging the aquifer could be substantially less than 130 tons.

Nitrogen in ground water of the Fountain Creek alluvium enters the Widefield aquifer near the confluence of Sand Creek and Fountain Creek. In this area, nitrogen in ground water may originate as recharge from Fountain Creek, seepage from Canal No. 4, underflow from Sand Creek alluvium, and underflow from Fountain Creek alluvium north of Highway 29. The amount of nitrogen that reaches the Widefield aquifer from Fountain Creek alluvium north of Highway 29 for 1982 was calculated by using an underflow of 700 acre-feet (cross section A-A', section 3.1.2), and from the mean dissolved-nitrogen concentration of water samples collected periodically during 1982 from four wells located near Highway 29. Mean dissolved-nitrogen concentrations in the water collected from the four wells ranged from 7.7 to 9.1 mg/L as N (milligrams per liter as nitrogen), with a mean of 8.3 mg/L as N and a standard deviation of 0.59. The resulting nitrogen load to the Widefield aquifer from ground water in the Fountain Creek alluvium north of Highway 29 during 1982 was about 8 tons.

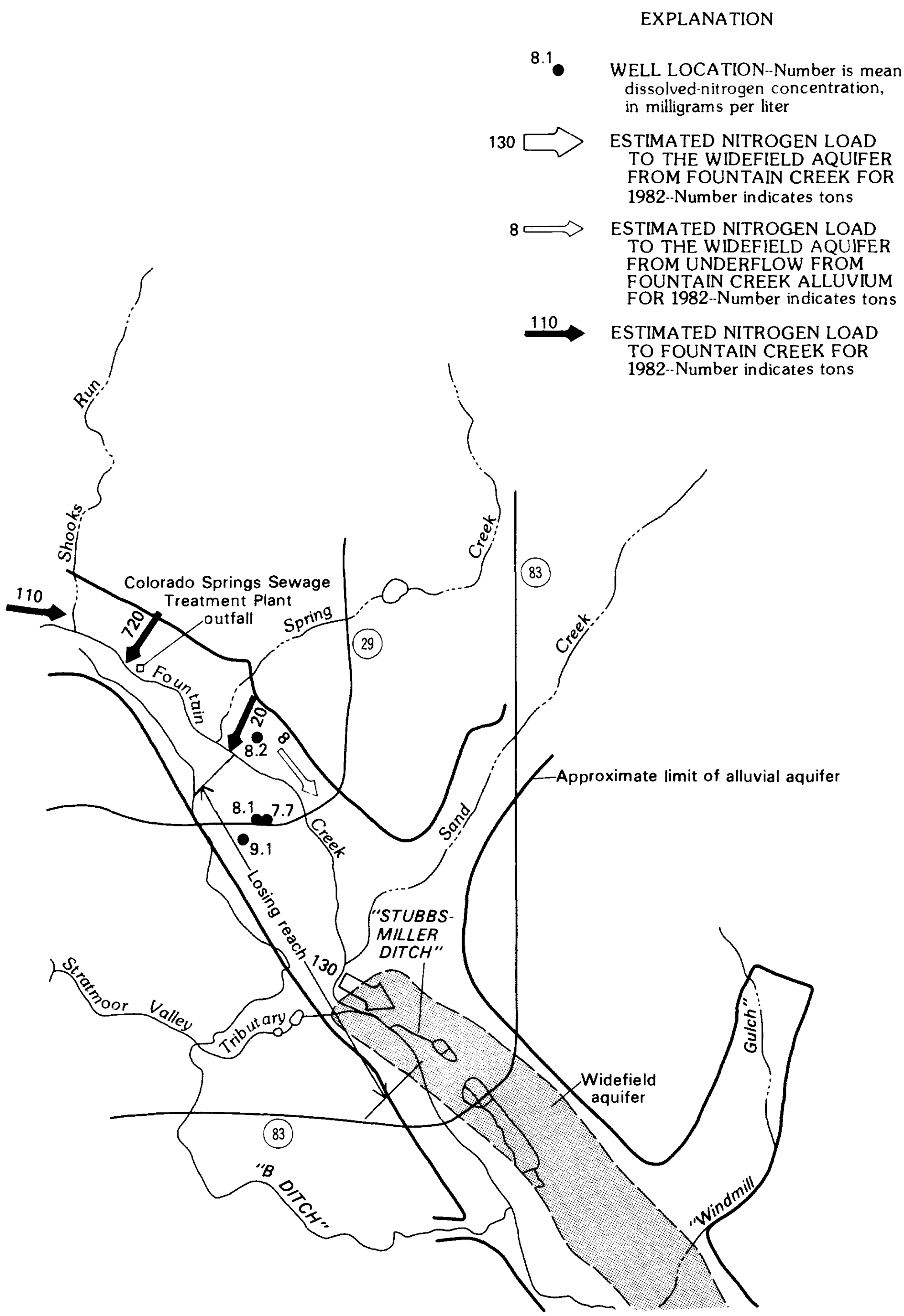

Figure 7.1-1.--Estimated nitrogen loads to the Widefield aquifer from Fountain Creek and from underflow from Fountain Creek alluvium for 1982.

7.2 *Tributary Alluvium*

Ground-water inflow to the Widefield aquifer from tributary alluvium is a source of nitrogen to the Widefield aquifer. Nitrogen loads to the aquifer for 1982 from tributary alluvium were estimated using underflows calculated in section 3.1.2, and from dissolved-nitrogen concentration of water samples collected from wells located in the tributary alluvium (fig. 7.2-1).

Nitrogen enters the Widefield aquifer from the east with underflow from Sand Creek alluvium, Windmill Gulch alluvium, Crews Gulch alluvium, and from saturated eolian deposits that are recharged by leakage from Canal No. 4. The mean dissolved-nitrogen concentration of ground water in Sand Creek alluvium was estimated to be 2.1 mg/L as N (milligrams per liter as nitrogen), based on water samples collected quarterly from a well located immediately upgradient from Canal No. 4 (fig. 7.2-1). Using an underflow of 28 acre-feet (table 3.1.2-1), and a dissolved-nitrogen concentration of 2.1 mg/L as N, the 1982 nitrogen load to the Widefield aquifer from Sand Creek alluvium was calculated to be less than 1 ton (160 pounds). The amount of nitrogen entering the Widefield aquifer from Windmill Gulch alluvium during 1982 was estimated to be almost 2 tons (3,850 pounds), using an underflow of 200 acre-feet (table 3.1.2-1) and a mean dissolved-nitrogen concentration of 7.1 mg/L as N (fig. 7.2-1). The amount of nitrogen reaching the Widefield aquifer with underflow from Crews Gulch alluvium during 1982 was estimated to be less than 1 ton (1,220 pounds). The amount is based on an underflow of 90 acre-feet and a mean dissolved-nitrogen concentration of 5.0 mg/L as N (fig. 7.2-1).

Nitrogen enters the Widefield aquifer with underflow from the saturated eolian deposits located east of the Widefield aquifer between Sand Creek and Windmill Gulch primarily as a result of seepage from Canal No. 4. During 1982, the estimated nitrogen load in Canal No. 4 was 195 tons. An estimated 93 percent of the 195 tons in Canal No. 4 was contributed by the Colorado Springs Sewage Treatment Plant; 7 percent of the load was from upstream sources (section 5.3). Assuming 880 acre-feet of canal water recharged the eolian deposits (section 3.1.2), and the mean total nitrogen concentration in the ditch water was 14 mg/L as N, the 1982 nitrogen load to the eolian deposits from Canal No. 4 was approximately 17 tons. This amount does not account for potential nitrogen losses through denitrification. Seven hundred and twenty acre-feet of water were estimated to have entered the Widefield aquifer as a result of underflow from the eolian deposits. Water samples collected from two wells located in the area indicated the ground water in the area contained large dissolved-nitrogen concentrations. A water sample from one well had a dissolved-nitrogen concentration of 11 mg/L as N; a water sample from the other well contained 29 mg/L as N, indicating some localized contamination, such as septic systems. Because the well water containing 11 mg/L of dissolved nitrogen probably was more representative of the concentration of nitrogen in the ground water in the area, it was used to calculate the 1982 nitrogen load to the aquifer from eolian deposits. The resulting nitrogen load to the aquifer was 13 tons.

Small amounts of nitrogen entered the Widefield aquifer from the west, with underflow from Stratmoor Valley tributary alluvium, B Ditch alluvium, and Clover Ditch alluvium. Although relatively large concentrations of dissolved nitrogen occurred in water produced from these alluvial deposits, the combined nitrogen load to the Widefield aquifer for 1982 from these areas was less than 1 ton, because of the small amount of water entering the Widefield aquifer from the west.

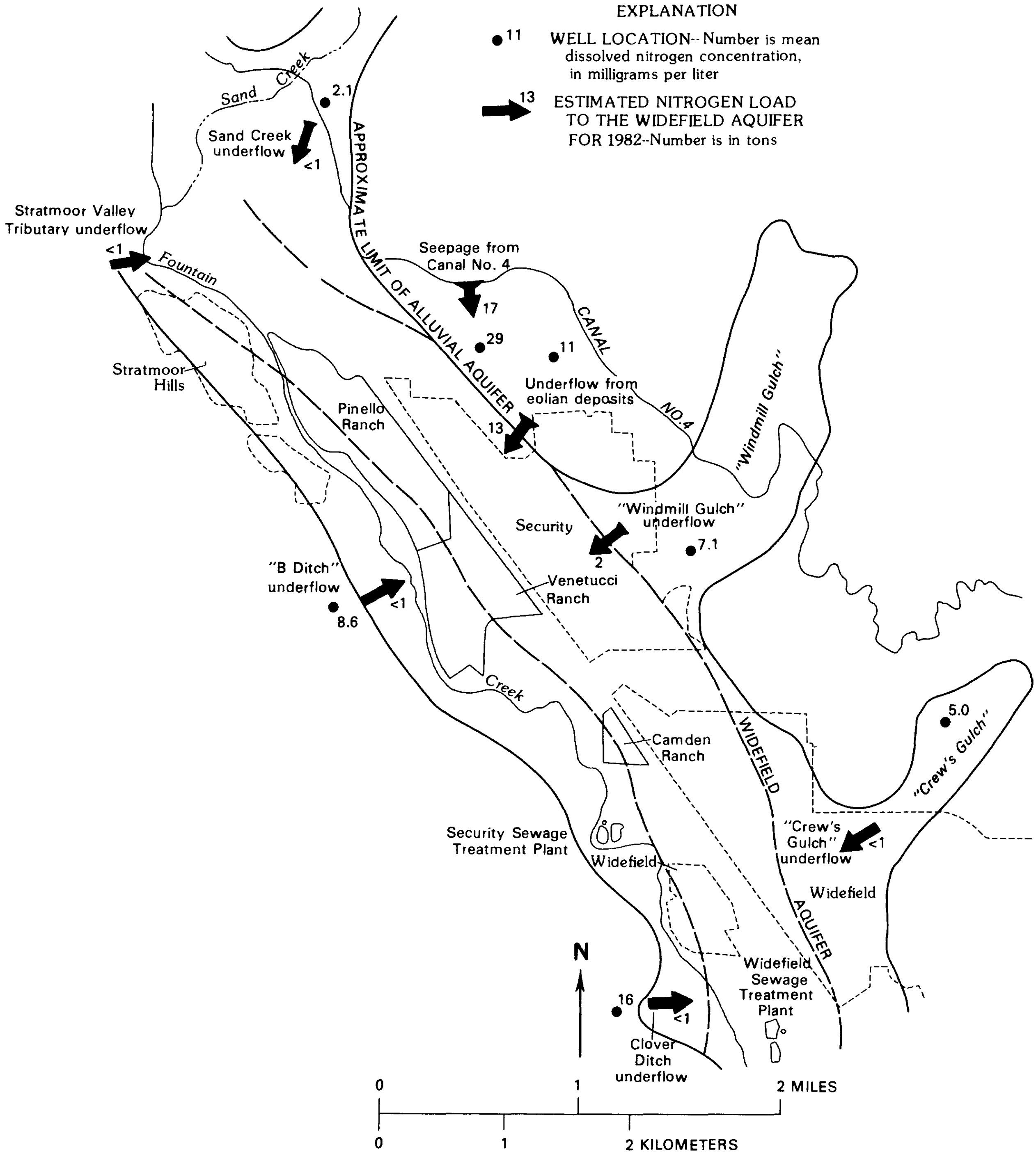

Figure 7.2-1.--Estimated nitrogen loads to the Widefield aquifer from underflow from tributary alluvium for 1982.

7.3 Recharge from Land Surface

Leaching of nitrogen to the Widefield aquifer from the land surface occurs as a result of infiltration and percolation of precipitation and irrigation water, artificial recharge at the Pinello Ranch, seepage from sewage lagoons, and septic systems. The amount of nitrogen that reached the aquifer as the result of deep percolation from precipitation and irrigation during 1982 was estimated separately for residential and agricultural areas. As mentioned in section 3.1.3, 435 acres of lawns and 286 acres of irrigated agricultural land overlie the aquifer. Alfalfa was grown on about 127 acres of the agricultural land; corn was grown on most of the remaining 159 acres. Because turf grass, alfalfa, and corn absorb different amounts of nitrogen, separate estimates of the 1982 nitrogen load to the aquifer were made for each crop.

Lawns in the area receive nitrogen from irrigation water and from fertilization. During 1982, the mean dissolved-nitrogen concentration of irrigation water was estimated to be 8.0 mg/L as N (milligrams per liter as nitrogen) in Security, and 8.7 mg/L as N in Widefield. Means were calculated from the dissolved-nitrogen concentration of water samples collected during the summer of 1982 from all wells supplying water to the two communities. Approximately 800 acre-feet of irrigation water, containing 8 mg/L of nitrogen, was applied to the 299 acres of lawns in Security during 1982, resulting in an application of about 58 pounds of nitrogen per acre through lawn irrigation. Approximately 100 acre-feet of irrigation water containing 8.7 mg/L of nitrogen was applied to the 136 acres of lawns in Widefield during 1982, resulting in an application of about 18 pounds of nitrogen per acre through lawn irrigation. The amount of fertilizer applied to the lawns was estimated from a national Gallup survey (Dr. John Long, O.M. Scott Inc., oral commun., 1983). Based on the survey, the maximum amount of fertilizer applied during 1 year would be about 6.8 pounds per 1,000 square feet or 296 pounds per acre. When combined with the amount of nitrogen in irrigation water, the maximum amount of applied nitrogen was estimated to be 354 pounds per acre in Security, and 314 pounds per acre in Widefield. Bouwer (1978, p. 425) noted that frequently mowed grasses may absorb as much as 560 pounds of nitrogen per acre per year. Because the maximum application rate was less than the potential annual nitrogen uptake for turf grasses, the amount of nitrogen leached to the ground water from lawn irrigation and fertilization during 1982 probably was small. However, during periods of excessive irrigation or precipitation, some nitrogen may have leached past the root zone and into the aquifer.

The leaching of nitrogen to the aquifer as a result of agricultural irrigation was estimated for each agricultural area. Because fertilizers are not presently used on any of the agricultural areas (Nick Venetucci, Ralph Chappel, and William J. McCullough, oral commun., 1982), the only source of nitrogen is the nitrogen in the irrigation water. Because of the small number of livestock in the area, the nitrogen from livestock waste was considered negligible.

One of three agricultural areas is the Camden Ranch (fig. 7.3-1), where approximately 31 acres of alfalfa were irrigated by one well. The nitrogen concentration of the irrigation water, based on one water sample during summer 1982, was 5 mg/L as N. Approximately 145 acre-feet of irrigation water was used to irrigate the 31 acres of alfalfa, resulting in an application of 63 pounds of nitrogen per acre. Alfalfa can fix atmospheric nitrogen and can use an estimated 224 pounds of nitrogen per acre during the growing season (Stewart and others, 1975). Because the application rate of nitrogen was less than the potential uptake rate, it was estimated that nitrogen applied to the alfalfa on Camden Ranch was used by the crop and not leached to the water table. However, during periods of excessive irrigation or precipitation, some nitrogen may have leached past the root zone and into the aquifer.

Alfalfa also was grown at the Pinello Ranch, where approximately 96 acres of alfalfa were irrigated during 1982. Most of the irrigation water is from the Stubbs-Miller Ditch, which is diverted from Fountain Creek; the remainder of the irrigation is ground water pumped from the Pinello Ranch wells.

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8.0 NITROGEN OUTFLOWS FROM THE WIDEFIELD AQUIFER

Dissolved nitrogen moves out of the Widefield aquifer into Fountain Creek in those areas where water flows from the aquifer to Fountain Creek. Nitrogen also moves from the aquifer with ground-water outflows to the south, and with water withdrawn from the aquifer through pumpage. The amount of nitrogen removed by each outflow was estimated by using dissolved-nitrogen concentrations in water samples collected during the summer of 1982 from wells completed in the Widefield aquifer.

The quantity of nitrogen moving from the aquifer to Fountain Creek during 1982 was estimated, using a flow of 2,300 acre-ft/yr (acre-feet per year), as determined from gain-loss investigations and a dissolved-nitrogen concentration of 8.4 mg/L as N (milligrams per liter as nitrogen). The nitrogen concentration was the mean found in water samples collected from 44 wells completed in the Widefield aquifer, adjacent to the reach where water generally flows from the aquifer to Fountain Creek. Using these concentrations, the amount of nitrogen lost from the aquifer to Fountain Creek was estimated to be 26 tons. Because of the higher than normal water table that occurred during 1982, this estimate may be low.

The quantity of nitrogen moving from the aquifer with ground-water underflow to the south was estimated by using a mean dissolved-nitrogen concentration of 9.2 mg/L as N from analyses of samples collected from three wells located near the southern boundary of the Widefield aquifer (fig. 8.0-1). The amount of underflow was calculated earlier (section 3.2.2) to be about 2,500 acre-ft/yr. The resulting nitrogen loss from the aquifer across the southern boundary was estimated to be 31 tons during 1982.

Tbe largest amount of nitrogen removed from the aquifer during 1982 (and probably during most years) was through pumpage; nearly 5,400 acre-feet of ground water was withdrawn from the aquifer by pumpage. Fourteen wells operated by the Security Water and Sanitation District withdrew a reported 1,399 acre-feet of ground water. Mean dissolved-nitrogen concentration of the ground water withdrawn by the Security wells was nearly 8 mg/L as N, resulting in about 15 tons of nitrogen withdrawal. Ten wells operated by the Widefield Water Company withdrew a reported 1,254 acre-feet of ground water. Mean dissolved-nitrogen concentration of the ground water withdrawn by the Widefield wells was about 9 mg/L as N, resulting in about 15 tons of nitrogen being removed from the aquifer. Four Stratmoor Hills wells pumped a reported 659 acre-feet of ground water during 1982. Mean dissolved-nitrogen concentration of the ground water withdrawn by the Stratmoor Hills wells was about 9 mg/L as N, resulting in a withdrawal of about 8 tons of nitrogen during 1982. Wells on the Pinello Ranch withdrew a reported 1,825 acre-feet of ground water during 1982. Mean dissolved-nitrogen concentration of this ground water was about 8 mg/L as N, and approximately 20 tons of nitrogen were withdrawn from the aquifer as a result of pumpage of the Pinello Ranch wells. Five wells on the Venetucci Ranch withdrew about 93 acre-feet; mean dissolved-nitrogen concentration of this ground water was about 8 mg/L as N. Thus, approximately 1 ton of nitrogen was removed from the aquifer as a result of pumpage of the Venetucci Ranch wells. The well on the Camden Ranch withdrew about 145 acre-feet of ground water during 1982; mean dissolved-nitrogen concentration was approximately 5 mg/L as N, resulting in nearly 1 ton of nitrogen being removed from the aquifer. The total amount of nitrogen removed from the aquifer as a result of well pumpage for 1982 was about 60 tons. When combined with flow to Fountain Creek and underflow to the south, ground-water outflows resulted in almost 120 tons of nitrogen being removed from the aquifer during 1982. Because 1982 was a wet year, the aquifer was not pumped as extensively as normal, and the water table was higher than normal. Thus, the amount of nitrogen removed from the aquifer during 1982 would not be representative of most years.

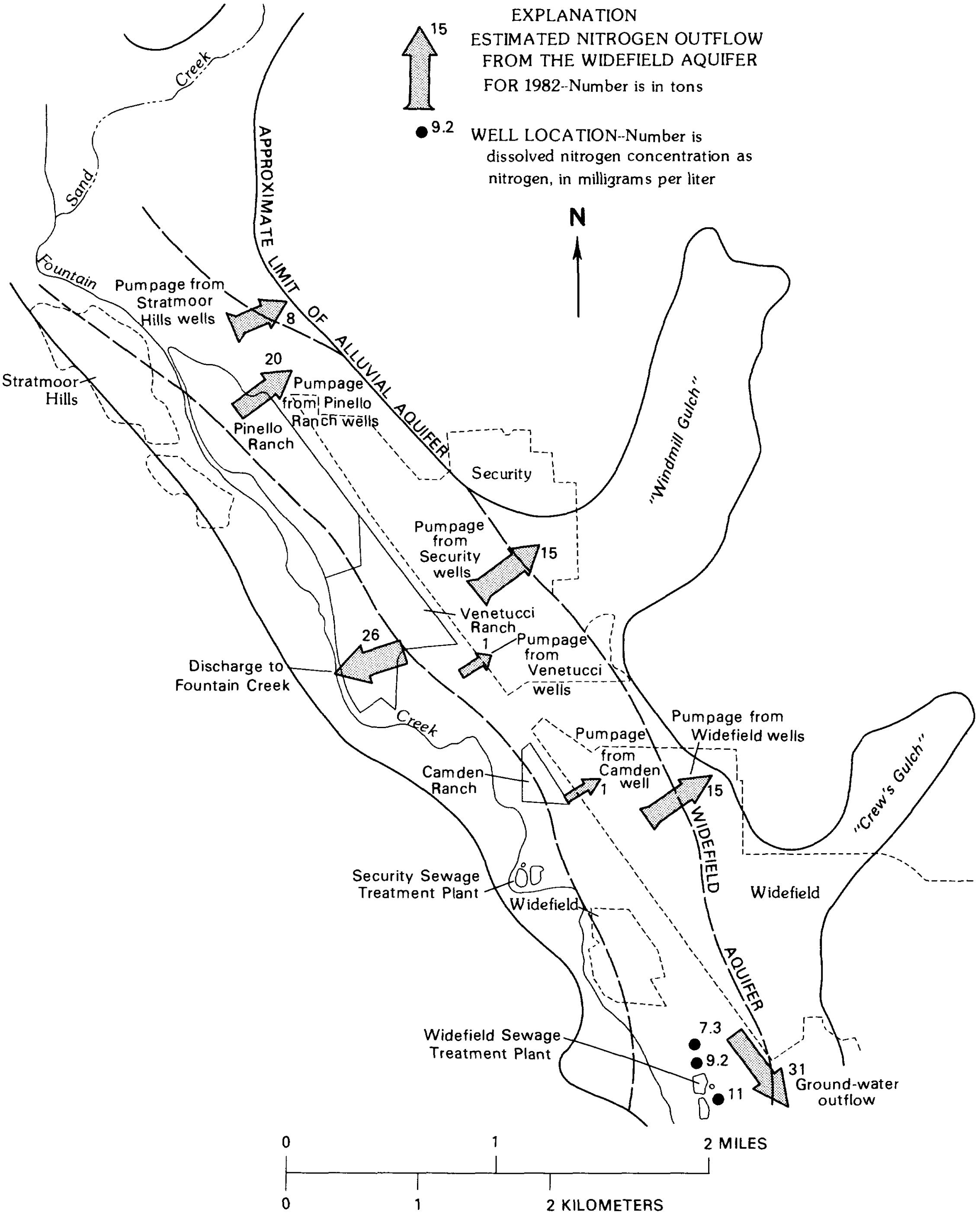

Figure 8.0-1.--Estimated amount of nitrogen removed from the Widefield aquifer during 1982 from ground-water outflow, flow to Fountain Creek, and pumpage.

9.0 SUMMARY OF NITROGEN SOURCES AND LOADS FOR THE WIDEFIELD AQUIFER

Nitrogen enters the Widefield aquifer from several sources. Almost all surface and ground water hydraulically connected to the aquifer contains significant concentrations of nitrogen; therefore, all these waters contribute to the overall nitrogen load of the aquifer. Because some nitrogen forms are unstable and may be transformed to other forms of nitrogen through nitrification or denitrification, the nitrogen loads from the various sources were estimated by using either total or dissolved nitrogen. Estimated 1982 nitrogen loads to the Widefield aquifer from various sources are shown in figure 9.0-1.

Effluent from the Colorado Springs Sewage Treatment Plant is the primary source of nitrogen entering the aquifer from all sources of recharge considered. Nitrogen in the effluent enters the aquifer as a result of streamflow losses from Fountain Creek, seepage from Canal No. 4, and artificial recharge ponds and irrigation at the Pinello Ranch. During 1982, the Colorado Springs Sewage Treatment Plant discharged 720 tons of nitrogen to Fountain Creek, resulting in a total nitrogen load in the losing reach of Fountain Creek of about 850 tons. Approximately 15 percent of the total nitrogen load, or about 130 tons of nitrogen, was estimated to be available to recharge the aquifer. Some of this nitrogen may not reach the ground-water system because of nitrogen loss through denitrification. The Colorado Springs Sewage Treatment Plant also discharged about 182 tons of nitrogen to Canal No. 4 during 1982. Approximately 17 tons of nitrogen were estimated to have been lost from the canal to the underlying eolian deposits as a result of seepage; an estimated 13 tons of nitrogen entered the Widefield aquifer as a result of underflow from eolian deposits. Because the predominant source of nitrogen in Canal No. 4 is from the Colorado Springs Sewage Treatment Plant, and seepage from Canal No. 4 appears to be the major source of nitrogen to the eolian deposits, the primary source of nitrogen to the aquifer from the eolian deposits is believed to be from the Colorado Springs Sewage Treatment Plant.

Water from Fountain Creek is diverted to Pinello Ranch recharge ponds via the Stubbs-Miller Ditch. Relatively small concentrations of nitrogen were detected in water samples collected from the ponds, because of consumption by aquatic plants or ammonia loss through volatilization. However, because the water is diverted from Fountain Creek, most of the nitrogen that is present can be attributed to the Colorado Springs Sewage Treatment Plant. During 1982, the amount of nitrogen reaching the aquifer from the recharge ponds was probably less than 1 ton. Approximately 5 tons of nitrogen entered the aquifer as the result of agricultural irrigation via the Stubbs-Miller Ditch.

Assuming no losses through denitrification, the total amount of nitrogen reaching the Widefield aquifer as the result of the Colorado Springs Sewage Treatment Plant effluent during 1982 would have been about 150 tons, or 93 percent of the total nitrogen load to the Widefield aquifer. Of the remaining 12 tons of nitrogen, approximately 8 tons were estimated to have entered the Widefield aquifer as a result of ground-water underflow from Fountain Creek alluvium; almost 3 tons of nitrogen were discharged to the Widefield aquifer from underflow from tributary alluvium; and about 1 ton of nitrogen was estimated to have leached to the water table by the process of infiltration and percolation from lawn irrigation, agricultural irrigation at the Venetucci Ranch and Camden Ranch, and from septic systems. Most of the nitrogen applied to the land through irrigation and fertilization probably was consumed by various crops in the area.

Nitrogen leaves the Widefield aquifer as a result of ground-water flow to Fountain Creek, ground-water outflow to the south, and ground-water pumpage. During 1982, an estimated 26 tons of nitrogen was discharged from the aquifer to Fountain Creek. Approximately 31 tons of nitrogen left the aquifer with underflow to the south, and 60 tons of nitrogen were removed from the aquifer as the result of pumpage. During most years, ground-water withdrawals have been nearly 1,700 acre-feet greater, which could result in about 20 more tons of nitrogen being removed from the aquifer as a result of pumpage. During 1982, nearly 120 tons of nitrogen were removed from the aquifer.

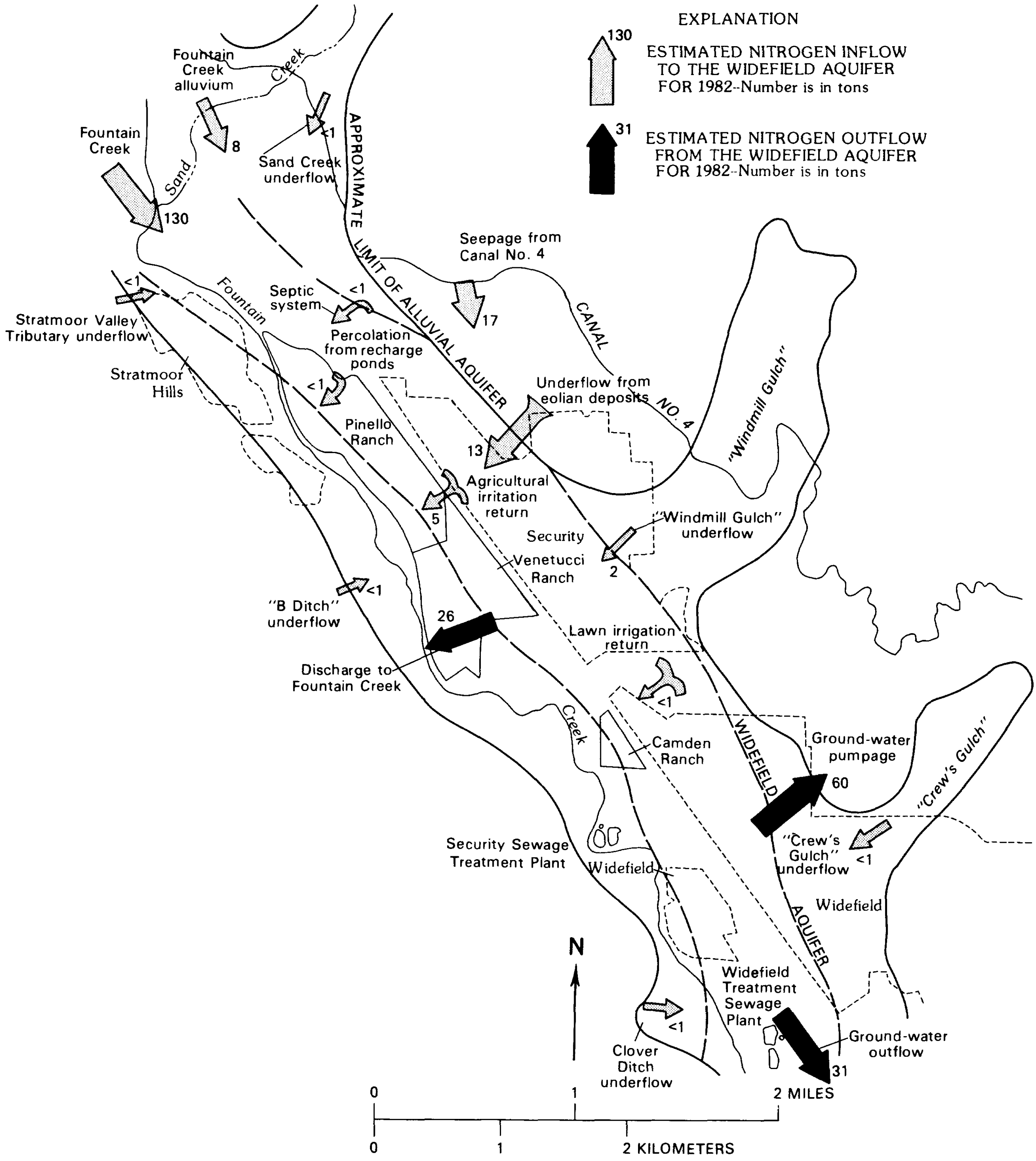

Figure 9.0-1.--Estimated nitrogen inflows and outflows to the Widefield aquifer during 1982.

10.0 SELECTED REFERENCES

Bentall, Ray, 1963, Methods of determining permeability, transmissibility, and drawdown: U.S. Geological Survey Water-Supply Paper 1536-I, 341 p.

Bingham, D.L., and Klein, J.M., 1973, Extent of development and hydrologic conditions of the alluvial aquifer, Fountain and Jimmy Camp Valleys, Colorado: Denver, Colorado Water Conservation Board Water-Resources Circular 16, 28 p.

Broadbent, F.E., and Clark, F.E., 1965, Denitrification *in* Bartholemew, W.V., and Clark, F.E., eds., Soil nitrogen: Madison, Wis., American Society of Agronomy, p. 344-354.

Broadbent, F.E., Pal, D., and Aref, K., 1977, Nitrification and denitrification in soils receiving municipal wastewater, *in* D'Itri, F.M., ed., Wastewater renovation and reuse: New York, Marcel Dekker, p. 164-175.

Bouwer, Herman, 1978, Groundwater hydrology: New York, McGraw-Hill, p. 396-455.

Bouwer, Herman, Lance, J.C., and Riggs, M.S., 1974, High-rate land treatment II--Water quality and economic aspects of the Flushing Meadows project: Journal of the Water Pollution Control Federation, v. 46, no. 5, p. 844-859.

CH2M Hill, Inc., 1982, Estimated lawn irrigation return flows: Denver, Colo., 27 p.

Danielson, R.E., Feldhake, C.M., and Hart, W.E., 1981, Urban lawn irrigation and management practices for water saving with minimum effect on lawn quality: Fort Collins, Colorado Water Resources Research Institute Completion Report 106, 48 p.

Danielson, R.E., Hart, W.E., Feldhake, C.M., and Haw, P.M., 1980, Water requirements for urban lawns in Colorado: Fort Collins, Colorado Water Resources Research Institute Completion Report 97, 90 p.

Davis, S.N., and DeWiest, R.J.M., 1966, Hydrogeology: New York, John Wiley and Sons, 463 p.

DiNatale, K.N., 1981, An assessment of water use and policies in northern Colorado cities: Fort Collins, Colorado Water Resources Research Institute Technical Report 28, 229 p.

Eccles, L.A., and Bradford, W.L., 1977, Distribution of nitrate in ground water, Redland, California: U.S. Geological Survey Water-Resources Investigations 76-117, 38 p.

Emmons, P.J., 1977, Artificial-recharge tests in upper Black Squirrel Creek basin, Jimmy Creek Valley, and Fountain Valley, El Paso County, Colorado: U.S. Geological Survey Water-Resources Investigations 77-11, 49 p.

Ferris, J.G., Knowles, D.B., Brown, R.H., and Stallman, R.W., 1962, Theory of aquifer tests: U.S. Geological Survey Water-Supply Paper 1536-E, 174 p.

Flack, J.E., Weakley, W.P., and Hill, D.W., 1977, Achieving urban water conservation--A handbook: Fort Collins, Colorado Water Resources Institute Completion Report 80, 207 p.

Focht, D.D., and Verstraete, W., 1977, Biochemical ecology of nitrification and denitrification, *in* Alexander, M., ed., Advances in microbial ecology: New York, Plenum Press, v. 1, p. 135-214.

Gerwing, J.R., Caldwell, A.C., and Goodroad, L.L., 1979, Fertilizer nitrogen distribution under irrigation between soil, plant, and aquifer: Journal of Environmental Quality, v. 8, no. 3, p. 281-284.

Gormly, J.R., and Spalding, R.F., 1979, Sources and concentration of nitrate-nitrogen in ground water of central Platte region, Nebraska: Ground Water, v. 17, no. 3, p. 291-301.

Hansen, W.R., Chronic, John, and Matelock, John, 1978, Climatography of the front range urban corridor and vicinity, Colorado: U.S. Geological Survey Professional Paper 1019, 59 p.

Jenkins, E.D., 1961, Records, logs, and water-level measurements of selected wells and test holes and chemical analysis of ground water in Fountain, Jimmy Camp, and Black Squirrel Valleys, El Paso County, Colorado: Denver, Colorado Water Conservation Board Ground-Water Basic-Data Report 3, 25 p.

_____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.

Jensen, M.E., ed., 1973, Consumptive use of water and irrigation water requirements: New York, American Society of Civil Engineers, 215 p.

Johnson Division, UOP Co., 1975, Ground water and wells: St. Paul, Minn., 440 p.

Keeney, D.R., 1981, Soil nitrogen chemistry and biochemistry, *in* Iskandar, I.K., ed., Modeling wastewater renovation: New York, John Wiley and Sons, p. 259-276.

Kittrell, F.W., 1969, A practical guide to water-quality studies of streams: U.S. Federal Water Pollution Control Administration, Report CWR-5, 135 p.

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

Klein, J.M., and Bradford, W.L., 1979, Distribution of nitrate and related nitrogen species in the unsaturated zone, Redland and vicinity, San Bernardino County, California: U.S. Geological Survey Water-Resources Investigations 79-60, 81 p.

Lance, J.C., 1972, Nitrogen removal by soil mechanising: Journal of the Water Pollution Control Federation, v. 44, no. 1, p. 1352-1361.

Lance, J.C., and Whistler, F.D., 1972, Nitrogen balance in soil columns intermittently flooded with secondary sewage effluents: Journal of Environmental Quality, v. 1, no. 2, p. 180-186.

Livingston, R.K., Bingham, D.L., and Klein, J.M., 1975, Appraisal of water resources of northwestern El Paso County, Colorado: Denver, Colorado Water Conservation Board Water Resources Circular 22, 75 p.

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

_____1976b, Appraisal of water resources of southwestern El Paso County, Colorado: Denver, Colorado Water Conservation Board Water Resources Circular 33, 66 p.

National Oceanic and Atmospheric Administration, 1982, Climatological data annual summary Colorado: Asheville, N.C., National Climatic Data Center, v. 87, no. 13, 28 p.

Nightingale, H.I., and Bianchi, W.C., 1980, Well-water quality changes correlated with well pumping time and aquifer parameters--Fresno, California: Ground Water, v. 18, no. 3, p. 274-280.

Porter, K.S., 1980, An evaluation of nitrogen as causes of groundwater contamination in Nassau County, Long Island: Ground Water, v. 18, no. 6, p. 617-625.

Reddy, K.R., Sacco, P.D., and Graetz, D.A., 1980, Nitrate reduction in an organic soil-water system: Journal of Environmental Quality, v. 9, no. 2, p. 283-288.

Robinson, C.S., and Gooldy, P.L., 1973, Ground water in Windmill Gulch, El Paso County, Colorado: Denver, Charles S. Robinson and Associates, 31 p.

Ryden, J.C., 1981, Gaseous nitrogen losses, *in* Iskandar, I.K., ed., Modeling wastewater renovation: New York, John Wiley and Sons, p. 277-312.

SAS Institute, Inc., 1982, SAS users guide--Statistics: 584 p.

Schmidt, K.D., 1977, Water quality variations for pumping wells: Ground Water, v. 15, no. 2, p. 130-137.

Schneider, P.A., Jr., and Turk, J.T., 1983, A reconnaissance of ground-water contamination at selected landfills in Colorado: U.S. Geological Survey Water-Resources Investigations Report 83-4021, 33 p.

Schuman, G.E., and Elliot, L.F., 1978, Cropping an abandoned feedlot to prevent deep percolation of nitrate-nitrogen: Soil Science, v. 126, no. 4, p. 237-243.

Scott, F.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, scale 1:62,500, 2 sheets.

Skougstad, M.W., Fishman, M.T., Friedman, L.C., Erdman, D.E., and Duncan, S.S., 1979, Methods of analysis of water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 5, Chapter A-1, 626 p.

Stewart, B.A., Woolhiser, D.A., Wisehmeier, W.H., Caro, J.H., and Frere, M.H., 1975, Control of Water pollution from cropland: Agricultural Research Service, U.S. Department of Agriculture, and U.S. Environmental Protection Agency, Report ARS-H-5-1, U.S. Department of Agriculture, 111 p.

U.S. Environmental Protection Agency, 1976, National interim primary drinking water regulations: 570/9-76-003, 159 p.

_____1977, Quality criteria for water: U.S. Government Printing Office, 256 p.

U.S. Geological Survey, 1974, Water Resources Data for Colorado--Part 1. Surface water records: U.S. Geological Survey, Water-Data Report, 396 p.

_____1978, Water Resources Data for Colorado--Volume 1. Missouri River basin, Arkansas River basin, and Rio Grande River basin: U.S. Geological Survey Water-Data Report CO-78-1, 415 p.

U.S. Soil Conservation Service, 1967, Irrigation water requirements: U.S. Soil Conservation Service Technical Release 21, 88 p.

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

Wood, W.W., 1976, Guidelines for collection and field analysis of ground-water samples for selected unstable constituents: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 1, Chapter D2, 24 p.

Table 11.0-1.--*Surface-water quality data*

[ft^3/s, cubic feet per second; °C, degrees Celsius; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; <, less than; E, estimated; dashes indicate no data]

Site number on figure 2.0-1	Date of sample	Time	Flow, instantaneous (ft^3/s)	Temperature (°C)	pH (standard units)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	Dissolved-solids residue at 105°C (mg/L)	Dissolved chloride (mg/L as Cl)	Total nitrite nitrogen (mg/L as N)	Total nitrogen NO_2+NO_3 (mg/L as N)	Total ammonia nitrogen (mg/L as N)	Total ammonia and organic nitrogen (mg/L as N)	Total nitrogen (mg/L as N)
							Station 07105500 Fountain Creek at Colorado Springs							
1	10-23-80	1250	25	9.5	--	--	650	--	--	--	--	--	--	--
	12-02-80	1155	25	1.0	--	--	620	--	--	--	--	--	--	--
	01-06-81	1525	14	5.5	--	--	750	--	--	--	--	--	--	--
	02-09-81	1500	18	1.0	--	--	800	--	--	--	--	--	--	--
	02-12-81	1430	45	2.5	7.8	10.9	740	492	22	0.020	2.40	0.060	0.99	3.4
	02-23-81	0930	--	--	--	--	570	--	--	--	--	--	--	--
	03-12-81	1110	23	10.0	--	--	667	--	--	--	--	--	--	--
	03-17-81	1500	29	10.0	7.8	9.2	635	384	21	.060	2.50	.510	1.6	4.1
	04-20-81	1320	37	17.5	8.0	8.3	466	291	20	.020	1.20	.090	1.4	2.6
	05-19-81	1130	51	7.5	--	--	450	--	--	--	--	--	--	--
	05-21-81	1115	39	19.5	7.7	7.8	485	294	42	.040	1.20	.280	2.1	3.3
	05-28-81	1815	1,280	15.5	--	--	180	--	--	--	--	--	--	--
	06-03-81	0950	214	16.5	--	--	550	--	--	--	--	--	--	--
	06-04-81	1420	108	22.0	--	--	510	--	--	--	--	--	--	--
	06-08-81	1440	58	24.0	--	--	600	--	--	--	--	--	--	--
	06-16-81	1540	17	23.5	--	--	690	--	--	--	--	--	--	--
	06-17-81	1015	17	18.0	7.8	7.9	711	484	18	.030	1.30	.300	.98	2.3
	06-29-81	1115	31	19.0	--	--	600	--	--	--	--	--	--	--
	07-02-81	1140	49	20.0	--	--	580	--	--	--	--	--	--	--
	07-13-81	1255	31	25.0	--	--	730	--	--	--	--	--	--	--
	07-15-81	1050	14	24.5	7.3	6.4	783	405	24	.030	1.50	.160	1.1	2.7
	08-04-81	1205	68	25.5	--	--	350	--	--	--	--	--	--	--
	08-12-81	1025	546	16.5	--	--	200	--	--	--	--	--	--	--
	08-19-81	1045	113	20.0	7.3	7.4	465	195	11	.030	.700	<.060	1.1	1.8
	09-09-81	1355	38	23.0	--	--	640	--	--	--	--	--	--	--
	09-16-81	0900	95	12.5	7.4	8.1	498	287	13	.270	1.00	.520	2.7	3.7
	10-21-81	0915	29	6.0	7.5	9.9	470	277	12	.060	1.10	.360	.81	1.9
	11-19-81	1045	16	4.5	7.5	9.6	499	425	18	.020	1.50	.180	1.4	2.9
	12-17-81	1020	14	1.0	7.8	10.6	672	538	21	<.020	2.30	.120	.79	3.1
	01-19-82	0900	34	2.0	7.8	10.9	684	468	23	<.020	2.40	.300	.57	3.0

Table 11.0-1.--*Surface-water quality data*--Continued

Site number on figure 2.0-1	Date of sample	Time	Flow, instantaneous (ft^3/s)	Temperature (°C)	pH (standard units)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	Dissolved-solids residue at 105°C (mg/L)	Dissolved chloride (mg/L as Cl)	Total nitrite nitrogen (mg/L as N)	Total nitrogen NO_2+NO_3 (mg/L as N)	Total ammonia nitrogen (mg/L as N)	Total ammonia and organic nitrogen (mg/L as N)	Total nitrogen (mg/L as N)
	Station 07105500 Fountain Creek at Colorado Springs--Continued													
1	02-23-82	0930	33	4.0	7.8	10.4	570	--	--	0.020	2.00	0.150	0.70	2.7
	03-24-82	0930	19	7.0	7.8	10.1	640	--	--	<.020	2.00	.100	.79	2.8
	04-28-82	1000	26	11.5	7.4	8.6	655	--	--	.050	1.40	.170	1.4	2.8
	05-27-82	1045	120	16.5	7.3	8.5	456	--	--	.040	.700	.140	.90	1.6
	06-16-82	0930	78	13.5	7.6	8.7	431	--	--	.030	.810	.190	1.3	2.1
	07-15-82	1030	29	20.5	7.7	7.8	573	--	--	.020	1.10	<.060	.90	2.0
	08-11-82	1530	88	22.5	7.5	6.8	316	--	--	.040	.780	.120	1.6	2.4
	09-13-82	1030	102	13.0	7.6	8.9	--	--	--	.040	.700	.110	1.1	1.9
	10-21-82	0915	77	4.5	7.9	12.1	393	--	--	.030	1.10	.080	1.1	2.2
	11-18-82	0915	45	3.5	7.8	12.2	434	--	--	<.020	1.40	.060	.70	2.1
	12-15-82	0845	8.2	1.5	7.5	13.5	592	--	--	<.020	1.90	.100	.70	2.6
	Station 384906104485800 Shooks Run downstream from Las Vegas Street													
2	03-24-82	1750	.80	7.0	12.5	9.7	3,670	1,280	49	.170	4.80	.180	1.1	5.9
	06-16-82	1430	1.0	21.0	8.2	6.7	1,670	1,280	47	.120	6.20	.130	1.9	8.1
	09-13-82	1710	<300	10.0	8.8	--	150	164	5.1	.170	.500	.320	8.1	8.6
	10-06-82	1350	.58	15.0	9.3	8.8	1,960	1,480	64	.250	9.30	.220	2.7	12
	12-15-82	1630	.96	.0	8.6	12.3	1,850	1,510	73	.110	8.50	<.060	.70	9.2
	Station 384840104481200 Canal No. 4 at headgate													
4	04-28-82	1145	11	15.5	6.8	4.5	800	465	48	.050	.380	15.0	21	21
	05-10-82	0940	12	15.0	7.1	4.9	815	470	43	.050	.210	17.0	22	22
	05-27-82	1200	10	16.0	6.9	5.8	678	397	32	.040	.300	10.0	20	20
	06-16-82	1515	40	18.5	7.0	5.2	721	445	29	.080	5.40	10.0	9.1	15
	07-15-82	1115	12	20.0	6.8	5.4	778	476	34	--	5.40	12.0	18	23
	08-11-82	1430	35	20.5	6.8	5.3	765	484	32	.220	.670	9.30	9.3	10
	09-29-82	0645	12	12.5	7.1	7.8	691	428	32	.280	.900	6.40	8.3	9.2
	10-21-82	1255	13	14.5	6.4	5.9	777	471	36	1.30	2.00	10.0	15	17
	11-18-82	1210	21	13.0	6.9	6.0	795	492	41	<.020	.500	14.0	17	18
	Station 384720104455400 Canal No. 4 downstream from Sand Creek													
5	05-10-82	1130	7.9	13.0	7.3	7.2	725	443	30	.130	.880	9.40	11	12
	06-16-82	1620	30	19.0	7.0	4.4	707	435	28	.180	.600	9.50	14	15
	09-29-82	1030	13	13.0	---	---	720	433	38	.400	1.10	6.50	10	11

Table 11.0-1.--*Surface-water quality data*--Continued

Site number on figure 2.0-1	Date of sample	Time	Flow, instantaneous (ft^3/s)	Temperature (°C)	pH (standard units)	Dissolved oxygen (mg/L)	Specific conductance (μS/cm)	Dissolved-solids residue at 105°C (mg/L)	Dissolved chloride (mg/L as Cl)	Total nitrite nitrogen (mg/L as N)	Total nitrogen NO_2+NO_3 (mg/L as N)	Total ammonia nitrogen (mg/L as N)	Total ammonia and organic nitrogen (mg/L as N)	Total nitrogen (mg/L as N)
Station 384610104441700 Canal No. 4 downstream from Hancock Road														
6	05-10-82	1245	8.5	16.5	7.6	8.1	770	460	32	0.250	3.00	11.0	14	17
	06-16-82	1720	30	19.0	7.0	4.6	696	420	28	.190	.620	8.60	12	13
	09-29-82	1430	12	16.0	--	--	730	433	32	.340	1.20	6.40	10	11
Station 384458104423000 Canal No. 4 near Fountain Valley School														
7	05-10-82	1345	8.2	19.5	7.6	9.0	814	461	40	.210	.560	17.0	21	22
	06-16-82	1810	31	18.5	7.1	4.9	664	407	28	.240	.780	8.00	11	12
	09-29-82	1905	11	--	--	--	720	433	32	.310	1.40	6.80	11	12
Station 384450104415300 Big Johnson Reservoir outflow														
8	05-10-82	1500	31	12.5	7.6	6.8	810	519	42	.120	.900	6.60	8.3	9.2
	06-16-82	0950	8.4	16.5	7.5	5.6	775	504	42	.180	.790	6.80	7.0	7.8
	10-06-82	1045	14	14.0	8.4	7.5	705	446	34	.270	2.40	1.80	4.1	6.5
Station 384833104473900 Spring Creek downstream from Las Vegas Street														
9	03-24-82	1710	1.8	10.0	8.5	9.5	1,100	869	29	.600	6.60	.080	.95	7.6
	06-16-82	1400	2.7	22.5	8.1	6.4	1,050	790	20	.120	4.70	.090	2.0	6.7
	09-13-82	1630	<110	15.0	7.9	--	170	277	8.0	.060	.800	.140	7.3	8.1
	10-06-82	1530	2.7	16.5	8.6	8.3	1,400	981	28	.090	8.70	<.060	2.0	11
	12-15-82	1545	1.6	3.0	8.4	10.8	1,350	1,010	50	.100	11.0	<.060	1.0	12
Station 07105530 Fountain Creek below Janitell Road														
10	02-17-81	1030	70	11.0	7.5	8.5	860	513	40	.080	1.10	12.0	24	25
	03-18-81	0955	84	10.0	7.4	8.7	770	443	41	.100	1.20	10.0	14	15
	04-20-81	1415	75	17.0	7.4	7.5	--	429	32	.080	.940	--	14	15
	05-21-81	1215	64	18.0	7.1	7.1	--	1,200	27	.080	.980	--	15	16
	06-17-81	1200	68	20.0	7.1	6.5	869	539	39	.090	.620	--	14	15
	07-15-81	1215	66	24.5	7.1	6.0	--	580	40	.130	.780	8.90	11	12
	08-19-81	1220	143	20.0	7.1	6.9	--	333	23	.060	.620	4.50	6.8	7.4
	09-16-81	1020	124	14.5	7.3	7.9	623	426	33	.180	.910	6.10	10	11
	10-21-81	1040	85	9.5	7.3	8.8	641	426	36	.140	.830	--	11	12
	11-19-81	1145	38	12.0	7.2	7.2	--	489	50	.180	.990	12.0	16	17
	12-17-81	1115	36	9.0	7.2	8.1	--	523	39	.110	1.70	12.0	14	16
	01-19-82	1000	86	8.5	7.2	8.7	804	487	45	.070	1.10	--	17	18
	02-23-82	1045	91	9.0	7.0	8.6	729	449	42	.060	.990	12.0	15	16

Table 11.0-1.--*Surface-water quality data*--Continued

Site number on figure 2.0-1	Date of sample	Time	Flow, instantaneous (ft^3/s)	Temperature (°C)	pH (standard units)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	Dissolved-solids residue at 105°C (mg/L)	Dissolved chloride (mg/L as Cl)	Total nitrite nitrogen (mg/L as N)	Total nitrogen NO_2+NO_3 (mg/L as N)	Total ammonia nitrogen (mg/L as N)	Total ammonia and organic nitrogen (mg/L as N)	Total nitrogen (mg/L as N)
					Station 07105530 Fountain Creek below Janitell Road--Continued									
10	03-24-82	1030	67	11.5	7.0	8.0	770	495	46	0.080	0.940	13.0	17	18
	04-28-82	1230	76	17.0	7.3	7.1	793	487	40	.090	1.20	10.0	15	16
	05-27-82	1245	149	15.5	7.4	8.3	--	303	17	.060	.700	4.60	6.5	7.2
	06-16-82	1100	111	16.0	7.4	7.8	--	385	31	.070	.890	5.50	5.5	6.4
	07-15-82	1200	69	21.5	7.0	6.7	798	493	34	.210	.960	11.0	13	14
	08-11-82	1315	136	20.5	7.0	6.9	595	385	24	.170	.880	5.10	9.3	10
	09-13-82	1115	172	14.0	7.5	8.6	--	376	21	.550	1.30	5.20	9.4	11
	10-21-82	1100	95	11.0	6.9	8.8	677	438	29	.950	2.00	5.30	9.5	12
	11-18-82	1140	78	10.5	7.3	9.2	746	478	36	<.020	1.30	9.80	10	11
	12-15-82	1030	86	8.5	7.1	10.1	813	521	44	.130	1.20	13.0	15	16
					Station 384747104470500 Garden Valley Sewage Treatment Plant outfall									
11	06-16-82	1550	.03	17.0	6.9	7.4	864	527	97	3.90	13.0	2.90	9.5	23
	09-13-82	1245	.10	16.5	6.8	4.8	901	646	110	.330	10.0	1.20	3.8	14
	12-15-82	1215	.16	4.5	7.0	12.4	1,160	780	200	.020	19.0	.090	1.1	20
					Station 384758104452900 Sand Creek downstream from Academy Boulevard									
12	03-24-82	1630	.05	10.5	8.5	13.4	980	747	18	<.020	3.70	<.060	.89	4.6
	06-16-82	1330	.08	25.5	7.5	5.7	--	693	15	.030	3.60	.070	1.6	5.2
	09-13-82	1415	E.80	11.0	8.0	8.4	550	488	11	<.020	3.90	.080	1.1	5.1
	12-15-82	1515	.33	3.0	7.0	10.7	1,860	1,150	21	.050	5.30	.060	.90	6.2
					Station 384713104463200 Sand Creek downstream from Las Vegas Street									
13	03-24-82	1540	.31	12.5	8.2	9.2	335	239	9.3	.040	11.0	.860	1.5	13
	06-16-82	1225	.71	25.0	7.5	6.6	138	361	3.9	.230	.280	.421	4.8	5.1
	09-13-82	1500	<.60	15.0	8.3	7.9	--	250	7.1	.040	2.30	.070	1.7	4.0
					Station 384633104464800 Stratmoor Valley Tributary at I-25									
14	03-24-82	1500	.13	14.0	8.4	9.1	1,260	978	35	.020	3.30	.110	1.3	4.6
	06-16-82	1145	.41	21.5	8.7	8.6	1,690	1,350	32	.060	1.00	.080	2.4	3.4
	10-06-82	1220	.44	15.0	8.8	10.4	1,850	1,440	35	.060	3.50	.100	2.2	5.7
	12-15-82	1400	1.1	.5	8.2	12.2	1,490	1,160	35	.060	4.50	.200	1.4	5.9

Table 11.0-1.--Surface-water *quality* data--Continued

Site number on figure 2.0-1	Date of sample	Time	Flow, instantaneous (ft^3/s)	Temperature (°C)	pH (standard units)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	Dissolved-solids residue at 105°C (mg/L)	Dissolved chloride (mg/L as Cl)	Total nitrite nitrogen (mg/L as N)	Total nitrogen NO_2+NO_3 (mg/L as N)	Total ammonia nitrogen (mg/L as N)	Total ammonia and organic nitrogen (mg/L as N)	Total nitrogen (mg/L as N)
	Station 384617104460600 Stubbs-Miller Ditch at headgate													
15	03-24-82	1410	1.3	11.0	8.0	8.3	--	482	39	0.210	1.10	12.0	16	17
	12-15-82	1310	15	9.0	7.5	9.1	850	566	44	.170	1.50	12.0	16	18
	Station 07105780 B Ditch Drain near Security													
16	04-02-81	1415	.07	14.5	--	--	6,500	--	--	--	--	--	--	--
	04-23-81	0845	.09	10.5	--	--	4,250	--	--	--	--	--	--	--
	05-20-81	0840	.10	8.5	--	--	5,000	--	--	--	--	--	--	--
	06-04-81	1545	1.3	22.0	--	--	2,700	--	--	--	--	--	--	--
	07-22-81	0930	.07	20.0	--	--	4,750	--	--	--	--	--	--	--
	08-03-81	1010	.45	21.0	--	--	2,000	--	--	--	--	--	--	--
	08-07-81	1455	.76	24.0	--	--	2,000	--	--	--	--	--	--	--
	08-21-81	1810	.20	24.0	--	--	6,000	--	--	--	--	--	--	--
	10-23-81	0930	.04	5.0	7.8	10.5	--	5,920	120	.020	17.0	<.060	2.1	19
	11-18-81	1315	.17	9.0	7.8	10.2	6,170	6,420	190	.060	19.0	.220	1.8	21
	12-14-81	1220	.17	3.5	7.9	13.1	--	7,170	160	.020	27.0	.170	1.5	29
	01-18-82	1130	.18	1.0	7.6	9.1	5,410	5,090	120	1.70	4.20	.180	1.6	5.8
	02-22-82	1315	.17	7.0	7.8	12.2	4,830	4,520	85	.160	12.0	.140	1.6	14
	03-24-82	1215	.11	8.5	7.5	15.0	6,590	6,650	110	.100	15.0	.110	1.1	16
	04-28-82	1400	.06	20.5	7.6	6.5	3,640	--	--	.130	7.50	.210	2.1	9.6
	05-28-82	1210	.21	23.0	7.4	10.8	4,430	3,870	85	.130	7.70	.220	1.8	9.5
	06-16-82	1515	.25	24.0	7.5	7.2	4,390	3,900	65	.120	7.70	.170	1.0	8.7
	07-15-82	1345	.35	25.5	7.6	8.5	4,650	--	--	.060	11.0	.150	2.1	13
	08-13-82	1330	.33	27.0	7.3	6.1	3,590	3,140	63	--	6.80	--	1.1	8.0
	08-24-82	1525	.43	19.0	--	--	5,500	--	--	--	--	--	--	--
	09-13-82	1345	.57	18.5	7.5	6.8	3,240	1,300	50	.040	6.70	.060	1.3	8.0
	10-16-82	1340	.36	13.0	--	--	5,500	--	--	--	--	--	--	--
	10-21-82	1415	E.31	14.0	7.8	10.4	4,000	3,520	58	.200	11.0	.090	1.8	13
	11-18-82	1325	.31	8.0	8.3	14.5	3,400	3,010	63	.120	10.0	.100	1.6	12
	12-15-82	1300	.40	.0	8.0	--	4,560	4,270	95	.240	15.0	.060	.80	16
	Station 384531104432200 Windmill Gulch at Bradley													
17	03-24-82	1150	.15	8.0	8.3	10.8	520	360	13	<.020	<.100	.080	.88	--
	06-16-82	1100	.09	16.0	7.3	3.9	564	382	11	<.020	<.100	<.060	1.3	--
	09-13-82	1200	E.60	13.0	7.9	6.8	600	519	16	<.020	<.100	.060	1.3	--
	12-15-82	1130	E.05	2.0	7.4	11.1	642	391	13	.030	.700	.120	.70	1.4

Table 11.0-1.--*Surface-water quality data*--Continued

Site number on figure 2.0-1	Date of sample	Time	Flow, instantaneous (ft³/s)	Temperature (°C)	pH (standard units)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	Dissolved-solids residue at 105°C (mg/L)	Dissolved chloride (mg/L as Cl)	Total nitrite nitrogen (mg/L as N)	Total nitrogen NO_2+NO_3 (mg/L as N)	Total ammonia nitrogen (mg/L as N)	Total ammonia and organic nitrogen (mg/L as N)	Total nitrogen (mg/L as N)
						Station 384418104440700 Security Sewage Treatment Plant outfall								
18	03-17-82	1200	--	--	--	--	--	--	--	--	0.290	25.0	--	--
	03-29-82	1200	--	--	--	--	--	--	--	--	.420	25.0	--	--
	04-15-82	1200	--	--	--	--	--	--	--	--	.230	24.0	--	--
	04-20-82	1200	--	--	--	--	--	--	--	--	.180	23.0	--	--
	05-05-82	1200	--	--	--	--	--	--	--	.100	<.100	21.0	--	--
	05-19-82	1200	--	--	--	--	--	--	--	--	.390	22.0	--	--
	06-03-82	1200	--	--	--	--	--	--	--	--	<.100	23.0	--	--
	06-15-82	1100	--	--	--	--	--	--	--	--	.140	22.0	--	--
	06-28-82	1330	--	--	--	--	--	--	--	--	.410	18.0	--	--
	07-15-82	1130	--	--	--	--	--	--	--	--	.170	22.0	--	--
	07-29-82	1200	--	--	--	--	--	--	--	--	.140	19.0	--	--
	08-10-82	1130	--	--	--	--	--	--	--	--	.310	17.0	--	--
	09-07-82	1500	--	--	--	--	--	--	--	--	<.100	20.0	--	--
	09-21-82	0550	--	--	--	--	--	--	--	--	.100	21.0	--	--
	10-06-82	0900	--	--	--	--	--	--	--	--	.200	20.0	--	--
	10-21-82	1115	--	--	--	--	--	--	--	--	.100	24.0	--	--
	11-02-82	1345	--	--	--	--	--	--	--	--	.100	23.0	--	--
	11-15-82	0830	--	--	--	--	--	--	--	--	.200	24.0	--	--
	11-29-82	1125	--	--	--	--	--	--	--	--	.200	23.0	--	--
	12-15-82	1000	--	--	--	--	--	--	--	--	<.100	24.0	--	--
	12-28-82	0830	--	--	--	--	--	--	--	--	.300	24.0	--	--
						Station 384356104425400 Crews Gulch downstream from Quebec Street								
20	03-24-82	1120	.43	13.0	8.4	8.1	1,320	916	49	.030	.150	.220	1.5	1.7
	06-16-82	0900	.87	16.0	7.6	7.1	1,310	965	49	.090	.220	.260	1.5	1.7
	09-13-82	1000	.84	14.5	8.4	7.3	1,100	882	50	.040	.100	.360	3.9	4.0
	12-15-82	0945	1.1	2.5	8.5	11.7	1,330	1,020	56	.020	.200	.120	2.8	3.0
						Station 07105820 Clover Ditch Drain near Widefield								
21	04-01-81	1150	5.1	15.0	--	--	1,210	--	--	--	--	--	--	--
	04-22-81	1605	5.5	14.0	--	--	840	--	--	--	--	--	--	--
	05-20-81	1535	5.0	20.5	--	--	1,290	--	--	--	--	--	--	--
	05-26-81	1130	6.1	21.0	--	--	1,130	--	--	--	--	--	--	--
	05-28-81	1345	5.8	20.0	--	--	1,290	--	--	--	--	--	--	--
	07-09-81	1400	3.6	25.0	--	--	1,470	--	--	--	--	--	--	--
	07-21-81	1340	4.3	25.0	--	--	650	--	--	--	--	--	--	--
	08-03-81	1240	2.8	25.0	--	--	1,000	--	--	--	--	--	--	--

Table 11.0-1.--*Surface-water quality data*--Continued

Site number on figure 2.0-1	Date of sample	Time	Flow, instantaneous (ft^3/s)	Temperature (°C)	pH (standard units)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	Dissolved-solids residue at 105°C (mg/L)	Dissolved chloride (mg/L as Cl)	Total nitrite nitrogen (mg/L as N)	Total nitrogen NO_2+NO_3 (mg/L as N)	Total ammonia nitrogen (mg/L as N)	Total ammonia and organic nitrogen (mg/L as N)	Total nitrogen (mg/L as N)
	Station 07105820 Clover Ditch Drain near Widefield--Continued													
21	08-07-81	1120	2.8	23.0	--	--	1,350	--	--	--	--	--	--	--
	08-20-81	1440	3.7	22.0	--	--	1,400	--	--	--	--	--	--	--
	10-23-81	1110	3.0	11.0	7.3	8.6	1,540	1,110	48	0.720	2.70	1.20	9.7	12
	11-18-81	1415	3.6	13.5	7.4	6.0	1,300	922	51	.960	2.90	--	14	17
	12-14-81	1345	4.3	11.0	7.3	6.5	1,190	860	41	1.00	3.70	14.0	16	20
	01-15-82	1230	3.3	8.5	7.0	8.6	1,260	818	39	.450	2.00	21.0	19	21
	02-22-82	1400	4.7	13.5	7.5	9.3	1,250	858	42	.440	3.40	14.0	18	21
	03-24-82	1445	3.5	15.0	7.2	8.5	1,210	--	--	.480	3.20	14.0	18	21
	04-28-82	1445	4.5	20.0	7.5	6.5	1,280	867	60	.610	4.00	9.90	15	19
	05-27-82	1415	5.8	20.0	7.3	7.6	1,310	--	--	.680	3.70	9.90	11	15
	06-16-82	1430	4.9	21.0	7.4	6.2	1,360	--	--	1.10	4.50	8.30	11	16
	07-16-82	1230	2.0	24.5	7.4	6.2	1,530	1,120	62	1.60	5.90	2.20	5.5	11
	08-12-82	1215	6.0	23.5	7.3	6.0	1,480	--	--	.500	2.60	4.20	11	14
	09-13-82	1420	4.3	18.0	7.4	6.9	1,410	--	--	.510	2.40	8.50	17	19
	10-21-82	1710	4.2	15.0	7.7	7.4	--	--	--	.500	2.10	2.20	17	19
	11-18-82	1405	3.3	12.5	7.9	9.5	1,550	--	--	.800	3.30	11.0	14	17
	12-15-82	1345	1.0	8.5	7.5	11.0	1,420	--	--	.640	2.90	9.80	14	17
	Station 384312104432100 Widefield Sewage Treatment Plant outfall													
22	03-26-82	1000	--	--	--	--	--	--	--	--	<.100	21.0	--	--
	04-09-82	0800	--	--	--	--	--	--	--	--	<.100	21.0	--	--
	04-20-82	1100	--	--	--	--	--	--	--	--	<.100	21.0	--	--
	05-19-82	--	--	--	--	--	--	--	--	--	<.100	22.0	--	--
	06-16-82	1240	1.8	18.0	7.1	6.4	2,320	1,400	370	.040	<.100	23.0	29	--
	07-15-82	1500	--	--	--	--	--	--	--	--	.790	22.0	--	--
	Station 07105825 Fountain Creek below Widefield													
23	02-17-81	1415	87	12.0	7.6	8.3	960	591	47	.350	2.30	9.70	15	17
	03-18-81	1330	104	13.0	7.7	8.2	890	530	49	.340	2.40	7.20	19	21
	04-21-81	1315	88	17.0	7.6	6.7	821	493	36	.510	2.20	5.50	11	13
	05-21-81	1630	62	21.5	7.3	5.5	824	541	46	1.00	3.10	3.90	10	13
	06-18-81	1030	34	18.0	7.8	6.9	1,010	678	62	.940	2.30	5.70	10	12
	07-15-81	1520	84	29.5	7.3	4.5	916	598	47	1.60	2.50	6.60	8.5	11
	08-20-81	1245	122	23.5	7.1	5.8	682	428	35	.490	2.00	1.90	3.9	5.9
	09-16-81	1410	124	14.0	7.3	7.1	745	485	32	.370	2.20	3.60	8.9	11
	10-21-81	1410	100	7.5	7.3	9.0	740	492	36	.280	2.40	6.10	7.3	9.7

Table 11.0-1.--*Surface-water quality data*--Continued

Site number on figure 2.0-1	Date of sample	Time	Flow, instantaneous (ft^3/s)	Temperature (°C)	pH (standard units)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	Dissolved-solids residue at 105°C (mg/L)	Dissolved chloride (mg/L as Cl)	Total nitrite nitrogen (mg/L as N)	Total nitrogen NO_2+NO_3 (mg/L as N)	Total ammonia nitrogen (mg/L as N)	Total ammonia and organic nitrogen (mg/L as N)	Total nitrogen (mg/L as N)
					Station 07105825 Fountain Creek below Widefield--Continued									
23	11-20-81	0900	30	4.0	7.7	8.3	929	697	84	0.170	2.40	11.0	15	17
	12-17-81	1400	42	5.5	7.7	9.0	924	643	55	.280	3.10	6.60	8.5	12
	01-19-82	1300	90	8.0	7.4	8.6	920	592	57	.250	2.10	9.50	13	15
	02-23-82	1215	95	9.0	7.3	9.0	800	541	41	.120	1.50	5.10	5.9	7.4
	03-24-82	1315	84	15.0	7.2	7.2	874	567	58	.270	2.20	8.80	11	13
	04-28-82	1530	89	22.0	7.5	5.9	929	591	48	.420	2.20	7.40	13	15
	05-28-82	1340	170	21.5	7.2	6.5	--	400	31	.360	2.10	3.20	4.2	6.3
	06-16-82	1245	121	21.0	7.2	6.1	--	491	43	.370	2.50	3.40	4.7	7.2
	07-15-82	1430	91	26.0	7.0	4.6	894	587	64	.990	4.10	5.00	5.6	9.7
	08-11-82	1130	170	20.0	7.1	6.4	631	419	40	.310	1.70	2.00	5.3	7.0
	09-13-82	1515	191	17.0	7.1	6.7	648	456	33	.500	2.70	3.70	7.2	9.9
	10-21-82	1510	103	15.0	7.1	6.8	800	529	37	.510	3.60	4.60	6.8	10
	11-18-82	1600	90	11.0	7.7	7.7	878	550	48	.150	3.20	6.80	8.7	12
	12-15-82	1445	103	6.5	7.0	9.9	942	630	51	.140	2.70	9.50	14	17

Table 11.0-2.--*Ground-water quality data*

[Ground-water quality data are presented by well owners, in ascending order, generally from the north to the south in the study area, in the following order: Stratmoor Hills, Pinello, Venetucci, Security, Widefield, and miscellaneous; °C, degrees Celsius; μS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; Cl, chloride; N, nitrogen; lat, latitude; long, longitude]

Date	Time	Temperature (°C)	pH (standard units)	Specific conductance (μS/cm)	Dissolved-solids residue at 105°C (mg/L)	Dissolved chloride (mg/L as Cl)	Dissolved nitrite nitrogen (mg/L as N)	Dissolved nitrogen NO_2+NO_3 (mg/L as N)	Dissolved ammonia nitrogen (mg/L as N)	Dissolved nitrogen, ammonia and organic (mg/L as N)	Dissolved nitrogen (mg/L as N)
Site 384617104455901; well SC01506603CAD1 Stratmoor Hills 4 (lat 38°46'17", long 104°45'59")											
02-13-81	1140	13.0	7.0	1,000	694	33	0.000	8.80	0.180	1.3	10
03-19-81	1045	13.0	6.6	1,020	668	34	.000	7.50	.270	.94	8.4
05-21-81	1545	13.5	6.6	901	651	37	.000	6.10	.090	1.4	7.5
06-18-81	1200	13.0	6.6	--	703	31	.000	6.60	.210	.90	7.5
07-17-81	1130	13.0	6.5	--	659	37	.010	6.50	.260	1.2	7.7
09-04-81	1055	14.0	6.6	943	651	37	.010	6.20	<.060	1.1	7.3
09-18-81	1050	13.5	6.4	945	661	32	.030	6.10	.230	1.2	7.3
10-26-81	1145	14.0	6.5	934	648	40	<.020	6.90	.200	1.4	8.3
11-24-81	1155	14.0	6.5	921	666	32	.020	7.60	.360	.33	7.9
12-21-81	1100	13.5	6.3	976	664	26	<.020	6.10	.270	1.3	7.4
01-20-82	1125	13.5	6.3	929	628	38	<.020	6.80	.230	.51	7.3
02-24-82	1155	13.0	6.2	991	701	34	<.020	7.40	.080	.72	8.1
03-26-82	1210	13.0	6.1	1,020	721	33	<.020	7.60	.190	2.6	10
04-30-82	0935	13.0	6.7	1,010	729	39	<.020	7.60	.130	1.4	9.0
05-28-82	1110	13.0	6.6	928	636	42	<.020	5.20	.070	--	--
06-23-82	1130	14.0	7.1	1,100	715	31	<.020	7.70	.090	1.6	9.3
07-16-82	1100	13.0	6.7	933	677	32	<.020	7.50	.200	.90	8.4
08-13-82	1120	13.0	6.6	950	738	32	<.020	7.50	.130	1.8	9.3
09-17-82	1220	13.0	6.6	940	771	35	.020	7.40	.090	1.9	9.3
10-22-82	1240	14.0	--	--	662	32	<.020	8.20	<.060	2.0	10
11-19-82	1130	14.0	6.8	930	651	33	<.020	8.50	<.060	.60	9.1
12-17-82	1130	13.5	6.8	865	603	40	<.020	7.50	<.060	.60	8.1
Site 384619104460201; well SC01506603CAA Stratmoor Hills 5 (lat 38°46'19", long 104°46'02")											
07-02-81	1235	15.0	7.0	1,070	792	35	<.010	11.0	<.060	.98	12
09-04-81	1120	14.5	6.8	1,120	806	30	.000	6.80	<.060	1.4	8.2
12-21-81	1040	13.5	6.4	1,120	808	24	<.020	6.90	<.060	1.1	8.0
06-23-82	1230	13.0	7.0	1,100	790	23	<.020	8.40	<.060	1.5	9.9
Site 384612104461801; well SC01506603CBD Stratmoor Hills 7 (lat 38°46'12", long 104°46'18")											
06-18-81	1045	13.0	6.8	1,500	1,140	77	.000	4.80	.690	1.3	6.1
06-23-82	1310	12.0	6.9	1,700	1,240	87	<.020	6.10	.280	1.4	7.5
Site 384611104454601; well SC01506603DCA1 Stratmoor Hills 10 (lat 38°46'11", long 104°45'46")											
06-18-81	1120	14.0	7.2	494	329	11	.000	6.00	<.060	.68	6.7
06-23-82	1030	14.0	7.5	--	337	12	<.020	8.40	<.060	1.6	10
Site 384538104450101; well SC01506611BCD1 Pinello 1 (lat 38°45'38", long 104°45'01")											
11-24-81	1225	13.5	6.5	425	283	78	.020	9.80	.160	.26	10
09-17-82	1300	13.5	6.5	405	352	11	<.020	7.90	.090	2.1	10

Table 11.0-2.--*Ground-water quality data*--Continued

Date	Time	Temperature (°C)	pH (standard units)	Specific conductance (μS/cm)	Dissolved-solids residue at 105°C (mg/L)	Dissolved chloride (mg/L as Cl)	Dissolved nitrite nitrogen (mg/L as N)	Dissolved nitrogen NO_2+NO_3 (mg/L as N)	Dissolved ammonia nitrogen (mg/L as N)	Dissolved nitrogen, ammonia and organic (mg/L as N)	Dissolved nitrogen (mg/L as N)
Site 384538104451301; well SC01506611CBA3 Pinello 2 (lat 38°45'38", long 104°45'13")											
06-22-81	0910	13.5	6.7	562	402	22	.000	5.90	<.060	1.2	7.1
06-21-82	1155	13.0	7.3	580	370	16	<.020	6.50	.100	1.5	8.0
Site 384534104452101; well SC01506611BCC2 Pinello 5 (lat 38°45'34", long 104°45'21")											
06-19-81	1100	13.0	7.1	680	442	26	.000	5.00	.110	1.4	6.4
06-21-82	1615	14.0	7.0	560	370	18	<.020	5.00	.250	1.7	6.7
Site 384538104452201; well SC01506611BCC1 Pinello 6 (lat 38°45'38", long 104°45'22")											
06-19-81	1245	12.5	6.7	720	467	28	0.000	5.20	0.340	1.4	6.6
06-22-82	1020	11.0	6.9	640	401	18	<.020	6.70	.070	1.5	8.2
Site 384548104452801; well SC01506610ADD Pinello 7 (lat 38°45'48", long 104°45'23")											
06-18-81	1340	13.0	7.0	630	409	22	.000	6.20	.060	.91	7.1
06-21-82	1510	12.0	7.2	570	364	17	<.020	6.90	.150	1.4	8.3
Site 384554104453601; well SC01506610AAB Pinello 8 (lat 38°45'54", long 104°45'36")											
06-18-81	1405	13.5	7.0	626	396	18	.000	9.80	<.060	1.3	11
06-21-82	1400	13.0	7.2	--	341	14	<.020	9.50	.100	1.4	11
Site 384543104451801; well SC01506611BCB Pinello 9 (lat 38°45'43", long 104°45'18")											
06-19-81	1140	14.0	7.1	525	347	19	.000	7.70	.060	1.6	9.3
06-22-82	1115	12.5	7.3	500	332	14	<.020	7.80	<.060	1.5	9.3
Site 384558104453901; well SC01506610AAB2 Pinello 10 (lat 38°45'58", long 104°45'39")											
06-19-81	1000	14.0	6.8	690	460	23	.010	7.30	.140	1.5	8.8
06-21-82	1330	12.5	7.1	520	347	13	<.020	8.00	<.060	1.3	9.3
Site 384606104455201; well SC01506603DCC Pinello 11 (lat 38°46'06", long 104°45'52")											
06-18-81	1445	12.5	6.9	805	534	32	.000	4.40	1.20	1.9	6.3
06-21-82	1155	11.0	7.1	650	477	24	<.020	4.20	.850	1.8	6.0
Site 384608104454801; well SC01506603DCA2 Pinello 12 (lat 38°46'08", long 104°45'48")											
06-18-81	1505	13.5	7.1	650	421	14	.000	11.0	<.060	1.5	2.6
06-21-82	1120	12.5	7.3	440	336	11	<.020	8.10	.060	.80	8.9
Site 384559104453201; well SC01506603DDD Pinello 13 (lat 38°45'59", long 104°45'32")											
06-19-81	1040	13.5	7.1	549	344	16	.000	5.80	.070	1.5	7.3
06-21-82	1445	12.0	7.5	550	355	18	<.020	4.80	.120	1.4	6.2
Site 384518104450501; well SC01506611CDB Venetucci 1 (lat 38°45'18", long 104°45'05")											
06-23-81	1330	13.0	6.7	714	509	32	.000	4.80	.070	1.5	6.3
06-24-82	1155	12.0	6.5	760	486	29	<.020	3.20	<.060	1.7	4.9

Table 11.0-2.--*Ground-water quality data*--Continued

Date	Time	Temperature (°C)	pH (standard units)	Specific conductance (µS/cm)	Dissolved-solids residue at 105°C (mg/L)	Dissolved chloride (mg/L as Cl)	Dissolved nitrite nitrogen (mg/L as N)	Dissolved nitrogen NO_2+NO_3 (mg/L as N)	Dissolved ammonia nitrogen (mg/L as N)	Dissolved nitrogen, ammonia and organic (mg/L as N)	Dissolved nitrogen (mg/L as N)
Site 384522104450601; well SC01506611CAC Venetucci 2 (lat 38°45'22", long 104°45'06")											
06-23-81	1350	13.5	6.6	716	529	33	.000	5.40	.070	1.2	6.6
06-24-82	1240	12.5	6.8	690	437	21	<.020	4.50	.060	1.4	5.9
Site 384535104450801; well SC01506611BCD2 Venetucci 3 (lat 38°45'35", long 104°45'08")											
02-13-81	1115	13.0	6.8	460	294	13	.000	9.10	<.060	1.1	10
03-19-81	1130	13.0	6.5	422	275	13	.000	8.30	<.060	.78	9.1
04-21-81	1045	13.5	6.7	417	292	12	.160	8.70	.160	1.2	9.9
05-19-81	1345	12.5	6.3	449	316	14	.010	7.60	.090	1.1	8.7
06-19-81	1535	14.0	6.6	430	282	11	.000	8.20	.070	1.6	9.8
07-17-81	1200	13.0	6.5	--	288	13	.010	8.60	.060	.63	9.2
08-19-81	1135	13.5	6.8	420	281	11	.030	7.90	.130	1.0	8.9
09-18-81	1125	13.0	6.3	407	287	11	.020	6.80	.130	1.2	8.0
10-26-81	1210	13.0	6.5	431	303	14	<.020	7.80	<.060	1.2	9.0
11-24-81	1250	13.5	6.6	425	270	12	.020	9.80	.080	--	--
Site 384535104450801; well SC01506611BCD2 Venetucci 3 (lat 38°45'35", long 104°45'08")--Continued											
12-21-81	1125	13.5	6.3	444	271	11	<0.020	6.70	0.090	0.87	7.6
01-20-82	0950	13.5	6.4	403	284	11	<.020	8.40	.130	.79	9.2
02-24-82	1135	13.5	6.3	406	287	11	<.020	8.40	<.060	.92	9.3
03-26-82	1050	14.0	6.3	460	313	13	<.020	8.60	<.060	.57	9.2
04-30-82	1000	13.0	6.5	435	311	14	<.020	8.40	<.060	1.1	9.5
05-28-82	1130	13.0	6.7	415	286	10	<.020	9.70	.070	--	--
06-24-82	0950	13.5	7.0	420	293	10	<.020	8.40	<.060	1.1	9.5
10-22-82	1315	13.0	--	420	276	10	<.020	8.20	<.060	1.2	9.4
11-19-82	1145	13.5	6.7	469	319	14	<.020	9.10	<.060	.90	10
12-17-82	1340	14.0	6.6	400	277	10	<.020	9.00	<.060	.70	9.7
Site 384517104445501; well SC01506611CDA1 Venetucci 4 (lat 38°45'17", long 104°44'55")											
06-19-81	1330	15.5	6.8	770	502	32	.000	7.50	.090	1.4	8.9
Site 384532104450801; well SC01506611CBA1 Venetucci 6 (lat 38°45'32", long 104°45'08")											
08-19-81	1220	13.5	6.7	715	468	30	.030	6.30	.140	1.0	7.3
06-24-82	1005	11.5	6.9	605	399	21	<.020	8.80	<.060	1.4	10
Site 384511104444301; well SC01506611DCC Venetucci 7 (lat 38°45'11", long 104°44'43")											
06-22-81	1000	14.5	6.4	743	530	33	.000	5.10	.060	1.5	6.6
Site 384515104444801; well SC01506611DCB1 Venetucci 8 (lat 38°45'15", long 104°44'48")											
06-19-81	1410	14.0	7.0	785	515	32	.000	5.80	.090	2.8	8.6
Site 384531104450301; well SC01506611CAB Venetucci 9 (lat 38°45'31", long 104°45'03")											
06-19-81	1455	14.5	6.6	630	420	26	.000	9.10	.080	1.5	11
06-24-82	1105	14.0	6.9	479	316	13	<.020	8.10	<.060	1.8	9.9

Table 11.0-2.--*Ground-water quality data*--Continued

Date	Time	Temperature (°C)	pH (standard units)	Specific conductance (μS/cm)	Dissolved-solids residue at 105°C (mg/L)	Dissolved chloride (mg/L as Cl)	Dissolved nitrite nitrogen (mg/L as N)	Dissolved nitrogen NO_2+NO_3 (mg/L as N)	Dissolved ammonia nitrogen (mg/L as N)	Dissolved nitrogen, ammonia and organic (mg/L as N)	Dissolved nitrogen (mg/L as N)
Site 384458104442601; well SC01506614AAD Security 2 (lat 38°44'58", long 104°44'26")											
02-13-81	1025	13.0	6.8	650	407	24	.000	7.00	<.060	.82	7.8
03-19-81	1330	13.0	6.3	--	401	26	.000	4.80	<.060	.72	5.5
05-21-81	1500	14.0	6.6	642	440	19	.000	7.00	.100	2.2	9.2
06-22-81	1105	14.5	6.2	--	400	22	.000	7.10	<.060	1.6	8.7
07-17-81	0955	13.0	6.4	--	362	20	.000	8.00	.080	1.0	9.0
11-24-81	1050	13.0	6.5	635	428	22	.020	7.70	.160	.42	8.1
12-21-81	0950	13.5	6.2	668	416	20	<.020	4.90	.080	1.0	5.9
01-20-82	1020	13.5	6.2	661	445	27	<.020	6.10	.120	1.0	7.1
02-24-82	0920	13.0	6.5	647	438	23	<.020	6.40	<.060	1.0	7.4
03-26-82	0945	13.5	6.3	646	427	29	<.020	6.00	.060	.37	6.4
04-30-82	1020	13.5	6.4	638	439	26	<.020	5.80	.070	1.0	6.8
05-28-82	1040	13.5	6.3	648	436	26	<.020	6.50	.070	1.1	7.6
06-22-82	1025	14.0	6.7	663	446	24	<.020	5.70	.080	1.4	7.1
07-16-82	0950	13.0	6.5	638	447	28	<.020	6.30	<.060	1.4	7.7
09-17-82	1010	13.0	6.3	653	513	28	<.020	6.00	.070	2.1	8.1
10-22-82	1050	13.0	--	660	446	29	<.020	5.80	<.060	2.1	7.9
11-19-82	1115	13.5	6.5	670	443	29	<.020	5.70	<.060	.70	6.4
12-17-82	1045	13.5	6.5	633	429	28	<.020	5.70	<.060	1.2	6.9
Site 384524104445101; well SC01506611CAD Security 4 (lat 38°45'24", long 104°44'51")											
06-22-81	1320	14.5	6.6	455	329	17	.000	7.90	.060	1.4	9.3
06-22-82	1330	14.0	6.8	491	322	14	<.020	8.10	.080	1.4	9.5
Site 384527104445601; well SC01506611CAA Security 7 (lat 38°45'27", long 104°44'56")											
06-22-81	1350	14.5	6.5	490	354	19	0.000	8.10	<0.060	1.6	9.7
06-22-82	1530	14.0	6.9	470	322	11	<.020	8.40	<.060	1.7	10
Site 384521104444301; well SC01506611DCB2 Security 8 (lat 38°45'21", long 104°44'43")											
06-22-81	1155	14.5	6.5	597	424	24	.000	6.60	<.060	1.9	8.5
06-22-82	1315	14.0	6.7	630	416	21	<.020	7.50	<.060	1.5	9.0
Site 384422104435201; well SC01506613CDA Security 9 (lat 38°44'22", long 104°43'52")											
06-22-81	1550	14.0	6.6	627	447	27	.000	8.10	.060	1.7	9.8
06-21-82	1445	14.0	6.9	640	428	38	<.020	7.10	.070	1.5	8.6
Site 384416104434701; well SC01506613CDD Security 10 (lat 38°44'16", long 104°43'47")											
06-22-81	1525	14.5	6.7	740	532	29	.000	6.90	<.060	1.4	8.3
06-21-82	1420	14.5	6.6	765	512	28	<.020	8.60	.070	1.1	9.7

Table 11.0-2.--*Ground-water quality data*--Continued

Date	Time	Temperature (°C)	pH (standard units)	Specific conductance (µS/cm)	Dissolved-solids residue at 105°C (mg/L)	Dissolved chloride (mg/L as Cl)	Dissolved nitrite nitrogen (mg/L as N)	Dissolved nitrogen NO_2+NO_3 (mg/L as N)	Dissolved ammonia nitrogen (mg/L as N)	Dissolved nitrogen, ammonia and organic (mg/L as N)	Dissolved nitrogen (mg/L as N)
Site 384553104451801; well SC01506611BBB2 Security 11 (lat 38°45'53", long 104°45'18")											
06-22-81	1430	14.0	6.8	406	292	12	.000	7.70	<.060	1.6	9.3
04-14-82	0928	--	6.9	441	--	--	--	6.60	.110	--	--
04-14-82	0930	--	6.9	435	--	--	--	6.80	.080	--	--
04-14-82	0932	--	6.3	431	--	--	--	7.00	.060	--	--
04-14-82	0937	--	6.6	423	--	--	--	7.30	.060	--	--
04-14-82	0947	--	6.6	417	--	--	--	7.60	.070	--	--
04-14-82	1017	--	6.6	417	--	--	--	7.70	.060	--	--
04-14-82	1127	14.5	6.7	417	--	--	--	7.60	.060	--	--
04-14-82	1527	14.5	6.7	411	--	--	--	7.50	.060	--	--
04-14-82	2127	15.0	6.6	414	--	--	--	7.70	.060	--	--
04-15-82	0927	13.5	6.7	416	--	--	--	8.00	.060	--	--
06-22-82	1410	14.0	6.9	530	349	15	<.020	5.60	.250	2.1	7.7
Site 384606104453101; well SC01506603DDA Security 13 (lat 38°46'06", long 104°45'31")											
06-23-81	1055	14.0	6.7	513	351	21	.000	4.70	.060	1.1	5.8
06-22-82	1435	14.0	6.9	535	346	16	<.020	5.50	.060	1.4	6.9
08-13-82	1020	13.0	6.5	501	435	19	<.020	5.20	.100	1.3	6.5
Site 384610104453501; well SC01506603DDB Security 14 (lat 38°46'10", long 104°45'35")											
02-13-81	1100	13.0	7.3	500	326	12	.000	5.00	<.060	.97	6.0
03-19-81	1355	13.0	6.7	485	306	13	.000	4.70	<.060	.59	5.3
04-21-81	0930	13.5	7.1	488	336	17	.060	5.70	.120	1.1	6.8
05-19-81	1230	12.5	6.7	480	324	13	.010	6.10	.120	1.6	7.7
06-23-81	1030	14.0	7.2	--	324	22	.000	5.30	.060	1.4	6.7
07-17-81	1025	13.0	6.8	--	322	15	.000	6.80	.060	.64	7.4
08-19-81	1005	12.5	6.9	500	317	14	.030	4.70	.070	.75	5.5
09-18-81	0945	12.5	6.8	468	323	23	.030	4.20	.120	1.5	5.7
10-26-81	1105	12.5	6.8	486	325	11	<.020	5.50	<.060	1.2	6.7
11-24-81	1120	13.0	6.8	498	330	14	.020	7.40	.160	.72	8.1
12-21-81	1005	13.0	6.5	530	324	10	<.020	4.70	.070	1.1	5.8
01-20-82	1050	13.5	6.6	504	336	17	<.020	6.40	.150	.41	6.8
02-24-82	0950	13.5	6.7	503	338	15	<.020	6.40	<.060	2.0	8.4
03-26-82	1015	13.5	6.6	511	336	15	<.020	5.10	.100	.76	5.8
04-30-82	1045	13.5	6.8	512	348	17	<.020	6.10	.070	.95	7.1
05-28-82	1020	13.0	6.8	511	340	16	<.020	3.30	.060	--	--
Site 384610104453501; well SC01506603DDB Security 14 (lat 38°46'10", long 104°45'35")--Continued											
06-22-82	1450	13.5	7.2	540	349	14	<0.020	5.90	<0.060	2.1	8.0
07-16-82	1020	13.0	6.9	493	350	17	<.020	6.40	<.060	1.4	7.8
09-17-82	1030	12.5	6.8	496	403	16	<.020	5.40	.100	1.2	6.6
10-22-82	1110	13.0	--	530	336	17	<.020	6.40	<.060	1.1	7.5
11-19-82	1120	13.5	6.9	525	349	19	<.020	7.00	<.060	.60	7.6
12-17-82	1110	13.5	7.0	522	351	18	<.020	7.00	<.060	.90	7.9

Table 11.0-2.--*Ground-water quality data*--Continued

Date	Time	Temperature (°C)	pH (standard units)	Specific conductance (μS/cm)	Dissolved-solids residue at 105°C (mg/L)	Dissolved chloride (mg/L as Cl)	Dissolved nitrite nitrogen (mg/L as N)	Dissolved nitrogen NO_2+NO_3 (mg/L as N)	Dissolved ammonia nitrogen (mg/L as N)	Dissolved nitrogen, ammonia and organic (mg/L as N)	Dissolved nitrogen (mg/L as N)
Site 384507104443501; well SC01506611DCD Security 15 (lat 38°45'07", long 104°44'35")											
06-22-81	1130	14.0	6.5	518	367	19	.000	9.30	.020	1.6	2.5
08-19-81	0940	13.0	6.9	690	452	26	.030	6.20	.170	1.2	7.4
06-22-82	1130	13.5	6.8	705	453	26	<.020	6.30	.090	1.6	7.9
Site 384459104443401; well SC01506614AAC1 Security 16 (lat 38°44'59", long 104°44'34")											
08-19-81	0905	13.5	6.8	670	424	25	.030	6.60	.160	1.0	7.6
09-18-81	0915	13.0	6.6	--	474	29	.020	4.90	.110	1.2	6.1
10-26-81	1040	13.0	6.5	730	470	32	<.020	6.00	<.060	1.1	7.1
11-24-81	1030	13.0	6.5	695	483	27	.020	9.00	.160	.81	9.8
06-22-82	1110	14.0	6.8	750	476	25	<.020	5.40	.060	1.6	7.0
08-13-82	1050	13.0	6.5	680	506	29	<.020	5.10	.120	1.4	6.5
Site 384442104441201; well SC01506613BCC1 Security 17 (lat 38°44'42", long 104°44'12")											
06-23-81	1125	14.0	6.5	610	427	25	.000	7.00	<.060	1.0	8.0
06-21-82	1510	13.5	6.7	730	484	31	<.020	4.90	.070	2.0	6.9
Site 384427104440301; well SC01506613CAA REAM 1 (lat 38°44'27", long 104°44'03")											
06-23-81	1145	14.0	7.0	860	619	41	.000	7.00	.070	1.4	8.4
06-21-82	1110	15.0	6.7	930	584	38	<.020	4.20	<.060	1.3	5.5
Site 384416104435401; well SC01506613CDC REAM 2 (lat 38°44'16", long 104°43'54")											
06-22-81	1455	14.0	6.9	678	487	31	.000	6.60	<.060	1.2	7.8
06-21-82	1320	14.0	6.8	760	503	34	<.020	5.00	.070	1.7	6.7
Site 384413104434601; well SC01506624BAA1 Widefield 1 (lat 38°44'13", long 104°43'46")											
06-24-81	0945	14.5	6.8	795	581	37	.000	8.80	.110	1.6	10
06-24-82	0930	13.0	7.3	740	530	28	<.020	9.40	<.060	1.6	11
Site 384411104434301; well SC01506624BAA2 Widefield 2 (lat 38°44'11", long 104°43'43")											
06-24-81	1015	14.5	7.1	850	623	36	.000	7.20	.110	1.1	8.3
05-06-82	0903	--	6.8	907	--	--	--	8.40	.130	--	--
05-06-62	0905	13.0	6.7	900	--	--	--	8.40	.080	--	--
05-06-82	0907	13.0	6.7	905	--	--	--	8.40	.080	--	--
05-06-82	0912	13.0	6.7	900	--	--	--	8.50	.070	--	--
05-06-82	0922	13.0	6.8	903	--	--	--	8.50	.070	--	--
05-06-82	0952	12.5	6.7	902	--	--	--	8.50	<.060	--	--
05-06-82	1102	13.5	6.7	891	--	--	--	8.50	<.060	--	--
05-06-82	1502	14.0	6.8	890	--	--	--	8.50	<.060	--	--
05-06-82	1902	14.5	6.8	908	--	--	--	8.50	<.060	--	--
05-07-82	0902	13.0	6.8	883	--	--	--	8.40	.060	--	--
06-24-82	1030	14.0	7.4	870	600	35	<.020	8.90	<.060	1.9	11
Site 384402104434801; well SC01506624BAD2 Widefield 3 (lat 38°44'02", long 104°43'48")											
06-24-81	1110	13.5	6.7	650	454	27	.000	7.50	.120	1.2	8.7
06-24-82	1210	14.0	7.0	660	453	26	<.020	7.30	<.060	1.7	9.0

Table 11.0-2.--*Ground-water quality data*--Continued

Date	Time	Temper-ature (°C)	pH (stand-ard units)	Specific conduct-ance (µS/cm)	Dissolved-solids residue at 105°C (mg/L)	Dissolved chloride (mg/L as Cl)	Dissolved nitrite nitrogen (mg/L as N)	Dissolved nitrogen NO_2+NO_3 (mg/L as N)	Dissolved ammonia nitrogen (mg/L as N)	Dissolved nitrogen, ammonia and organic (mg/L as N)	Dis-solved nitrogen (mg/L as N)
Site 384407104434801; well SC01506624BAD1 Widefield 4 (lat 38°44'07", long 104°43'48")											
02-13-81	0905	13.0	6.8	--	571	38	0.000	8.70	<0.060	1.1	9.8
03-19-81	0955	12.5	6.7	910	586	39	.000	7.80	.060	1.0	8.8
04-21-81	1000	13.0	6.8	770	534	33	.000	7.60	.070	1.2	8.8
05-19-81	1315	12.5	6.5	771	525	34	.010	6.20	.060	1.3	7.5
06-24-81	1040	13.5	6.7	727	515	34	.000	6.70	.100	1.1	7.8
07-17-81	1100	13.0	6.4	--	518	36	.000	7.00	.110	1.0	8.0
08-19-81	1055	14.0	6.9	810	524	36	.030	7.00	.130	1.2	8.2
09-18-81	1030	13.5	6.4	803	549	35	.020	6.00	.120	1.3	7.3
10-26-81	1300	14.0	6.8	774	497	37	<.020	7.50	<.060	1.3	8.8
11-24-81	1330	13.0	6.6	716	487	26	.020	9.20	.150	.57	9.8
12-21-81	1140	13.0	6.4	773	497	26	<.020	5.90	<.070	.83	6.7
01-20-82	1200	13.5	6.3	787	534	34	<.020	7.20	.120	.95	8.2
02-24-82	1030	12.5	6.4	794	531	33	<.020	6.90	<.060	.81	7.7
03-26-82	1140	13.0	6.2	782	521	31	<.020	6.70	.060	.56	7.3
04-30-82	1115	13.0	6.5	728	486	30	<.020	6.70	.070	1.1	7.8
05-28-82	0945	13.0	6.6	737	464	31	<.020	6.90	.060	1.2	8.1
06-24-82	1100	13.5	7.1	750	502	31	<.020	6.20	<.060	1.5	7.7
07-16-82	1130	13.0	6.7	751	522	35	<.020	6.60	<.060	1.9	8.5
08-13-82	1215	15.0	6.6	835	618	34	<.020	6.00	.110	1.6	7.6
09-17-82	1115	13.0	6.5	788	611	35	<.020	5.60	.070	1.8	7.4
10-22-82	1140	13.0	--	770	508	34	<.020	6.60	<.060	2.6	9.2
11-19-82	1000	14.0	7.0	769	460	35	<.020	7.00	<.060	1.1	8.1
12-17-82	1025	13.5	6.7	771	516	36	<.020	7.00	<.060	1.0	8.0
Site 384323104432201; well SC01506625AAB Widefield 5 (lat 38°43'23", long 104°43'22")											
07-21-82	1330	14.0	6.9	1,350	1,020	53	<.020	8.00	.060	1.2	9.2
Site 384343104432501; well SC01506624DAB Widefield 7 (lat 38°43'43", long 104°43'25")											
06-24-81	1335	15.0	7.2	703	485	24	.000	7.20	.120	1.4	8.6
06-02-82	1530	14.0	7.3	720	520	28	<.020	6.80	<.060	1.4	8.2
Site 384610104432401; well SC01506601DDB Widefield 8 (lat 38°46'10", long 104°43'24")											
06-24-81	1550	14.0	7.2	441	323	6.2	.000	5.10	.120	1.2	6.3
06-25-82	1000	13.0	7.6	440	292	6.5	<.020	5.30	.060	1.9	7.2
Site 384553104432901; well SC01506602ABA Widefield 9 (lat 38°45'53", long 104°43'29")											
06-24-81	1610	13.5	7.2	448	305	5.9	.000	5.00	.110	1.1	6.1
06-25-82	1100	13.0	7.6	460	290	6.6	<.020	5.00	<.060	2.4	7.4
Site 384628104432301; well SC01506601ADC Widefield 11 (lat 38°46'28", long 104°43'23")											
06-25-81	1035	15.0	7.4	486	306	6.3	.000	4.20	.070	.92	5.1
06-25-82	1145	13.0	7.6	480	290	6.0	<.020	3.70	.070	1.6	5.3
Site 384544104433101; well SC01506612ACA Widefield 12 (lat 38°45'44", long 104°43'31")											
07-07-82	1530	17.0	7.2	580	388	13	<.020	7.20	.070	1.3	8.5

Table 11.0-2.--*Ground-water quality data*--Continued

Date	Time	Temperature (°C)	pH (standard units)	Specific conductance (µS/cm)	Dissolved-solids residue at 105°C (mg/L)	Dissolved chloride (mg/L as Cl)	Dissolved nitrite nitrogen (mg/L as N)	Dissolved nitrogen NO_2+NO_3 (mg/L as N)	Dissolved ammonia nitrogen (mg/L as N)	Dissolved nitrogen, ammonia and organic (mg/L as N)	Dissolved nitrogen (mg/L as N)
Site 384313104431801; well SC01506625AAD Widefield 14 (lat 38°43'13", long 104°43'18")											
06-24-81	1425	14.0	7.1	1,240	937	45	.000	10.0	.110	1.0	11
01-20-82	1230	13.5	6.5	1,510	1,150	50	<.020	10.7	.110	1.1	12
02-24-82	1105	13.5	6.5	1,550	1,190	50	<.020	11.0	.060	1.1	12
03-26-82	1115	14.0	6.4	1,500	1,150	49	<.020	10.0	.080	.32	10
04-30-82	1140	14.0	6.7	1,400	1,040	49	<.020	9.20	.060	1.1	10
Site 384313104431801; well SC01506625AAD Widefield 14 (lat 38°43'13", long 104°43'18")--Continued											
05-28-82	0930	14.0	6.6	1,370	1,030	50	<0.020	9.10	0.090	1.6	11
06-25-82	1230	13.0	7.3	--	1,220	52	<.020	9.60	.090	1.7	11
07-16-82	1200	13.0	6.9	1,540	1,220	53	<.020	11.0	.090	2.1	13
08-13-82	1245	13.0	6.8	1,500	1,190	55	<.020	12.0	.120	2.1	14
09-17-82	1140	13.0	6.7	1,480	1,230	58	<.020	11.0	.060	1.9	13
10-22-82	1205	13.5	--	1,500	1,110	57	<.020	11.0	<.060	1.2	12
11-19-82	1200	13.5	7.0	1,470	1,080	60	<.020	10.0	<.060	1.2	11
12-17-82	0950	--	6.9	1,480	1,130	58	<.020	9.60	.060	1.0	11
Site 384346104433301; well SC01506624DBA Ceresa 1 (lat 38°43'46", long 104°43'33")											
06-24-81	1305	15.0	7.4	779	549	32	.000	8.10	..100	.76	8.9
06-24-82	1430	14.5	7.9	800	535	30	<.020	7.80	<.060	1.1	8.9
Site 384347104434201; well SC01506624DBB Ceresa 3 (lat 38°43'47", long 104°43'42")											
06-24-81	1140	14.5	7.1	703	497	31	.000	8.00	.110	.95	9.0
06-24-82	1330	14.0	7.5	750	486	28	<.020	8.40	<.060	1.6	10
Site 384327104432501; well SC01506624DDC Enfeld 3 (lat 38°43'27", long 104°43'25")											
06-24-81	1355	14.0	6.9	804	570	31	.000	7.20	.110	1.2	8.4
06-24-82	1600	14.0	7.2	760	517	27	<.020	6.40	.070	.90	7.3
Site 384348104391201; well SC01506522DBB2 JHW 1 (lat 38°43'48", long 104°39'12")											
06-28-82	1300	14.0	7.2	1,650	1,200	30	<.020	1.70	.070	1.2	2.9
Site 384349104390401; well SC01506522DBA1 JHW 2 (lat 38°43'49", long 104°39'04")											
06-25-82	1600	13.0	7.5	1,300	1,120	39	<.020	2.70	<.060	1.7	4.4
Site 384347104390901; well SC01506522DBB JHW 3 (lat 38°43'47", long 104°39'09")											
06-28-82	1330	14.0	7.4	1,520	1,380	24	<.020	1.40	<.070	1.0	2.4
Site 384339104390001; well SC01506522DBD JHW 4 (lat 38°43'39", long 104°39'00")											
06-25-82	1500	13.0	7.6	1,300	900	44	<.020	2.70	.080	1.7	4.4
Site 384347104385901; well SC01506522DBA4 JHW 5 (lat 38°43'47", long 104°38'59")											
06-28-82	1415	14.0	7.5	1,620	1,270	34	<.020	2.50	.070	1.5	4.0

Table 11.0-2.--*Ground-water quality data*--Continued

Date	Time	Temper-ature (°C)	pH (stand-ard units)	Specific conduct-ance (µS/cm)	Dissolved-solids residue at 105°C (mg/L)	Dissolved chloride (mg/L as Cl)	Dissolved nitrite nitrogen (mg/L as N)	Dissolved nitrogen NO_2+NO_3 (mg/L as N)	Dissolved ammonia nitrogen (mg/L as N)	Dissolved nitrogen, ammonia and organic (mg/L as N)	Dis-solved nitrogen (mg/L as N)
MISCELLANEOUS WELLS (generally located north to south in study area)											
Site 384905104491301; well SC01406619ACC Manley (lat 38°49'05", long 104°49'13")											
07-20-82	1445	16.0	6.9	1,120	803	39	<.020	8.40	.060	.80	9.2
Site 384839104490601; well SC01406619DCD Hayes (lat 38°48'39", long 104°49'06")											
07-07-82	1200	13.0	6.8	320	189	11	<.020	.960	.060	.50	1.5
Site 384840104482201; well SC01406620CDC1 Colorado Springs Sewage Treatment Plant well (lat 38°48'40", long 104°48'22")											
07-02-81	1445	13.0	6.6	1,520	1,170	65	.000	.100	.800	.99	1.1
07-09-82	0845	14.0	6.8	1,200	861	48	.030	.520	1.40	1.8	2.3
Site 384746104453501; well SC01406627DDC HA & AC 7 (lat 38°47'46", long 104°45'35")											
03-11-82	1245	13.0	7.4	890	409	22	.020	.410	5.20	5.9	6.3
Site 384814104473101; well SC01406628BCC Janitell Road (lat 38°48'14", long 104°47'31")											
06-25-81	1610	13.5	6.7	920	627	41	0.000	7.70	0.060	1.4	9.1
04-13-82	1350	17.0	6.8	1,080	775	37	<.020	6.20	.070	.53	6.7
07-06-82	1330	14.0	6.9	--	614	40	.040	9.00	.060	2.2	11
10-14-82	1520	--	6.5	932	631	34	.090	7.30	.070	1.5	8.8
12-20-82	1530	12.0	6.2	898	627	37	.020	5.50	.270	.90	6.4
Site 384747104473701; well SC01406628CCC1 Standard gas (lat 38°47'47", long 104°47'37")											
04-14-82	1245	15.0	6.5	662	442	54	.020	6.60	.090	.71	7.3
07-09-82	1035	14.0	6.9	600	389	39	<.020	7.80	.070	1.5	18
12-20-82	1510	13.0	5.8	1,300	942	300	<.020	6.50	.070	1.1	7.6
Site 384747104473201; well SC01406628CCC2 Trailer Park (lat 38°47'47", long 104°47'32")											
04-14-82	1340	13.0	6.7	641	411	55	<.020	5.50	.160	1.1	6.6
07-09-82	1010	16.0	7.0	710	431	49	.020	7.20	.150	1.6	8.8
Site 384755104480301; well SC01406629DCA1 Robertson (lat 38°47'55", long 104°48'03")											
07-20-82	1330	14.5	6.8	650	403	38	<.020	7.10	.060	1.7	8.8
Site 384738104473801; well SC01406632AAD Harrison High School (lat 38°47'38", long 104°47'38")											
06-25-81	1435	14.5	6.7	804	550	33	.000	8.90	.080	1.2	10
04-14-82	1310	14.5	6.9	843	594	36	<.020	7.50	.080	.63	8.1
07-06-82	1215	15.0	7.1	790	568	34	<.020	7.60	<.060	1.7	9.3
Site 384718104463701; well SC01406633DAA Barnes (lat 38°47'18", long 104°46'37")											
06-25-81	1540	15.5	6.9	1,310	951	45	.000	14.0	.060	1.6	16
07-01-82	0900	14.0	7.3	1,100	985	33	<.020	13.0	<.070	1.2	14
Site 384659104464301; well SC01406633DDC Colar Compound (lat 38°46'59", long 104°46'43")											
10-13-82	1130	15.5	7.3	230	165	3.1	<.020	1.10	<.060	1.0	2.1

Table 11.0-2.--*Ground-water quality data*--Continued

Date	Time	Temperature (°C)	pH (standard units)	Specific conductance (µS/cm)	Dissolved-solids residue at 105°C (mg/L)	Dissolved chloride (mg/L as Cl)	Dissolved nitrite nitrogen (mg/L as N)	Dissolved nitrogen NO_2+NO_3 (mg/L as N)	Dissolved ammonia nitrogen (mg/L as N)	Dissolved nitrogen, ammonia and organic (mg/L as N)	Dissolved nitrogen (mg/L as N)
Site 384746104452801; well SC01406634AAA HA & AC 8 (lat 38°47'46", long 104°45'28")											
03-11-82	1120	--	7.2	535	345	13	<.020	2.30	.070	.72	3.0
06-18-82	1100	14.0	6.9	580	413	23	.020	2.70	.200	1.0	3.7
12-20-82	1430	13.0	6.3	532	361	40	<.020	2.20	.120	1.0	3.2
Site 384717104455201; well SC01406634DBB1 Cormack East (lat 38°47'17", long 104°45'52")											
03-10-82	1700	--	6.9	1,340	860	120	<.020	1.00	.390	1.5	1.6
Site 384717104455301; well SC01406634DBB2 Cormack West (lat 38°47'17", long 104°45'53")											
03-11-82	1700	14.0	6.9	1,380	827	100	<.020	.500	.390	1.4	1.9
07-15-82	1400	14.0	6.8	1,250	783	86	<.020	.590	.410	1.4	2.0
10-28-82	1735	13.0	6.9	1,180	757	82	<.020	.690	.480	1.5	2.2
Site 384656104460901; well SC01406634CDC Cormack 3 (lat 38°45'56", long 104°46'09)											
10-14-82	1400	--	6.8	1,150	844	27	<.020	7.90	.060	1.2	9.1
Site 384658104460001; well SC01406634CDD1 Cormack Domestic (lat 38°46'58", long 104°46'00"											
03-10-82	1400	--	7.4	1,030	686	55	<.020	3.90	.060	.71	4.6
07-09-82	1445	16.0	7.3	1,100	709	52	<.020	4.30	<.060	1.1	5.4
10-14-82	1435	--	6.7	986	686	43	<.020	4.60	<.060	1.2	5.8
12-20-82	1550	--	6.4	955	659	46	<.020	4.60	<.060	.70	5.3
Site 384551104462601; well SC01506603BBB Ball well (lat 38°45'51", long 104°46'26")											
10-13-82	1220	13.5	7.0	550	367	29	<0.020	15.0	<0.060	1.2	16
Site 384614104445701; well SC01506602CAD (lat°38'46'14", long 104°44'57")											
10-13-82	1500	13.0	7.2	1,240	865	39	<.020	27.0	.070	1.6	29
Site 384613104443601; well SC01506602DAC Burr well (lat 38°46'13", long 104°44'36")											
10-13-82	1430	12.0	7.8	1,420	1,080	35	<.020	9.50	.080	1.0	11
Site 384639104461401; well SC01506603BAC1 Mars Gas (lat 38°46'39", long 104°46'14")											
06-23-81	1450	16.5	6.8	884	659	23	.010	9.90	.070	1.0	11
07-01-82	1030	15.0	7.1	940	668	20	<.020	13.0	<.070	.90	14
Site 384643104463601; well SC01506604AAD CSTL CONC (lat°38'46"43, long 104°46'36")											
10-14-82	1300	--	6.4	708	477	18	<.020	5.00	.060	1.1	6.1
Site 384443104441801; well SC01506614ADD Camden (lat 38°44'43", long 104°44'18")											
06-25-81	1225	13.5	6.5	775	520	33	.000	6.80	.060	1.2	8.0
07-09-82	1120	14.0	7.0	820	549	34	<.020	4.00	.070	1.3	5.3
Site 384509104454801; well SC01506610DCD B Ditch well 1 (lat 38°45'09", long 104°45'48")											
06-22-82	1400	11.0	7.5	--	6,050	100	<.020	7.20	<.060	1.4	8.6

Table 11.0-2.--*Ground-water quality data*--Continued

Date	Time	Temperature (°C)	pH (standard units)	Specific conductance (μS/cm)	Dissolved-solids residue at 105°C (mg/L)	Dissolved chloride (mg/L as Cl)	Dissolved nitrite nitrogen (mg/L as N)	Dissolved nitrogen NO_2+NO_3 (mg/L as N)	Dissolved ammonia nitrogen (mg/L as N)	Dissolved nitrogen, ammonia and organic (mg/L as N)	Dissolved nitrogen (mg/L as N)
Site 384547104454801; well SC01506615ABA B Ditch well 2 (lat 38°45'47", long 104°45'48")											
06-22-82	1600	11.0	7.4	--	25,900	240	.040	1.00	1.10	3.3	4.3
Site 384409104440801; well SC01506624BBB Security Sewage Treatment Plant well (lat 38°44'09", long 104°44'08")											
06-25-81	1700	14.0	6.7	1,260	794	120	.000	5.90	4.20	5.5	11
07-09-82	1215	14.0	7.2	1,380	789	110	.190	4.00	2.40	3.0	7.0
Site 384448104441401; well SC01506613BCB2 Fountain Valley School (lat 38°44'48", long 104°44'14")											
08-19-81	1305	14.0	6.9	655	421	25	.030	6.40	.130	.93	7.3
07-02-82	1315	15.0	7.1	760	495	36	<.020	6.10	<.060	1.5	7.6
Site 384437104422601; well SC01506518DBA Fountain Valley School (lat 38°44'37", long 104°42'26")											
06-25-81	1335	14.0	7.1	1,620	1,280	52	.000	4.60	.060	.97	5.6
07-02-82	1215	12.5	7.3	1,620	1,350	45	<.020	3.40	.110	1.6	5.0
Site 384308104431601; well SC01506625ADA1 Rice Dom (lat 38°43'08", long 104°43'16")											
07-09-82	1315	13.0	7.4	1,520	1,080	61	<.020	5.10	<.060	1.0	6.1
Site 384308104431901; well SC01506625ADA2 Rice 2 (lat 38°43'08", long 104°43'19")											
08-09-82	1530	14.0	7.0	1,300	1,090	54	<.020	6.10	.110	.70	6.8
Site 384236104425401; well SC01506530CCD3 Finkbeiner (lat 38°42'36", long 104°42'54")											
07-01-82	1400	14.0	7.5	900	583	41	<.020	6.20	<.070	1.1	7.3
Site 384240104424501; well SC01506530CDA Francois (lat 38°42'40", long 104°42'45")											
07-01-82	1250	17.0	7.3	1,100	708	44	<.020	4.0	<.070	.90	4.9
Site 384349104411501; Black Squirrel pipe line (lat 38°43'49", long 104°41'15")											
06-25-82	1500	15.0	7.6	340	218	8.4	<.020	4.60	<.070	1.5	6.1

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