# Geochemical Characterization of Ground-water Flow in the Santa Fe Group Aquifer System, Middle Rio Grande Basin, New Mexico

**Water-Resources Investigations Report 03-4131**

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

Cover photo:

View looking west from the Sandia Mountains across the Albuquerque metropolitan area. Mount Taylor, approximately 30 miles west of the western boundary of the basin, appears on the horizon. The Rio Grande and the distinctive bosque of the inner valley are visible across the middle part of the image.

# Geochemical characterization of ground-water flow in the Santa Fe Group aquifer system, Middle Rio Grande Basin, New Mexico

By L. Niel Plummer, Laura M. Bexfield, Scott K. Anderholm, Ward E. Sanford, and Eurybiades Busenberg

---

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 03-4131

Reston, Virginia
2004

**U.S. DEPARTMENT OF THE INTERIOR**
GALE A. NORTON, *Secretary*

**U.S. GEOLOGICAL SURVEY**
Charles G. Groat, *Director*



---

For additional information write to:

District Chief
U.S. Geological Survey
Water Resources Discipline
5338 Montgomery NE, Suite 400
Albuquerque, New Mexico 87109-1311

Copies of this report can be purchased from:

U.S. Geological Survey
Information Services
Building 810
Box 25286, Federal Center
Denver, CO 80225-0286

# CONTENTS

## BACK POCKET

CD-ROM Containing:

1. Readme file
2. Electronic copy of this report in PDF format
3. Microsoft Excel spreadsheet containing data of appendix tables

## FIGURES

## TABLES

# CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED UNITS

## Conversion Factors

| Multiply | By | To obtain |
|---|---|---|
| acre | 4,047 | square meter |
| acre-foot (acre-ft) | 1,233 | cubic meter |
| cubic centimeters ($cm^3$) | 0.06102 | cubic inch |
| cubic foot per second ($ft^3/s$) | 0.02832 | cubic meter per second |
| foot (ft) | 0.3048 | meter |
| foot per mile (ft/mi) | 0.1894 | meter per kilometer |
| [1] foot squared per day ($ft^2/d$) | 0.0929 | meter squared per day |
| gallon per minute (gal/min) | 0.06309 | liter per second |
| gram (g) | 0.03527 | ounce |
| inch (in.) | 25.4 | millimeter |
| kilogram (kg) | 2.205 | pound |
| kilometer (km) | 0.6215 | mile |
| square kilometer ($km^2$) | 0.3861 | square mile |
| meter (m) | 3.281 | foot |
| mile (mi) | 1.609 | kilometer |
| square mile ($mi^2$) | 2.590 | square kilometer |
| millimeter (mm) | 0.03937 | inch |
| centimeter (cm) | 0.3937 | inch |
| becquerel per liter (Bq/L) | 0.027 | picocuries per liter |
| terra becquerels (TBq) | 27 | curies |
| tritium units (TU) | 3.19 | picocuries per liter |
| kilopascal (kPa) | 5.28 | atmosphere, standard |
| picogram (pg) | $1x10^{-12}$ | gram |
| femtogram (fg) | $1x10^{-15}$ | gram |

[1] The standard unit for transmissivity is cubic foot per day per square foot times feet of aquifer thickness [($ft^3/d$)/$ft^2$]ft. In this report, the mathematically reduced form, foot squared per day ($ft^2/d$), is used for convenience.

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) by using the formula: °F=(1.8)(°C) + 32.

Stable isotope ratios are reported as δ values computed from the formula

$$\delta_x = \left( \frac{R_x}{R_{STD}} - 1 \right) 1000$$

where $R_x$ is the ratio of the isotopes measured in the sample and $R_{STD}$ is the isotope ratio in the reference standard. The value of $R_x$ is in parts per thousand (per mil).

## Vertical Datum

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

## Base Credits

The base for the maps of the Middle Rio Grande Basin was compiled from several sources. The hydrography is from 1977-78 U.S. Geological Survey digital data, scale 1:100,000. Cultural features are from 1992 City of Albuquerque digital data, scale 1:2,400, and digitized from 1977-78 U.S. Geological Survey maps, scale 1:100,000. Other sources are noted on the maps themselves.

## Abbreviations

| | |
|---|---|
| kg | kilogram |
| L | liter |
| mL | milliliter |
| pg | picogram |
| mol | mole |
| µmol | micromole |
| fmol | femtomol |
| fg | femtogram |
| pptv | parts per trillion by volume |
| mg/L | milligrams per liter |
| µg/L | micrograms per liter |
| STP | standard temperature and pressure, 0 degrees Celsius and 1 atmosphere pressure |
| pCi/L | picocuries per liter |
| TU | tritium units |
| pmC | percent modern carbon |

# Geochemical Characterization of Ground-water Flow in the Santa Fe Group Aquifer System, Middle Rio Grande Basin, New Mexico

By L. Niel Plummer, Laura M. Bexfield, Scott K. Anderholm, Ward E. Sanford, and Eurybiades Busenberg

## ABSTRACT

Chemical and isotopic data were obtained from ground water and surface water throughout the Middle Rio Grande Basin (MRGB), New Mexico, and supplemented with selected data from the U.S. Geological Survey (USGS) National Water Information System (NWIS) and City of Albuquerque water-quality database in an effort to refine the conceptual model of ground-water flow in the basin. The ground-water data collected as part of this study include major- and minor-element chemistry (30 elements), oxygen-18 and deuterium content of water, carbon-13 content and carbon-14 activity of dissolved inorganic carbon, sulfur-34 content of dissolved sulfate, tritium, and dissolved atmospheric gases including nitrogen, argon, helium, chlorofluoro-carbons, and sulfur hexafluoride from 288 wells and springs in parts of the Santa Fe Group aquifer system. The surface-water data collected as part of this study include monthly measurements of major- and minor-element chemistry (30 elements), oxygen-18 and deuterium content of water, chlorofluorocarbons, and tritium content at 14 locations throughout the basin. Additional data include stable isotope analyses of precipitation and of ground water from City of Albuquerque production wells collected and archived from the early 1980's, and other data on the chemical and isotopic composition of air, unsaturated zone air, plants, and carbonate minerals from throughout the basin.

The data were used to identify 12 sources of water to the basin, map spatial and vertical extents of ground-water flow, map water chemistry in relation to hydrogeologic, stratigraphic, and structural properties of the basin, determine radiocarbon ages of ground water, and reconstruct paleo-environmental conditions in the basin over the past 30,000 years.

The data indicate that concentrations of most elements and isotopes generally parallel the predominant north to south direction of ground-water flow. The radiocarbon ages of dissolved inorganic carbon in ground water range from modern (post-1950) to more than 30,000 years before present, and appear to be particularly well defined in the predominantly siliciclastic aquifer system. Major sources of water to the basin include (1) recharge from mountains along the north, east and southwest margins (median age 5,000-9,000 years); (2) seepage from the Rio Grande and Rio Puerco (median age 4,000-8,000 years), and from Abo and Tijeras Arroyos (median age 3,000-9,000 years); (3) inflow of saline water along the southwestern basin margin (median age 20,000 years); and (4) inflow along the northern basin margin that probably represents recharge from the Jemez Mountains during the last glacial period (median age 20,000 years). Water recharged from the Jemez Mountains during the last glacial period occurs at the water table in the central part of the basin and beneath younger recharge along the Rio Grande and the northern mountain front.

In some parts of the basin, boundaries between hydrochemical zones appear to be near major faults that may affect ground-water flow. However, in other parts of the basin, such as along the east side of Albuquerque near the Sandia Fault zone, ground-water flow appears to be unaffected by major faults. Upward leakage of saline water occurs along some faults and can be a source of salinity and elevated arsenic concentrations in some ground water.

A trough in the modern and predevelopment water table west of Albuquerque is centered along a zone of predominantly late Pleistocene age water through the center of the basin and is flanked and overlain along the trough boundary by water that infiltrated from the Rio Puerco on the west and the Rio Grande to the east. It is suggested that the ground-water trough is a relatively recent transient feature of the Santa Fe Group aquifer system.

At Albuquerque, a distinct north-south boundary in deuterium content of ground water marks the division between recharge from the eastern mountain front and that from the Rio Grande. Water beneath approximately two-thirds of the City of Albuquerque is predominantly of Rio Grande origin infiltrated from areas north of the city.

The stable isotope data for ground water in the vicinity of Albuquerque indicate little movement of ground water in response to withdrawals from public supply wells during the past 20 years, even though in places the modern water table has fallen as much as 140 feet below the predevelopment potentiometric surface. Small shifts over the past 20 years in stable isotope composition of water discharged from public supply wells along the boundaries between the West-Central zone (paleowater) and Central zone (Rio Grande water) west of the Rio Grande, and along the boundary between the Central zone and Eastern Mountain Front zone east of the Rio Grande indicate local areas where paleowater of Rio Grande origin is beginning to move west and east in response to ground-water pumping.

Age gradients from piezometer nests range from 0.1 to 2 yr $cm^{-1}$ and indicate a recharge rate of about 3 cm $yr^{-1}$ for recharge along the eastern mountain front and infiltration from the Rio Grande near Albuquerque. There has been appreciably less recharge along the eastern mountain front in areas both north and south of Albuquerque.

The $\delta^2H$ isotopic composition of water, and recharge temperatures based on dissolved $N_2$ and Ar data, were interpreted in conjunction with the radiocarbon age to improve understanding of water source, and mechanism and timing of recharge. The $N_2$-Ar recharge temperatures vary widely throughout the MRGB. The minimum recharge temperature for a particular hydrochemical zone appears to be near the mean annual temperature, and the maximum recharge temperature approaches that of ground water beneath the deep (greater than 300 feet) unsaturated zones. The dissolved gas recharge temperatures demonstrate cases of both focused (cold recharge temperatures) and diffuse flow (warm recharge temperatures) recharge mechanisms in the predominantly semi-arid MRGB.

During the last glacial period, water recharged to the West-Central zone varied widely in stable isotope composition and recharge temperature, indicating the occurrence of both diffuse and focused recharge of low- and high-altitude precipitation. The range in $\delta^2H$ of West-Central zone waters from the last glacial maximum (LGM, approximately 18,000 radiocarbon years before present, B.P.), indicates recharge that occurred over a 4,000-foot range in altitude.

Ground water in the Central zone was recharged by direct infiltration from the Rio Grande and apparently records surface-water temperature and stable isotopic composition at the time of recharge. The dissolved $N_2$-Ar data indicate that the average temperature of water infiltrated from the Rio Grande varied by only about ± 1 degree Celsius (°C) from the modern mean annual temperature (13.6°C) at Albuquerque over the past 27,000 years. Rio Grande water was coldest (12.7 ± 1.4°C) during the period 15,000-27,000 years B.P., and warmest (14.5 ± 1.4°C) during the period 5,000-9,000 years B.P., and averaged 13.0 ± 2.2°C during the past 5,000 years. Together, the stable isotope data and dissolved gas recharge temperatures indicate that in the past, the timing of the spring runoff of northern New Mexico and southern Colorado snowmelt varied, coming late into early- to mid-summer during cold periods and overlapping, in part, with the summer monsoon season (currently July-October). During warm periods, such as modern times, the peak discharge of the Rio Grande occurred in mid- to late spring in advance of the summer monsoon season.

Recharge temperatures from approximately 20,000 radiocarbon years ago were as low as 3.2°C, as recorded in the dissolved gas composition of water recharged north of the basin, and 8.1°C along the eastern mountain front. During the last 5,000 years, the $\delta^2H$ isotopic composition of eastern mountain front recharge has decreased about 7 per mil. This decrease indicates an average cooling of about 1.4°C following the mid-Holocene warm period. Over the same time span, the $\delta^2H$ isotopic composition of Rio Grande water increased approximately 6 per mil, consistent with a shift in season of peak snowmelt into the beginning of the summer monsoon season.

The $\delta^{13}C$ isotopic composition of dissolved inorganic carbon in ground water is remarkably constant throughout most of the basin indicating a nearly constant historical predominance of $C_4$ over $C_3$ plants. However, recent recharge along the basin margins indicates a rather abrupt increase in $C_3$ plant abundance during the past 1,000 years, and perhaps even more recently than 1,000 years, as recorded in depleted $\delta^{13}C$ isotopic compositions of dissolved inorganic carbon (DIC).

This study demonstrates the benefits of obtaining a diverse and extensive chemical and isotopic dataset when characterizing hydrochemical processes in ground-water systems, retrieving historical environmental records from ground water, and/or refining conceptual models of ground-water system.

## INTRODUCTION

The Middle Rio Grande Basin (MRGB) of central New Mexico (fig. 1) recently was the subject of a multi-year (1995-2001) inter-disciplinary investigation by the U.S. Geological Survey (USGS) and other agencies to improve understanding of the water resources in the basin (Bartolino and Cole, 2002). The population of the basin, which includes the City of Albuquerque, increased approximately 119 percent between 1970 and 2000, from about 314,900 to 690,000 people (Bartolino and Cole, 2002). Since the mid-1940's, groundwater withdrawals in the vicinity of Albuquerque have resulted in declines in water levels in excess of 120 feet (Bexfield and Anderholm, 2002b). Hawley and Haase (1992) showed that the highly productive sediments of the Santa Fe Group aquifer system, from which the City of Albuquerque obtains its water supply, are much less extensive and thinner than previously thought (Bjorklund and Maxwell, 1961; Reeder and others, 1967). A series of investigations, including the 6-year USGS study, were conducted beginning in the early 1990's to improve understanding of the geohydrologic framework and hydrologic conditions in the aquifer system (Hawley and Haase, 1992; Thorn and others, 1993; Thomas, 1995; Hawley and others, 1995; Kernodle and others, 1995; Constantz and Thomas, 1996; Haneberg and Hawley, 1996; Hawley, 1996; McAda, 1996; Anderholm, 1997; Bexfield and Anderholm, 1997, 2000, 2002; Stone and others, 1998; Tiedeman and others, 1998; Connell and others, 1998; Grauch and others, 1999, 2001; Bexfield and others, 1999; Bartolino and Niswonger 1999; Anderholm 2001; Plummer and others, 2001; Sanford and others, 2001; Connell 2001; McAda and Barroll 2002; Bartolino and Cole 2002; Sanford and others, 2004), and to incorporate the new information into improved versions of the USGS groundwater-flow model for the basin (Kernodle and Scott, 1986; Kernodle and others, 1987; Kernodle and others, 1995; Kernodle 1998; McAda and Barroll 2002). This report presents results from a part of the 6-year USGS investigation, in which chemical and isotopic data from groundwater in the MRGB were used to identify and map groundwater flow of various sources of water to the basin, evaluate radiocarbon ages, and refine the conceptual model of the Santa Fe Group aquifer system.

Previous investigations in other ground-water basins (see for example, Plummer and others, 1990; Busby and others, 1991; Robertson, 1991; Parkhurst and others, 1995; Thomas and others, 1996; Plummer and Sprinkle, 2001) have demonstrated that the chemical and isotopic compositions of water can be extremely useful in identifying geochemical and hydrologic processes in ground-water systems. For example, major- and minor-element chemistry can help to delineate the spatial extent of waters of similar chemical composition and to determine the amounts of evaporation and the types of rocks and minerals in the ground-water-flow system. Stable isotopes of water can be used to identify different sources of water and the particular altitude and/or climatic conditions at which recharge occurred. Selected radioactive isotopes can be used to determine ground-water ages, which are useful in calculating flow rates and recharge rates. Dissolved gases in water help to determine mechanisms of ground-water recharge. The use of isotopes and dissolved gases, in combination with other essential hydrologic and geologic information, can provide a detailed and accurate picture of the movement of water through a ground-water-flow system.

The data set collected for this chemical and isotopic study of ground water in the MRGB is uniquely large and comprehensive. A total of 288 wells and springs were sampled for a wide variety of constituents. Data discussed in this report include major and minor elements, stable isotopes of water ($^{2}H$ and $^{18}O$), stable carbon isotopic composition ($^{13}C$) of dissolved inorganic carbon (DIC), stable sulfur isotopic composition ($^{34}S$) of dissolved sulfate ($SO_4$), and radioactive carbon isotopic composition ($^{14}C$) of DIC.

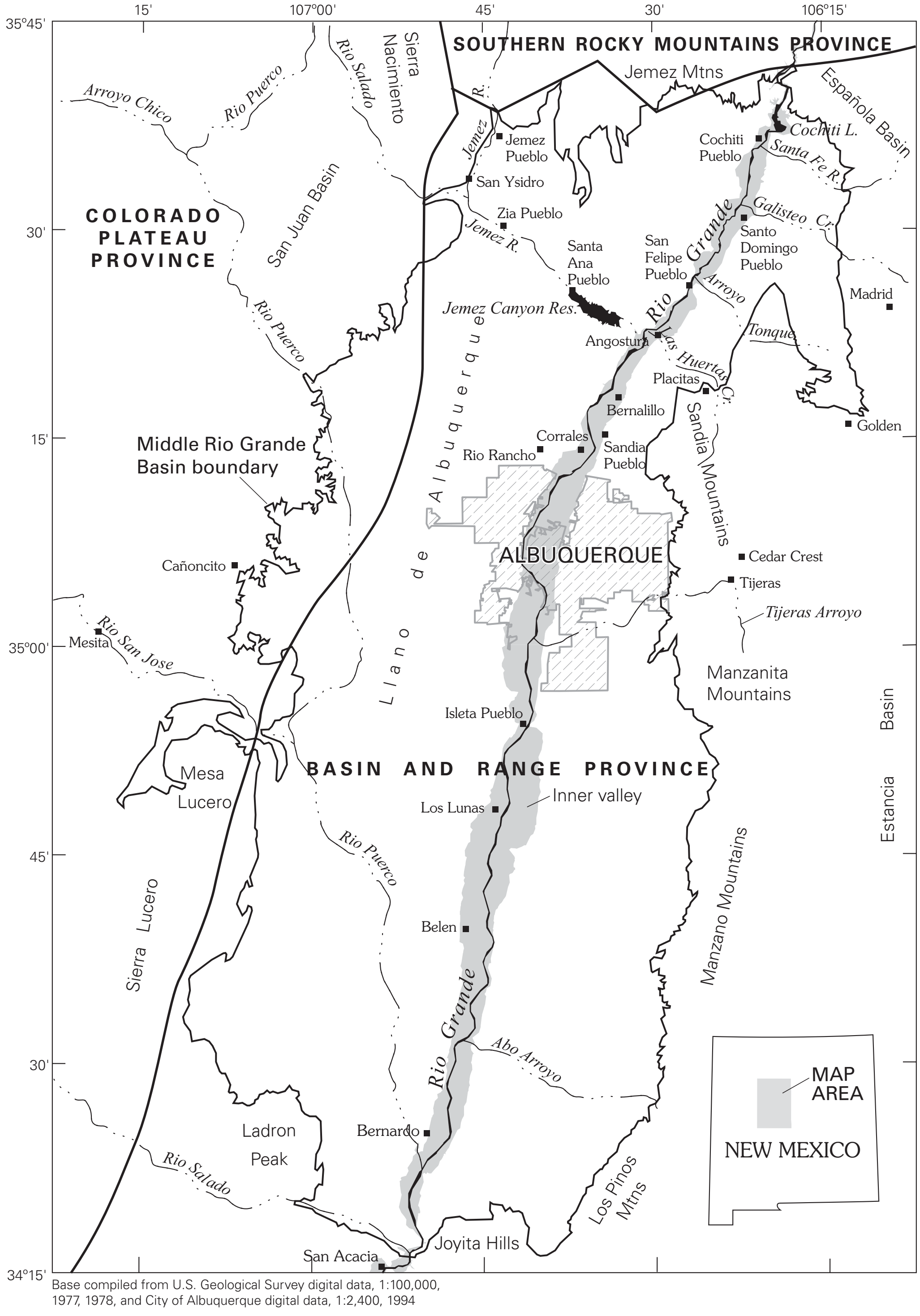



**Figure 1.** Selected physiographic features of the Middle Rio Grande Basin and vicinity, New Mexico.

Data for concentrations of dissolved nitrogen ($N_2$), argon (Ar), helium (He), neon (Ne), sulfur hexafluoride ($SF_6$), chlorofluorocarbons (CFCs), tritium ($^3H$), and tritiogenic helium-3 ($^3He_{tri}$) also are presented. These chemical and isotopic data are synthesized to permit identification of particular ground-water-recharge sources and processes and of ground-water-flow paths and travel times. Sanford and others (2004) discuss use of the results of this chemical and isotopic investigation to refine the USGS ground-water-flow model for the basin, as given in McAda and Barroll (2002).

## Purpose and Scope

For this study, selected chemical and isotopic data from ground water of the Santa Fe Group aquifer system in the MRGB have been examined to improve understanding of the hydrologic system. Particular purposes of this investigation were to: (1) characterize the chemical composition of water in the aquifer system and delineate areas of similar properties; (2) identify individual sources and mechanisms of ground-water recharge; (3) delineate ground-water-flow paths and areas of mixing; (4) determine the major physical and chemical processes affecting chemical and isotopic compositions; (5) determine ground-water ages and calculate associated travel times; and (6) estimate historical and recent recharge rates for the basin.

This report describes the distributions of chemical and isotopic parameters in ground water of the MRGB and relates these parameters to the current knowledge of the hydrogeology of the basin and potential sources of recharge to the aquifer system. Supplementary chemical and isotopic data for surface water, air, solids, and unsaturated-zone gas also are discussed. In addition to chemical data collected specifically in connection with this MRGB study, the report includes selected historical data from the USGS National Water Information System (NWIS) database and the City of Albuquerque. Geochemical processes in the aquifer system are modeled and used to test sensitivity of radiocarbon age of ground water to uncertainties in geochemical reactions. The radiocarbon ages are combined with other chemical, geologic, and hydrologic data to retrieve from the aquifer system information about variations in ground-water age with depth and timing of other hydrologic and environmental processes occurring in the basin over the past 30,000 years.

## Previous Investigations

Thorn and others (1993) and Bartolino and Cole (2002) provide comprehensive overviews of the geohydrology of the MRGB (otherwise known as the Albuquerque Basin) and refer to most of the key publications that have contributed to the current knowledge. Therefore, only the investigations most relevant to the current study are mentioned here. Kelley (1977) and Lozinsky (1988) provided detailed studies of the basin geology, including structure and stratigraphy, and Hawley and Haase (1992) focused particular attention on the hydrogeology of the Santa Fe Group aquifer system in the Albuquerque area. Anderholm (1985) provided mineralogic data for some aquifer materials. Russell and Snelson (1990) investigated the deep structure of the basin, and Heywood (1992) presented data on isostatic residual gravity anomalies that could be used to estimate basin thickness and geometry. Investigations of ground-water resources within individual counties of the basin were conducted by Spiegel (1955) for Socorro County, Titus (1963) for Valencia County, and Bjorklund and Maxwell (1961) for Bernalillo and Sandoval Counties.

Subsequent to publication of the report by Thorn and others (1993), numerous additional studies of the geology and hydrology of the MRGB have been conducted, many of which are part of the multidisciplinary 6-year effort by the USGS and other agencies to improve understanding of the water resources of the basin. Bartolino and Cole (2002) describe these studies in some detail. Studies included in this effort include investigations of fault locations (Minor and Shock, 1998) and lithologic variations using high-resolution aeromagnetic data (Grauch and others, 1999; 2001), estimation of mountain-front recharge using environmental tracers (Anderholm, 2001; Niswonger and Constantz, 2001), and investigation of interaction between the Rio Grande and the aquifer system (Bartolino and Niswonger, 1999). In addition, Bexfield and Anderholm (2000) published a predevelopment water-level map for the MRGB.

Various investigations have focused on the geochemistry of ground water in the MRGB. Anderholm (1988) presented a detailed study of the geochemical data available for the basin at that time and the implications of geochemistry for recharge sources and for chemical processes occurring in the aquifer system. Logan (1990) conducted a similar type of study for the Albuquerque area using geochemical data then available primarily for municipal-supply wells. Bexfield and others (1999) summarized data that had been collected over a 10-year period by the City of Albuquerque from its municipal-supply wells; Bexfield and Anderholm (2002a) discussed the implications of those data for the aquifer system of the Albuquerque area.

## Acknowledgments

The successful completion of this study required the contributions of a large number of people. Some people provided assistance in the form of advice about the information needed to improve knowledge of the aquifer system, whereas others graciously provided access to their lands and information about their wells, and still others assisted in searching for wells in the field, collecting samples, and analyzing water samples. The authors thank the numerous individual landowners who provided access to their wells. In addition, the authors wish to particularly acknowledge the contributions of those people and agencies listed below, and apologize to those we have inadvertently overlooked.

Many of the Indian Pueblos with lands located in the MRGB participated in this study by providing permission to sample wells, in addition to assistance in locating both wells and records of well construction. Therefore, the authors thank the Governors, Governors' staffs, and environmental departments' staffs of the Pueblos of Cochiti, Isleta, Jemez, Sandia, San Felipe, Santa Ana, Santo Domingo, and Zia. The authors also thank Bill White with the Bureau of Indian Affairs for his assistance in contacting the Pueblos and his advice about the most appropriate wells for sampling. Also, water samples from many of the windmills on Pueblo lands could not have been obtained without the generous assistance of John Sanchez and the windmill crew of the Southern Pueblos Agency.

Individuals from many Federal, State, and local agencies provided access to wells and assisted in locating the most appropriate wells for sampling. Those agencies include the U.S. Forest Service, the Bureau of Land Management, the U.S. Fish and Wildlife Service, Kirtland Air Force Base, Sandia National Laboratories, the New Mexico Office of the State Engineer, the New Mexico Environment Department, the University of New Mexico, the City of Albuquerque, the City of Belen, and the Town of Los Lunas. Doug Earp and others with the City of Albuquerque Environment Department were particularly helpful both in locating monitoring wells to sample and in contributing their time and equipment to obtaining water samples from deep piezometer nests drilled by the City of Albuquerque in cooperation with the USGS. Individuals from the City of Albuquerque Water Utility Division also spent a great deal of time and effort providing access to many city production wells and collecting water samples from each well for analysis of stable isotopes of H and O. The advice and assistance of Linda Logan of the New Mexico Office of the State Engineer is gratefully acknowledged.

Many utilities and other businesses also generously provided access to wells. These include Rio Rancho Utilities, Rio Grande Utilities, Sandia Peak Utility Company, National Utilities, New Mexico Utilities, DRESCO, Intel, AT&T, King Brothers Ranch, and the Huning Ltd. Partnership.

The authors thank the many individuals in the Reston, Virginia office of the USGS who performed most of the sampling and analysis that made this study possible. These people include Jerry Casile, Mike Doughten, Julian Wayland, Peggy Widman, Andrew Stack, Anne Burton, and Daniel Webster. Numerous analyses of stable H and O isotopic composition of water, and of stable S and C isotopic compositions of dissolved $SO_4$ and dissolved inorganic carbon were provided by Tyler Coplen, Kinga Revesz, and the staff of the U.S. Geological Survey Stable Isotope Laboratory, Reston, Virginia. We thank Robert L. Michel, USGS, Menlo Park, California for numerous tritium measurements. Personnel in the Albuquerque, New Mexico office of the USGS also contributed a great deal of effort to locating and/or sampling of wells. These individuals include Fred Gebhardt, R.K. DeWees, Jim Bartolino, Joe Sterling, Carolina Trevizo, and Lori Shue.

The authors thank Doug McAda, Mark Hudson, and Scott Minor of the USGS, Fred Phillips of New Mexico Tech, and John Hawley and Sean Connell of the New Mexico Bureau of Geology and Mineral Resources (NMBGMR) who shared their knowledge and advice about the hydrology and geology of the basin. The report was improved by the technical reviews of Jim Bartolino and Don Thorstenson (USGS). Finally, the authors are grateful to Brian Norton, David Jones, Angel Martin, and Ami Mitchell (USGS) for their assistance in preparing the final document for publication.

# DESCRIPTION OF THE STUDY AREA

The MRGB is located in the Basin and Range physiographic province of central New Mexico (fig. 1). The basin, which covers about 3,060 square miles and contains basin-fill deposits up to about 14,000 feet thick (Thorn and others, 1993), is among a series of alluvial basins that are located in the Rio Grande rift and contain deposits that constitute important aquifers for the region. The basin boundaries have been defined by the extent of Cenozoic deposits. The basin is surrounded partly by mountain ranges, which include the Jemez Mountains to the north, the Sandia, Manzanita, Manzano, and Los Pinos Mountains to the east, and the Joyita Hills and Ladron Peak to the south (fig. 1). Lower topographic relief occurs along the west side of the basin, which is bounded by the Lucero and Nacimiento uplifts and the Rio Puerco fault zone. Within the basin, piedmont slopes extend from the eastern mountain fronts toward the main drainage, the Rio Grande, which is inset in a terraced valley with a flood plain up to about 4.5 miles wide. The Rio Puerco also is inset in a terraced valley; the high mesa between these two drainages has been designated the Llano de Albuquerque (Hawley and Haase, 1992). Land-surface altitude above sea level ranges from about 4,700 feet at the southern end of the basin to about 8,000 feet on the flanks of the Sandia and Monzano mountains.

Most land in the MRGB is classified as rangeland, whereas other land-use types and land cover (in order of decreasing area) are forest, urban, agriculture, barren land, and water (Thorn and others, 1993). Most rangeland is classified as "mixed" and most forests consist primarily of piñon and juniper, except in riparian areas where they consist largely of phreatophytes. Urban areas include the City of Albuquerque, which is the largest city in New Mexico. In 2000, the population of the Albuquerque metropolitan area was about 712,700 people (U.S. Census Bureau, 2001). All of the communities in the basin rely primarily on ground water for domestic and industrial uses. Agricultural land is confined primarily to the Rio Grande flood plain, where depth to water generally is less than about 25 feet (Anderholm, 1997). Most agriculture is irrigated with surface water that is diverted from the Rio Grande into a system of canals. Riverside and interior ground-water drains in the flood plain maintain ground-water levels several feet below land surface.

## Climate

The climate of the MRGB generally is categorized as semiarid, although the climate in parts of the surrounding mountainous areas ranges to humid continental (Thorn and others, 1993). As a result of altitude differences, precipitation in the region varies widely with location. For the period of record (variously between 1914 and 2003), weather stations at lower altitudes within the basin (Bernardo and the Albuquerque Airport, respectively) showed mean annual precipitation from 7.9 to 8.6 inches (table 1 and fig. 2). Mean annual precipitation at weather stations in surrounding areas of higher altitude (Sandia Park and Mountainair, respectively) was 19.0 and 14.3 inches. Mean annual snowfall ranged from 4.0 inches at Bernardo to 58.7 inches at Sandia Park.

At lower altitudes, most precipitation occurs between the months of July and October (fig. 3a). Precipitation during this time comes primarily from high-intensity thunderstorms of relatively short duration. Most winter precipitation is from lower-intensity storms of longer duration. Winter storms make a greater contribution to annual precipitation at higher altitudes, although the months of July through September in these areas tend to be wettest (fig. 3b). Total annual precipitation at any particular location can be quite variable from year to year. At the Albuquerque Weather Service Forcast Office (WSFO) Airport location, total annual precipitation between 1914 and 2003 ranged from 3.29 to 15.88 inches; at Sandia Park (1935-2001), the range was from 9.96 to 32.76 inches (fig. 2). Annual potential evaporation in the region is substantially greater than annual precipitation, ranging from less than 50 inches in the eastern part of the basin to more than 60 inches in the southern and central parts of the basin (Thorn and others, 1993).

Characteristics of the climate in the MRGB include large daily temperature changes and low humidity. For the period of record (table 1), the average difference between daily maximum and minimum temperatures was 14.9°C at the Albuquerque WSFO Airport and 16.0°C at Sandia Park. Mean annual temperatures for weather stations in the region range between 9.6 and 13.6°C (table 1). For the period 1914-2003, mean monthly temperatures at the Albuquerque Airport ranged from 1.8°C in January to 25.6°C in July.

**Table 1.** Climatic data from selected stations in the Middle Rio Grande Basin, New Mexico, and vicinity, period of record

[From Western Region Climate Center, Desert Research Institute, http://www.wrcc.dri.edu/summary/climsmnm.html]

| Station name | Station altitude (feet) | Period of record | Mean January temperature (°C) | Mean July temperature (°C) | Mean annual temperature (°C) | Mean annual precipitation (inches) | Mean annual snowfall (inches) |
|---|---|---|---|---|---|---|---|
| Albuquerque WSFO AP[1] | 5,309 | 1914-2003 | 1.8 | 25.6 | 13.6 | 8.6 | 9.9 |
| Sandia Park | 7,019 | 1935-2001 | -0.8 | 20.6 | 9.6 | 19.0 | 58.7 |
| Bernardo | 4,735 | 1933-2003 | 1.8 | 25.1 | 13.3 | 7.9 | 4.0 |
| Mountainair | 6,520 | 1914-2003 | 0.3 | 21.8 | 10.8 | 14.3 | 24.6 |

[1]WSFO AP is Weather Service Forecast Office at Albuquerque Airport

## Surface Water

### Rio Grande

The main surface drainage for the MRGB is the Rio Grande, which extends the entire length of the basin (fig. 1). The headwaters of the Rio Grande are located in the San Juan Mountains of southwestern Colorado, which exceed 13,500 feet in altitude (Ellis and others, 1993). Prior to entering the basin, the present-day Rio Grande is affected by irrigation diversions and return flows, reservoirs on its tributaries—completed as early as 1913 (Crawford and others, 1993)—and inflow that includes surface water diverted from the San Juan River Basin. Where it enters the MRGB, the Rio Grande has a drainage area of about 14,900 square miles.

Within the basin, the configuration of the river and its seasonal discharge patterns have been altered by man-made structures. Prior to regulation, the Rio Grande probably was a perennial, braided river that migrated back and forth across the flood plain, with its discharge reflecting seasonal snowmelt and storm events (Crawford and others, 1993). The frequency of periodic flooding increased as a result of greater sediment deposition associated with land-use activities, so that a system of levees and jetty jack works was emplaced during the 1920's-50's to confine the river to a single channel. Also during this time period, the system of irrigation canals in the valley was improved and levees and interior and riverside drains were constructed. The drains lowered the water table so that lands that had been waterlogged by previous canal leakage and irrigation could be reclaimed.

Substantial irrigation diversions both upstream and downstream of Albuquerque affect the discharge of the Rio Grande. Norman (1968) reports that as a result of irrigation diversions, the river channel has been completely dry at times below the town of Bernalillo. Since 1973, the discharge of the Rio Grande has been regulated by Cochiti Dam at the north end of the basin for flood and sediment control. Regulation has resulted in greater discharge throughout the irrigation season and an otherwise more even seasonal distribution of discharge than would be expected under "natural" conditions (fig. 4). For water years (the water year is from October 1 through September 30, and named for the 2$^{nd}$ of the two years spanned) 1974-98, the mean annual discharge of the Rio Grande at Albuquerque was about 1,450 cubic feet per second (Ortiz and others, 1999).

The Rio Grande alternately gains and loses flow through the MRGB. At the north end of the basin, ground-water inflow apparently adds to discharge in the river between Cochiti Dam and San Felipe; Trainer and others (2000) measured increases in discharge between these two sites on individual days in February of 1974. In the vicinity of Albuquerque, seepage of water to the aquifer system is known to occur from both the Rio Grande and its associated irrigation system. Although the exact quantity of seepage is uncertain, ground-water temperature profiles obtained beneath the river near Albuquerque by Bartolino and Niswonger (1999) were used to estimate downward fluxes of about 0.058 to 0.12 feet per day. Spiegel (1955) indicates that in Socorro County, at the south end of the basin, the inner valley of the Rio Grande gains ground water from the adjacent mesas, but the river channel actually might lose water naturally to the inner valley because evapotranspiration in the inner valley is greater than inflow from the mesas. The chemistry of water in the Rio Grande and implications

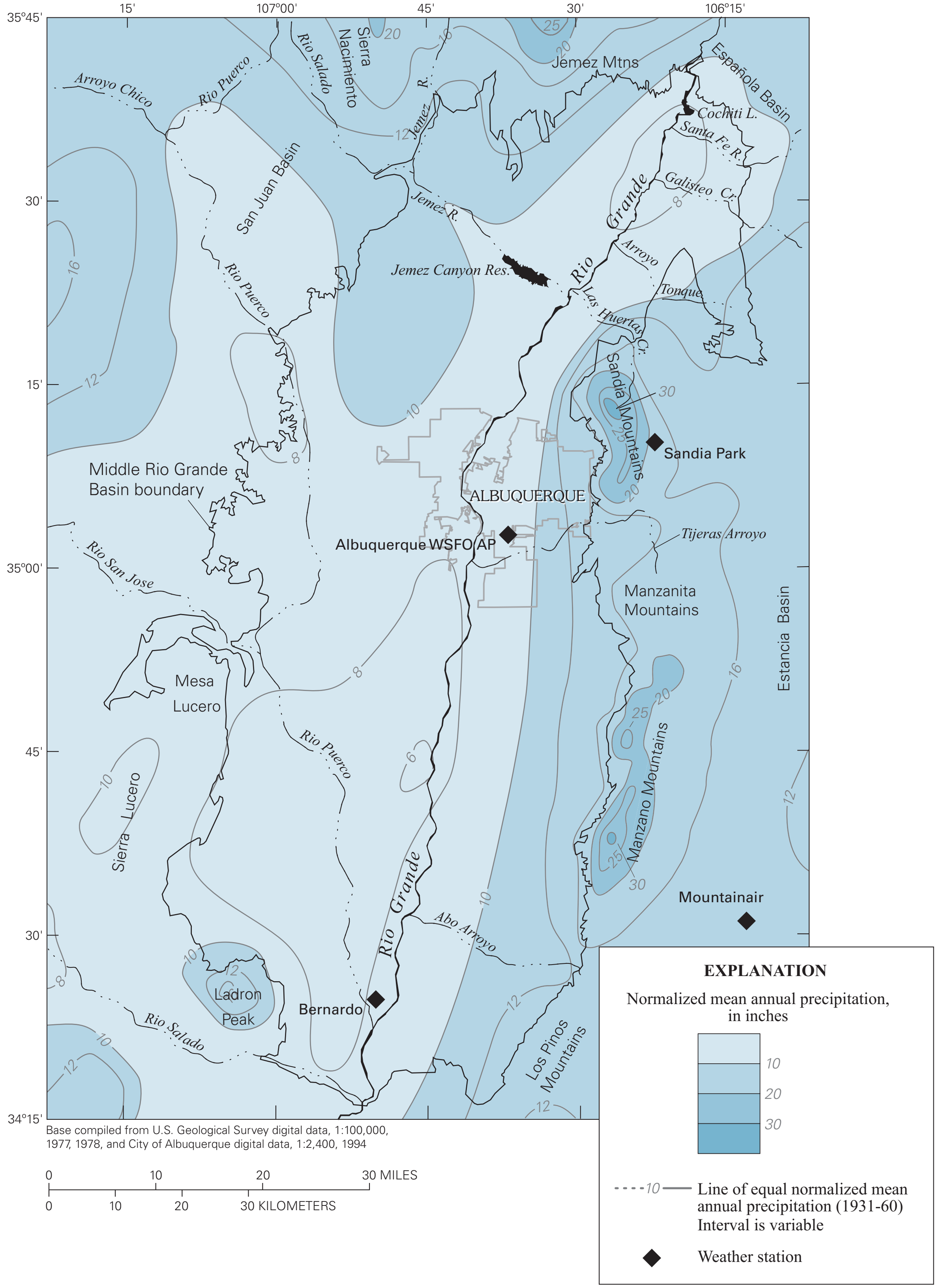



**Figure 2.** Normalized mean annual precipitation in the Middle Rio Grande Basin and vicinity, central New Mexico, 1931-60. (from U.S. Department of Commerce, no date).

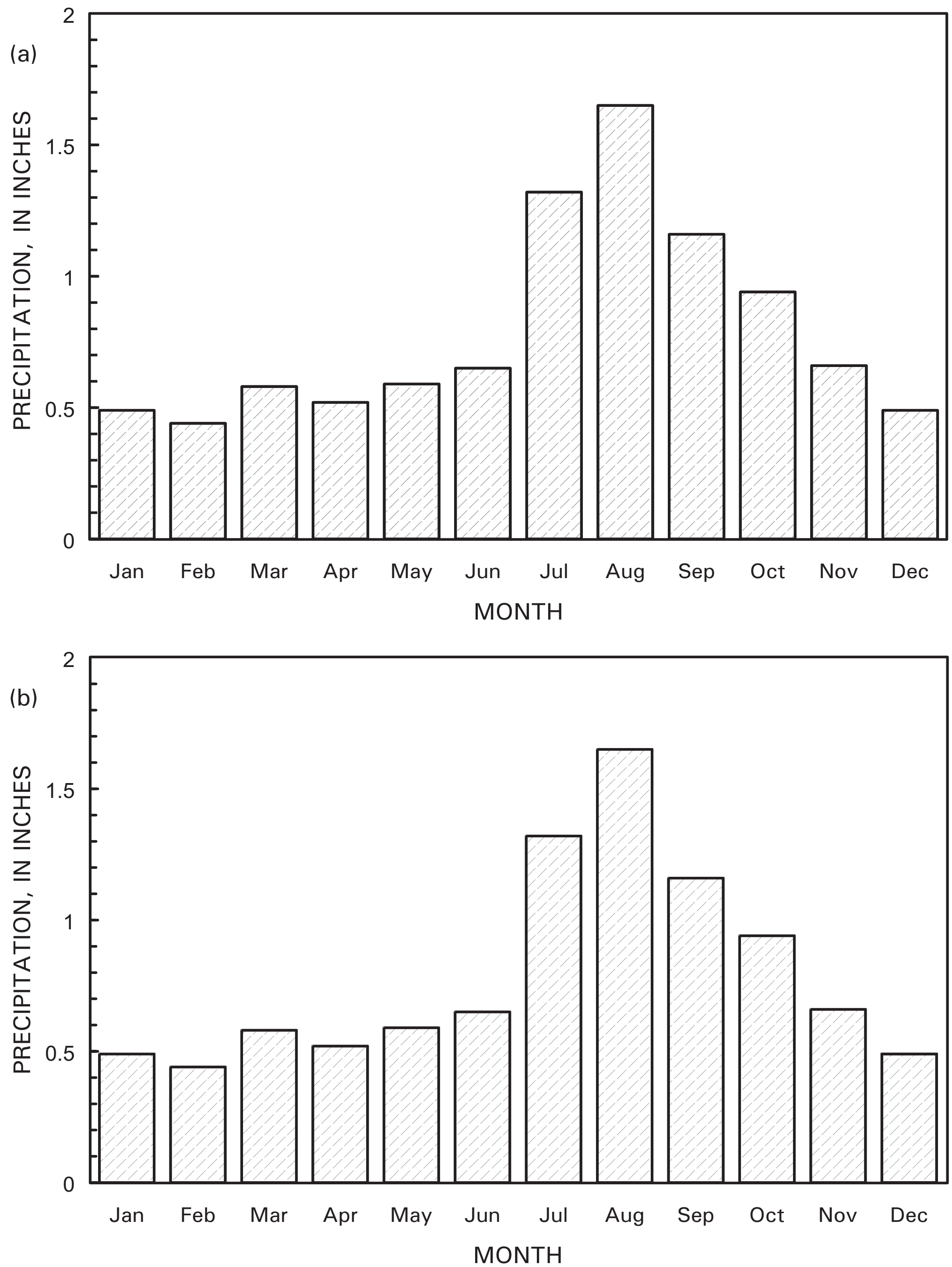



**Figure 3.** Average monthly precipitation at the (a) Albuquerque Airport and (b) Sandia Peak stations, New Mexico, 1971-2000.

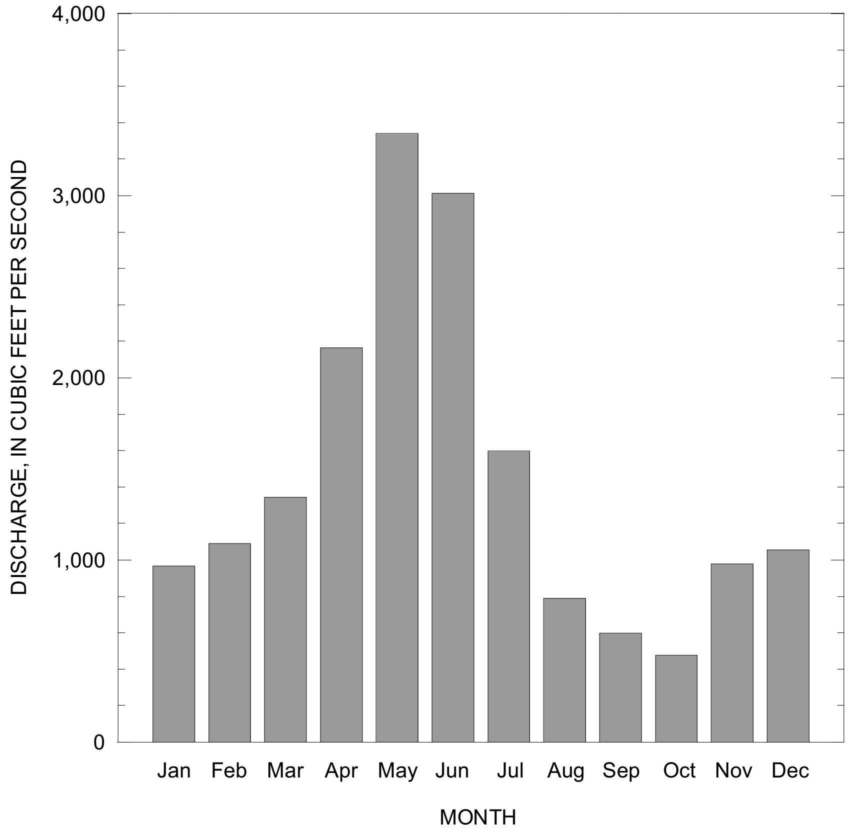



**Figure 4.** Mean monthly discharge for the Rio Grande at Albuquerque, New Mexico, water years 1974-98.

of the infiltration of river water for ground-water chemistry are discussed in the sections "Sources of Recharge and Underflow to the Santa Fe Group Aquifer System" and "Tracing Sources of Water in the Middle Rio Grande Basin-- Definition of Hydrochemical Zones and Water Sources".

### Tributaries

Although the Rio Grande and Santa Fe River are the only perennial streams in the MRGB, several tributaries can contribute substantial flow to the Rio Grande, and potentially can contribute substantial quantities of recharge to the underlying aquifer system. Of the tributaries for which detailed streamflow records are available, the Jemez River and the Rio Puerco are among the largest (fig. 1). However, numerous ephemeral channels also can carry substantial quantities of water to the Rio Grande during large storm events. In addition, man-made channels, such as ground-water drains and flood-diversion channels, also are tributary to the Rio Grande. The chemistry of water in tributaries to the Rio Grande and implications for the chemistry of the Rio Grande and for the aquifer system because of infiltration are discussed in the section "Sources of Recharge and Underflow to the Santa Fe Group Aquifer System".

The Jemez River originates in the Jemez Mountains at the north end of the basin (fig. 1), which exceed 11,000 feet in altitude. In its upper reaches, the river receives substantial contributions from both ground-water discharge, including discharge from some geothermal springs, and snowmelt, which typically contributes most of the discharge from March through June. Runoff from summer thunderstorms also contributes flow. At the Jemez River near Jemez, the mean annual discharge for 1954-98 was 79.6 cubic feet per second; on average, about 70 percent of the total annual discharge was recorded from March through June (Ortiz and others, 1999). Upstream of the town of Jemez, the river drains an area consisting primarily of Precambrian crystalline rocks, Paleozoic sandstone, shale, and limestone, and Tertiary and Quaternary volcanic rocks (Craigg, 1992). Shortly after entering the MRGB, the Jemez River is joined by the Rio Salado, which drains Cretaceous, Jurassic, and Triassic rocks in a semiarid area west of the Sierra Nacimiento (Craigg, 1992). From there, the Jemez River flows primarily southeast across basin-fill sediments toward the Rio Grande. Seepage investigations conducted by Craigg (1992) showed seasonal variations in the tendency for the Jemez River to lose or gain flow between the Jemez River near the Jemez streamflow gage and Santa Ana Pueblo (fig. 1). During March, the river generally gained throughout this reach, while during August (when evapotranspiration is high) the river was a losing stream between Zia and Santa Ana Pueblos.

Discharge of the Jemez River to the Rio Grande has been regulated since 1953 by Jemez Canyon Dam (intended solely for desilting and flood control); the mean average discharge below the dam was 62.6 cubic feet per second for 1943-98 (Ortiz and others, 1999). Where the Jemez River meets the Rio Grande north of Bernalillo, its drainage area is about 1,050 square miles (Craigg, 1992).

The Rio Puerco enters the MRGB from the San Juan Basin to the northwest (fig. 1). Near its headwaters, the Rio Puerco drains Precambrian and Paleozoic rocks on the west side of San Pedro Mountain, in the vicinity of Cuba, New Mexico. However, upstream of the MRGB, most of the drainage area of the Rio Puerco is underlain by Cretaceous sedimentary rocks (Spiegel, 1955). Once within the basin, the river flows over primarily Quaternary and Tertiary deposits. Risser and Lyford (1983) state that for the 1935-76 water years, a discontinued streamflow gage (Rio Puerco at Rio Puerco) located about 6 miles downstream from the confluence of the Rio Puerco and the Rio San Jose showed that the Rio Puerco was dry about 50 percent of the time; the mean annual discharge was about 58 cubic feet per second. About 77 percent of the total annual discharge at the site occurred during the summer storm season of July through October. During the remainder of the year, most of the flow was contributed by the Rio San Jose, which drains areas underlain by Triassic, Jurassic, and Cretaceous rocks (Spiegel, 1955).

The Rio Puerco meets the Rio Grande just south of Bernardo (fig. 1), where its drainage area is about 7,350 square miles and its mean annual discharge (at the Rio Puerco near Bernardo) was 42.5 cubic feet per second for water years 1940-98 (Ortiz and others, 1999). Records of discharge for 1940-47 for the Rio Puerco at Rio Puerco and the Rio Puerco near Bernardo indicated that this reach of the river lost an average of at least 5,800 acre-feet per year (Spiegel, 1955). The Rio Puerco channel historically has undergone large-scale, rapid changes; over about the past 3,000 years, the channel has experienced three episodes of aggradation and incision (Elliot and others, 1999). The most recent episode of incision began in the late 1880’s. As a result of incision, the Rio Puerco carries a high suspended-sediment load that averages about 2,580,000 tons per year (Ellis and others, 1993).

Tijeras Arroyo enters the MRGB just south of the Sandia Mountains (fig. 1). The arroyo drains mainly Paleozoic and Precambrian rocks at altitudes up to about 9,800 feet and has a drainage area of about 99.3 square miles where it enters the basin (Anderholm, 2001). Although flow in Tijeras Arroyo is perennial in some sections east of the basin because of spring and ground-water discharge, water in the arroyo typically infiltrates a short distance inside the MRGB boundary because of the permeability and thickness of basin-fill sediments. In response to storm runoff (particularly during the summer), the arroyo intermittently flows to the Rio Grande. Streamflow gages located about 1,500 feet apart were operated near the mountain front for the periods April 1943-June 1949 and May 1989-September 1991. Data from these sites indicate that the arroyo shows little or no response to snowmelt (Anderholm, 2001). Also, the data indicate that the mean annual discharge in Tijeras Arroyo has decreased substantially from greater than 13 cubic feet per second during 1944-48 (U.S. Geological Survey, 1960) to less than 0.15 cubic feet per second during 1990-91 (data from the U.S. Geological Survey National Water Information System database). Anderholm (2001) suggests that this observed decrease in discharge probably is related to recent development in the watershed. If discharge was consistently higher in the past, ground-water recharge by infiltration through Tijeras Arroyo likely also was higher.

Abo Arroyo enters the MRGB just south of the Manzano Mountains (fig. 1) and has the largest watershed along the eastern edge of the basin (about 248 square miles). The arroyo drains mostly Paleozoic sedimentary rocks, along with some crystalline Precambrian rocks (Anderholm, 2001). Data collected from a streamflow gage near the mountain front for October 1996-September 1997 show a small amount of perennial flow, which infiltrates a short distance inside the basin boundary. Anderholm (2001) assumes a discharge of about 0.35 cubic feet per second in calculating the yearly base flow at the gage site. The effect of snowmelt on discharge apparently is small, but summer storms result in high flows that can account for over half of the annual discharge at the gage (Anderholm, 2001), and that periodically reach the Rio Grande.

Several additional ephemeral channels have the potential to contribute substantial amounts of recharge to the aquifer system and to periodically contribute substantial flow to the Rio Grande. However, little generally is known about the amount and seasonality of discharge of these channels within the margins of the MRGB. These channels include Galisteo Creek, Las Huertas Creek, Arroyo Tonque, and the Rio Salado (fig. 1). Flow in the Santa Fe River, in the northeastern part of the basin, is sustained largely by outflow from the City of Santa Fe sewage-treatment plant. The mean annual discharge at the Santa Fe River above Cochiti Lake was about 11.6 cubic feet per second for water years 1970-98 (Ortiz and others, 1999).

## Geologic Setting

### Tectonic Framework

The crustal extension that resulted in the formation of the Rio Grande rift began in the late Oligocene, about 32 million years ago, and continues into the present (Russell and Snelson, 1990). Successive episodes of extension caused large blocks of crust to drop down relative to adjacent areas, forming a series of generally north- to south-trending structural and physiographic basins that are hydrologically connected. These basins occur over a distance of more than 600 miles from Colorado to Texas. The basins are typified by thin crust, high heat flow, young faulting, recent volcanism, and thick basin fill (Lozinsky, 1988).

For this study, the MRGB (or Albuquerque Basin) is defined by Thorn and others (1993) to include the Santo Domingo Basin and the Hagan Embayment (fig. 5). As defined, the basin is about 100 miles long and 35 miles wide and is the third largest basin in the Rio Grande rift. South of the Santo Domingo Basin, the MRGB consists of two subbasins formed by a northern, eastward-dipping half-graben and a southern, westward-dipping half-graben (Russell and Snelson, 1990). Recent studies (Heywood, 1992; Grauch and others, 1999) show the presence of a high in isostatic residual gravity between the Santo Domingo Basin and the Calabacillas subbasin (fig. 5) that corresponds to the Ziana anticline as delineated by Kelley (1977) and to a structural high in basement rocks. A gravity high also is indicated between the Calabacillas and Belen subbasins near their eastern extents. These gravity highs are representative of transitional areas between subbasins where the denser, relatively low permeability rocks that underlie the Santa Fe Group rise closer to the land surface (Grauch and others, 2001). These transitional areas are covered by Santa Fe Group, but its thickness here can be less than 3,000 feet, compared with more than 10,000 feet within the Santo Domingo Basin and the two subbasins (Grauch and others, 1999 and 2001). The deep, inner portions of the subbasins generally also are bordered on the sides by shallow benches that step up to the margin areas (Hawley and Haase, 1992). These benches include the Hubbell and Laguna benches (fig. 5).

The west side of the MRGB is bounded mainly by the Ladron Mountains, the Lucero uplift, and the Rio Puerco fault zone (fig. 1). The Ladron Mountains in the southwest consist primarily of Precambrian granitic and metamorphic rocks and some Paleozoic rocks. The Lucero uplift tilts westward and is composed of Paleozoic limestone, sandstone, and shale capped by late Cenozoic basalt flows (Hawley and Haase, 1992). Faults separating the Lucero uplift from the basin juxtapose Pennsylvanian rocks with Precambrian or Permian rocks in some areas and juxtapose Permian with Triassic rocks in other areas (Anderholm, 1988). The Rio Puerco fault zone is a northeast-trending fault belt that separates the basin from the Colorado Plateau. These faults generally juxtapose Mesozoic rocks with Santa Fe Group deposits (Anderholm, 1988). West of the fault zone, exposed rocks include Cretaceous sandstone and shale and local Jurassic gypsum and clastic units (Hawley and Haase, 1992).

The northern part of the basin is bounded primarily by the Nacimiento uplift and the Jemez Mountains (fig. 1). The Nacimiento uplift in the northwest includes Precambrian plutonic and metamorphic rocks overlain by Paleozoic and Mesozoic sedimentary rocks (Hawley and Haase, 1992). Just east of the uplift are the Jemez Mountains, a major Cenozoic volcanic center of mafic to silicic rocks. East of the Jemez Mountains, the MRGB is

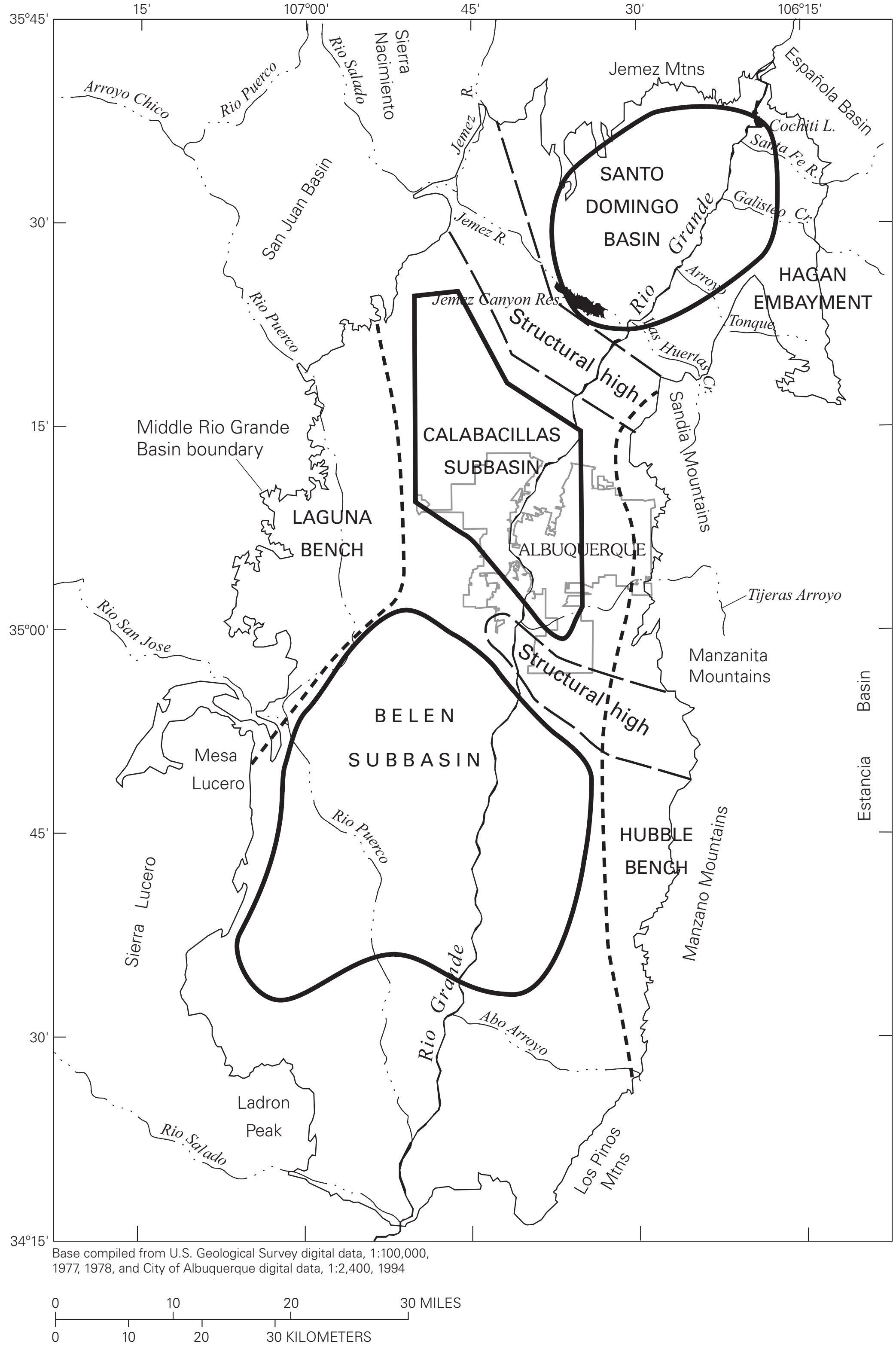



**Figure 5.** Simplified structure of the Middle Rio Grande Basin, New Mexico (Grauch and others, 1999).

connected to the Española Basin, a rift basin, by a narrow area referred to by Kelley (1977) as the White Rock channel. The Hagan Embayment, which constitutes the eastern part of the Hagan Basin (the part that is underlain by Santa Fe Group deposits) (Kelley, 1977), is included within the northeastern portion of the MRGB. The Hagan Embayment is bounded on the east by La Bajada fault, which juxtaposes Santa Fe Group sediments on the west side of the fault with Mesozoic beds on the east side (Kelley, 1977).

The fault-line scarp of the uplifted blocks of the Sandia, Manzano, and Los Pinos Mountains marks the distinct eastern boundary of the basin (fig. 1). These blocks consist primarily of a core of west-facing Precambrian metamorphic and plutonic rocks that are overlain unconformably by east-facing dip slopes of Paleozoic limestone and sandstone (Anderholm, 1988; Hawley and Haase, 1992). In the southeast, the Precambrian, Paleozoic, and Mesozoic rocks of the Joyita Hills bound the basin. South of the MRGB, the Joyita uplift on the east and the Socorro uplift on the west converge, forming a constriction between the MRGB and the Socorro Basin.

Besides the basin-bounding faults, numerous additional faults extend through parts of the MRGB (fig. 6) (Minor and Shock, 1998). Most of these faults offset Santa Fe Group deposits of similar lithology, although some faults result in the juxtaposition of geologic units that differ substantially in age and hydrologic properties (Kelley, 1977). Although the effects of faults on the hydrologic system of the basin have not been well characterized, the predevelopment water-level map of Bexfield and Anderholm (2000) indicates faults that appear to have the greatest effect on water levels. These faults appear to include portions of the Rincon, Sandia, Tijeras, Hubbell Springs, Jemez, Sand Hill, and Cat Mesa Faults as defined by Kelley (1977) (fig. 6). Faults that do not show large offsets causing the juxtaposition of different geologic units do not appear to affect predevelopment water levels. Therefore, any effects that might be caused by cementation along faults of small displacement are not readily apparent from the water-level map. Another property of faults that has not been well characterized is their potential to facilitate upward flow of deep water into shallower parts of the aquifer system.

### Santa Fe Group Aquifer System

The primary aquifer system of the MRGB consists of the generally unconsolidated to moderately consolidated basin-fill sediments of the Santa Fe Group. The Santa Fe Group aquifer system is defined by Thorn and others (1993) as including both the Santa Fe Group deposits, which are of Oligocene to middle Pleistocene age, and the more recent (post-Santa Fe Group) flood-plain, channel, and basin-fill deposits of Pleistocene to Holocene age that are in hydraulic connection with the Santa Fe Group. For this report, the Thorn and others (1993) definition is assumed whenever the term “Santa Fe Group aquifer system,” or simply, “aquifer system” is used. Hawley and Haase (1992) provide a detailed discussion of the hydrostratigraphic and lithofacies units of the aquifer system in the general vicinity of Albuquerque, where the largest body of information is available. The following discussion is from their publication, except where otherwise specified.

#### *Hydrostratigraphic Units*

Santa Fe Group deposits, which range in thickness from about 3,000 to over 14,000 feet, have been divided broadly into upper, middle, and lower units based on depositional environment and age. As a whole, the group consists primarily of alluvium from both nearby mountains and distant sources outside the basin, but includes locally thick playa-lake and eolian deposits, as well as some volcanic rocks. The lower Santa Fe Group, which was deposited about 30 to 15 million years ago and ranges in thickness from approximately 1,000 to 3,500 feet, represents deposition in a shallow, internally drained basin prior to the substantial uplift of surrounding mountains. The unit consists largely of piedmont-slope, eolian, and fine-grained basin-floor deposits. The basin-floor sediments were deposited primarily in playa lakes and generally have small hydraulic conductivity.

The middle Santa Fe Group, which was deposited about 15 to 5 million years ago and ranges from about 250 to 9,000 feet thick, represents the time of the most active tectonism and highest sedimentation rates in the basin. Deposition of piedmont-slope sediments continued and fluvial deposition occurred on the basin floor as a result of the transport of sediments into the basin by major fluvial systems from the north, northeast, and southwest. These systems probably

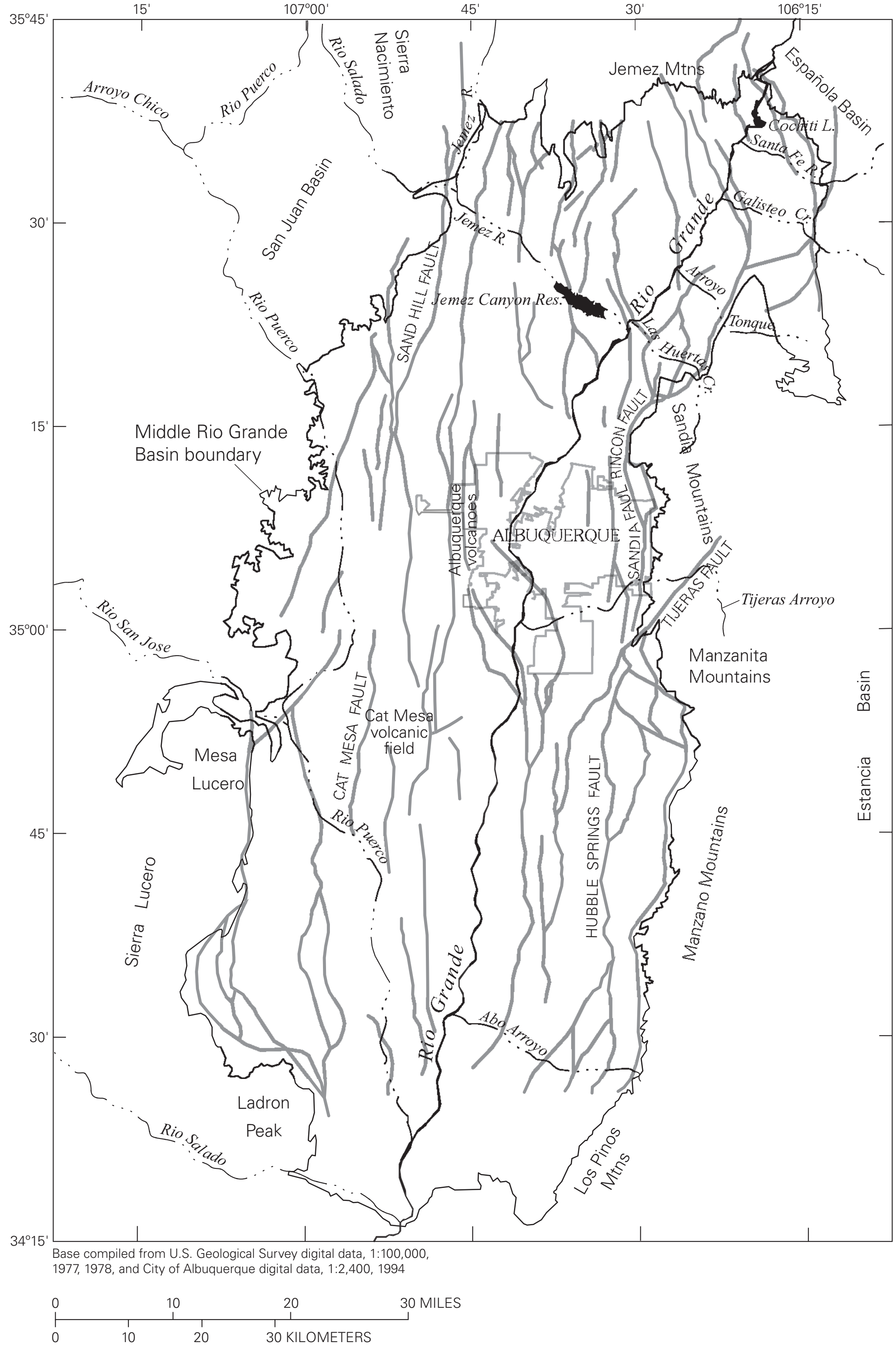



**Figure 6.** Major faults and volcanic fields of the Middle Rio Grande Basin, New Mexico. (faults from Mark Hudson and Scott Minor, U.S. Geological Survey, written commun., 1999).

flowed into playa lakes located in the southern part of the basin. During this time, the Calabacillas and Belen subbasins filled to form a single topographic basin. In the central part of the basin (near the City of Albuquerque), the top of the middle Santa Fe Group has been delineated using a distinctive red-brown clay layer that can be up to a few hundred feet thick. Connell and others (1998) named this layer the Atrisco member. The exact geographical extent of the layer is not known.

The upper Santa Fe Group, which was deposited about 5 to 1 million years ago and generally is less than about 1,000 feet thick (except in some areas near Albuquerque), consists largely of intertonguing piedmont-slope and fluvial basin-floor deposits. During this time, the ancestral Rio Grande system developed and was joined by two ancestral tributaries, the Rio San Jose and Rio Puerco. Because the fluvial system was of fairly high energy during this time, the ancestral river sediments that were deposited include thick zones of clean sand and pebble gravel and compose some of the most productive aquifer materials in the basin. When the Rio Grande and Rio Puerco began to cut their present valleys, Santa Fe Group deposition ceased.

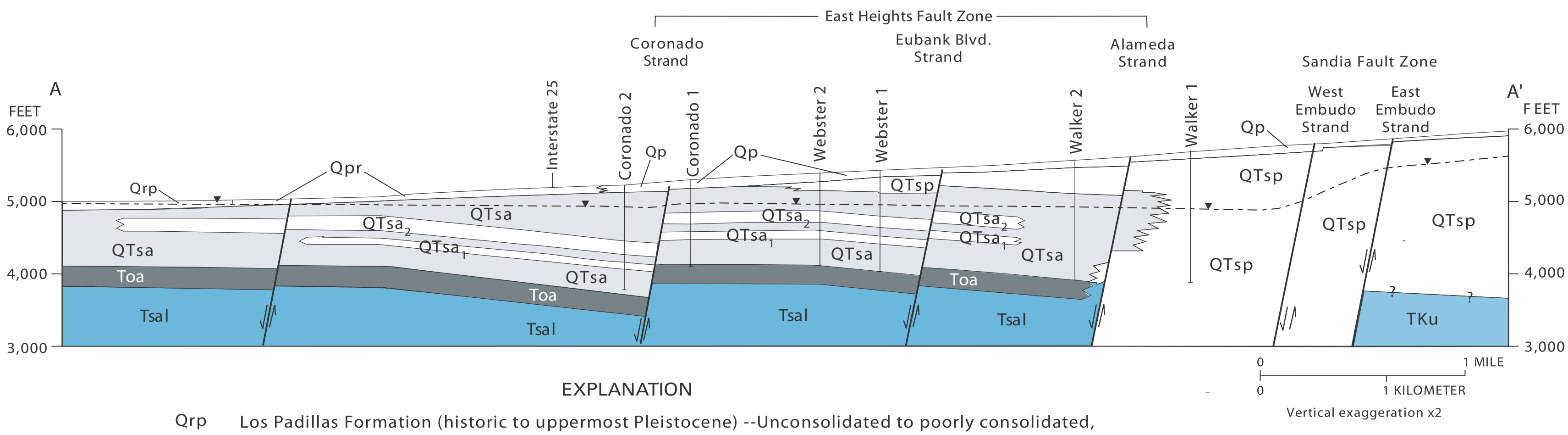
Deposition of post-Santa Fe Group sediments occurred during a series of river incision and partial backfilling episodes. River valley aggradation has been occurring over about the past 10,000 to 15,000 years because of large tributary input of sediment. Younger basin and valley fills include fan, pediment, inset-terrace, eolian, and floodplain deposits and volcanics. Younger valley fill is up to about 130 feet thick and provides a connection between the surface-water system and the underlying Santa Fe Group. Two volcanic fields, the Albuquerque field and the Cat Hills field (fig. 6), were emplaced during middle to late Pleistocene time.

More detail on the lithofacies units of the Santa Fe Group aquifer system can be found in Hawley and Haase (1992), Thorn and others (1993), and Connell and others (1999). A geologic section of hydrostratigraphic and lithofacies units typical of the Santa Fe Group aquifer system in the vicinity of Albuquerque is shown in figure 7. A conceptual diagram of the extent of major lithostratigraphic units throughout the basin during the Pliocene is shown in figure 8. The Sierra Ladrones Formation is subdivided into: piedmont facies along the east and southwest margins of the basin, ancestral Rio Grande facies through the center of the basin, and ancestral Rio Puerco/Rio San Jose facies in the southwest (fig. 8) (Connell and others, 1999; Sean Connell, New Mexico Bureau of Geology and Mineral Resources, written commun., 2001). Fluvial deposits of the ancestral Jemez River, which contain abundant silicic-intermediate-basaltic volcanic sediments derived from the Jemez Mountains, compose the Cochiti Formation and the northern part of the Arroyo Ojito Formation. Farther south, the Arroyo Ojito Formation includes primarily fluvial deposits of the ancestral Rio Puerco (Sean Connell, New Mexico Bureau of Geology and Mineral Resources, written commun., 2001).

Horizontal hydraulic conductivity values assigned to aquifer materials for the ground-water model of the MRGB constructed by Kernodle and others (1995) were based on the descriptions of Hawley and Haase (1992). These values generally ranged from less than 5 feet per day for most of the lower and middle Santa Fe Group to more than 40 feet per day for parts of the upper Santa Fe Group and post-Santa Fe Group alluvium.

#### Petrologic Data

Hawley and Haase (1992) discuss the composition and origin of sediments within the Santa Fe Group deposits. Much of their information is from cores and cuttings obtained from City of Albuquerque production wells. They found that sandstone composition ranged from arkose to feldspathic litharenite. Framework grains consisted of monocrystalline quartz, feldspar, and rock fragments, with lesser amounts of biotite, muscovite, chlorite, and heavy minerals. Rock fragments were volcanic, granitic/gneissic, sedimentary, and metamorphic, with volcanic fragments being most abundant. Volcanic fragments consisted primarily of plagioclase-dominated porphyries with lesser amounts of rhyolite. Below the northeastern part of Albuquerque, sediments at depths of about 200 to 3,200 feet were described as volcanic-rich, with glassy pumice being present from about 200 to 400 feet. Hawley and Haase (1992) concluded that the glassy pumice was probably derived from the Jemez volcanic field, whereas volcanic detritus likely originated from southern Colorado and northern New Mexico, such as from the San Juan volcanic field. Non-framework components of sandstones from all wells were principally detrital clay, zeolites, and calcite. Fine-grained sediments that were




EXPLANATION

Qrp — Los Padillas Formation (historic to uppermost Pleistocene) --Unconsolidated to poorly consolidated, fine- to coarse-grained sand and rounded gravel with interbeds of fine-grained sand, silt, and clay derived from the Rio Grande

Qp — Piedmont and stream alluvium, undivided (historic to middle Pleistocene)

Qpr — Fluvial deposits, piedmont alluvium, and stream alluvium, undivided (historic to middle Pleistocene)

QTsa — Axial-fluvial deposits of the ancestral Rio Grande, undivided (lower Pleistocene to Pliocene)

- $QTsa_2$ — Upper sandy mudstone marker bed (Pliocene)
- $QTsa_1$ — Lower sandy mudstone marker bed (Pliocene)

QTsp — Piedmont deposits (lower Pleistocene to Miocene)

Toa — Arroyo Ojito Formation, Atrisco Member (Pliocene) --Moderately to well consolidated, locally cemented succession of fine-grained silty sandstone and mudstone

Tsal — Lower fluvial deposits (Pliocene to upper Miocene)

TKu — Lower Tertiary and Cretaceous sedimentary rocks, undivided (Paleogene-Cretaceous)

**Figure 7.** Geologic section along Paseo del Norte in northern Albuquerque. (modified from Connell, 1997). See line A-A' on figure 18 for location.

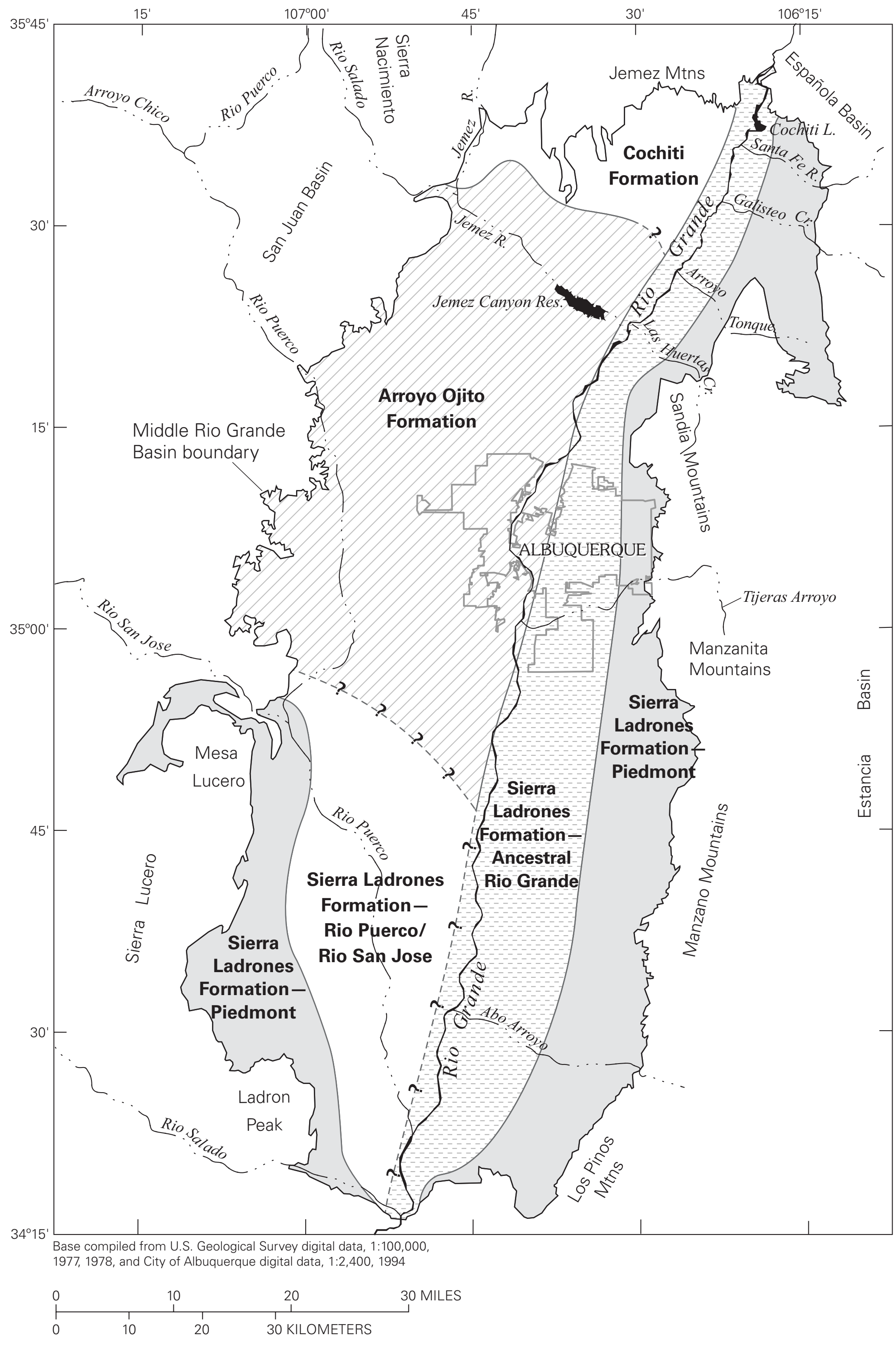



**Figure 8.** Inferred lateral extent of major lithostratigraphic units during the Pliocene in central New Mexico. (modified from Connell and others, 1999).

sampled consisted primarily of clay, with lesser amounts of sand and silt, and occasionally calcite cement. The principal clay minerals present were smectite, illite, kaolinite, and interlayered illite/smectite. The bulk composition of well cuttings was estimated to be approximately 60-percent granitic-metamorphic detritus of Precambrian derivation, 30-percent volcanic detritus of middle Tertiary derivation, and less than 10-percent sedimentary detritus of Paleozoic or Mesozoic derivation.

Additional investigators, including Lozinsky (1988), Stone and others (1998), and Anderholm (1985) have documented petrographic data similar to those of Hawley and Haase (1992). Lozinsky (1988) observed generally similar sandstone composition around the MRGB, including in the northern, central, southeastern, and southwestern parts of the basin. He found that monocrystalline quartz and plagioclase feldspar were the dominant detrital grains, but that their percentages could vary spatially and vertically. Rock fragments were primarily volcanic in all areas, although volcanic fragments were generally less numerous in the northwest part of the basin. In samples collected throughout the basin, Anderholm (1985) found that calcium smectite and mixed layer illite-smectite were the most common clay groups and quartz, calcite, plagioclase, and orthoclase were the most common nonclay minerals; gypsum also was observed in several whole-rock samples. Similarly, as a part of the present investigation, whole rock x-ray diffraction analysis of 14 samples of well cuttings from various locations and depths collected during drilling of monitoring wells in the vicinity of Albuquerque commonly identified quartz, plagioclase feldspar, potassium feldspar, smectite, calcite, and mica. Dolomite was detected in two samples, as were possible identifications of pyroxene and kaolinite.

Cementation, primarily by calcite, affects the hydraulic conductivity of aquifer materials across parts of the basin. Calcite in the form of caliche has been observed in Quaternary deposits, such as those capping the mesa that separates the valleys of the Rio Grande and Rio Puerco (Kelley, 1977). Below the northeastern part of Albuquerque, Hawley and Haase (1992) observed that Santa Fe Group sediments were mostly unconsolidated or poorly cemented to a depth of about 1,300 feet. However, they did find caliche-cemented sandstones in about the upper 200 feet of strata. Cementation and induration were observed to be appreciable at depths of about 1,700 to 2,000 feet. In a core hole located near the western edge of Albuquerque, Stone and others (1998) observed sandstones that were indurated and cemented by calcite that virtually filled the entire original pore space. Scattered carbonate in nodular concretions, discontinuous patches, and thin lenses was observed throughout the core. Lozinsky (1988) also noted calcite as the primary cement in various parts of the basin.

Mozley and others (1995) also have observed that calcite is the most abundant cement in the Santa Fe Group, occurring both as concretions and as laterally extensive cemented beds that can form thick aquicludes/aquitards over substantial areas. Calcite was observed to be most abundant in sediments associated with tributaries to the Rio Grande, in closed-basin fluvial facies, and in piedmont facies; calcite was least abundant in ancestral Rio Grande facies. Although coarser-grained and better-sorted sediments appeared to be preferentially cemented (reducing the hydraulic conductivity of aquifer materials that were originally among the most permeable), the lack of cementation in the permeable Rio Grande facies indicated that pore-water chemistry could be a substantial factor in determining the extent of cementation. Mozley and Goodwin (1995) observed selective calcite cementation along the Sand Hill fault in the western part of the basin. They concluded that the calcite had precipitated from flowing ground water and that the concretions were elongate parallel to flow at the time of precipitation.

## Ground-Water-Flow System

The ground-water-flow system of the MRGB between Cochiti and San Acacia is complex and in some areas has not been well characterized because of a lack of data. Multiple sources of recharge to the aquifer system are present across the basin. Land use, particularly the presence of irrigation and septic systems, has added to the potential sources of recharge. Characterization of the flow system also has been complicated by drawdown because of sustained ground-water pumping, particularly in the vicinity of Albuquerque, which has altered directions of ground-water flow and probably changed the rates of recharge resulting from various sources. Faults that juxtapose relatively permeable deposits with impermeable units also appear to affect directions and rates of ground-water flow. These faults also have been proposed as possible conduits for the upward flow of relatively deep (from depths of thousands of feet) ground water (Bexfield and Anderholm, 2002a).

A map of predevelopment water levels compiled by Bexfield and Anderholm (2000) indicates that ground-water movement through the central part of the basin has historically been oriented primarily north to south (fig. 9). Near the basin margins, ground-water flow has historically been oriented primarily toward the central part of the basin. Maps published by Bjorklund and Maxwell (1961) and Titus (1961) of pre-1960 water levels show similar patterns, although they indicate a greater east-to-west component of ground-water flow east of the Rio Grande in the vicinity of Albuquerque.

On various predevelopment water-level maps of the region (Bexfield and Anderholm, 2000; Bjorklund and Maxwell, 1961; Meeks, 1949; Titus, 1961; Titus, 1963), a depression in the water-level surface, commonly referred to as the "ground-water trough", is apparent west of the Rio Grande, from just south of the Jemez River south to the area of Los Lunas (fig. 9). This trough is located on the east side of the Sand Hill and Cat Mesa faults. Previous investigators have theorized that the presence of the trough indicates that there is a thicker sequence of more permeable material in the area of the trough than in areas on either side (Kernodle and others, 1995). However, lithologic logs of wells drilled in the trough area generally do not appear to support this hypothesis (Hawley, 1996; Stone and others, 1998). Further discussion of the origin of the ground-water trough is given in the section "Summary of Implications from Geochemical and Isotopic Data for the Conceptual Model of the Aquifer System".

There has been a steady increase in ground-water pumping in the MRGB since about the mid-1940's (Thorn and others, 1993; Bartolino and Cole, 2002). Estimates of urban, rural, commercial, and industrial ground-water withdrawals in the MRGB were 97,000, 131,000, and 152,700 acre-feet for the years of 1970, 1980, and 1990 (Thorn and others, 1993, and references within). Estimates of total ground-water withdrawals for the 7 counties that extend over at least part of the MRGB totaled nearly 310,000 acre-feet in 1995 (Wilson and Lucero, 1997; Bartolino and Cole, 2002). Over the period 1974-92, 72 percent of the total basin ground-water withdrawals were made by the City of Albuquerque (Thorn and others, 1993). Pumping in the vicinity of Albuquerque has resulted in substantial declines in water levels, as indicated by water-level data for 1999-2002 (Bexfield and Anderholm, 2002b) (fig. 10). The largest and most widespread declines compared to predevelopment levels are east of the Rio Grande, where water levels have fallen in excess of 120 feet; declines of as much as 100 feet have been observed west of the Rio Grande (Bexfield and Anderholm, 2002b). Water-level declines have resulted in ground-water movement being directed into the major pumping centers on the east and west sides of the Rio Grande (fig. 10). These large-scale shifts in the directions of ground-water flow during the past 40 to 50 years locally may affect interpretation of some geochemical data, although ground-water flow velocities are low enough that regionally significant changes in water-quality patterns are not likely to have occurred during this time period. Smaller-scale changes in ground-water flow directions also likely have occurred as a result of ground-water pumping in the vicinity of other communities, such as Bernalillo, Los Lunas, and Belen.

Bexfield and Anderholm (2002a) investigated water levels in deep nested piezometers in the Albuquerque area and found that the direction and magnitude of vertical hydraulic gradients differed substantially around the city. Vertical gradients in piezometer nests located in the Rio Grande flood plain and west of the river were directed primarily downward. In piezometer nests located outside of the flood plain to the east of the Rio Grande, vertical gradients were directed primarily upward, except in the two shallowest completions of a piezometer nest located near the mountain front. The largest downward gradients appeared to exist near the mountain front and west of the Rio Grande. However, seasonal differences in ground-water pumping affected both the direction and magnitude of gradients in some piezometer nests. Because data are not available from deep nested piezometers prior to sustained ground-water pumping, it is not known how well these vertical gradients represent predevelopment conditions.

Many investigators have attempted to identify and quantify the major sources of recharge to the aquifer system of the basin. Estimates of the quantity of recharge contributed by various sources have been compiled in reports describing ground-water models of the basin, such as Kernodle and others (1995). Mountain-front recharge probably is one of the most important sources of recharge to the basin (Thorn and others, 1993; Anderholm, 2001). Mountain-front

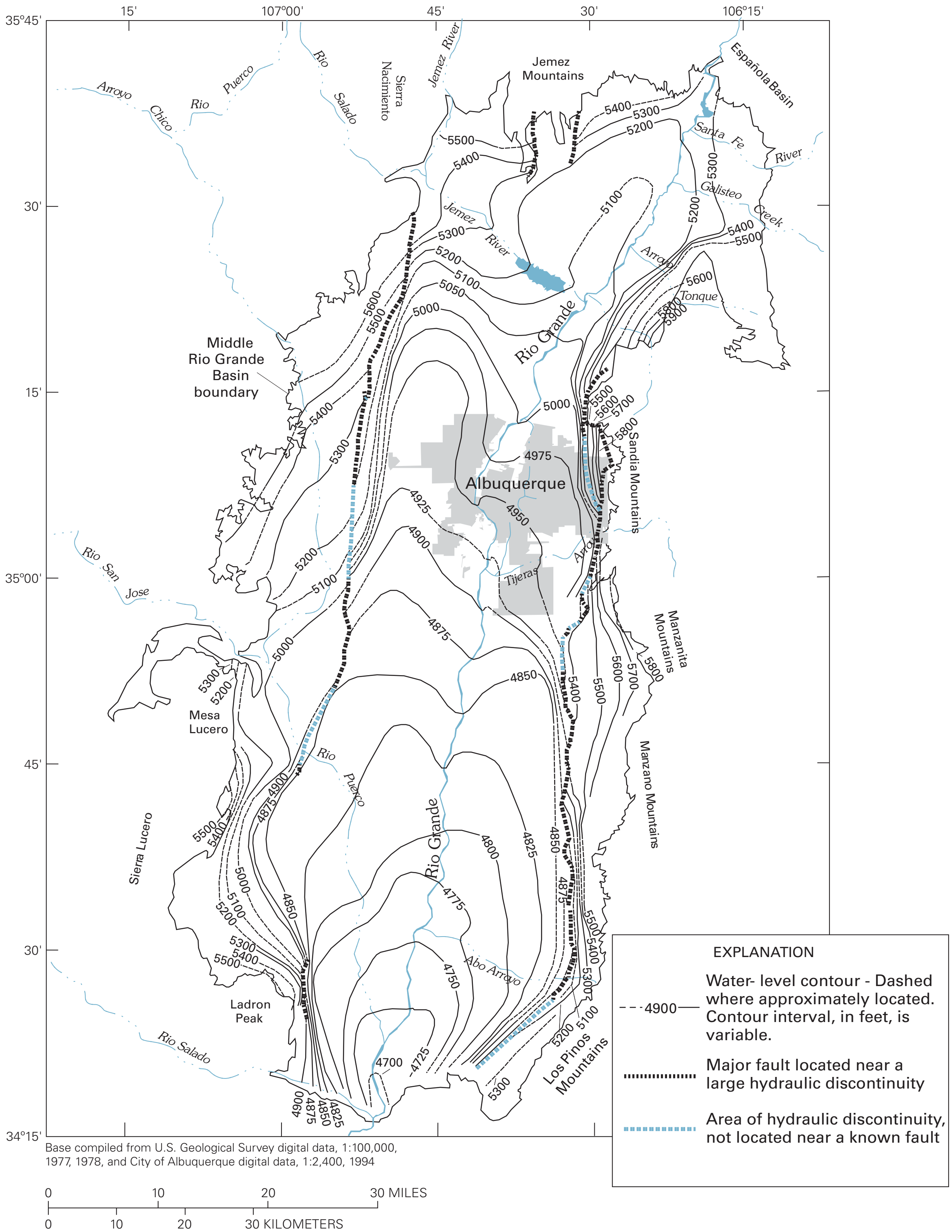



**Figure 9.** Predevelopment water levels in the Middle Rio Grande Basin, New Mexico. (modified from Bexfield and Anderholm, 2000; faults modified from Mark Hudson and Scott Minor, U.S. Geological Survey written commun., 1999).

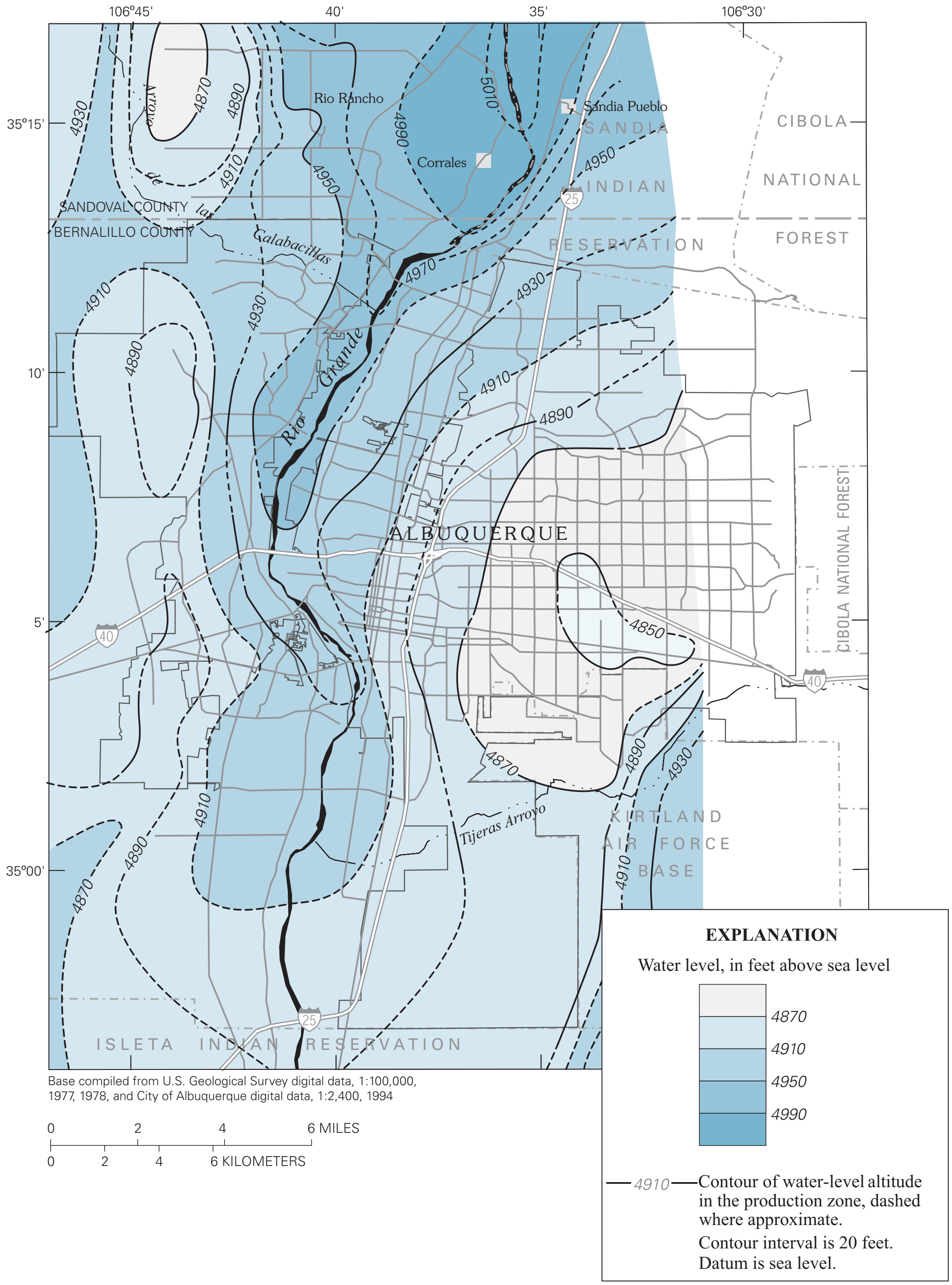



**Figure 10.** Water levels that represent 1999-2002 conditions in the production zone of the Santa Fe Group aquifer system in the Albuquerque area, New Mexico (modified from Bexfield and Anderholm, 2002a).

recharge is the general term used to describe recharge that occurs parallel to mountainous areas along the margins of a regional aquifer system, and usually refers more specifically to infiltration through mountain stream channels and to shallow subsurface inflow (Anderholm, 2001). Estimates of the quantity of mountain-front recharge occurring along the east side of the basin range from about 11,000 to 38,000 acre-feet per year (Anderholm, 2001). Mountain-front recharge could also be substantial along the Jemez Mountains in the northern part of the basin, and perhaps along the Ladron Mountains in the southwest, although studies have not been performed to establish the quantities of recharge occurring to the MRGB from these areas.

Subsurface ground-water inflow from adjacent basins also occurs along the margins of the MRGB, typically at fairly substantial depths. Along the northern margin of the basin, inflow occurs from the basin-fill deposits of the upgradient Española Basin and possibly from the Jemez volcanic deposits. Ground-water inflow along the entire northern margin has been estimated at about 14,300 acre-feet per year (Kernodle and others, 1995). Along the western margin, inflow probably occurs from Mesozoic rocks of the San Juan Basin toward the north and from Precambrian and Palezoic rocks toward the south. Ground-water inflow along the entire western margin has been estimated at about 8,800 acre-feet per year (Kernodle and others, 1995). Deep ground-water inflow may also occur from Precambrian and Paleozoic rocks along the eastern margin of the basin, and from Paleozoic and Mesozoic rocks in the area of the Hagan Embayment (fig. 5), but the quantity of inflow occurring in these areas is not well known.

As discussed above, infiltration is known to occur from the Rio Grande and its tributary streams and arroyos, as well as from the irrigation systems in the Rio Grande flood plain. The quantity of water from these sources that contributes to ground-water recharge is affected by evapotranspiration. Also, in the Rio Grande flood plain, the quantity of recharge is dependent upon the complex interactions between the river and the canals and drains of the associated irrigation system. Kernodle and others (1995) estimated through use of their ground-water model that about 79,000 acre-feet of water was contributed to the aquifer system from the Rio Grande and associated canals during the year ending in March 1994. Substantial quantities of recharge from the Jemez River, the Santa Fe River, Galisteo Creek, the Rio Puerco, Tijeras Arroyo, Abo Arroyo, and the Rio Salado (fig. 1) were also assumed in model simulation. Other sources that probably contribute to recharge, particularly in the Rio Grande flood plain (where depths to water typically are less than about 25 feet), include infiltrating irrigation water and septic systems. Residents of most areas that fall outside of the incorporated boundaries of the City of Albuquerque or selected other cities, such as Los Lunas and Belen, have individual septic systems. Although the direct infiltration of precipitation within the basin is a potential source of recharge to the aquifer system, any such infiltration is probably fairly localized and the quantity of recharge it contributes generally is believed to be minor (Anderholm, 1988).

Ground water discharges from the MRGB to the Socorro Basin near San Acacia (fig. 1). Ground-water discharge also occurs within the MRGB through evapotranspiration (particularly in the Rio Grande flood plain), ground-water pumpage, and discharge of ground water into drains and some reaches of the Rio Grande. The Kernodle and others (1995) ground-water model indicated that under predevelopment conditions, ground-water discharge occurred primarily through evapotranspiration. However, ground-water pumpage, estimated to be about 152,700 acre-feet in 1990 for all uses (Thorn and others, 1993), has substantially reduced the amount of ground-water discharge that occurs through evapotranspiration.

# METHODS

## Data Used in the Investigation

The data used in this investigation include both new data collected specifically for this USGS MRGB study and historical ground- and surface-water data from the USGS NWIS database and the City of Albuquerque. Details about site characteristics, sample collection, and sample analysis for each data source are discussed below.

## New Middle Rio Grande Basin Study Data

### Site Characteristics

For the MRGB study, more than 300 sets of samples were collected at 288 ground-water sites (wells and springs) across the basin (fig. 11, and appendix A) between June 1996 and August 1998. Sampling sites were selected primarily on the basis of location in an attempt to attain the best possible areal coverage of the basin. Efforts also were made to locate wells with discrete sampling intervals (in other words, short screened intervals) and groups of wells that allowed samples to be obtained from a variety of depths within the aquifer system at a given location. However, in most areas of the basin except in the vicinity of Albuquerque, so few wells were available for sampling that well construction was not a primary consideration. About 100 of the wells are located in or near Albuquerque.

Ground-water sampling sites consisted of 280 wells and 8 springs (table A1). Of the wells that were sampled, 116 were classified as monitoring wells (wells from which water is not obtained for any purpose other than monitoring of water level and ground-water quality), 82 were classified as production wells (wells used to supply water to more than 3 households or to industrial operations), 34 were classified as domestic wells (wells used to supply water to fewer than 3 households), 45 were classified as windmills (wells having a piston mechanism to lift water, which is used primarily to water livestock), and 3 were classified as stock wells (wells with submersible pumps, where water is used primarily for livestock). Well depths ranged from about 23 to 2,020 feet, with a median of about 500 feet. Screen lengths ranged from 5 to 1,270 feet, with a median of 20 feet. Casing material was steel in at least 167 wells and polyvinylchloride (PVC) in at least 108 wells; the material was not noted for 5 wells. Construction information for each category of well type is summarized in table 2, which shows that production wells typically were deepest but also had the longest screened intervals, whereas monitoring wells typically provided the most discrete sampling intervals.

All data from each ground-water source (wells and springs) are listed in appendix A. A unique 3-digit site number preceeded by “S” (designated “Syyy”) was assigned to each ground-water site. Each water sample was assigned a unique 3-digit sample number preceeded by “NM” (designated “NMxxx”). In some cases, multiple samples were collected at a particular site.

Based on the chemical and isotopic data of this investigation, source areas of recharge were identified and each water sample in appendix A was assigned to a primary hydrochemical zone, indicating the primary source area for recharge; in some cases, samples were identified as containing water from a secondary hydrochemical zone. Thirteen hydrochemical zones were recognized and numbered 1-13. The basis and definition of the various hydrochemical zones is discussed in the section “Tracing Sources of Water in the Middle Rio Grande Basin-- Definition of Hydrochemical Zones and Water Sources”. Data from some of the ground-water sites sampled for the MRGB study have not been included in the main body of data used for most analysis. These data are marked in the tables of appendix A with an “E” (for “exotic”) as the primary hydrochemical zone. Data for 14 sites (S009, S023, S038, S057, S063, S067, S070, S202, S249-251, S256, S258, and S273) were removed from the main data set because the sites fell outside the boundaries of the MRGB and may have produced water from an aquifer system other than that of the Santa Fe Group. Data for a few other selected sites were removed from the main data set because they were determined not to be representative of regional water quality. Examples are data from wells that were believed to produce water from a perched system not in hydraulic connection with the Santa Fe Group aquifer system (S094), wells that were believed to have been substantially affected by local contamination and/or evapotranspiration (S099, S129, S182, S225, and S282), wells that were believed to produce water associated primarily with geothermal systems (S028, S054, S112, and S211), and wells that

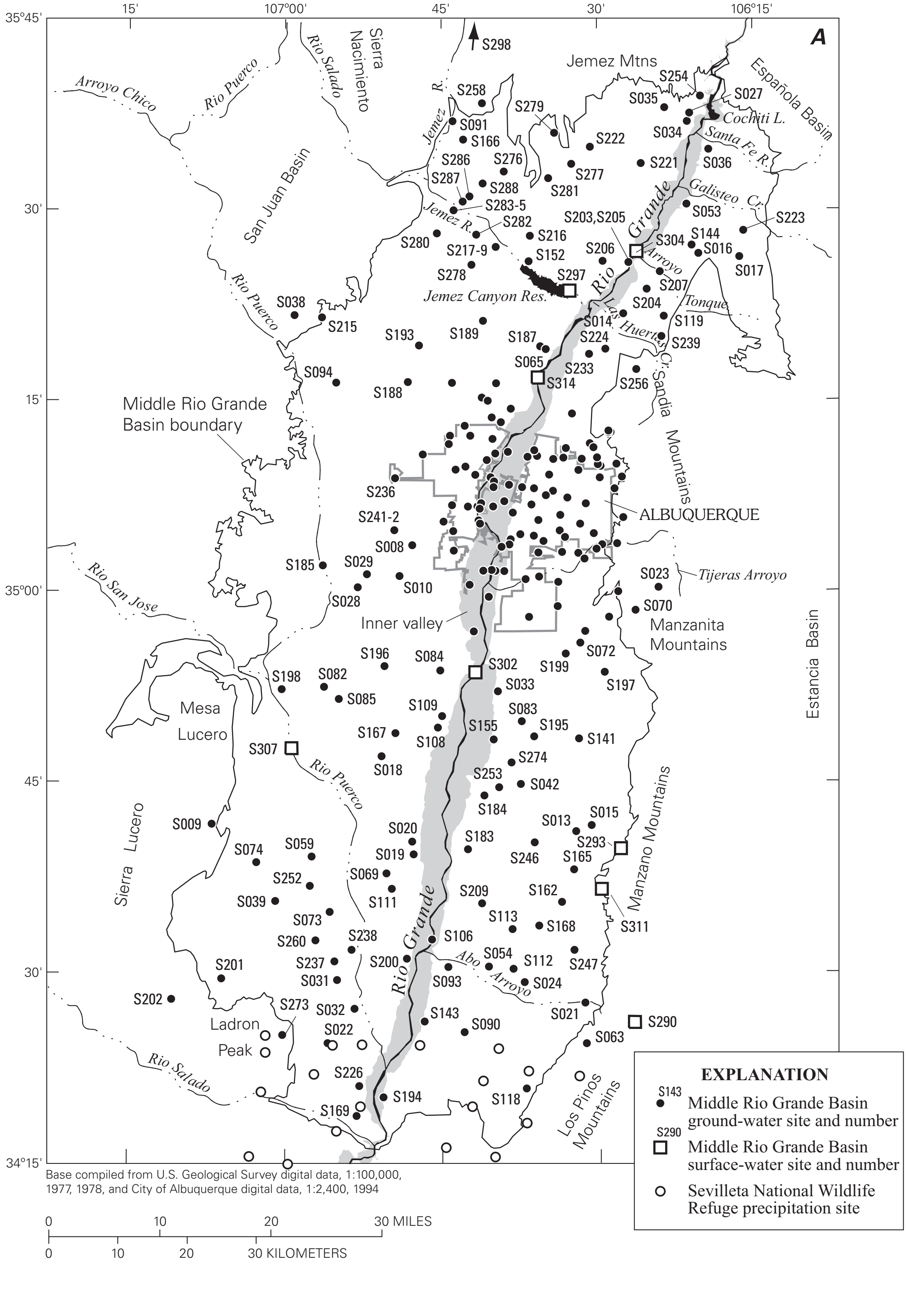


**Figure 11a.** Locations of ground-water and surface-water samples collected for the Middle Rio Grande Basin study outside the Albuquerque area, and locations of precipitation sites on Sevilleta National Wildlife Refuge (Moore, 1999).

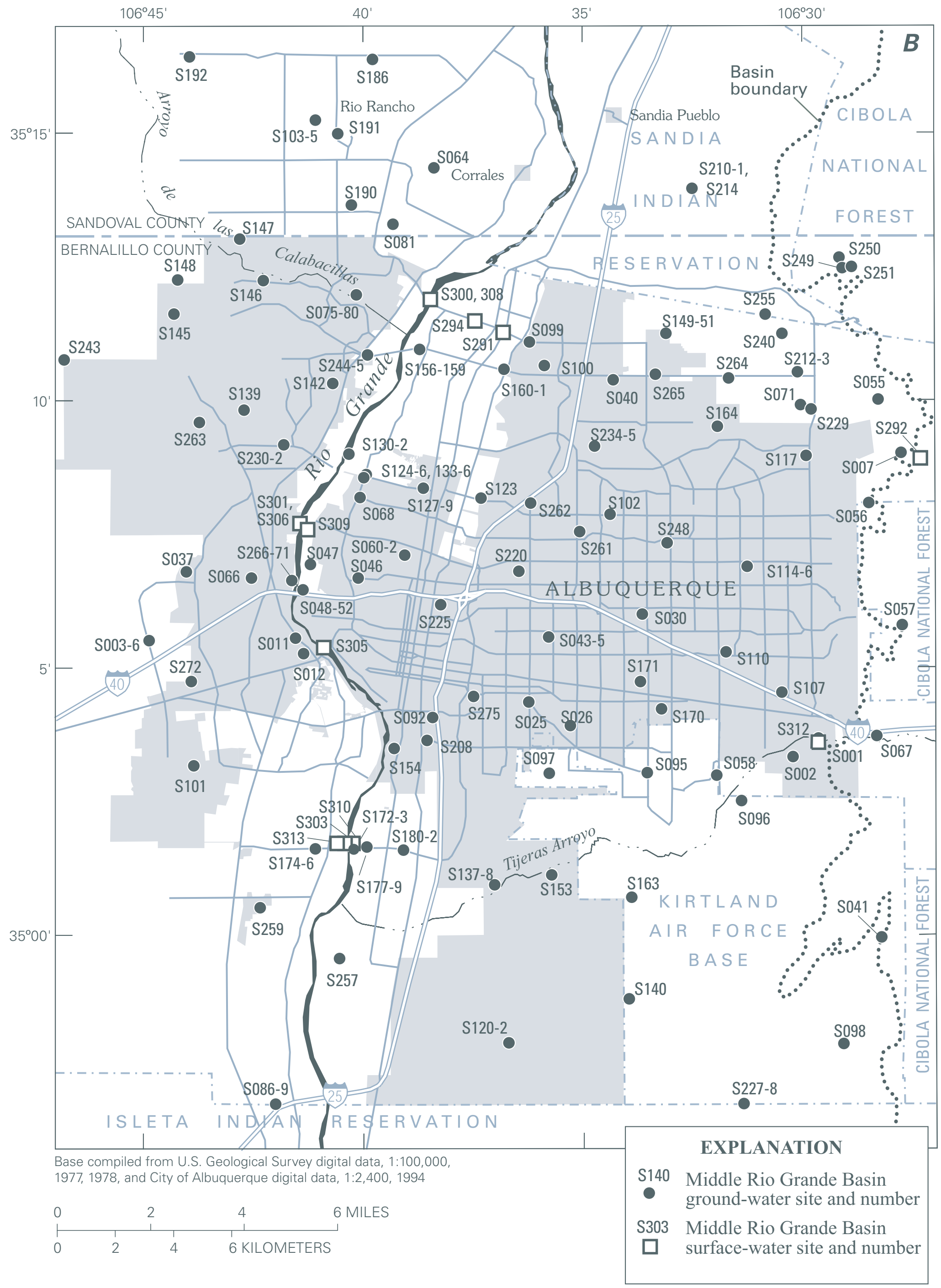



**Figure 11b.** Locations of ground-water and surface-water samples collected for the Middle Rio Grande Basin study inside the Albuquerque area.

**Table 2.** Statistical summary of well-construction information by well type, Middle Rio Grande Basin, New Mexico

[Length of sample interval is in feet; all other data are in feet below land surface; nd, not determined]

| Parameter | Number of wells | Minimum value | Median value | Maximum value |
|---|---|---|---|---|
| Domestic wells | | | | |
| Depth of well | 34 | 55 | 379 | 985 |
| Depth to top of sample interval | 27 | 120 | 390 | 965 |
| Depth to bottom of sample interval | 27 | 130 | 400 | 980 |
| Length of sample interval | 27 | | 20 | 40 |
| Depth to water | 32 | 8 | 252 | 530 |
| Monitoring wells | | | | |
| Depth of well | 116 | 23 | 394 | 1,805 |
| Depth to top of sample interval | 115 | 10 | 349 | 1,634 |
| Depth to bottom of sample interval | 115 | 20 | 415 | 1,795 |
| Length of sample interval | 115 | 5 | 10 | 270 |
| Depth to water | 115 | 6 | 98 | 887 |
| Production wells | | | | |
| Depth of well | 81 | 81 | 1,000 | 2,020 |
| Depth to top of sample interval | 79 | 19 | 425 | 1,355 |
| Depth to bottom of sample interval | 79 | 81 | 950 | 2,000 |
| Length of sample interval | 79 | 18 | 400 | 1,270 |
| Depth to water | 81 | 4 | 269 | 1,101 |
| Stock wells | | | | |
| Depth of well | 3 | 120 | 192 | 460 |
| Depth to top of sample interval | | nd | nd | nd |
| Depth to bottom of sample interval | | nd | nd | nd |
| Length of sample interval | | nd | nd | nd |
| Depth to water | 2 | 107 | 139 | 171 |
| Windmills | | | | |
| Depth of well | 44 | 42 | 291 | 1,109 |
| Depth to top of sample interval | 7 | 125 | 269 | 715 |
| Depth to bottom of sample interval | 7 | 135 | 279 | 725 |
| Length of sample interval | 7 | 5 | 10 | 40 |
| Depth to water | 33 | 13 | 207 | 991 |

were believed to have been affected only locally and at relatively shallow depths by surface-water bodies (S091 and S152). Some of these data are nevertheless discussed in certain sections of this report; the *exotic* waters discussed in such sections are explicitly identified.

Each ground-water site, the site number, site name, location, altitude, depth, water level, and other well construction information is listed in table A1. Also listed are the primary and secondary hydrochemical zone numbers, assigned as a part of this investigation.

All the chemical and isotopic data for ground-water samples collected as a part of this study are listed in tables A2-A12. The site number, sample number, site name, date of collection, and primary and secondary hydrochemical zone is listed for each sample (except for those in table A10 that contain isotopic data specific for City of Albuquerque production wells that were sampled only for $^{2}H$ and $^{18}O$ isotopic composition). The water-quality parameters measured in the field (temperature, dissolved oxygen, pH, and specific conductance), and the major-element chemical composition (Ca, Mg, Na, K, Cl, Br, $SO_4$, and $HCO_3$) are listed in table A2. The concentrations of selected minor constituents (Sr, $SiO_2$, Fe, Mn, $NO_3$ (as N), and F) are listed in table A3. The concentrations of selected trace elements (Al, B, Ba, Li, Zn, Pb, Cu, Rb, V, Cr, Co, Mo, As, Se, and U) for each ground-water sample are listed in table A4. Not all constituents were measured for each water sample.

The concentrations of selected dissolved gases ($N_2$, Ar, $O_2$, $CO_2$, and $CH_4$) are listed in table A5 for each ground-water sample. Additional values given in table A5 are discussed in a later section of this report and include the assigned altitude of recharge, a calculated concentration of excess $N_2$ from denitrification, and the recharge temperature and excess air calculated at the recharge altitude. The results of a sensitivity calculation of the recharge temperature and excess air as a function of recharge altitude, calculated with and without consideration of denitrification, are summarized in table A6.

The concentrations of the chlorofluorocarbons (CFCs), CFC-11, CFC-12, and CFC-113, in picograms of CFC compound per kilogram of water (pg/kg) are given in table A7 for each ground-water sample. The CFC concentrations are also given as the calculated atmospheric partial pressure and percentage of modern concentrations. For uniformity of results, and because the presence of most CFCs indicate anthropogenic sources rather than recharge conditions, the calculated atmospheric partial pressures and percentage of modern concentrations of CFCs in ground-water samples assume an altitude of 5,000 feet above sea level and temperature of 13.5°C. For some water samples containing recent recharge (water recharged within the past 50 years), the atmospheric partial pressure and percent modern concentration should be re-calculated at the actual recharge altitude and temperature, if recharge date is desired (Plummer and Busenberg, 1999). Because of uncertainties in recharge conditions resulting from infiltration of water through relatively deep unsaturated zones and/or contamination from anthropogenic sources, ground-water age based on CFCs was not evaluated as a part of this report. Instead, the CFC data were used to recognize water samples that contained at least a fraction of post-1940’s water.

The concentrations of dissolved sulfur hexafluoride and dissolved helium gas determined by gas chromatography at the U.S. Geological Survey Dissolved Gas Laboratory, Reston, Virginia, and by mass spectrometric methods at the Noble Gas Laboratory, Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York, respectively, are summarized in table A8.

The values of the stable H and O isotopic compositions of water, $\delta^2H$ and $\delta^{18}O$, and stable S isotopic composition of dissolved $SO_4$, $\delta^{34}S$, are given for each ground-water sample in table A9. The stable isotopic composition of water from City of Albuquerque production wells analyzed by the U.S. Geological Survey Stable Isotope Laboratory, Reston, Virginia are given in table A10. Water samples from City of Albuquerque wells collected as a part of this study (1996-97), archived samples collected by C. Yapp from the early 1980’s and re-analyzed by the USGS as a part of this study, and additional water samples collected by City of Albuquerque personnel from all City of Albuquerque production wells that were in operation during July-August 1997 are included in the table. Values of $\delta^2H$ reported by Yapp (1985) and values of $\delta^2H$ and $\delta^{18}O$ reported by Lambert and Balsley (1997) are included for comparison.

The tritium concentration and uncertainty in the tritium measurement, the CFC-12 concentration, the stable carbon isotopic composition of DIC, $\delta^{13}C$, the measured $^{14}C$ activity and standard deviation of the measurement, and the unadjusted radiocarbon age in years are given for each ground-water sample in table A11. The inclusion of CFC-12 and tritium concentration is redundant with other tables but useful in recognizing water samples that may contain fractions of post-nuclear detonation (post-bomb) $^{14}C$ activities.

Data collected for the determination of the $^3H/^3He$ age of water are summarized in table A12. The data were measured at the Noble Gas Laboratory, Lamont-Doherty Earth Observatory (LDEO) of Columbia University, Palisades, New York. Values of tritium concentration, $\delta^3He$, $^3He/^4He$ isotope ratio, the dissolved He and Ne concentration, the calculated values of $\Delta^4He$ and $\Delta Ne$ in percent of solubility equilibrium, the uncorrected $^3H/^3He$ age (uncorrected for terrigenic helium sources) and the corrected $^3H/^3He$ age (corrected for presence of terrigenic helium assuming an $^3He/^4He$ ratio of $2x10^{-8}$ for terrigenic helium), and associated uncertainties are summarized in table A12. Although the tritium and helium data are referred to in this report, the $^3H/^3He$ ages are not, because the emphasis of the present study concerns ground-water recharge and flow on the 10 ka timescale; however, the $^{3}H/^{3}He$ ages are included for completion of the data collected as a part of this study.

Surface-water samples also were collected for the MRGB study at multiple sites. Between January 1997 and April 1999, samples were collected as frequently as monthly at up to 14 surface-water sites on the Rio Grande and associated drains and irrigation canals, the Jemez River, the Rio Puerco, Tijeras Arroyo, and Bear Canyon Arroyo (fig. 11, and appendix B). The site number, site name, latitude, longitude, and altitude of each surface-water site sampled are given in table B1. The site number, sample number, site name, and date of collection are given for each sample in tables B2-B6, and B9. The barometric pressure, water temperature, pH, dissolved oxygen concentration, specific conductance, and the major-element concentrations of Ca, Mg, Na, K, Cl, Br, $SO_4$, and $HCO_3$ are given for each water sample in table B2. The minor-element chemistry including Sr, $SiO_2$, Fe, Mn, $NO_3$ (as N), and F for each surface-water sample are listed in table B3. The trace element concentrations of Al, B, Ba, Li, Zn, Pb, Cu, Rb, V, Cu, Co, Mo, As, Se, U, Ag, and Cd in surface-water samples are given in table B4. The water temperature and altitude of the sample site, and concentrations of CFC-11, CFC-12, and CFC-113 in picomoles per kilogram (pM/kg) and in pg/kg are given in table B5. The CFC concentrations are also given in table B5 as the partial pressure in parts per trillion by volume, pptv, calculated at the water temperature and site altitude, and as percent saturation with respect to solubility equilibrium with air, assuming average air mixing ratios of 270, 543, and 84 pptv for CFC-11, CFC-12, and CFC-113, respectively, during the period of sampling.

Values of stable O and H isotopic composition of water, $\delta^{2}H$ and $\delta^{18}O$, stable S isotopic composition of dissolved $SO_4$, $\delta^{34}S$, stable C isotopic composition of DIC, $\delta^{13}C$, and radioactive carbon isotopic composition of DIC, $^{14}C$ activity, in surface water samples are given in table B6. Values of the stable H and O isotopic composition of precipitation that was collected and archived in the 1980's and analyzed by the U.S. Geological Survey Stable Isotope Laboratory as a part of this investigation are summarized in table B7. Values of the stable H and O isotopic composition of Rio Grande water and other surface-water sources in samples that were collected and archived in the 1980's and analyzed by the U.S. Geological Survey Stable Isotope Laboratory as a part of this investigation are given in table B8. Measurements of tritium concentration and associated error measured in surface-water samples collected as a part of this investigation, June 1996 through February 1998, are summarized in table B9. Not all constituents were measured at all sites and all sampling times.

Additional data collected as a part of this study are tabulated in appendix C. Chlorofluorocarbon and sulfur hexafluoride concentrations measured in air samples and shallow unsaturated-zone air collected in the vicinity of the MRGB are given in table C1. Values of $\delta^{13}C$ and $^{14}C$ activity measured on limestone and caliche fragments from the MRGB are given in table C2. Values of $\delta^{13}C$ measured on plants sampled along the Sandia and Manzano Mountain front are given in table C3. Values of saturation indices calculated for selected minerals for each hydrochemical zone are given in table C4. Quality-control and quality-assurance data that are discussed in the next section of this report are given in appendix D, and additional water-quality data selected from the USGS NWIS and City of Albuquerque data sets are listed in appendices E and F.

### Sample Collection, Analysis, and Reporting Units for Water Samples

#### _Field Procedures_

Ground-water samples were collected between June 1996 and August 1998 from a variety of sources, including municipal production wells, domestic wells with permanently installed submersible pumps, monitoring wells, and springs. Surface-water samples were collected between June 1996 and April 1999. At most ground-water sites, a closed path was established between the source and sampling equipment to prevent contact of the sample with air. However, in a few cases, such as for some windmills, it was not possible to construct a closed path from the source to the sample container. For these samples, parameters that could be altered by gas-exchange with the atmosphere (including CFCs, $N_2$-Ar, $^{3}H/^{3}He$) were not collected. Parameters measured at all ground-water and surface-water sites included water temperature ($^{o}C$), specific conductance ($\mu$S/cm at $25^{o}C$), dissolved oxygen (mg/L), and pH (units). A commercial pH probe was calibrated using standard buffers of pH 4.0, 7.0, and 10.0 in the field prior to taking the first sample of the day. A commercial dissolved oxygen probe was calibrated at each site with water-saturated air, with correction for the local barometric pressure. A specific conductance probe was calibrated approximately weekly using standard KCl solutions of specific conductivity in the ranges of 100 and 1000 µS/cm at 25°C, obtained from the U.S. Geological Survey Laboratory, Ocala, Florida, after calibration against National Institute of Standards and Technology (NIST) standards. The field parameters were measured within a flow-through cell connected to the discharge line from the well. Accuracy of the field measurements were typically ±0.1 units for pH, ± 0.1 mg/L for dissolved oxygen, ± 0.2°C for water temperature, and ± 2 percent of the reported value for specific conductance. There are a few exceptions to these general values for accuracy of field parameters. Water temperature is generally not reliable for samples from monitoring wells that are more than 120 feet below land surface because pumping rates were too low (approximately 0.8 gallons per minute) to prevent temperature changes within the sample tubing during purging. Some of the samples from windmills were also affected, because of low discharge rates on calm days. However, most windmills located on pueblos were sampled using a mechanical device connected to the lift pipe to drive the pump and produce steady discharge from the well. In other cases, windmills were operating for unknown periods, depending on the prevailing wind conditions, but were likely adequately purged prior to sampling.

Wells were normally purged of at least three casing volumes before sampling, except for some of the deepest completions of monitoring wells that were purged of at least one casing volume. Stability in field parameters including water temperature, specific conductance, pH, and dissolved oxygen provided additional guidelines in determining when to sample wells. Samples were collected in appropriate containers and preserved in accordance with the procedures specified in U.S. Geological Survey (1998). Samples for cations were filtered through 0.45-micron filters and collected in acid-rinsed 250-mL polyethylene bottles (denoted the FA, filtered and acidified, sample). A cartridge filter attached to the tubing was purged of air. The containers were rinsed three times with the filtered water before filling. The FA bottles were then acidified with ultra pure nitric acid (lot number NA 5318-1GS1, http://wwwnwql.cr.usgs.gov/USGS/certificates/na5318.0196.html). Exactly the same procedure was used for the field blanks, except inorganic blank water was used in this case (Ocala lot number 95171-22 bottle 222, http://owqrl.er.usgs.gov/certificates/ibw/ibw_22.shtml). The samples for anions were filtered through 0.45-micron filters and collected in 500-mL polyethylene bottles, after rinsing the bottle 2-3 times with the sample (denoted the FU, filtered, unacidified sample). Titration alkalinity usually was determined within 2-3 days of collection at a local field laboratory from an approximately 35-mL aliquot taken from the FU sample. The bottles, filters, and acid were obtained from the U.S. Geological Survey's National Water-Quality Laboratory. Collection procedures for other chemical and isotopic substances are listed separately below.

#### Ground Water

Details of the various ground-water sources, including total depth, depth to water, length of the open interval, well type, casing material, and type of pump used to sample are given in table A1. For all in-service wells, the permanently installed pumps were used and samples were taken before any form of treatment, such as chlorination, and before water entered a pressure tank, such as in use with domestic wells. Most municipal production wells in the vicinity of Albuquerque were sampled in the early morning, near the end of each nightly production run. Typically, the municipal production wells had been in continuous operation for periods of 8 hours or more prior to sampling. Domestic wells were pumped continuously during sampling by opening sufficient outlets to keep the pump in continuous operation.

Various pump types were used to sample monitoring wells, depending mainly on depth to water. For relatively shallow wells, where depth to water was less than approximately 200 feet, a portable electric pump with steel impellor, capable of discharging up to about 8 gallons per minute (gpm) (denoted Grundfos (model Rediflow 2) in table A1), was used to purge the well of at least three casing volumes. The Grundfos pump was fitted with 250 feet of discharge line. Sampling was then performed using a stainless-steel piston-type pump driven by compressed nitrogen (denoted Bennett in table A1) that discharged water at about 1 gpm. The Bennett pump (Bennett pump model 1400) was placed just above the open interval of the well, if the depth to the open interval was less than 200 feet below land surface. The pump discharge was split at the pump between a ¼-inch Nylon line and ¼-inch copper line. In other cases, discharge from the Grundfos pump was split at the pump and sampled through a Nylon line (denoted Grundfos in table A1).

For monitoring wells outside the inner valley of the Rio Grande, depth to water was as much as 800 feet or more. For all monitoring wells with depth to water greater than approximately 200 feet, a higher capacity stainless-steel piston-type pump was used (also denoted as Bennett on table A1), and was driven by compressed air. The high capacity Bennett pump (Bennett Sample Pumps model 1800) was attached to a power reel mounted on a trailer. A stainless steel "Y" connector was fabricated to split the discharge from the pump to two separate lines that carried water to the surface. One discharge line was ½-inch polypropolene used for purging and supply to a flow-through cell where pH, dissolved oxygen, specific conductance and water temperature were measured. The other line was ¼-inch Nylon, which was split at the land surface to a second ¼-inch Nylon line, both of which were used to collect all the water samples, including the chlorofluorocarbon, tritium/helium-3, and sulfur hexafluoride samples. A clamp was used to restrict flow on the ½-inch line during sampling from the ¼-inch lines. The two discharge lines were bundled with two air lines; one from the compressor to drive the piston pump and the other to exhaust the air to the land surface. All four lines were wound on the power reel. An oil-lubricated electric compressor that produced compressed air (165 psi) and a generator were also mounted on the trailer and used to drive the pump and power reel. The compressed air was cleaned using an in-line filter and dried in a cold trap prior to entering the pump. Where depth to water was less than 800 feet, the high capacity piston pump was placed typically 50-75 feet below the water table and the well was purged of at least three casing volumes. The pump was then lowered to a point just above the open interval or to the maximum length of discharge line on the reel (800 feet) for sampling. Discharge rate was typically about 1.2 gpm and, in some cases, well purging required more than 10 hours to complete. Because of the long discharge line and depth of the unsaturated zone, water temperatures measured at the land surface from deep monitoring wells were usually not representative of *in-situ* temperatures. For some of the monitoring wells, depth to the open interval exceeded 1,500 feet below the land surface, and for these, the open interval of the well could not be reached by the high-capacity piston pump. In these cases, the pump was left at approximately 800 feet below land surface, but because of the considerable depth to the water table, the pump was, in cases of thick unsaturated zones, typically set at relatively shallow depths below the water table for sampling.

At the monitoring wells SWAB 1 and SWAB 2, the water table was more than 800 feet below the land surface and could not be reached by the Bennett pump. For these, water samples were obtained using a swabbing technique. A power winch was used to lower a swab device down the well casing. The device allowed water to pass through as it was lowered below the water table, but allowed water to be lifted on the upstroke. The device was capable of lifting 15-20 gallons of water to the land surface with each cycle. The wells were purged sufficiently to discharge fresh water from the aquifer system, but the total volume of water removed did not exceed two casing volumes.

Springs were sampled either with a Bennett pump or peristaltic pump. The Bennett pump was placed in the opening of the spring where maximum discharge occurred. In springs with low flow, such as some seeps, a drive point with a screened opening was placed in the spring (seep) and pumped with a peristaltic pump.

#### Surface Water

Surface-water samples were simple grab samples taken from the main flow within the stream channel. An open container was rinsed at least two times with surface water, and returned to shore where about 500 mL of native water was pumped with a peristaltic pump to rinse the tubing. The peristaltic pump was used to filter the sample water through 0.45-micron cartridge filters for FA and FU samples. Surface-water samples typically were collected for major and minor-element chemistry, stable isotopes of water, tritium, and chlorofluorocarbons. In addition, the field parameters of pH, dissolved oxygen, specific conductance, and temperature were measured.

### *Inorganic Chemistry*

Filtered unacidified water samples collected in 500-mL polypropolene bottles were returned to the local USGS field laboratory where titration alkalinity was determined, usually within 2-3 days after collection. The procedure consisted of titrating water samples of about 30 grams, weighed to the nearest 0.0001 g, with standardized HCl. The HCl was standardized with NIST Standard Reference Material 192a sodium carbonate. The $Na_2CO_3$ was heated at 285°C for one hour and then cooled to room temperature in a desiccator. Portions of between 4 and 10 mg of the reference $Na_2CO_3$ were weighed to the nearest microgram and titrated with HCl. Duplicate analyses agreed to better than 1 percent. The titrations were performed with a Radiometer Research Meter Model PHM84 and a Radiometer Autoburette Model ABU80 in derivative mode. Four liters of acid were prepared with concentrations of 0.03976 ± 0.00006N in 1996, 0.02996 ± 0.00007N in 1997, and 0.02948 ± 0.00006N in 1998.

Major cations and silica were analyzed from the acidified samples at the U.S. Geological Survey's Common-Use Laboratory in Reston, Virginia using the ARL SpectraSpan V, a multi-element direct-current plasma spectrometer (DCP). The instrument is equipped with the Interface Design Adam analytical manager and background corrector.

Trace elements were measured in the acidified samples with a Perkin Elmer Elan 6000 inductively coupled plasma instrument with a mass spectrometer detector (ICP-MS), using procedures described in U.S. Environmental Protection Agency (USEPA) method 200.8 (U.S. Environmental Protection Agency, 1994). The quadropole mass separator has a high degree of specificity, there are few molecular interferences, and isotopic overlaps are predictable and correctable by evaluating other isotopes of the same element or of the interfering element. The background mass-spectral features of the argon plasma are characterized by Tan and Horlick (1986). All isotopic corrections were performed by the software package of the ICP-MS. Oxide interference corrections were made separately. The analytical procedures are described by Faires (1992).

A Dionex series 4000i ion chromatograph equipped with a Dionex AS14 column was used for the analysis of F, Cl, $NO_3$, and $SO_4$. Bromide was measured with a Dionex DX-120 ion chromatograph. The eluant solution concentration was 3.5 mmol/L sodium carbonate with 1 mmol/L sodium bicarbonate. Standards were prepared using VHG Laboratory multi-ion standard solution #1 (ICM1-100) and solution #4 (ICM4-100), and Dionex standard multi-element solutions.

*Isotopes*

#### Sulfur-34

The stable S isotopic composition of dissolved $SO_4$, $\delta^{34}S$, was determined for $SO_4$ in approximately 170 water samples (28 surface-water samples and 142 ground-water samples). The isotopic abundance of sulfur-34 is expressed in per mil deviation from the sulfur isotopic composition of the Vienna Canyon Diablo Troilite (VCDT; Krouse and Coplen, 1997; Coplen and Krouse, 1998), where $\delta^{34}S$ relative to VCDT is

$$\delta^{34}S = \left( \frac{\left(\frac{^{34}S}{^{32}S}\right)_{Sample}}{\left(\frac{^{34}S}{^{32}S}\right)_{VCDT}} - 1 \right) 1000 \, . \qquad (1)$$

Barium sulfate was precipitated in the laboratory from the FU water sample, using methodology described in Carmody and others (1998). The $BaSO_4$ was filtered, dried, and homogenized, converted to $SO_2$ in a Carlo Erba Elemental Analyzer 2500, and analyzed in a Finnigen Delta Plus Continuous Flow Isotope Ratio Mass Spectrometer system at the U.S. Geological Survey Stable Isotope Laboratory, Reston, Virginia. The analytical method was based on that of Giesemann and others (1994). The $\delta^{34}S$ values were normalized on scales such that the $\delta^{34}S$ values of the standards IAEA-SO-6 $BaSO_4$ and NBS 127 $BaSO_4$ were -32.85 and 20.91 per mil, respectively. The average 1-$\sigma$ precision of $\delta^{34}S$ values is ± 0.2 per mil.

#### Oxygen-18 and Hydrogen-2

The U.S. Geological Survey Stable Isotope Laboratory in Reston, Virginia analyzed a total of 907 water samples from the MRGB for the stable isotope ratios of oxygen ($^{18}O/^{16}O$) and hydrogen ($^{2}H/^{1}H$). The samples are as follows:

- 341 ground-water samples from the 288 ground-water sites sampled throughout the MRGB between June 1996 and August 1998 (as discussed above), including approximately 150 samples from wells in the vicinity of Albuquerque.

- 267 water samples from the Rio Grande and associated drains and laterals, Bear Canyon Arroyo, and Tijeras Arroyo collected approximately monthly from January 1997 through April 1999, and variously from the Rio Grande, Abo Arroyo, the Rio Puerco, the Jemez River, and Embudo and Embudito Springs during the period June 1996 through April 1999 (as discussed above).
- 91 water samples from all active City of Albuquerque production wells from July through August 1997.
- 17 archived samples of precipitation from Albuquerque, collected by Robert Hejl (formerly with the USGS, Albuquerque) between May 1987 and July 1988.
- 191 archived water samples collected in the early 1980's by Crayton Yapp, (formerly with the University of New Mexico, Albuquerque) from various sources in the vicinity of Albuquerque, including multiple samples from City of Albuquerque production wells, local precipitation, the Rio Grande, and Embudo Spring in Embudo Canyon along the west side of the Sandia Mountain front near Albuquerque.

All water samples collected during and subsequent to June 1996 for determination of stable isotopic composition were collected in 60-mL glass bottles with polycone-seal liner caps and untreated. Many of the original water samples collected by Crayton Yapp in the early 1980's had been retained in their original glass bottles and were re-analyzed for stable isotope composition as a part of this study. The water samples of Crayton Yapp, in their original 250-mL glass bottles, were archived at Sandia National Laboratories (SNL) and made available to the USGS. Labels on the bottles identified the water source, sample date, and a "raw water sample, RSW" sample number. The RSW numbers on the bottles were largely consecutive to 301, but only 193 samples remained in archive at SNL. From these bottles, aliquots were poured off into 60-mL glass bottles with polycone-seal caps, labeled, and returned to SNL. After providing the sample to be returned to SNL, two samples of precipitation were of insufficient volume to be analyzed by the USGS. The remaining 191 water samples were analyzed by the U.S. Geological Survey Stable Isotope Laboratory in Reston, Virginia. Forty of the 45 samples with $\delta^2H$ values tabulated in Yapp (1985) remain and were re-analyzed at the USGS laboratory (table A10).

The stable isotopes of oxygen and hydrogen (expressed as $\delta^{18}O$ and $\delta^2H$) determined on water samples at the USGS Stable Isotope Laboratory, Reston, Virginia are expressed as the per mil (parts per thousand) deviation from the Vienna SMOW (VSMOW, Vienna Standard Mean Ocean Water; Coplen, 1996) standard as

$$\delta^{18}O = \left( \frac{\left( \frac{^{18}O}{^{16}O} \right)_{sample}}{\left( \frac{^{18}O}{^{16}O} \right)_{VSMOW}} - 1 \right) 1000 \,, \qquad (2)$$

and

$$\delta^{2}H = \left( \frac{\left( \frac{^{2}H}{^{1}H} \right)_{sample}}{\left( \frac{^{2}H}{^{1}H} \right)_{VSMOW}} - 1 \right) 1000 \,. \qquad (3)$$

The $\delta^{18}O$ and $\delta^2H$ values were normalized (Coplen, 1988) on scales such that the $\delta^{18}O$ and $\delta^2H$ values of SLAP (Standard Light Antarctic Precipitation) are -55.5 and -428 per mil, respectively. The one standard deviation ($1\text{-}\sigma$) accuracy of O- and H-isotope results were 0.1 and 0.8 per mil, respectively.

### Tritium

Tritium values for ground-water samples are given in tables A11 and A12, and for surface-water samples in table B9. Tritium was determined in water from 180 ground-water sites (200 samples) and 20 surface-water sites (117 samples). Each tritium sample was collected in a 500-mL glass bottle with a polycone seal cap. A head space of approximately 2-3 mL was left in the bottles during filling to accommodate expansion on warming. Tritium activity is reported in tritium units (TU) where 1 TU is defined as 1 atom of $^3H$ in $10^{18}$ atoms of $^1H$. Two laboratory procedures were used to determine tritium activity. Water samples sent to the U.S. Geological Survey Low-Level Tritium Laboratory in Menlo Park, California (all surface-water samples and a subset of the ground-water samples) were enriched electrolytically and analyzed by liquid scintillation counting, following procedures described in Thatcher and others (1977). The 1-σ analytical precision of these values was typically ± 0.3-0.6 TU.

For all of the ground-water samples in which tritium/helium-3 dating was attempted, tritium was determined by the helium in-growth method (Clarke and others, 1976; Bayer and others, 1989) at the Noble Gas Laboratory at Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York. The 1-σ analytical precision of these values is typically ± 0.1-0.3 TU. In 18 ground-water samples, tritium was determined by both laboratories. The average difference was -0.32 TU (LDEO-USGS), which is within the reported precision of the measurements. However, the standard deviation of the differences was 3.7 TU, indicating some errors higher than the reported precision of the measurements. Although the helium in-growth method usually is more precise than the electrolytic enrichment/liquid scintillation counting method, analytical problems at the LDEO laboratory may have affected some of the reported tritium values, especially in the samples from 1996. The 18 co-measured samples are compared in figure 12. Two of the LDEO samples have a significant low bias relative to the USGS values and one of these is significantly negative, indicating analytical error. Three other LDEO values have a significant positive bias relative to the USGS values. The remaining 13 co-measured samples are in agreement within the reported analytical precision (fig. 12). In the 18 co-measured samples, the USGS tritium measurement was selected over the LDEO value, even if the two differed by less than 0.3 TU. Overall, the LDEO tritium data set was accepted, however, because of its consistency with the CFC-12 data. In comparing tritium and CFC-12 concentrations, two populations of samples are present in the complete MRGB ground-water data set. One group of samples has low tritium (<1.0 TU) and variable CFC-12 (group B on fig. 13). These are apparently old (pre-bomb)

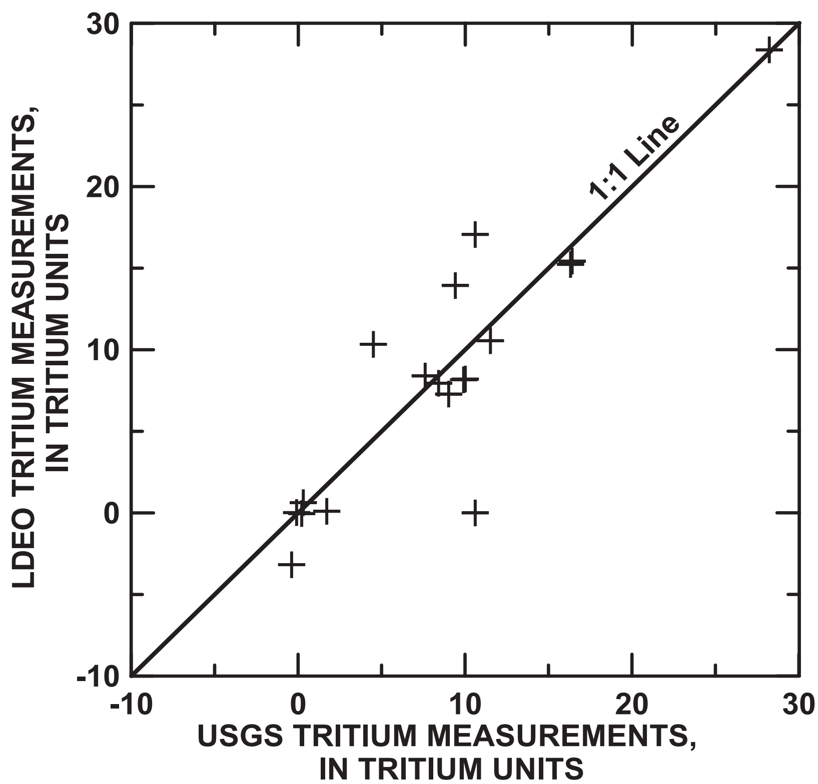



**Figure 12**. Comparison of tritium measurements from the Noble Gas Laboratory of Lamont-Doherty Earth Observatory (LDEO) and from the U.S. Geological Survey (USGS) Low-Level Tritium Laboratory.

waters that are mixed with a very low fraction of young and/or CFC-12 contaminated water. The second group of samples represents water that has infiltrated since the late 1950's (group A on fig. 13), and has tritium concentrations greater than about 4 TU and variable CFC-12 concentrations. Both the USGS and the LDEO sample sets demonstrate these patterns when compared to CFC-12 concentrations (fig. 13). Therefore, there is no basis for rejection of one data set over the other.

### Carbon-14 and Carbon-13

Water samples for the determination of $\delta^{13}C$ and $^{14}C$ activity of dissolved inorganic carbon (DIC) were filtered in the field (0.45-micron filter) and collected in two ways: (1) the DIC was precipitated in the field as $BaCO_3$ (in duplicate) in 500-mL safety-coated glass bottles with polycone-seal cap, without headspace, using an excess of $CO_2$-free $Ba(OH)_2$ solution (pH>11) and returned to the laboratory for further processing, and (2) a 250-ml water sample was collected without headspace in safety-coated glass bottles with septum caps (in duplicate).

In the laboratory, following procedure (1), the $BaCO_3$-$BaSO_4$ precipitate from the first collection procedure was washed and filtered under nitrogen with $CO_2$-free deionized water. The precipitate was dried in air and homogenized by passage through a 60-mesh sieve, and stored in a capped glass bottle. Each sample was considered to be a mixture of $BaCO_3$ and $BaSO_4$. The DIC content was estimated from the titration alkalinity assuming 90-percent recovery of the precipitate. The dry homogenized powders and estimates of the weight of each sample needed to produce 5 mg of carbon were submitted to a contract

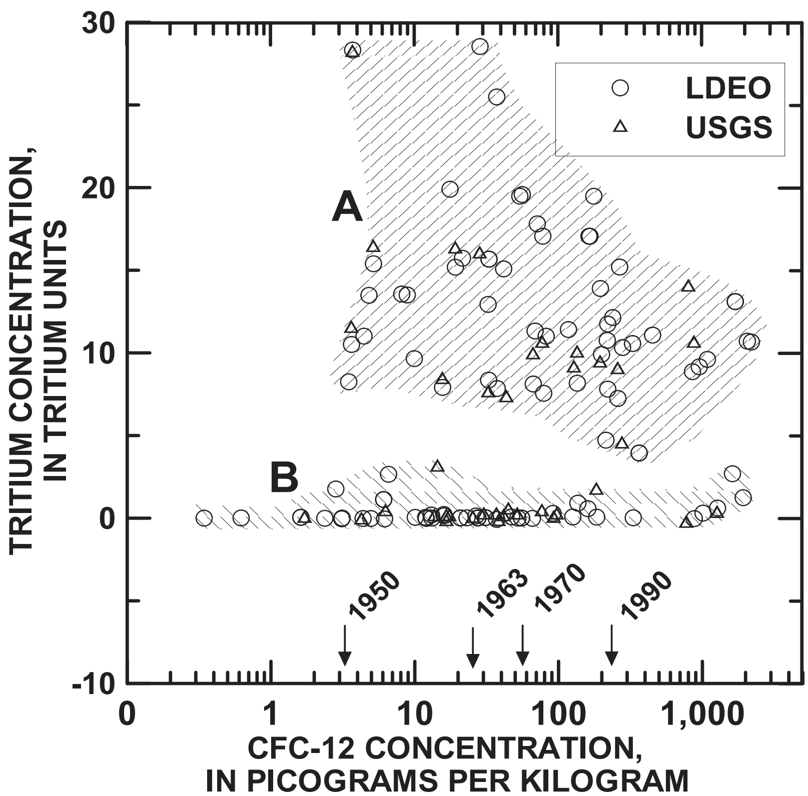



**Figure 13.** Tritium concentration in ground water as a function of CFC-12 concentration. Both tracers occur in post-1950's water. Apparent ages based on CFC-12 concentration are shown for recharge at 13.6 °C and altitude of 5,000 feet. The highest tritium concentrations are associated with the mid-1960's atmospheric testing of nuclear bombs. Data are from the Noble Gas Laboratory of Lamont-Doherty Earth Observatory (LDEO), Palisades, New York, and the U.S. Geological Survey (USGS) Low-Level Tritium Laboratory, Menlo Park, California. Two groups of waters are recognized: (A) those that contain both CFC-12 and tritium are probably post-1950's infiltration waters, and (B) those with low tritium content but significant CFC-12 concentrations are probably mixtures of old water and small fractions of CFC-12 contaminated water.

laboratory (Environmental Isotope Laboratory, University of Waterloo, Waterloo, Ontario, Canada) for preparation of $CO_2$ gas and determination of $\delta^{13}C$. The $CO_2$ was produced by acidification in an extraction line. Water was removed in a cold trap and the dry, homogeneous $CO_2$ gas was flame-sealed into three separate Pyrex glass tubes (breakseals). The breakseals were labeled and one sample was used by the contract laboratory to determine $\delta^{13}C$, one was sent under subcontract to an Accelerator Mass Spectrometry (AMS) facility (Rafter Radiocarbon Laboratory, Institute of Geological & Nuclear Sciences, Ltd., Lower Hutt, New Zealand) for graphite target preparation and $^{14}C$ determination, and one was retained at the contract laboratory as a backup. The $\delta^{13}C$ of DIC in the sample was determined by mass spectrometry on the Vienna Pee Dee Belemnite (VPDB) scale with a precision of typically $\pm$ 0.3 per mil or better. The AMS facility prepared the graphite sample targets and determined the $^{14}C$ activity of DIC in the sample. For samples collected in the summer of 1996 (NM001 - NM186), values of $\delta^{13}C$ and $^{14}C$ activity of DIC were determined on the $BaCO_3$ samples.

For samples collected in 1997 and 1998 (procedure (2)), values of $\delta^{13}C$ and $^{14}C$ activity of DIC were determined on samples in which the $CO_2$ was extracted from water samples collected in the glass septum bottles. Following generation of $CO_2$ by acidification in the extraction line, the same procedures were followed as in procedure (1).

All $^{14}C$ activity measurements are reported as the $^{14}C$ activity ratio, $^{14}a$, expressed in "percent of modern carbon" (pmC) at the time of sampling, not normalized for $^{13}C$ fractionation and defined as

$$pmC = {}^{14}a \cdot 100 = \left( \frac{{}^{14}A_{sample}}{{}^{14}A_{reference}} \right) 100, \qquad (4)$$

where

$^{14}A_{sample}$ is the absolute (specific) $^{14}C$ activity of the sample (in disintegrations per minute per gram of carbon), and

$^{14}A_{reference}$ is the standard activity defined as 95 percent of the activity of National Bureau of Standards (NBS) oxalic acid (Ox 1) in the year A.D. 1950 (see, for example, Mook and van der Plicht, 1999).

Various other $^{14}C$ reporting units are used in the radiocarbon literature. Stuiver and Polach (1977) recommend reporting $^{14}C$ measurements that have been normalized for isotope fractionation effects to a common $\delta^{13}C$ value of –25 per mil. These recommendations for normalization have been adopted by most radiocarbon laboratories world-wide, providing conformity in reporting units between the various radiocarbon laboratories and continuity of results with previously reported data. However, for geochemical and hydrologic use, it is the number of atoms of $^{14}C$ that need to be considered, and not the normalized values (Kalin, 1999), and in some cases it is necessary to "de-normalize" the commonly reported normalized $^{14}C$ activity (Mook and van der Plicht, 1999). Normalized $^{14}C$ activities can be converted to non-normalized values by the equation (Mook and van der Plicht, 1999) as

$$^{14}a^{S} = {}^{14}a_{N}\left[\left(1 + {}^{13}\delta/1000\right)/0.975\right]^{2} \exp\left[-(t-1950)/8267\right], \qquad (5)$$

where

$^{14}a^S$ is the $^{14}C$ activity ratio of the sample at the time of sample collection,

$^{14}a_N$ is the commonly reported normalized $^{14}C$ activity ratio,

$^{13}\delta$ is the $\delta^{13}C$ of the DIC in per mil,

$t$ is the year of sample collection or year of analysis,

8267 is $1/\lambda$, where $\lambda$ is the $^{14}C$ decay constant;

$\lambda$ is (ln 2) / (5730), where 5730 is the modern $^{14}C$ half-life.

The practice of normalization of $^{14}C$ measurements is well established in the radiocarbon community, but, unfortunately, geochemists and hydrologists sometimes fail to recognize that radiocarbon dating of dissolved inorganic carbon (DIC) in ground water is based on the actual measured $^{14}C$ activity rather than the commonly reported normalized $^{14}C$ activity that has been modified (normalized) for assumed $^{13}C$ isotope fractionation from an assumed initial value of -25 per mil to the measured $\delta^{13}C$ of the sample. In some cases, such as in studies of $^{14}C$ activity in plants, bones, and tree rings, it is convenient and scientifically justifiable to normalize $^{14}C$ activities to a common $\delta^{13}C$ value of -25 per mil, to correct for in-vitro fractionation processes that affect both $^{13}C$ and $^{14}C$. However, in ground water, most of the isotopic variation in $\delta^{13}C$ of DIC is caused by water-rock interaction, in other words, by geochemical reactions in the aquifer. For example, $\delta^{13}C$ of DIC can be more positive than -25 per mil because of isotope dilution from dissolution of carbonate rocks that are enriched in $^{13}C$, and not because of in-vitro fractionation processes. When dating DIC in ground water, the actual number of $^{14}C$ atoms in the dissolved inorganic carbon is needed to determine the time elapsed since the DIC of the modern reservoir (that is, the soil $CO_2$ derived from plants and air) and its $^{14}C$ atoms were recharged and isolated from air. Corrections (adjustments) to the $^{14}C$ of DIC are normally made through geochemical calculations (see for example, Fontes and Garnier, 1979; Wigley and others, 1978; Wigley and Muller, 1981; Kalin, 1999; Mook and van der Plicht, 1999), such as can be made with the computer program NETPATH (Plummer and others, 1994).

The commonly recognized reporting units of $^{14}C$ data are summarized in table 3. All $^{14}C$ activity values used in this report are based on $\delta^{14}C$ or pmC, which have been corrected for decay since 1950 to the date of measurement (but not normalized with $^{13}C$ differences from –25 per mil). The value of pmC is related to $\delta^{14}C$ by

$$pmC = \left( \frac{\delta^{14}C}{1000} + 1 \right) 100\,. \tag{6}$$

$\delta^{14}C$ is related to $\Delta^{14}C$ by the equation (Stuiver and Robinson, 1974)

$$\delta^{14}C = \left( \frac{1 + \Delta^{14}C/1000}{0.975^2 / \left(1 + \delta^{13}C/1000\right)^2} - 1 \right) 1000\,. \tag{7}$$

The absolute percent Modern (pM) relative to the NBS I oxalic acid standard, normalized for $^{13}C$ isotope fractionation, and corrected for decay since 1950 to the date of measurement is

$$pM = \left( \frac{\Delta^{14}C}{1000} + 1 \right) 100\,. \tag{8}$$

The Conventional Radiocarbon Age (Stuiver and Polach, 1977), t, is expressed in years before 1950, the year on which the absolute international radiocarbon standard was based. Because pM is referenced to the year of measurement, the Conventional Radiocarbon Age is

$$t = \frac{5568}{\ln 2} \ln\left( \frac{100}{pM} \right) - \frac{y - 1950}{1.029}\,, \tag{9}$$

where

5568 is the "Libby half-life" of $^{14}C$,
y is the year of measurement, and
1.029 is the ratio of $\lambda_{5730}/\lambda_{5568}$.
$\lambda$ is the decay constant equal to ln 2 divided by the $^{14}C$ half-life, and
5730 is the modern $^{14}C$ half-life.

**Table 3.** Terminology of $^{14}C$ reporting units

[$^{o}/_{oo}$, per mil; %, percent; 1σ, 1 standard deviation; NBS, National Bureau of Standards (now NIST, National Institute of Standards and Technology, U.S. Department of Commerce)]

| Value | Unit | Uncer-tainty | Unit | Description |
|---|---|---|---|---|
| $\Delta^{14}C$ | $^{o}/_{oo}$ | ± 1σ | $^{o}/_{oo}$ | Per mil depletion or enrichment relative to the NBS I oxalic acid standard, normalized for $^{13}C$ isotopic fractionation, and corrected for decay since 1950. |
| $\delta^{14}C$ | $^{o}/_{oo}$ | ± 1σ | $^{o}/_{oo}$ | Per mil depletion or enrichment relative to the NBS I oxalic acid standard, corrected for decay since 1950. Not normalized for $^{13}C$ isotopic fractionation. |
| pM | % | ± 1σ | % | Absolute percent Modern (pM) relative to the NBS I oxalic acid standard, normalized for $^{13}C$ isotopic fractionation, and corrected for decay since 1950. |
| pmC | % | ± 1σ | % | Percent modern carbon (pmC) relative to the NBS I oxalic acid standard, corrected for decay since 1950. Not normalized for $^{13}C$ isotopic fractionation. |
| t | years | ± 1σ | years | Conventional Radiocarbon Age, years before 1950. |

In this study, all radiocarbon ages are reported as "unadjusted radiocarbon ages", $t_{unadj}$, and are analogous to the Conventional Radiocarbon Age, but based on the non-normalized $^{14}C$ activity, pmC, rather than the normalized, pM. Thus, the unadjusted radiocarbon age is defined

$$t_{unadj.} = \frac{5568}{\ln 2} \ln\left(\frac{A_o}{pmC}\right) - \frac{y-1950}{1.029}, \qquad (10)$$

where

$A_o$ is the initial $^{14}C$ activity in pmC at time of recharge.

By convention, a value of 100 percent is normally assigned to $A_o$, but in application, appropriate values of $A_o$ should be evaluated taking into account geochemical processes occurring in the recharge areas of aquifers. Geochemical corrections can lower estimates of $A_o$ to values less than 100 percent, and in cases of extensive water-rock reaction, values of $A_o$ as low as 10 percent have sometimes been used. As demonstrated in the section "Interpretation of Radiocarbon Age of Dissolved Inorganic Carbon in Ground Water", values of $A_o$ in the MRGB appear to be near 100 percent.

Regardless of the extent of geochemical corrections to $A_o$, use of the Libby half-life rather than the modern $^{14}C$ half-life in calculation of unadjusted radiocarbon age (or Conventional Radiocarbon Age) permits use of radiocarbon calibration scales (Stuiver and others, 1998). Radiocarbon calibration scales are needed because the strength of the Earth's geomagnetic field has varied over time, and, consequently, the $^{14}C$ activity of atmospheric $CO_2$ has varied in the past, and for the most part has been greater than 100 pM (Bard and others, 1990; Bard and others, 1993; Stuiver and others, 1986; Stuiver and Reimer, 1993; Bartlein and others, 1995). By using the Libby half-life for $^{14}C$ and making the appropriate corrections for geochemical reactions, calendar years before present (BP), where present refers to 1950, can be interpreted using radiocarbon calibration scales (Stuiver and others, 1998). The correction of the unadjusted radiocarbon age (unadjusted for geochemical reactions) to calendar years (Stuiver and others, 1998) is small for samples with radiocarbon ages of less than 10,000 years (fig. 14). The correction increases for samples with radiocarbon ages of 10,000 to 20,000 years. For example, if the radiocarbon age (Libby half-life, adjusted for all

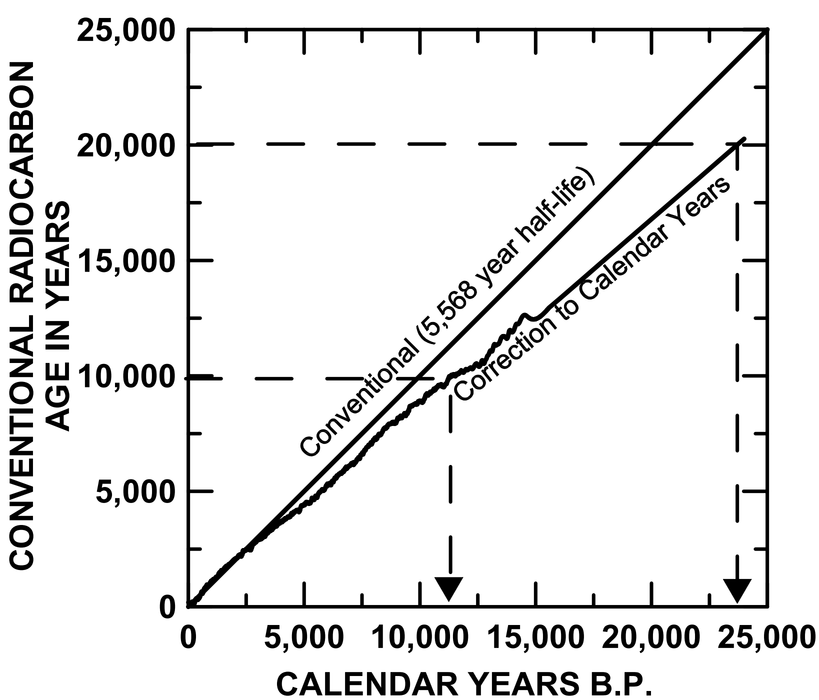



**Figure 14.** Calibration of Conventional Radiocarbon Age to calendar years, before present (B.P., where present is defined as the year the year 1950; Stuiver and others, 1998). The dashed lines sh two examples in which radiocarbon ages of 10,000 and 20,000 years were converted to calendar years.

geochemical reactions) is 20,000 years, the corresponding age in calendar years is nearly 24,000 years (fig. 14). Radiocarbon ages based on the Libby half-life of 5,568 years are related to radiocarbon ages based on the modern $^{14}C$ half-life of 5,730 years by the equation

$$t_{Libby} = 0.972\, t_{5730} \quad . \tag{11}$$

In subsequent sections of this report, reference to radiocarbon age refers to the unadjusted radiocarbon age (Libby half-life) based on the un-normalized (measured) $^{14}C$ activity, without calibration to calendar years.

### Dissolved Gases

#### Major Dissolved Gases (Nitrogen, Argon, Oxygen, Carbon Dioxide and Methane)

The water samples for determination of dissolved $N_2$, Ar, $O_2$, $CO_2$ and $CH_4$ gases were collected in 150-mL septum bottles that were filled without headspace in the field. The samples were stored on ice in the field, and in a refrigerator at 4°C in the laboratory prior to analysis. Concentrations of $N_2$, Ar, $O_2$, $CO_2$ and $CH_4$ were measured in the U.S. Geological Survey Dissolved Gas Laboratory, Reston, Virginia using gas chromatography procedures (See http://water.usgs.gov/lab/cfc/). Replicate analyses of $N_2$ and Ar in laboratory standards prepared by equilibrating water samples with air at 9, 16 and 24°C were typically within 1 percent and yielded calculated equilibration temperatures within ± 0.5°C (See Busenberg and others, 1998 for further details). The dissolved $O_2$ and $CO_2$ analyses have uncertainties similar to dissolved $N_2$ and Ar in laboratory standards, but can deviate as much as 20 percent of the reported value among replicate ground-water samples because of varying extents of microbiological processes occurring in the sample bottles.

#### Helium and Neon by Gas Chromatography

The water samples for determination of dissolved He and Ne by gas chromatography were collected in 150-mL septum bottles that were filled without headspace in the field. The samples were stored on ice in the field, and in a refrigerator at 4°C in the laboratory prior to analysis. After allowing the samples to come to room temperature overnight, a 10-mL headspace was created by removing some of the water through the septum with a needle connected to a vacuum pump. The water was allowed to equilibrate with this headspace overnight at room temperature before analysis. The entire headspace was injected into a gas chromatograph.

The concentrations of He and Ne were measured with a thermal conductivity detector (TCD). The procedure is given in Busenberg and others (2000) and is similar to the procedure described by Sugisaki and others (1982). The instrument was calibrated with five standards by injections of 1, 2, and 3 cubic centimeters ($cm^3$) of a gravimetric standard gas containing 35.0 parts per million by volume (ppmv) per volume of He. The concentration of He in this standard is known to within ± 1 percent. The two other standards used were 2.0 and 3.0 $cm^3$ of dry air. The concentrations of He and Ne in air are 5.24 and 18.18 ppmv per volume of gas (Committee on Extension to the Standard Atmosphere, 1976).

The precisions of the gas-chromatographic results are ± 10 and 20 percent for He and Ne, respectively. He and Ne results obtained by gas chromatography compare well with the results obtained by mass spectroscopy (Busenberg and others, 2000).

#### Helium, Neon, and Helium-3/Helium-4 Isotope Ratio by Mass Spectroscopy

Including replicates, and some incomplete analyses, a total of 138 samples were analyzed for the noble gases, He and Ne, and He isotopic composition, $\delta^3He$, (table A12) in an attempt to date waters by the tritium/helium-3 method (Schlosser and others, 1988; Schlosser and others, 1989; Solomon and Sudicky, 1991; Solomon and others, 1993; Schlosser and others, 1998; Solomon and Cook, 1999). The samples were collected in 80-cm long copper tubes with pinch-off clamps. Back pressure was applied to limit the potential for gas bubble formation during collection. The samples were analyzed at the Noble Gas Laboratory, Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY, using mass-spectrometric procedures (Ekwurzel and others, 1994; Ludin and others, 1998). Gases were extracted quantitatively (>99.9 percent) from water samples in the copper sample tubes using a vacuum extraction line and transferred into flame-sealed glass ampoules. After separation of water vapor and dissolved gases in cryogenic traps, He isotopes were measured on a VG

5400 mass spectrometer. Analyses of duplicate samples agreed within the analytical error of about ± 2 percent for the $^4He$ concentration and ± 1 percent for the $^3He/^4He$ ratio. Neon was measured in parallel to the He isotopes in a quadrupole mass spectrometer with a precision of ≤± 4 percent. The analytical errors assigned to the He and Ne concentrations, as well as the $^3He/^4He$ ratios, were based on factors affecting both the extraction procedures and the mass spectrometric measurements. The term $\delta^3He$ expresses the deviation of the $^3He/^4He$ ratio of the sample from that of air in percent as

$$\delta^3\mathrm{He} = \left( \frac{\left( \frac{^3He}{^4He} \right)_{sample}}{\left( \frac{^3He}{^4He} \right)_{air}} - 1 \right) 100, \qquad (12)$$

where the $^3He/^4He$ ratio of air is equal to $1.384 \times 10^{-6}$ (Clarke and others, 1976).

#### Chlorofluorocarbons

Water samples for determination of chlorofluorocarbons (CFCs) were fused into borosilicate 60-mL ampoules in the field using collection procedures that exclude contact with air (Busenberg and Plummer, 1992). Concentrations of CFC-11 (trichlorofluoromethane, $CFCl_3$), CFC-12 (dichlorodifluoromethane, $CF_2Cl_2$), and CFC-113, (trichlorotrifluoroethane, $C_2F_3Cl_3$), were determined at the U.S. Geological Survey Chlorofluorocarbon Laboratory, Reston, Virginia using purge and trap gas chromatography with an electron-capture detector (ECD) (Busenberg and Plummer, 1992; http://water.usgs.gov/lab/cfc/). The CFC concentrations are referenced to average air compositions measured at Niwot Ridge, Colorado (Climate Monitoring and Diagnostics Laboratory (CMDL) of the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce (see http://www.cmdl.noaa.gov/)). The standard deviation of repeated measurements is typically less than 2 percent of the reported value for CFC-11 and CFC-12, and about 3 percent for CFC-113, but increases as concentrations approach the detection limits of about 1 pg/kg for CFC-113 and about 0.5 pg/kg for CFC-11 and CFC-12. The analytical precision is about 50 percent at the detection limit and about 3 percent above 25 pg/kg. Eight standards and a blank were used for calibration because the ECD response does not vary linearly with concentration. The calibration ranges of the gas chromatograph were 0-1,200 pg/kg for CFC-11, 0-2,500 pg/kg for CFC-12, and 0-900 pg/kg for CFC-113. Reported concentrations beyond the above calibration limits should be considered as estimates of concentrations of the three CFCs.

#### Sulfur Hexafluoride

Water samples for analysis of sulfur hexafluoride, $SF_6$, were collected in 4- or 2.5- L plastic-coated glass bottles. The bottles were filled by placing the water inflow tube in the bottom of the bottle, displacing the air with water. After at least 3 L of overflow, the tube was slowly removed. The bottles were sealed with screw caps with conical liners without headspace. The conical liners in the caps allowed for some expansion of the water on warming. However, caps periodically were loosened slightly to prevent the glass bottles from breaking when the ground-water temperature was significantly lower than the ambient air temperature. Most $SF_6$ analyses were performed in a field laboratory near the sampling site, using instrumentation and procedures of Busenberg and Plummer (2000). However, some bottles were shipped to the U.S. Geological Survey laboratory in Reston, Virginia. All $SF_6$ analyses were performed by purge and trap gas-chromatographic procedures (Busenberg and Plummer, 2000). Standard deviations of about 3 percent were routinely obtained for repeated measurements of standards. The calibration was linear through the entire measuring range. For water samples, precision was about 50 percent at the detection limit of 0.02 femtomoles per kilogram (fMol/kg) and about 5 percent for concentrations greater than 0.1 fMol/kg.

### Quality-Assurance and Quality-Control Procedures

*Inorganic Chemistry*

Quality-assurance and quality-control (QA/QC) data are summarized in appendix D. The recommended concentrations of five major and four trace elements in three standard reference water samples that were analyzed along with the water samples from the MRGB are given in table D1. The recommended and measured concentrations and the standard deviations of the reference materials analyzed by the DCP are given in table D2. The detection limits for Ca, Mg, Sr, $SiO_2$, Na, K, Fe, Mn, and Al by DCP are less than 0.1, 0.01, 0.005, 0.1, 0.05, 0.1, 0.01, 0.005, and 0.005 ppm, respectively. Accuracies for measurement of Ca, Mg, Sr, $SiO_2$, Na, K, Fe, Mn, and Al by DCP are 3 to 5, 3 to 5, 3 to 5, 5, 3 to 5, 5 to 10, 5 to 10, 5, and 10 to 15 percent, respectively.

The accuracy of the ion chromatographic (IC) system was checked with Simulated rainwater 2 (table D3, High Purity Standards). Bromide standard solutions were prepared from Dionex standard solutions and measured separately. Detection limits for Cl, $SO_4$, $NO_3$, and F are less than 1, 2, 0.1, and 0.05 ppm, respectively. The Br detection limit was determined by the volume of the sampling loop injected into the ion chromatograph and ranged from less than 0.005 to less than 0.02 ppm. The precisions for measurement of Cl, $SO_4$, $NO_3$, F, and Br are 3, 3 to 5, 3 to 5, 3, and 10 percent, respectively.

Trace elements were measured with an ICP-MS using the standard reference solutions given in table D4. The water used to prepare the standards and blanks was prepared by passing deionized water through a Millipore Milli-Q system to obtain ultra-pure, 18-megaohm reagent-grade water. Blanks were prepared in the acid-washed, 250-mL polypropylene bottles that were used to collect the ground-water samples. The samples were acidified in the field with the same lot of nitric acid. Working standard solutions were prepared from Claritas PPT grade 10 ppm multi-element solutions purchased from Spex CertiPrep. The acidified blanks were compared to reagent water and results are given in table D5. Separate blanks containing 100 ppm Ca and Cl also were used to determine for the possible presence of interfering molecular ions that can form in the argon plasma (Tan and Horlick, 1986). The recommended and measured concentrations and the standard deviations of the reference materials analyzed are given in table D5.

### Field Blank

A field blank was collected in such a way as to identify potential contamination problems in field-collection and laboratory-handling procedures of the FA samples. An FA sample bottle was rinsed two times with inorganic blank water (Ocala lot number 95171-22 bottle 222, http://owqrl.er.usgs.gov/certificates/ibw/ibw_22.shtml), and about 500 mL of the blank water was pumped with a peristaltic pump to rinse the tubing. A cartridge filter was attached to the tubing and purged of air, and the FA bottle was then rinsed three times with the filtered organic-free blank water, and then filled with this water to produce the field blank. The FA bottle was then acidified in the field with ultra-pure nitric acid (lot number NA 5318-1GS1, http://wwwnwql.cr.usgs.gov/USGS/certificates/na5318.0196.html), and a second FA bottle with reagent-grade nitric acid (table D6). The concentrations of metals in samples acidified with reagent grade and Ultrex (ulta-pure) nitric acids, analyzed by ICP-MS and DCP, were nearly identical indicating that the sampling and laboratory handling procedures did not normally introduce metals contamination.

### Sample Filtration

Concentrations of most major and trace cations, obtained for nine samples that were filtered in the field through standard 0.45-micron cartridge filters, were indistinguishable from the results obtained from samples collected from the same sites at the same time and filtered in the field by tangential filtration through 0.1-micron and 30,000-dalton pore-size filters; however, the 30,000-dalton tangential filter may contaminate some samples with Cu and Pb, whereas the 0.1-micron tangential filter may introduce a slight amount of Pb (table D7). There were appreciable differences in concentrations with test samples filtered through standard 0.2-micron membrane filters. All samples filtered through the 0.2-micron membrane filters were contaminated with Cu, Zn, Fe, and Al, relative to those filtered through a 0.45-micron membrane filter; some of the samples filtered through the 0.2-micron membrane filter also appear to be contaminated with Sr, Mg, and possibly Co and Pb, with respect to the 0.45-micron filter (table D7). Apparently, the 0.2-micron membrane filters were the source of contamination of the ground-water samples used in the filtration test. All of the results of this study are based on filtration using the 0.45-micron cartridge filters. The results indicate that, overall, the 0.45-micron cartridge filter used in this study performed as well as tangential filtration procedures at 0.1-micron and 30,000-dalton pore sizes on ground-water samples from the study area. The results also indicate that the reported concentrations represent dissolved concentrations and, apparently, colloids are not important sources of metals transport in the MRGB ground water sampled.

The concentrations of 12 trace elements in 5 samples that were filtered through 0.45-micron cartridge filters in the field are shown in table D8. The filtered water was refiltered in the laboratory through 0.2- and 0.1-micron membrane filters. The only appreciable decreases in concentration with reduced filter size were observed for Cr, Cu, and/or Zn concentrations in two samples (NM481 and NM258). No appreciable decreases in concentrations of these three trace metals were observed in any of the other samples. This suggests that filtration through the 0.2- and 0.1-micron pore-size filters removed particles in the sample; these particulates may have passed through the 0.45-micron filters or were introduced after the samples were filtered. One sample (NM323) showed an increase in concentrations of Ba, Cu, and Zn with reduced filter size, indicating possible contamination from the filter or contamination introduced during laboratory processing of the sample.

#### Replicate Analyses (Field Duplicates and Re-Sampled Wells)

Replicate analyses for five major elements and Sr in 79 ground-water samples from the study area were performed by DCP. The percent difference in replicate analyses as a function of the cumulative percent of analyses is shown in figure 15. The results of duplicate analyses agreed to better than 5 percent for Ca, $SiO_2$, Mg, Na, Sr, and K in 95, 89, 82, 75, 68, and 60 percent of the analyses, respectively. Replicate analyses agreed to better than 10 percent in 92 percent of the samples for all elements with the exception of K, which agreed in 84 percent of the samples (K is difficult to analyze because the emission spectrum is in the ultraviolet part of the spectrum). The percent difference between duplicate analyses generally increases as the sample concentration decreases (fig. 16), which provides guidelines on analytical uncertainties that can be expected as a function of concentration range.

Duplicate analyses for trace elements were performed on approximately 57 pairs of ground-water samples from New Mexico. For Al, As, B, Ba, Cr, Cu, Li, Mn, Mo, Pb, Rb, Se, U, V, and Zn, the pairs of analyses agreed to within ± 10 percent in 46, 75, 91, 96, 34, 59, 92, 64, 96, 56, 96, 88, 79, 77 and 43 percent of the cumulative total of analyses, respectively. The agreement was within ± 20 percent for 68, 97, 100, 100, 49, 78, 100, 86, 100, 71, 100, 88, 100, 96 and 67 percent of the cumulative total of the analyses of the above trace elements, respectively. The higher deviations between pairs of analyses were observed at or near the detection limits of the trace metals.

#### Electrical Balance

The charge balance between the anions and cations in 352 analyses was calculated using the equation

$$\frac{100\times(e_{cations}-e_{anions})}{(e_{cations}+e_{anions})/2}=CB \qquad (13)$$

where

*CB* is the percent difference between the sum of the equivalents of cations and anions, and

*e* is the sum of the equivalents of cations or anions.

In only 4 percent of the samples the difference was greater than ± 5 percent. The charge balance was better than ± 1, ± 2, ± 3, ± 4, and ± 5 percent in 26, 48, 66, 84, and 96 percent, respectively, of the samples analyzed.

### *Hydrogen-2 and Oxygen-18 Isotopes of Water*

The standard deviations of $\delta^{18}O$ values determined by the USGS on water collected from an individual well over relatively short periods of time were examined as an indication of analytical variability. Because some natural variability could be expected, this examination provides a measurement of the maximum likely analytical variability. From the archived Yapp samples (1980-82), there were typically 0-3 samples re-analyzed by the USGS per well. However, for 6 wells, as many as 11-14 waters (Ponderosa 2, Thomas 3, Volcano Cliffs 2, West Mesa 3, Duranes 4, and Atrisco 2) were re-analyzed by the USGS. In the USGS samples (1996-97), there were typically only 2 waters to be compared. The average of the standard deviations from the re-analyzed Yapp samples (1980-82) and the USGS samples (1996-97) were 0.12 and 0.06 per mil in $\delta^{18}O$, respectively. The maximum deviation in $\delta^{18}O$ from a single well was only 0.10 per mil in the USGS samples and 0.28 per mil in the re-analyzed Yapp samples (removing samples from West Mesa 3 that apparently show considerable natural variation).

The USGS Stable Isotope Laboratory was one of 44 laboratories that participated in the International Atomic Energy Agency (IAEA) intercomparison of

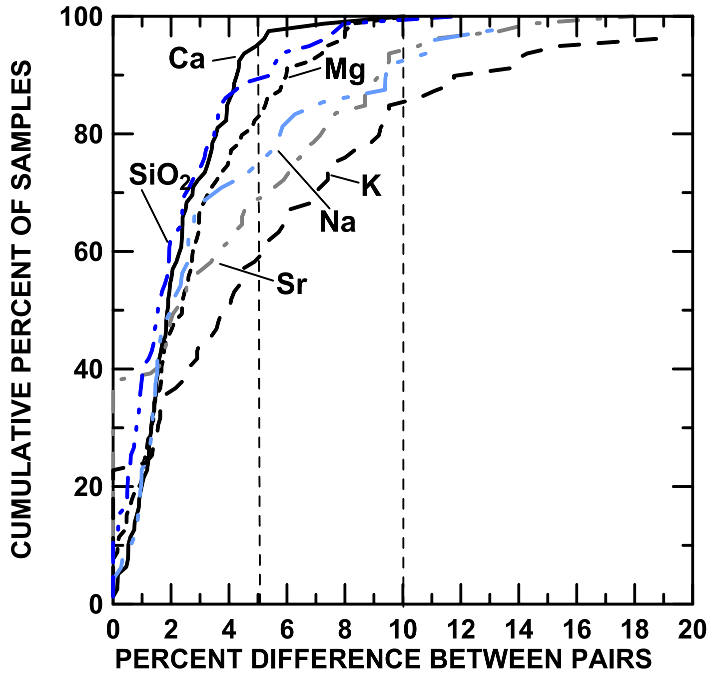



**Figure 15.** . Percent difference between duplicate samples as a function of the cumulative percent of the samples analyzed from the Middle Rio Grande Basin. The dashed lines represent 5 and 10 percent difference between duplicate analyses.

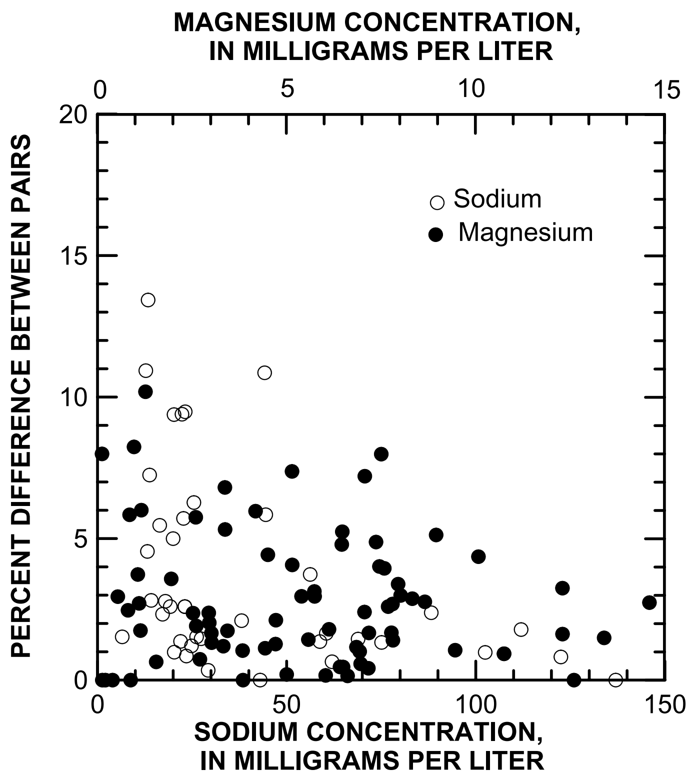



**Figure 16.** The difference in concentration between pairs of ground-water samples from the Middle Rio Grande Basin as a function of the concentration of cations in ground water.

measurements of the stable isotope composition of the GISP (Greenland Ice Sheet Precipitation) water sample distributed by the IAEA (Gonfiantini and others, 1995). The USGS Stable Isotope Laboratory completed an audit of the United States supply of VSMOW distributed by NIST. In 32 analyses of 3 samples of SMOW and VSMOW (Coplen and Hopple, 1995), $\delta^2H$ averaged 0.0 per mil with standard deviations of 0.6 to 1.3 per mil; in 16 determinations of the same SMOW and VSMOW samples $\delta^{18}O$ averaged 0.0 ± 0.05 per mil. Seven replicate analyses of SLAP reported by Coplen and Hopple (1995) averaged isotopic compositions identical to the internationally accepted compositions of this standard ($\delta^2H$ = -428.0 per mil, $\delta^{18}O$ = -55.50 per mil, Gonfiantini and others, 1995), with 1-$\sigma$ precisions of ± 0.8 and ± 0.03 per mil for $\delta^2H$ and $\delta^{18}O$, respectively. The USGS Stable Isotope Laboratory reported O- and H-isotope results with 1-$\sigma$ precisions of 0.1 and 0.8 per mil, respectively, for all the MRGB samples analyzed as a part of this study.

### Carbon-13 and Carbon-14 Isotopic Composition of Dissolved Inorganic Carbon

Tests showed that samples preserved as $BaCO_3$ were not as stable as samples collected in glass septum bottles without preservatives. Apparently, air reacted with the $BaCO_3$, resulting in isotopic exchange of atmospheric $CO_2$ with $BaCO_3$, which can affect the values of both $\delta^{13}C$ and $^{14}C$ activity. In an effort to assess the magnitude of possible isotopic variations and to validate the $\delta^{13}C$ and $^{14}C$ measurements, six QA/QC procedures were undertaken during the course of the investigation.

***1. Laboratory precision***. The AMS facility provided information on their laboratory analytical precision. Eighty-three replicate determinations of the $^{14}C/^{13}C$ isotope ratio of an oxalic acid standard determined as a normal part of the operation of the AMS facility during the period December 18, 1996 through March 16, 1997, when many of the samples from this study were analyzed, varied by only ± 1.5 percent (R. Sparks, Rafter Radiocarbon Laboratory, Institute of Geological & Nuclear Sciences, Ltd., Lower Hutt, New Zealand, written commun., 1997). In another test, 8 samples each of two sources of silk thread (16 samples in all) were processed separately and analyzed with mean $^{14}C$ activities of 86.3 and 86.2 pmC for the two sources, and analytical ranges of 85.5 ± 0.7 to 86.7 ± 0.7 pmC for one source and 85.2 ± 0.7 to 86.9 ± 0.7 pmC, respectively, for the other source (R. Sparks, Rafter Radiocarbon Laboratory, Institute of Geological & Nuclear Sciences, Ltd., Lower Hutt, New Zealand, written commun., 1997). The average standard deviation of the replicate analyses of the two sets of samples was ± 0.5 pmC, or only about ± 0.6 percent of the reported $^{14}C$ activity. Analyses of samples with low $^{14}C$ activity are less precise than those with high $^{14}C$ activity, and probably in the range of ± 5 percent of the reported activity in samples in the range of 3 to 8 pmC. For example, the $^{14}C$ activity of $CO_2$ in three of the backup breakseals was determined at the AMS facility and compared to the first determination from the original breakseal sent to the AMS facility. The three samples had average $^{14}C$ activities of 7.7, 5.4, and 3.0 pmC and differences in the replicate analyses were 4.8, 3.3, and 6.4 percent of the reported average value, respectively.

***2. Comparison of results from $BaCO_3$ samples and septum bottle samples***. Seven samples that were originally analyzed from $BaCO_3$ powders from the 1996 sampling were re-analyzed using the water sample from the septum bottle that was collected at the same time, but had been stored for approximately 1 year prior to analysis (group 1 of table D10). The $^{14}C$ activities determined on the samples from the septum bottles were either nearly identical to the results from the $BaCO_3$ samples or were lower in $^{14}C$ activity than the values determined on the original $BaCO_3$ samples (table D10). On average, the $^{14}C$ activities determined on $BaCO_3$ samples were only about 5 percent greater than values determined on the archived septum bottles, although the largest deviation was about 14 percent in one sample. Therefore, all differences were small, and in the case of $^{14}C$ samples with low $^{14}C$ activity, within the laboratory precision. Values of $\delta^{13}C$ of DIC from the $BaCO_3$ samples also were either mostly the same as those from the septum bottles (within the analytical uncertainty) or were shifted toward the $\delta^{13}C$ of $CO_2$ in air (approximately -8 per mil) from the value found for DIC in the septum bottle. That is, samples from septum bottles that were more depleted in $^{13}C$ than air were enriched in $^{13}C$ in the $BaCO_3$ sample relative to the septum bottles, and those in septum bottles that were more enriched in $^{13}C$ than air were depleted in $^{13}C$ in the $BaCO_3$ samples relative to those from the septum bottles (table D10).

***3. Comparison of $^{14}C$ results from $BaCO_3$ samples with storage***. Twelve samples of $BaCO_3$ from the 1996 sample set were re-submitted approximately 1 year following the initial analysis and re-analyzed (group 2 of table D10). In the interim between the initial analysis and re-analysis, the samples had been stored in capped glass bottles with, otherwise, no special precautions to exclude air. Most of the powders gained $^{14}C$ with time. The maximum increase in $^{14}C$ activity in one sample was a change of about 32 percent from the initial analysis, whereas the average increase in $^{14}C$ activity from the original analysis of all 12 samples was 14 percent on storage of about 1 year. Two factors probably contribute to the uptake of $CO_2$ from air. Recrystallization of the $BaCO_3$ precipitate probably occurs, and this process probably involves an isotope exchange process. Also, some samples of the precipitate may not have been sufficiently washed to remove all the $Ba(OH)_2$. Samples with high dissolved $SO_4$ would be most affected because $BaSO_4$ forms a fine precipitate that tends to clog filters and slow the washing process. Precipitates that still contained $Ba(OH)_2$ would react with air and take up additional $CO_2$ over time. Because the $CO_2$ from the original sample set of $BaCO_3$ powders from the 1996 sampling was extracted into breakseal tubes within approximately 3 months of preparation, the time during which changes in $^{14}C$ activity prior to extraction could occur was limited, particularly in comparison to the 12 months between preparation and extraction for the re-analyzed samples. The exchange of $^{14}C$ with air prior to $CO_2$ extraction of the original set of $BaCO_3$ samples apparently resulted in a change of only about 5 percent, on average, as the comparison with analyses from septum bottles (group 1, table D10) indicates. This difference is small and has been ignored in interpretation of radiocarbon age of DIC in the ground-water samples.

***4. Re-sampling of wells and comparison of $^{14}C$ results from septum bottles.*** In this test, eight wells that had been sampled in 1997 were re-sampled in 1998. During both years, $^{14}C$ samples were collected in septum bottles using identical collection procedures (group 3, table D10). Most of the wells re-sampled were deep monitoring wells that had been completed and developed within the year prior to the initial sampling. Differences in results in this sample set reflect uncertainties in analytical methods, field collection, and the extent to which identical water samples can be withdrawn from the monitoring wells. Traces of CFC-12 were detected in many of the samples from the monitoring wells, probably indicating that traces of drilling fluid were still present in the ground-water environment in the vicinity of the well screen. The re-sampling and collection of water samples from these wells by other agencies in the interim following the initial sample collection helped to further develop the wells prior to the second sampling in 1998. No systematic change in $^{14}C$ activity was found between the initial and second sampling (table D10). In terms of percent change, the largest change was for the deep completion of the $98^{th}$ Street well (site S003), where the $^{14}C$ activity increased from 0.6 to 1.1 pmC between the initial and second sampling. As these values are near the limits of the radiocarbon dating method, the differences in $^{14}C$ activity at the $98^{th}$ Street well are probably within expected limits. The rest of the samples either increased or decreased in $^{14}C$ activity with changes of approximately $\pm$ 0 to $\pm$ 8 percent of the average value, with an average change of only $\pm$ 0.2 percent from the original value for all the samples.

***5. Storage effects of $^{14}C$ samples in septum bottles.*** Duplicates of two samples collected in septum bottles were analyzed approximately 1 year apart (group 4, table D10). The results were nearly identical.

***6. Duplicate extraction and analysis of $BaCO_3$.*** Quality-assurance procedures identified one sample of $BaCO_3$ that was likely extracted twice, one time after the other, but analyzed as if it were two separate samples. The results for this sample were included (group 5, table D10) because they give some information on the differences that can result in the original homogenization of the $BaCO_3$ samples, extraction of $CO_2$, and subsequent analysis. In this case, the $^{14}C$ activities of the two extractions were 11.7 and 12.2 pmC (table D10).

## Historical Data

To obtain the most accurate representation of water chemistry in the MRGB that could reasonably be achieved, data collected specifically for the current study were supplemented with historical data. Supplementary data were obtained from two main sources that were readily accessible, that contained data for a substantial number of sample sites, and that included specific location information for those sites. These sources, which are described below, are the

USGS NWIS database and a database maintained by the City of Albuquerque on water chemistry from its production wells. No effort was made to obtain data from sources that did not include location information for sites in latitude and longitude or State-plane coordinates, that included only a small number of localized sites, or that did not have data in a digital format.

#### U.S.Geological Survey National Water Information System Database

The NWIS database maintained by the New Mexico District Office of the USGS includes water-chemistry data for ground-water sites (including both wells and springs) and surface-water sites across New Mexico. In addition to chemical analyses for samples collected primarily by the USGS as early as 1941, the database contains latitude and longitude for each ground-water sample site and, typically, includes well construction information. For this report, all available ground-water samples obtained from sites located within the MRGB were retrieved from the database. Samples that did not include either trace-element analyses or a full analysis of all major ions were not retained. Samples with major-element analyses that did not give an ion balance of 10 percent or better also were discarded. Finally, duplicate samples for the same site were eliminated (in general, the most recent sample was retained, unless a prior sample was analyzed for more parameters). For an individual ground-water site, a sample collected specifically for the MRGB study was always retained over any samples available from the NWIS database. Ground-water sites for which data were retained are shown in figure 17a,b; the data are given in appendix E, table E1. In addition to ground-water data, surface-water data also were retrieved from the NWIS database for selected sites (fig. 17a,b). Discharge-weighted compositions for surface-water sites in NWIS are summarized in table 4, along with other representative end-member water compositions for the MRGB. Chemical analysis of most ground- and surface-water samples from NWIS was performed at a USGS laboratory; methods of analysis vary because the dates of sample collection encompass many years. Although it cannot be determined with certainty, all samples are believed to have been passed through 0.45-micron filters, with minor-element samples being acidified in the field.

#### City of Albuquerque Database

Since 1988, the City of Albuquerque has periodically collected and analyzed water-quality samples from its production wells (fig. 18) through a voluntary effort to improve understanding of the regional ground-water resource. The database that has been compiled as a result of this effort is described by Bexfield and others (1999). The median constituent concentrations presented by Bexfield and others (1999) for major elements, minor elements, and field parameters from each of 93 production wells (generally deep wells with long screened intervals, see table 2 for example) were included in the data set used for this investigation, along with data for one additional well. Median values of the major ions for 93 of these 94 wells gave ion balances within 11 percent; one well (Vol Andia 1) had an ion balance of 15 percent. For production wells that also were sampled between June 1996 and August 1998 specifically for the MRGB study, the City of Albuquerque data for major elements, minor elements, and field parameters were eliminated; however, City of Albuquerque data were retained in favor of historical NWIS data when data for the same site were present in both databases. City of Albuquerque data are for unfiltered samples; minor-element samples were acidified on the day of collection. Readers are referred to Bexfield and others (1999) for further details on sample collection and methods of analysis, which have varied over time for some individual parameters.

One other data set was examined, but rejected. This data set included stable isotope measurements, some of which are tabulated in Logan (1990) and other values are unpublished, for approximately 500 ground-water samples collected from City of Albuquerque production wells during the period February 1987 – June 1990 (B. Gastian, City of Albuquerque, oral commun., 1997). Stable isotope samples were analyzed on the VSMOW scale by a contract laboratory; however, the analytical precision was not reported. The standard deviation of $\delta^{18}O$ values determined on water collected from an individual well over relatively short periods was examined for data from the contract laboratory for each City of Albuquerque production well. There are typically 3-5 replicate analyses from the contract laboratory on samples collected between 1987 and 1990, and as many as 44 samples at one well (at Love 1, site S110). The average standard deviation of $\delta^{18}O$ values from all replicate

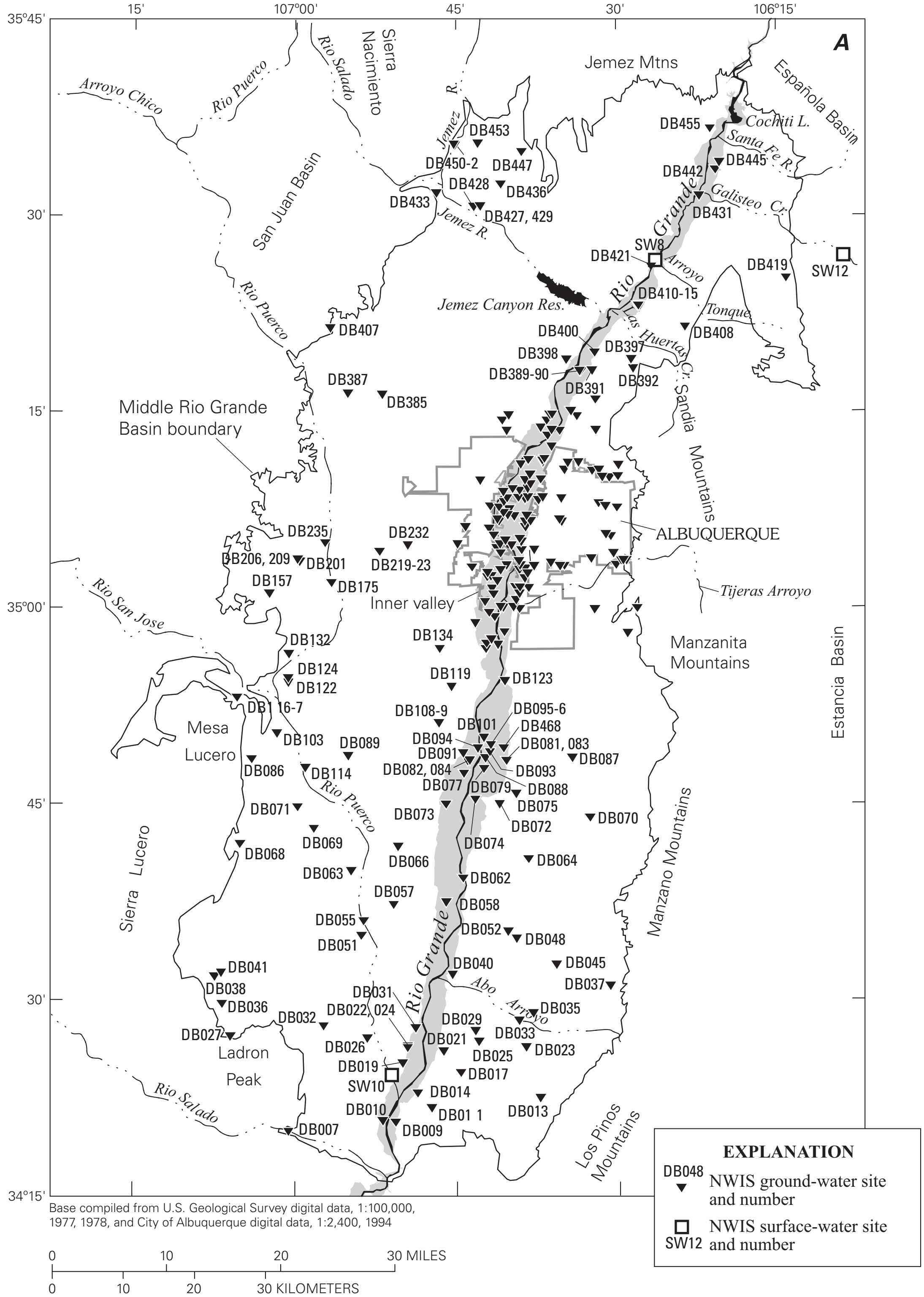



**Figure 17a.** Locations of ground-water and surface-water samples from the U.S. Geological Survey NWIS data base included in the final data set outside the Albuquerque area. Surface water sites SW8, SW10, and SW12 are the USGS gauge stations Rio Grande at San Felipe (site 08319000), Rio Puerco near Bernardo (site 08353000), and Galisteo Creek above Galisteo Reservoir (site 08317850), respectively.

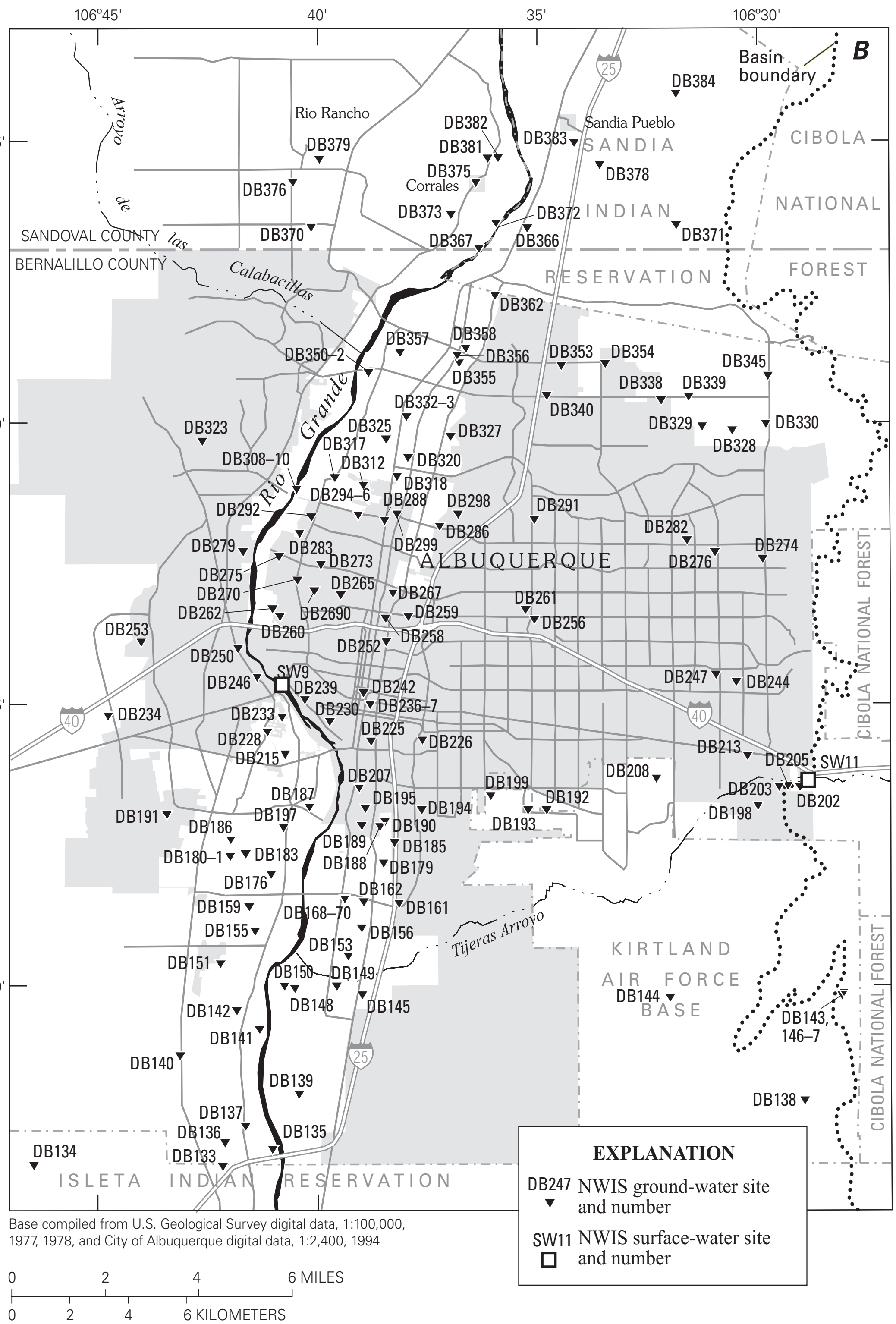



**Figure 17b.** Locations of ground-water and surface-water samples from the U.S. Geological Survey NWIS data base included in the final data set inside the Albuquerque area.

**Table 4.** Summary of chemical and isotopic properties of representative end-member waters for the Middle Rio Grande Basin, New Mexico

[Sevilleta, [Moore, 1999, Precipitation chemistry data on the Sevilleta National Wildlife Refuge, 1989-1995 (http://sevilleta.unm.edu/research/local/nutrient/precipitation/#data)]; PRECIPx8, Sevilleta with evapotranspiration (ET) factor of 8-fold; NMF, Northern Mountain; NMF, Northern Mountain Front, median, this study; EMF, Eastern Mountain Front, median, this study; SWMF, Southwestern Mountain Front, NWIS, representative sample; NEGW, Northeast Ground-Water Inflow, NWIS, representative sample; SWGW, Southwest Ground-Water Inflow, NWIS, median; ASSP, Arroyo Salado Spring; MWGW, Mid-West Ground-Water Inflow, NWIS, median; Saline 1, Mineralized upward leakage from Domestic Well #04, NM041; Saline 2, Mineralized upward leakage from Coyote Spring, NM031; RP, Discharge-weighted average NWIS Rio Puerco at Bernardo; RGA, Discharge-weighted average NWIS Rio Grande at Albuquerque; RGSF, Discharge-weighted average NWIS Rio Grande at San Felipe; JRW, Discharge-weighted average NWIS Jemez River below Jemez Canyon Dam; ABO, Median Abo Arroyo; TIJ, Discharge-weighted average NWIS Tijeras Arroyo above Four Hills Road; GAL, Galisteo Creek above Galisteo Reservoir, June 1974; LUC, Lucero-24, mg/L, milligrams per liter; per mil, parts per thousand; pmC, percent modern carbon; Est., estimated; nd, no data]

| Source | pH (standard units) | Est. dissolved oxygen (mg/L) | Alkalinity as $HCO_3^-$ (mg/L) | Calcium (mg/L) | Magnesium (mg/L) | Sodium (mg/L) | Potassium (mg/L) | Chloride (mg/L) | Sulfate (mg/L) | Silica as $SiO_2$ (mg/L) | Est. $\delta^{13}C$ ($^{o}/_{oo}$) | Est. $^{14}C$ activity (pmC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Precipitation** | | | | | | | | | | | | |
| Sevilleta (1989-95) bulk | 5.4 | nd | 1.7 | 0.94 | 0.09 | 0.12 | 0.15 | 0.21 | 1.40 | nd | - 8. | 100 |
| **Precipitation with ET of 8-fold** | | | | | | | | | | | | |
| PRECIPx8 | 5.4 | 8.0 | 0.525[1] | 7.5 | 0.7 | 1.0 | 1.2 | 1.7 | 11.2 | nd | - 8. | 100 |
| **Mountain-front recharge** | | | | | | | | | | | | |
| NMF | 7.4 | 8. | 124. | 29. | 3.9 | 16. | 4.3 | 4.4 | 14. | 53. | -12. | 100. |
| EMF | 7.4 | 8. | 212. | 61. | 7.5 | 16. | 1.6 | 6.4 | 31. | 23. | -12. | 100. |
| SWMF | 7.3 | 8. | 207. | 54. | 12. | 19. | 1.3 | 12. | 33. | 29. | -12. | 100. |
| **Ground-water inflow** | | | | | | | | | | | | |
| NEGW | 7.5 | 0. | 328. | 67. | 15. | 67. | 5. | 27. | 63. | 13. | - 4. | 2. |
| SWGW | 7.7 | 0. | 2,073. | 474. | 230. | 6,069. | 143. | 7,202. | 5,020. | 21. | - 4. | 2. |
| ASSP | 6.7 | 7.4 | 1,180. | 606.7 | 512.8 | 5,910. | 148.8 | 8,070. | 3,750. | 17.2 | 2.8 | 7.6 |
| MWGW | 7.7 | 0. | 1,366. | 300. | 145. | 3,532. | 117. | 2,700. | 3,250. | 21. | - 4. | 2. |
| **Upward leakage of saline waters** | | | | | | | | | | | | |
| Saline 1 | 7. | 0.1 | 181.6 | 185. | 25.7 | 1,530. | 107. | 2,520. | 296.2 | 43.4 | - 7.5 | 23. |
| Saline 2 | 6.5 | 2.8 | 1,305. | 322. | 70.3 | 382. | 43.7 | 581.3 | 139.5 | 16.9 | - 0.6 | 4.8 |
| **Surface waters** | | | | | | | | | | | | |
| RP | 8. | 1. | 183. | 138. | 29. | 200. | 7. | 46. | 707. | 10. | - 0.1 | 64. |
| RGA | 8.1 | 8. | 118. | 37. | 6.4 | 22. | 3. | 9.2 | 58. | 18.5 | - 7.5 | 100. |
| RGSF | 8.1 | 8. | 112. | 34.5 | 6.3 | 17. | 2.6 | 4.8 | 50. | 18. | - 7.5 | 100. |
| JRW | 8.1 | 8. | 129. | 39. | 4.6 | 62. | 5.5 | 50. | 79. | 22. | - 2.9 | 83. |
| ABO | 8.3 | 8. | 254. | 297. | 105. | 123. | 1.5 | 61. | 1,049. | 19. | - 7.1 | 87. |
| TIJ | 8.2 | 8. | 243. | 102. | 21. | 39. | 5.5 | 82. | 105. | 16. | - 7.1 | 87. |
| GAL | 8.1 | 8.8 | 220. | 150. | 45. | 140. | 3.7 | 23. | 630. | 17. | - 6. | 100. |
| LUC | 6.8 | nd | 536. | 171. | 56.8 | 131. | 5.4 | 46. | 183. | 18. | - 5. | 100. |

[1]mg/L as $CO_2$.

analyses provided by the contract laboratory was 0.22 per mil, and the maximum deviation from a single well ranged over more than 1 per mil. The stable isotope analyses used in this study were all obtained from the USGS Stable Isotope Laboratory, Reston, Virginia, and have a reported 1-$\sigma$ precision of 0.1 per mil in $\delta^{18}O$.

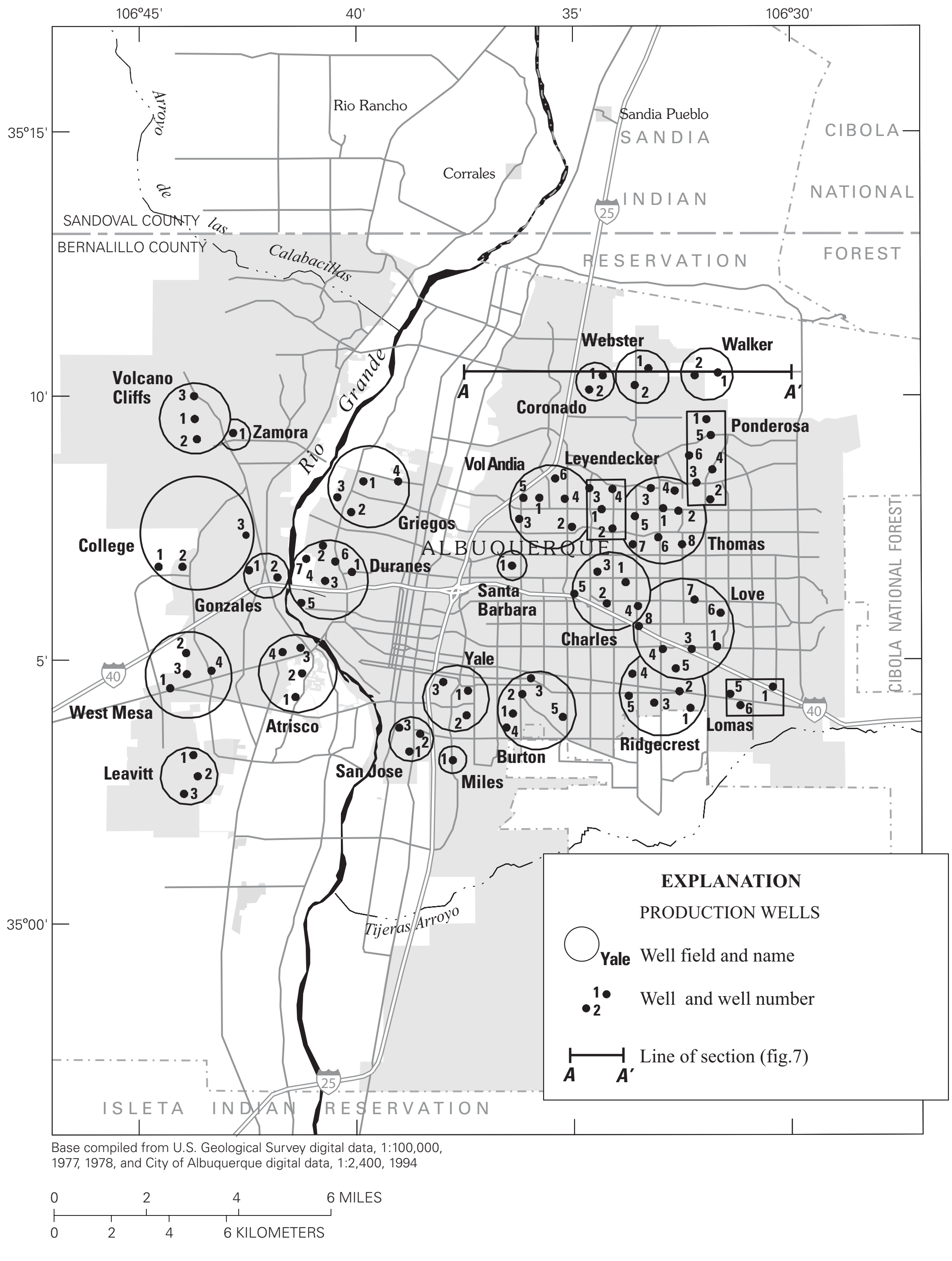



**Figure 18.** Locations of City of Albuquerque production wells. Wells for which City of Albuquerque, New Mexico, data were included in the final data set are listed in appendix F.

# SOURCES OF RECHARGE AND UNDERFLOW TO THE SANTA FE GROUP AQUIFER SYSTEM

As discussed in the "Description of the Study Area" section, multiple sources of recharge are known to contribute water to the Santa Fe Group aquifer system. These sources include mountain-front recharge processes, infiltration from the Rio Grande, tributaries to the Rio Grande, and arroyos, and ground-water inflow from adjacent basins. Although physical and chemical processes can affect these waters as they recharge and move along ground-water-flow paths, the chemical and isotopic characteristics of ground-water samples are likely to broadly reflect the characteristics of the source. The Santa Fe Group aquifer system of the MRGB is composed primarily of unreactive material—sands and gravels from the chemical and mechanical breakdown of silicate rocks and minerals—so that solute concentrations are likely to change only slightly with distance down a flow path. Therefore, knowledge of the chemical and isotopic characteristics of potential recharge waters should be extremely useful in identifying the primary recharge sources to various areas of the basin.

Because of the importance of characterizing possible sources of recharge to the basin, efforts were made to compile chemical and isotopic data for these sources. In addition to information on general water chemistry (major and trace elements), data were obtained on the $\delta^{18}O$ and $\delta^{2}H$ compositions of water because, although processes causing local variations in isotope composition can be recognized in a qualitative sense, it is not possible to *a priori* predict the isotopic composition of recharge waters with sufficient accuracy to be of use in tracing source waters in the MRGB. Having measured the chemical and isotopic composition of source waters to the basin, it was, in many cases, possible to use this information to trace ground-water flow.

The major factors that can affect the $\delta^{18}O$ and $\delta^{2}H$ isotopic composition of precipitation are season, latitude, temperature, altitude, storm track, and amount of precipitation. Most of the isotopic variations associated with these factors can be related to isotope-fractionation effects that occur during evaporation at the moisture source(s) and during moisture condensation (see Dansgaard, 1964; Rozanski and others, 1993; Clark and Fritz, 1997; Coplen and others, 1999; and references therein). In addition, most surface waters and shallow soil waters in the MRGB are evaporated partially. Depending on the relative humidity, evaporated surface waters can be enriched in $^{2}H$ and $^{18}O$ relative to the original source (Gat, 1981; Gilath and Gonfiantini, 1983; van der Straaten and Mook, 1983; Gonfiantini, 1986).

## Precipitation

### Inorganic Chemical Composition

Data for the inorganic chemical composition of precipitation in the general area of the MRGB are available from several sources: Popp and others (1984) for both wet and bulk precipitation at Albuquerque and Socorro; the University of New Mexico's Long-Term Ecological Research Program (LTER) on Sevilleta National Wildlife Refuge for bulk precipitation at the southern end of the MRGB; and the National Atmospheric Deposition Program for wet precipitation at Cuba and Bandelier, north of the basin. For this investigation, bulk precipitation data from the LTER were selected to represent historical precipitation chemistry. Bulk rather than wet precipitation chemistry was chosen for comparison to ground-water compositions because bulk concentrations are more representative of water that infiltrates after contact with dry particulate matter. LTER data were chosen over data from Popp and others (1984) because LTER data were available for a longer period of time at multiple sites. The LTER network (Sevilleta National Wildlife Refuge; fig. 11a) included 20 precipitation collectors from 1989 to 1995, and 6 collectors for 1996 to 2000. Samples were analyzed monthly for Na, K, Ca, Mg, $NO_3$, $NH_4$, $SO_4$, and Cl concentrations, along with conductivity and total Kjeldahl-N and $PO_4$ (http://sevilleta.unm.edu).

Average bulk precipitation compositions were calculated for the LTER data (table 4) by weighting the concentrations according to the quantity of precipitation represented by each sample. The data indicate that during the period of record (1989-2000), $SO_4$ concentrations exceeded Cl concentrations by several times; the ratio of $SO_4$ to Cl concentrations in milliequivalents per liter (meq/L) averaged about 5.2 (the yearly average varied from 3.4 in 1991 to 8.1 in 1998). Calcium was the dominant cation. The ratio of Ca to Na concentrations in meq/L averaged 9.6 (the yearly average varied from 5.4 in 1990 to 13.1 in 1989).

Precipitation chemistry has probably fluctuated between the time that much of the sampled ground water recharged (as long as tens of thousands of years ago) and today. Sulfate concentrations in precipitation today are probably higher than in the past, as a result of sulfur emissions associated with human activity that would have caused $SO_4$ (and the associated ratio to Cl) to increase. Variations in wind direction, amounts of atmospheric dust, and distance from the ocean are other factors that likely have changed over time and could have affected the composition of precipitation. Although the modern precipitation composition used for comparison to ground water may not represent the exact composition at the time of recharge, it provides a common reference point for comparison.

### Oxygen-18 and Hydrogen-2

Historical data on the stable isotope composition of precipitation in the vicinity of the MRGB is limited primarily to that of Yapp (1985), who found a wide range of -6 to -158 per mil in the $\delta^2H$ composition of amount-weighted precipitation samples collected monthly over 2 years from the roof of the Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque. Yapp (1985) did not tabulate the amounts of precipitation, but indicated that the yearly weighted average precipitation was -60 per mil in $\delta^2H$.

Precipitation samples were not collected systematically as a part of the current MRGB investigation. However, two sets of archived samples of precipitation from the vicinity of Albuquerque were analyzed for stable isotope composition: (1) the above-mentioned archived samples of precipitation collected by Crayton Yapp from October 1981 to March 1984 from the roof of Northrop Hall, University of New Mexico (latitude 35°04'58", longitude 106°37'20", altitude 5,160 feet above sea level), and (2) precipitation samples collected by Robert Hejl, May 1987 – July, 1988 from a location in Albuquerque (latitude 35°07'09", longitude 106°29'43", altitude 5,840 feet above sea level). The precipitation samples were collected on an event basis and composited monthly. There is a strong seasonal signal in stable isotopic composition, with the most depleted precipitation during the winter months of January and February, and the most enriched during part of the summer monsoon period of June-August (Yapp, 1985). Two seasonal records in $\delta^{18}O$ from the Yapp and Hejl samples are shown in figure 19. A least squares fit to all the precipitation samples defines a local meteoric water line for the vicinity of Albuquerque of

$$\delta^2H = 7.76\ \delta^{18}O + 4.73\ , \qquad (14)$$

as shown in figure 20. The average deuterium excess ($d_{excess}=\delta^2H-8.0\delta^{18}O$) is 7.1 per mil. The amount-weighted precipitation from 1987-1988 in the Hejl samples analyzed by the USGS has the isotopic composition, $\delta^2H = -56$, $\delta^{18}O = -7.9$ per mil. For consistency with the USGS measurements on the Hejl precipitation samples and other USGS stable isotope measurements (see section "Comparability of Results" in "Hydrogen-2 and Oxygen-18 Isotopes in Ground Water" for further details), Yapp's reported yearly weighted $\delta^2H$ composition of precipitation at Albuquerque from the early 1980's, -60 per mil, was adjusted to -62 per mil, and using the correlation of figure 20, the adjusted, amount-weighted $\delta^{18}O$ value of -8.6 per mil was estimated. Apparently, precipitation during 1987-1988 at Albuquerque was slightly more enriched in $^2H$ and $^{18}O$ than that from the early 1980's.

The local meteoric water line at Albuquerque has a slightly lower slope ($\delta^2H/\delta^{18}O=7.76$) and lower $d_{excess}$ (7.1 per mil) than that of cold ground water of meteoric origin from the Jemez Mountain region ($\delta^2H = 8\delta^{18}O + 12$, Vuataz and Goff, 1986; see also Adam and others, 1995) near Los Alamos, northwest of the study area, or that of precipitation from the Sangre de Cristo Mountains near Santa Fe, northeast of the study area ($\delta^2H = 8\delta^{18}O + 11.1$, Anderholm, 1994). Precipitation samples from the Sangre de Cristo Mountains were collected between August 1987 and March 1989 at an altitude of approximately 7,400 feet above sea level with an average amount-weighted $\delta^2H$ of -65.2 per mil (Anderholm, 1994). Additional stable isotope data are available for precipitation in the Los Alamos vicinity (Adams and others, 1995), and for water from wells, springs and streams in the Jemez Mountains region (Trainer and others, 2000).

From the recharge altitudes of cold meteoric waters from the Jemez Mountains, Vuataz and Goff (1986) found that the slopes of $\delta^2H$ and $\delta^{18}O$ with altitude (in meters), $\Delta\delta^2H/\Delta E$ and $\Delta\delta^{18}O/\Delta E$, where $\Delta E$ is the change in altitude in meters, were -2.2 and -0.32 per mil per 100 m, respectively. That is, $\delta^2H$ and $\delta^{18}O$ decrease by about 2.2 and 0.32 per mil, respectively,

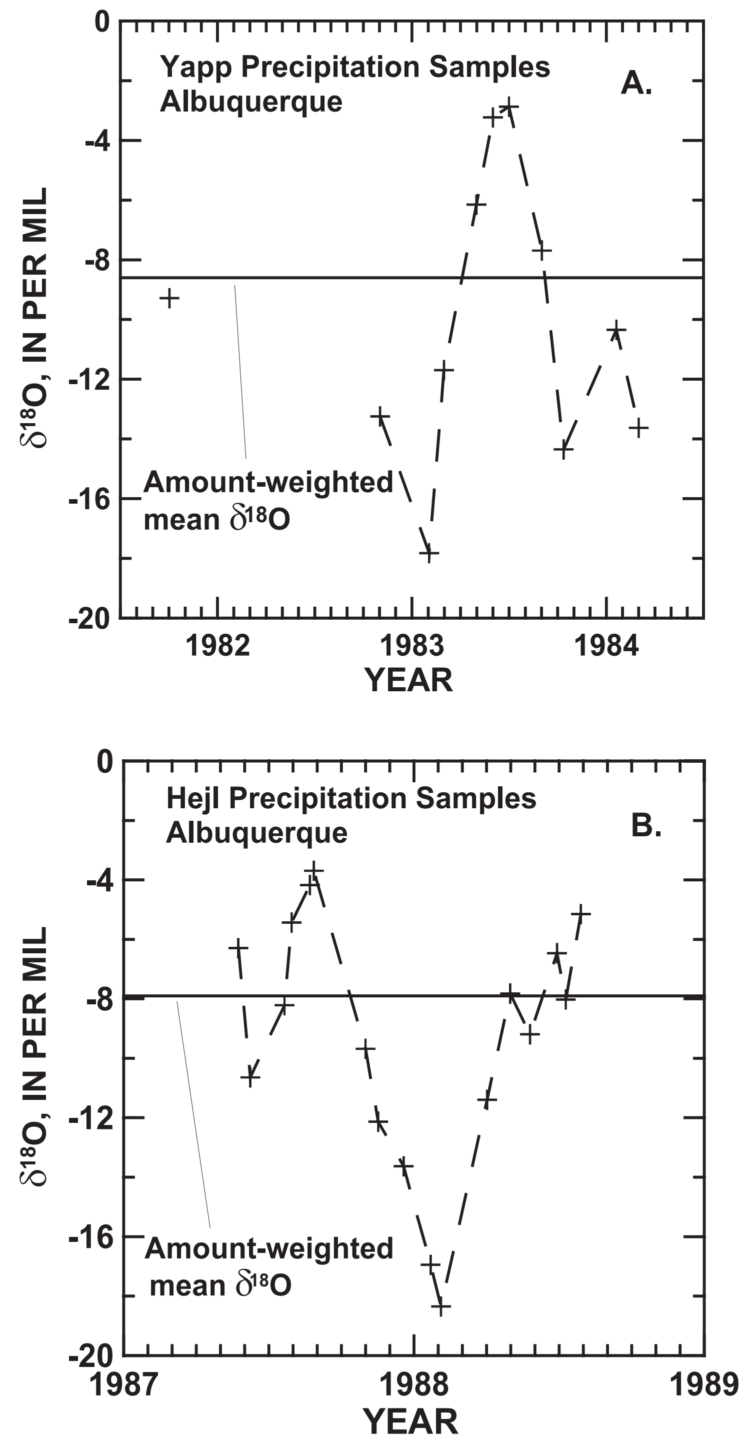



**Figure 19.** Comparison of $\delta^{18}O$ values in Albuquerque, New Mexico, precipitation: (a) Samples collected by C. Yapp, 1981-1984, (b) Samples collected by R. Hejl, 1987-1989.

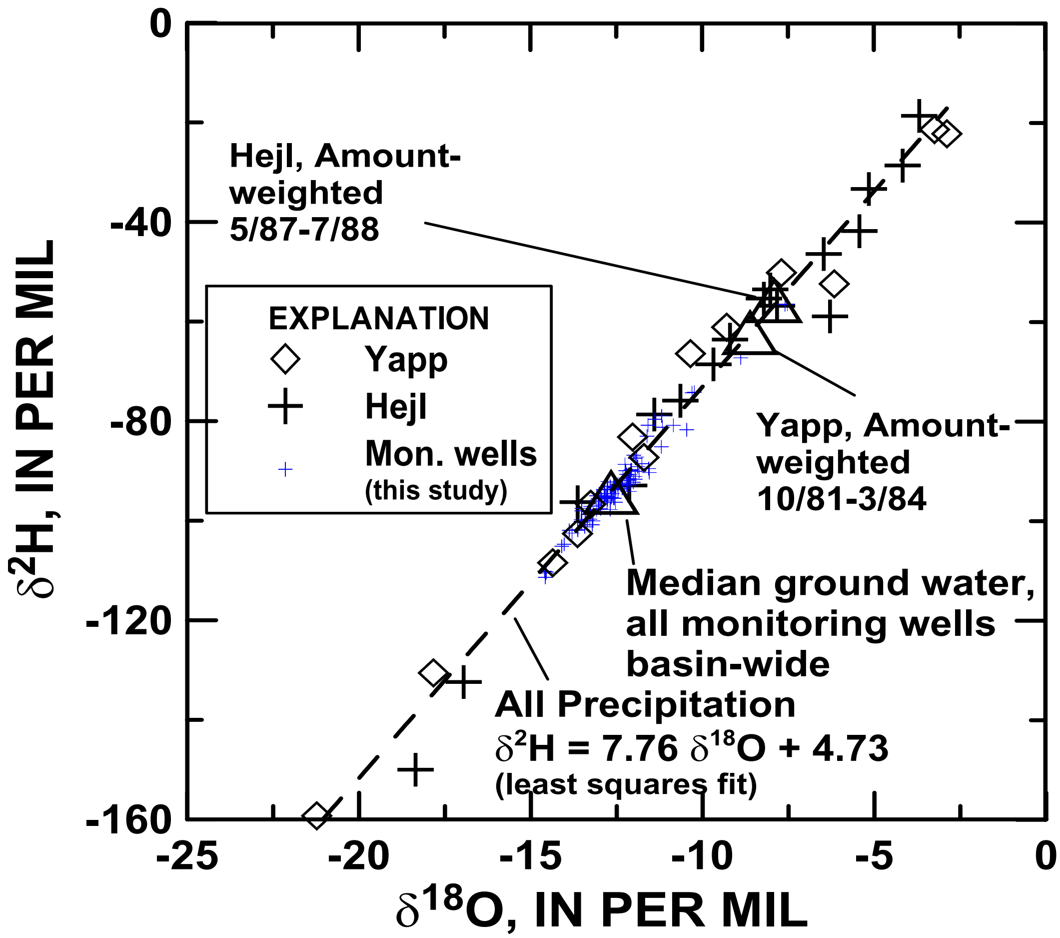



**Figure 20.** Relation between $\delta^2H$ and $\delta^{18}O$ isotopic composition of precipitation and ground water from monitoring wells in the vicinity of Albuquerque, New Mexico.

per 100 m increase in altitude, which is similar to shifts in stable isotopic composition of precipitation as a function of altitude (often referred to as the "altitude effect") reported from many other mountainous areas world-wide under a range of climatic and latitude differences (Vuataz and Goff, 1986).

The "altitude effect" can be derived by combining expressions for the latitudinal, yearly average temperature dependence of isotopic fractionation (van der Straaten and Mook, 1983) with values of the lapse rate (Meyer, 1992), which expresses the rate of average cooling at the earth's surface as a function of increasing altitude. The latitudinal, yearly average temperature dependence of $\delta^2H$ and $\delta^{18}O$ were derived from theoretical expressions of Rayleigh isotope fractionation in the condensation of water vapor across a latitudinal temperature gradient using known values of the temperature dependence of the isotope fractionation factors (van der Straaten and Mook, 1983)

$$d\delta^2H_c/dt = 6.0 - 0.09t \,, \qquad (15)$$

$$d\delta^{18}O_c/dt = 0.72 - 0.01t \,, \qquad (16)$$

where t is temperature in $^oC$ and the subscript "c" refers to condensation from vapor.

If the lapse rate is -5.5$^oC$ per km (Meyer, 1992) (-1.7$^oC$ per 1000 feet), at an average temperature of 10$^oC$, the change in $\delta^2H$ with change in altitude, $\Delta E$, $\Delta\delta^2H/\Delta E$, is –2.8 ± 0.5 per mil/100 m, and the change in $\delta^{18}O$ with change in altitude, $\Delta\delta^{18}O/\Delta E$, is –0.34 ± 0.05 per mil/100 m. The expressions above show that values of the "altitude effect" should theoretically decrease (become more negative) as average temperature is lowered, or as altitude increases. Consequently, for condensation at 5$^oC$, $\Delta\delta^2H/\Delta E$ and

$\Delta\delta^{18}O/\Delta E$ become –3.0 ± 0.5 and –0.37 ± 0.05 per mil/100 m.

These calculations show that the "altitude effect" is primarily a temperature effect in isotope fractionation. Consequently, isotope shifts observed for moisture falling at different altitudes on the side of a mountain, are, to a good approximation, caused by the same isotope fractionation processes that cause shifts in stable isotopic composition of ground water recharged to aquifers as a function of temperature changes in the recharge area. There are several approximations that were introduced by van der Straaten and Mook (1983) in deriving the above equations, such as lack of water vapor exchange with local sources. van der Straaten and Mook (1983) found greater discrepancies between theoretical and observed isotopic values at lower temperatures. Although the theoretical values of the "altitude effect" are nearly identical to the values of the "altitude effect" observed by Vuataz and Goff (1986) in cold meteoric water from the Jemez Mountains, those of Vuataz and Goff (1986) were used because they were determined in the vicinity of the MRGB and probably include local isotopic effects that could not be included in the theoretical calculations of van der Straaten and Mook (1983). However, the theoretical model shows that the value of the "altitude effect" should vary slightly with temperature (altitude), being more negative for precipitation at higher altitude or lower temperature than the conditions under which they were observed on the slopes of the Jemez Mountains (recharge altitude range of 7,400 to 9,400 feet; Vuataz and Goff, 1986).

### Tritium

The USGS low-level tritium laboratory has measured the activity of tritium in precipitation collected at Albuquerque over sampling intervals of weekly to quarterly since August 1958. The total record contained more than 200 measurements at the end of the year 2001. Tritium in precipitation data for Albuquerque for the period 1958-98 are available from International Atomic Energy Agency (IAEA), IAEA (2001), and data from 1999 through 2001 were obtained from R.L. Michel (U.S. Geological Survey, written commun., 2002). The precipitation samples, from a location at latitude 35°03'00"N, longitude 106°37'12"W and altitude 5,312 feet above sea level, were collected on an event basis and composited for the reported interval.

The highest tritium concentration in precipitation at Albuquerque was 4,400 TU in April, 1964, following the 1963-1964 period of atmospheric testing of nuclear bombs. The amount-weighted mean tritium concentrations were 1,898.7 and 1,688.3 TU, respectively, for the years 1963 and 1964 (IAEA, 2001), and fell rapidly from the late 1960's. The amount-weighted mean tritium concentration was about 200 TU in 1970 and 23 TU in 1980. Tritium concentrations measured in precipitation for Albuquerque from 1958 to 1998 are shown in figure 21. In more recent years, between 1985 and June 1997, the average tritium concentration in precipitation at Albuquerque was 13.4 TU, with a standard deviation of ± 6.4 TU. After correction for radioactive decay to June 1997, precipitation from the period 1985 through June 1997 would have an average tritium concentration of 9.1 ± 3.7 TU in the Albuquerque vicinity in June 1997. Ground water resulting from infiltration of precipitation from the mid-1960's would contain tritium in the range of about 100-700 TU in June 1997, if not diluted with older or younger water.

The natural, pre-nuclear detonation tritium concentration in precipitation was estimated at approximately 8 TU (Thatcher, 1962) in the southwestern United States. Therefore, water recharged from infiltration of precipitation, such as along the mountain-front margins of the basin, prior to the year 1950 would contain less than 0.5 TU in the late 1990's, the time during which the sampling for this study was conducted. Water samples containing more than 0.5 TU are post-1950's in age or are mixtures containing a fraction of post-1950's water. Additional data on tritium in precipitation at Albuquerque, Socorro, Los Alamos, and vicinity are given in von Buttlar and Wendt (1958), Rabinowitz and Gross (1972), and Adam and others (1995).

### Sulfur-34

No samples were collected for determination of the sulfur isotopic composition of sulfur in precipitation as a part of this study. However, Mast and others (2001) measured $\delta^{34}S$ of $SO_4$ in Rocky Mountain snowpacks at 52 high-altitude sites along the Continental Divide from northern New Mexico through parts of Montana. The average annual $\delta^{34}S$ values of snow were a function of latitude and ranged between values near +4 per mil in northern New Mexico to +8 per mil in central Wyoming, and then decreased through northern Wyoming into Montana. In parts of northern

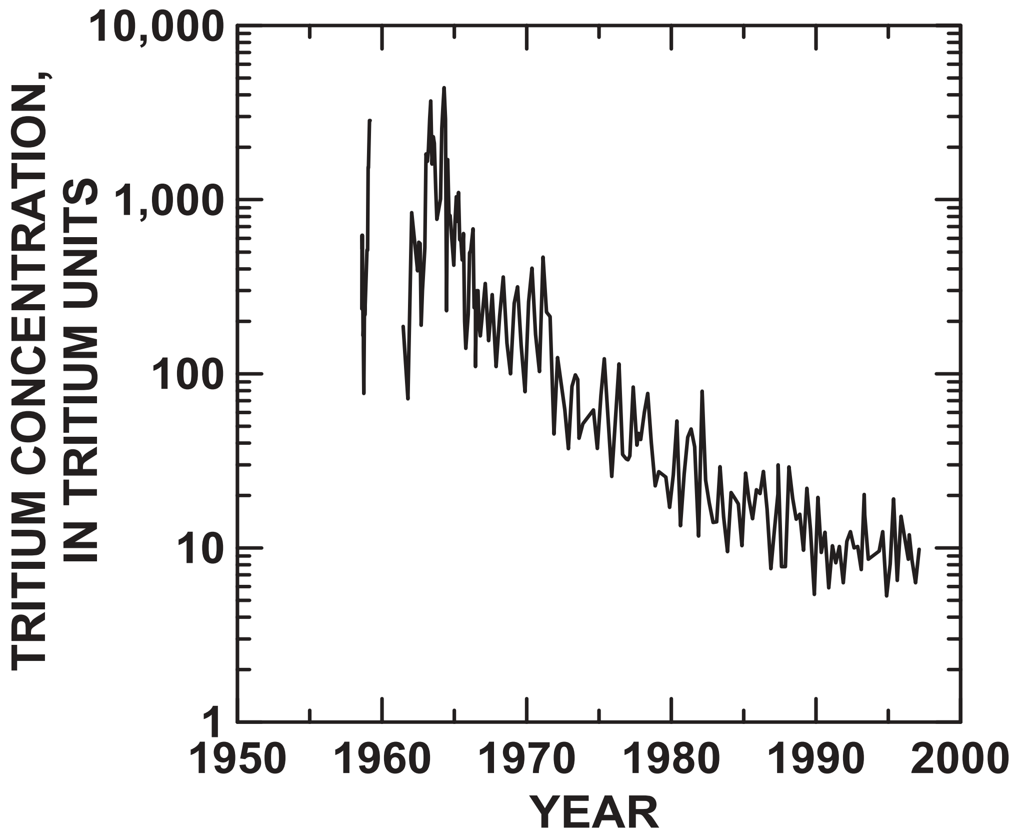



**Figure 21.** Tritium concentration in precipitation at Albuquerque, New Mexico, 1960-97 (International Atomic Energy Agency, 2001).

New Mexico and southern Colorado, $\delta^{34}S$ of S in snowpack averaged +4.4 ± 0.7 per mil between 1993 and 1999 (Mast and others, 2001). The averaged values of $\delta^{34}S$ reported by Mast and others (2001) are in agreement with earlier measurements of $\delta^{34}S$ of $SO_4$ in snow and wetfall from other high altitude parts of the Rocky Mountains (Turk and others, 1993; Finley and others, 1995), and from other parts of North America (see Jamieson and Wadleigh, 2000, and references therein).

## Surface Water

### Inorganic Chemical Composition

Chemical data are available from both the NWIS database and recent sampling through the MRGB study for surface water in several streams that could potentially contribute recharge to the Santa Fe Group aquifer system. Chemical analyses and their associated discharge data were used to calculate discharge-weighted mean compositions from the NWIS data for selected sites (table 4). Discharge data were not collected in association with the MRGB samples, and in many cases such data were not available from other sources. Therefore, median values were tabulated from the MRGB data, without considering discharge.

The dissolved solute content of surface water in the Rio Grande is relatively dilute compared to water in many other streams of the basin (table B2, table 4) (Bexfield and Anderholm, 1997). NWIS data for the Rio Grande at San Felipe (site SW8 in fig. 17a;) and Rio Grande at Albuquerque (site SW9 in fig. 17b) yielded discharge-weighted average specific conductance values of 297 and 323 μS/cm, respectively. MRGB data yielded a median specific conductance value of 360 μS/cm for a site located on the Rio Grande near the north end of Albuquerque at Alameda Blvd. (site S300 in fig. 11b). Discharge-weighted average ratios of $SO_4$ to Cl concentrations (in meq/L) from NWIS are 7.7 at San Felipe and 4.7 at Albuquerque; the median ratio value for the MRGB site is 3.7. The typical ratio for precipitation (5.2), therefore, falls within the range obtained for sites on the Rio Grande.

Discharge-weighted average ratios of Ca to Na concentrations (in meq/L) from NWIS are 2.3 at San Felipe and 1.9 at Albuquerque; the median ratio value for the MRGB site is 2.1. These ratios differ substantially from the typical ratio for precipitation (9.6). As part of the MRGB study, riverside drains and an irrigation canal also were sampled regularly. Median values of nearly all chemical constituents for water at these sites differed only minimally from the median values for water in the Rio Grande.

The chemical composition of water in the Jemez River can differ substantially between a site several miles north of the MRGB, in the Jemez Mountains, and a site just below Jemez Canyon Dam, near the confluence of the Jemez River with the Rio Grande. NWIS data for the Jemez River at Jemez (site S298 in fig. 11a) and below Jemez Canyon Dam (site S297 in fig. 11a) yielded discharge-weighted average specific conductance values of 233 and 528 µS/cm, respecively. MRGB data yielded median specific conductance values of 455 µS/cm for the site near Jemez and 937 µS/cm for the site below Jemez Canyon Dam. Between these two sites, the Jemez River receives mineralized flow from the Rio Salado; also, evapotranspiration, including in the Jemez Canyon Reservoir, and diversions for irrigation probably affect the chemical composition of water in the river. Discharge-weighted average ratios of $SO_4$ to Cl concentrations from NWIS are 0.4 at Jemez and 1.2 below the dam; the median ratio value for the MRGB site at Jemez is 0.2 and below the dam is 0.9. These ratios differ substantially from the typical ratios for precipitation and for the Rio Grande. Discharge-weighted average ratios of Ca to Na concentrations (in meq/L) from NWIS are 1.8 at Jemez and 0.7 below the dam; the median ratio value for the MRGB site at Jemez is 1.1 and below the dam is 0.6. These ratios also differ substantially from the typical ratio for precipitation.

Surface water in the Rio Puerco tends to be relatively mineralized compared to water in other streams of the MRGB. NWIS data for the Rio Puerco at Bernardo (site SW10 in fig. 17a) yielded a discharge-weighted average specific conductance value of 1,640 µS/cm. MRGB data for a site about 28 miles upstream (site S307 in fig. 11a) yielded a median specific conductance value of 3,210 µS/cm. The discharge-weighted average ratio of $SO_4$ to Cl concentrations from NWIS for the site at Bernardo is 11.3; the median ratio from the MRGB site is 2.6. The ratios from these two different sources might differ substantially because the Rio Puerco flows at Bernardo less often than at the site upstream, and is most likely to flow when precipitation events have greatly increased runoff/discharge. The ratios for $SO_4$ to Cl in the Rio Puerco fall outside the annual ratio range for precipitation. The discharge-weighted average ratio of Ca to Na concentrations from NWIS data at Bernardo is 0.8; the median ratio value for the MRGB site is 0.5. These ratios differ substantially from the typical ratio for precipitation.

Data for Abo Arroyo in the southeastern part of the MRGB are limited to two samples collected for the MRGB study at a site located a few miles outside the basin margin (site S290 in fig. 11a). The median specific conductance value for these samples is 2,230 µS/cm. The median ratio of $SO_4$ to Cl concentrations is 17.3; the median ratio of Ca to Na concentrations is 2.4. Both of these ratios differ substantially from the typical ratios for precipitation.

Data are available for similar basin-margin locations on Tijeras Arroyo from both the MRGB study (site S312 in fig. 11b) and the NWIS database (site SW11 in fig. 17b). NWIS data for the arroyo yielded a discharge-weighted average specific conductance value of 847 µS/cm; MRGB data yielded a median specific conductance value of 997 µS/cm. The discharge-weighted average ratio of $SO_4$ to Cl concentrations from NWIS is 1.0, as is the median ratio from the MRGB study. The discharge-weighted average ratio of Ca to Na concentrations from NWIS is 3.0; the median ratio value for the MRGB study is 2.9. The ratios for $SO_4$ to Cl and Ca to Na in Tijeras Arroyo are substantially lower than the typical ratios for precipitation.

Data are available in NWIS for two samples from Galisteo Creek above the reservoir, located a few miles outside the northeast basin margin (site SW12 in fig. 17a). The discharge-weighted average specific conductance value for the two samples is 1,680 µS/cm. The discharge-weighted average ratio of $SO_4$ to Cl concentrations is 22, and of Ca to Na concentrations is 1.3. Both of these ratios differ substantially from the typical ratios of precipitation.

### Oxygen-18 and Hydrogen-2

Measurements of the stable isotope composition of surface waters were made for the current investigation to determine if ground water with surface-water sources could be distinguished from other ground waters occurring in the MRGB on the basis of stable isotope composition.

Yapp (1985) presented a 3-year record (February 1980 - June 1983) of approximately monthly values of $\delta^2H$ for water samples from the Rio Grande collected at the Corrales Road Bridge on State Highway 46 (now Alameda Blvd.), near the subsequent MRGB site S300 (fig. 11b), averaging -92 per mil in $\delta^2H$. The $\delta^2H$ composition of the Rio Grande varied seasonally, with the most depleted waters occurring in the months of May and June, coinciding with peak discharge from snowmelt from the higher altitude source waters for the Rio Grande in southern Colorado and northern New Mexico, and the most enriched waters occurring in the summer months, when the river contained discharge from summer thunderstorms. Even the lack of a depleted, spring snowmelt signal in waters in the Rio Grande in May-June 1981 coincided with climatic conditions in the previous winter when the snowpack in the headwaters region for the Rio Grande averaged about 50 percent below normal. It was concluded that seasonal differences in the $\delta^2H$ composition of the Rio Grande were a function of snowpack thickness from the previous winter combined with variations in melting rate and amount of local summer precipitation. During the period October 1980 through October 1982, the $\delta^2H$ composition of water from the Rio Grande ranged from -103 to -79 per mil. Yapp (1985) showed that water from the Rio Grande at Albuquerque was, on average, more depleted in $\delta^2H$ than either yearly averaged precipitation at Albuquerque or mountain-front recharge from the Sandia and Monzano Mountains at Albuquerque.

Values of $\delta^2H$ in water from the Rio Grande from 1980 through 1983 (C. Yapp samples re-analyzed by the USGS Stable Isotope Laboratory) are compared with $\delta^2H$ values in Rio Grande water collected as a part of this study (1996-1999) and also analyzed by the USGS Stable Isotope Laboratory in figure 22. The validity of the stable isotope data obtained from the

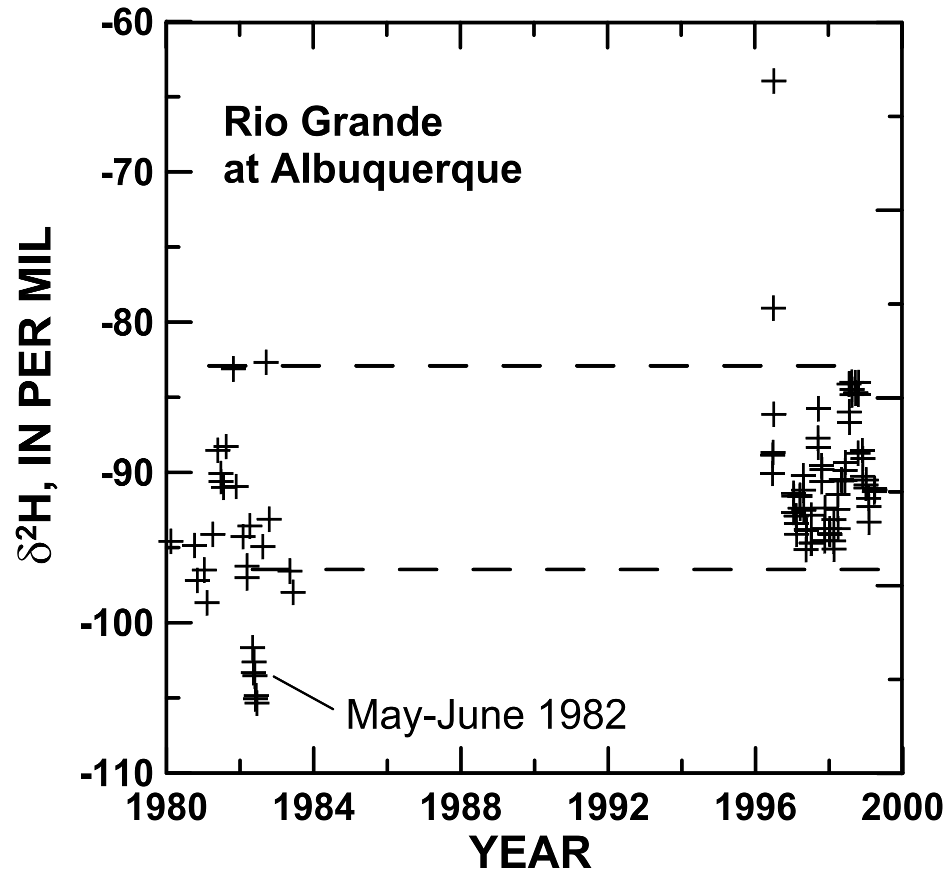



**Figure 22.** Comparison of $\delta^2H$ isotopic composition of Rio Grande water from 1980 through 1983 (C. Yapp samples re-analyzed by the USGS Stable Isotope Laboratory) with Rio Grande water collected as a part of this study (1996-99). The horizontal dashed lines bracket the range of most values of $\delta^2H$ of Rio Grande collected between 1996 and 1999, which were more enriched in $^2H$ than some Rio Grande water samples from 1980 to 1983.

re-analyzed, archived samples is given in the section "Hydrogen-2 and Oxygen Isotopes in Ground Water". Rio Grande water was apparently more depleted in $^2H$ in the early 1980's than the period 1997 through 1999. The average $\delta^2H$ value for Rio Grande water from the early 1980's was -95.5 per mil, and from 1997 through 1999 was -89.9 per mil. The stable isotopic composition of Rio Grande water is in part a function of the amount of snowfall from the previous winter in source-water areas for the Rio Grande in southern Colorado and northern New Mexico. The most depleted water in the Rio Grande averaged -103.7 per mil during the annual peak runoff of May-June 1982. The stable isotopic composition of Rio Grande water is also affected by evaporation (Phillips and others, 2003), which causes some enrichment in $^2H$ and $^{18}O$, and by inflow from tributaries and ground water along gaining reaches of the river. Although water in the Rio Grande was more enriched in stable isotope composition during the mid- to late-1990's relative to the early 1980's, the isotopic composition of the Rio Grande also varied seasonally during the mid- to late-1990's, with most enriched water occurring during low-flow conditions in late summer and early fall, and most depleted water occurring in winter and early spring (fig. 23). The isotopic composition of water in the drains and canals along the Rio Grande closely follows the isotopic composition of the Rio Grande (fig. 23). Samples from other surface-water sites show small but consistent seasonal patterns in stable isotopic composition that mimic the seasonal pattern of the Rio Grande. These include streams that contain runoff from mountain-front areas, such as Tijeras Arroyo and Jemez River at Jemez (fig. 23).

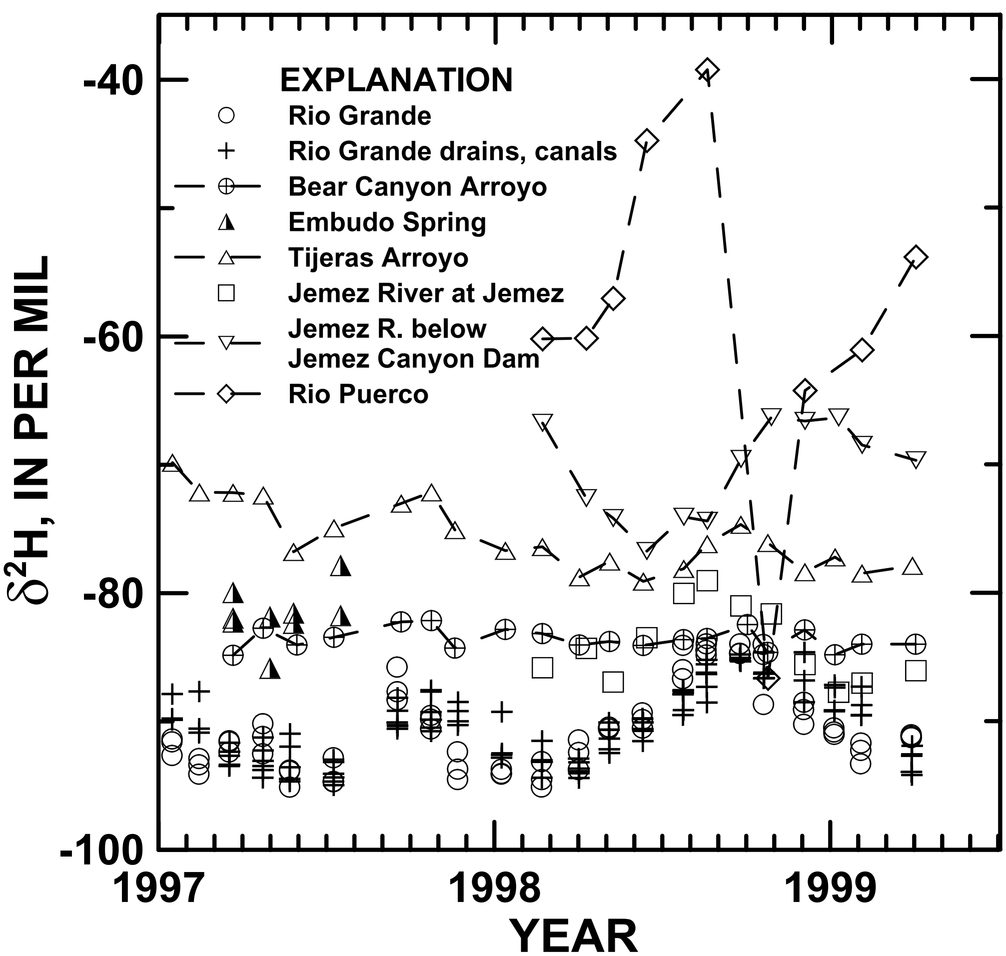



**Figure 23.** Comparison of monthly values of $\delta^2H$ in surface waters from the Middle Rio Grande Basin, New Mexico, 1997-99.

**Table 5.** Average stable isotopic composition of surface waters from the Middle Rio Grande Basin, New Mexico

[‰, per mil]

| Source | Period of record | Number of samples | Average $\delta^2H$ ‰ | Standard deviation | Average $\delta^{18}O$ ‰ | Standard deviation | Average $^2H$ excess ‰ | Standard deviation |
|---|---|---|---|---|---|---|---|---|
| Rio Grande | 1980-83 | 29 | -95.5 | 6.1 | -12.7 | 0.9 | 5.8 | 2.2 |
| Rio Grande | 1996-99 | 72 | -89.9 | 4.6 | -12.0 | 0.6 | 6.2 | 1.4 |
| Rio Grande Drains and Laterals | 1996-99 | 110 | -90.2 | 2.9 | -12.1 | 0.4 | 6.4 | 1.2 |
| Bear Canyon Arroyo | 1996-99 | 20 | -83.5 | 0.9 | -11.8 | 0.1 | 11.0 | 1.0 |
| Embudo and Embudito Sprs. | [1] 1997 | 11 | -81.8 | 1.9 | -11.4 | 0.3 | 9.7 | 1.0 |
| Tijeras Arroyo | 1996-99 | 22 | -75.7 | 2.6 | -10.5 | 0.4 | 8.3 | 1.0 |
| Jemez River at Jemez | 1998-99 | 12 | -84.1 | 3.0 | -11.7 | 0.5 | 9.3 | 2.0 |
| Rio Puerco at Hwy. 6 | 1998-99 | 9 | -58.6 | 13.3 | -6.9 | 2.7 | -3.4 | 10.5 |
| Abo Arroyo | 1997 | 2 | -59.2 | 5.6 | -8.3 | 1.0 | 7.1 | 2.2 |

[1]Includes 2 samples for 1983 (C. Yapp).

Average and standard deviations of $\delta^2H$, $\delta^{18}O$, and $^2H_{excess}$ are summarized in table 5 for surface waters in the MRGB. Although isotopic composition varies with season, water from the Rio Grande is typically more depleted in $^2H$ and $^{18}O$ than water from Tijeras Arroyo. Yapp (1985) also found that Tijeras Arroyo had a $\delta^2H$ composition near -70 per mil. The most enriched surface waters sampled in the MRGB are those from Abo Arroyo in the southeast part of the basin and water from the Rio Puerco (table 5).

Over the sampling period, the deuterium excess, $^2H_{excess}$, averaged about 6 per mil for water in the Rio Grande. Apparently, there is some temporal variability in the $^2H_{excess}$ of water from the Rio Grande. Between January 1997 and March 1999, the $^2H_{excess}$ of Rio Grande water peaked near 8 per mil in winter 1998 and was as low as 4 per mil in winter 1997.

Values of $\delta^2H$ and $\delta^{18}O$ for all surface water samples from the MRGB, including samples from some mountain-front streams discussed in the next section are compared in figure 24. Excluding samples from the Jemez River below Jemez Canyon Dam and samples from the Rio Puerco that appear evaporated, the rest of the surface-water samples are correlated along the line

$$\delta^2H = 8.15\ \delta^{18}O + 9.0 \quad . \qquad (17)$$

Apparently, most surface waters in the MRGB plot close to the global meteoric water line (fig. 24), and have isotopic compositions similar to that of local precipitation at Albuquerque (eq. 14). The samples from the Rio Grande, Jemez River, Tijeras Arroyo, and Bear Canyon Arroyo do not indicate isotopic compositions that have been appreciably affected by evaporation.

### Tritium

Tritium concentrations were determined approximately monthly in selected surface-water sources in the MRGB between January 1997 and February 1998. Most of the samples are from the Rio Grande and associated drains and canals in the vicinity of Albuquerque (See appendix B, table B9) (figs. 11b and 17b). Two other sites sampled approximately monthly for tritium are Tijeras Arroyo at Four Hills Rd. and Bear Canyon Arroyo (sites S312 and S292, respectively, fig.11b). A few other tritium samples were analyzed from the Rio Puerco at Highway 6 (site S307, fig. 11a), the Jemez River at Jemez (site S298, fig. 11a), and Abo Arroyo (site S290, fig. 11a). Tritium values in the selected surface-water sites are compared with tritium in precipitation at Albuquerque in figure 25. Several patterns are evident. First, the strong seasonal cycle in tritium in precipitation, associated with the “spring high” is apparent. Elevated tritium concentrations in precipitation from spring into early summer are usually attributed to the spring rise of the tropopause (Rozanski and others, 1991; Doney and others, 1992), which results in some exchange of stratospheric tritium with moisture in the troposphere.

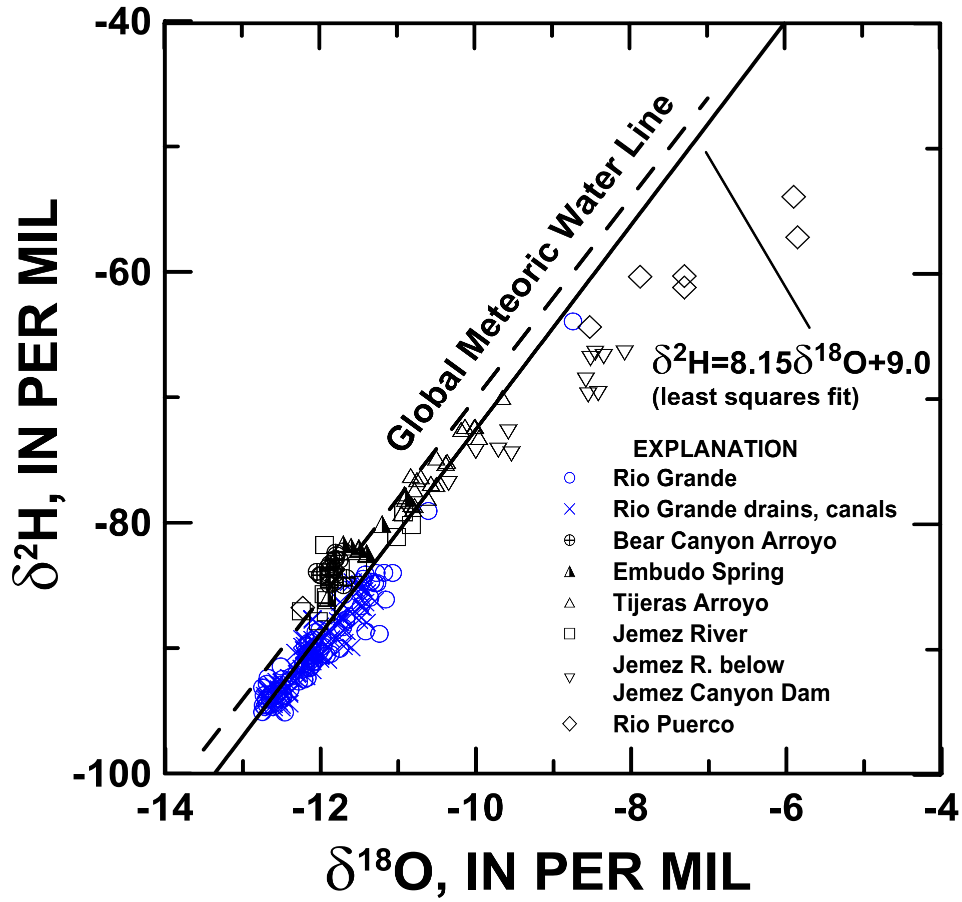



**Figure 24.** Relation between $\delta^2H$ and $\delta^{18}O$ isotopic composition of surface waters in the vicinity of Albuquerque, New Mexico.

Elevated tritium concentrations are apparent in spring runoff from Bear Canyon and from the Rio Grande (fig. 25), but are not clear in data from Tijeras Arroyo.

The seasonal signal of tritium in the Rio Grande may also reflect increased tritium associated with melting of winter snow pack in the southern Rocky Mountains. Because of a latitudinal effect, moisture falling in the southern Rockies should be elevated in tritium concentration relative to that of moisture falling at Albuquerque. Latitudinal gradients of tritium concentration in precipitation have been evaluated by Rozanski and others (1991) and can be used to estimate the average tritium in precipitation in recharge areas for the MRGB north of Albuquerque. The average latitudinal variation of log TU per degree of latitude in the northern hemisphere is approximately 0.023 log TU/degree latitude (Rozanski and others, 1991). Considering the latitudinal gradient, precipitation in the northern-most extent of the drainage basin for the MRGB, an area in the southern Rocky Mountains of southern Colorado located about 4 degrees latitude north of Albuquerque, should average about 11.2 TU relative to the average tritium content of precipitation at Albuquerque, 9.1 TU in 1997. If other factors such as variations in moisture sources are not significant, precipitation falling within the MRGB drainage between Albuquerque and its northern-most extent should range between 9.1 and 11.2 TU on average. The spring seasonal high in tritium concentration in Rio Grande water at Albuquerque probably reflects the combined effects of melting of snow pack from more northern sources and contributions from spring precipitation that is seasonally elevated in tritium concentration from stratosphere sources. In the period January 1997 through February 1998, tritium concentration in Rio Grande water at Albuquerque varied from 8 to about 11 TU, averaging about 9.2 TU. The average, standard deviation, and number of samples

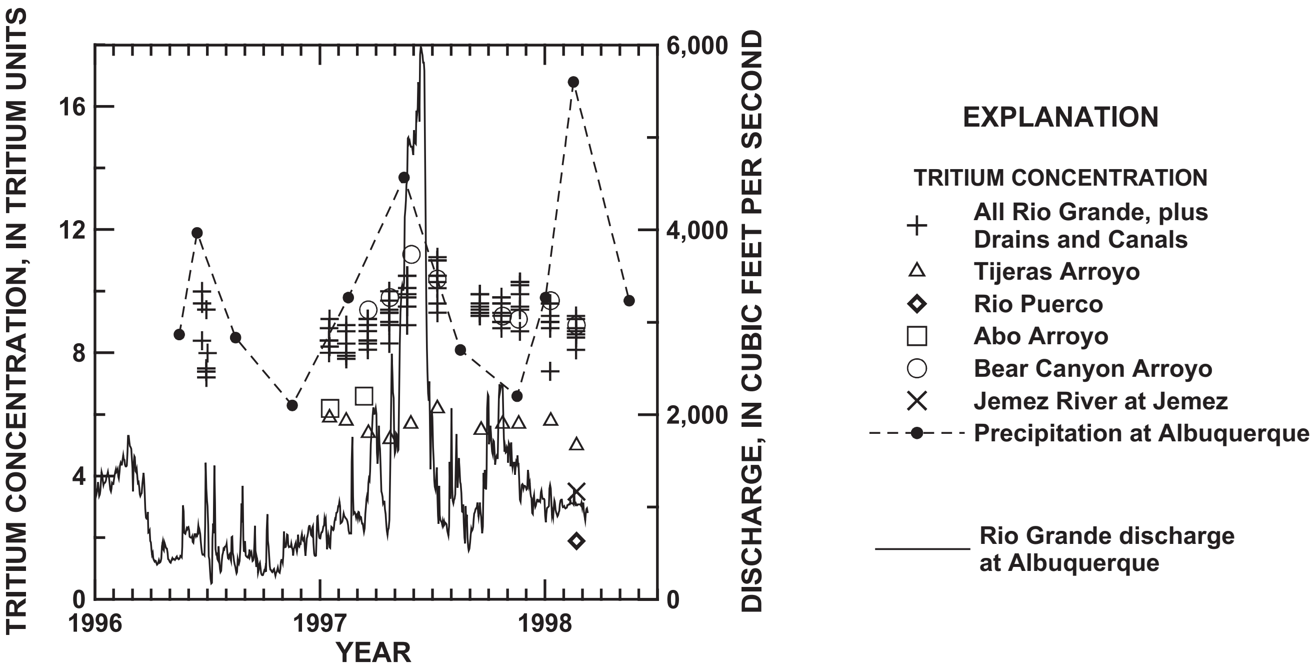



**Figure 25.** Tritium concentration in surface waters from the Middle Rio Grande Basin, New Mexico, in relation to tritium concentration in precipitation, 1996-98, and discharge of the Rio Grande.

analyzed for tritium from surface-water sites are summarized in table 6. In contrast to water from Bear Canyon and the Rio Grande and associated drains and laterals, the average tritium concentration in water from Tijeras Arroyo was only 5.6 ± 0.3 TU between January 1997 and February 1998 (table 6). Sparse data for other streams indicate appreciably lower tritium activity elsewhere in surface water of the MRGB (table 6). One sample from the Rio Puerco contained only 1.9 TU. Apparently, waters from the Jemez River, Tijeras Arroyo, Abo Arroyo, and the Rio Puerco contain significant fractions of pre-nuclear detonation (pre-1950's) water. In contrast, the Rio Grande apparently contains high fractions of recent runoff from the watershed, including a spring peak discharge dominated by melting of the snow pack in southern Colorado and northern New Mexico. Recent runoff from the Sandia Mountains at Albuquerque is apparently the dominant source for water in Bear Canyon Arroyo.

### Sulfur-34

The isotopic composition of sulfur in $SO_4$, $\delta^{34}S$, was determined in 27 samples of surface waters from the MRGB. For the Rio Grande at Alameda Blvd. (S300 in fig. 11b), $\delta^{34}S$ of dissolved $SO_4$ averaged -1.8 ± 2.2 per mil in 14 approximately monthly samples collected between January 1997 and June 1998, with an average $SO_4$ concentration of 49 ± 9 mg/L. For the Rio Puerco at Highway 6, $\delta^{34}S$ of dissolved $SO_4$ averaged 1.8 ± 5.1 per mil in nine approximately monthly samples collected between February 1998 and April 1999, with an average $SO_4$ concentration of 1,100 ± 300 mg/L. For three samples from the Jemez River below Jemez Canyon Dam, $\delta^{34}S$ of dissolved $SO_4$ averaged 7.8 ± 0.8 per mil between February and June, 1998 in water that contained an average of 116 ± 34 mg/L $SO_4$. One sample from the Chamizal Lateral near Alameda Blvd. ($SO_4$ = 48.6 mg/L) had a $\delta^{34}S$ value of dissolved $SO_4$ of 8.25 per mil. As indicated by the high standard deviation, $\delta^{34}S$ of dissolved $SO_4$ can be variable in water from the Rio Grande and especially the Rio Puerco.

Seasonal variations in $\delta^{34}S$ of dissolved $SO_4$ for the Rio Grande, the Rio Puerco, and the Jemez River in relation to discharge of the Rio Grande at Albuquerque are shown in figure 26. Both the Rio Grande and the Rio Puerco contain $SO_4$ that is more depleted in $^{34}S$ in the spring-early summer than at other times of the year.

**Table 6** Average tritium activity in surface water, Middle Rio Grande Basin, New Mexico, January 1997 through February 1998

[TU, Tritium Unit]

| River Source [1] | Site number | Average Tritium concentration (TU) | Standard deviation (TU) | Number of samples |
|---|---|---|---|---|
| Bear Canyon Arroyo | S292 | 9.7 | 0.8 | 8 |
| Chamizal Lateral at Alameda Blvd | S294 | 9.6 | 0.7 | 6 |
| West Riverside Drain at Rio Bravo Blvd | S313 | 9.5 | 0.5 | 9 |
| Riverside Drain at Campbell Rd. | S309 | 9.3 | 0.8 | 11 |
| Rio Grande at Campbell Rd. | S301 | 9.2 | 0.8 | 11 |
| Rio Grande at Alameda | S300 | 9.2 | 1.1 | 13 |
| Alameda Drain at Alameda Blvd | S291 | 9.2 | 0.6 | 4 |
| Riverside Drain at Rio Bravo Blvd | S310 | 9.1 | 0.5 | 11 |
| Rio Grande at Rio Bravo Blvd | S303 | 9.1 | 1.1 | 12 |
| Riverside Drain at Alameda Blvd | S308 | 9.0 | 0.5 | 11 |
| Jemez River below Jemez Canyon Dam | S297 | 6.5 | 0.4 | 1 |
| Abo Arroyo | S290 | 6.4 | 0.3 | 2 |
| Tijeras Arroyo at Four Hills | S312 | 5.6 | 0.3 | 11 |
| Jemez River at Jemez | S298 | 3.5 | 0.3 | 1 |
| Rio Puerco at Hwy 6 | S307 | 1.9 | 0.3 | 1 |

[1]See appendix B

For example, the sulfur isotopic composition of $SO_4$ varied from + 6.3 per mil (February 1999) to - 8.3 per mil (May 1998) in the Rio Puerco, and from + 1.3 per mil (March 1997) to - 5.3 per mil (May 1997) in the Rio Grande at Alameda Blvd.

Seasonal data on $\delta^2H$, $\delta^{18}O$, and $^3H$ in water from the Rio Grande (see above) indicate that the peak seasonal discharge of the Rio Grande in the period (April) May - June is dominated by water from melting of the winter snowpack in parts of southern Colorado and northern New Mexico. Although peak spring discharge of the Rio Grande and Rio Puerco can be dominated by high-altitude runoff, the sulfur isotopic data indicate that the runoff must contain contributions of sulfur from other sulfur source(s) that are, on average, depleted in $^{34}S$ relative to that of precipitation within the Rio Grande and Rio Puerco watersheds. Turk and others (1993) found that some lakes in the Rocky Mountains also contained $SO_4$ depleted in $^{34}S$ relative to that of precipitation and attributed the depletion to weathering (oxidation) of sulfide minerals. It is likely that the depletion in $^{34}S$ of $SO_4$ in peak spring discharge on the Rio Grande and Rio Puerco reflects weathering of sulfide minerals within their drainage basins.

If mountain-front ground water in the vicinity of the MRGB is dominated by atmospheric sulfur sources (average $\delta^{34}S$ of atmospheric S near 4.4 per mil, Mast and others, 2001), and there are no additional sulfur sources or sinks, such as through sulfide-mineral oxidation or $SO_4$ reduction, it may be possible in some cases to distinguish mountain-front recharge from ground water derived from the Rio Grande (average $\delta^{34}S$ near -2 per mil) on the basis of the sulfur isotopic composition of the dissolved $SO_4$.

## Mountain-Front Ground Water

### Inorganic Chemical Composition

Along mountainous basin margins, ratios of major cations and anions in both surface water in streams and ground water tend to reflect the inorganic chemical ratios found in precipitation. MRGB data from a mountain-front stream, Bear Canyon Arroyo

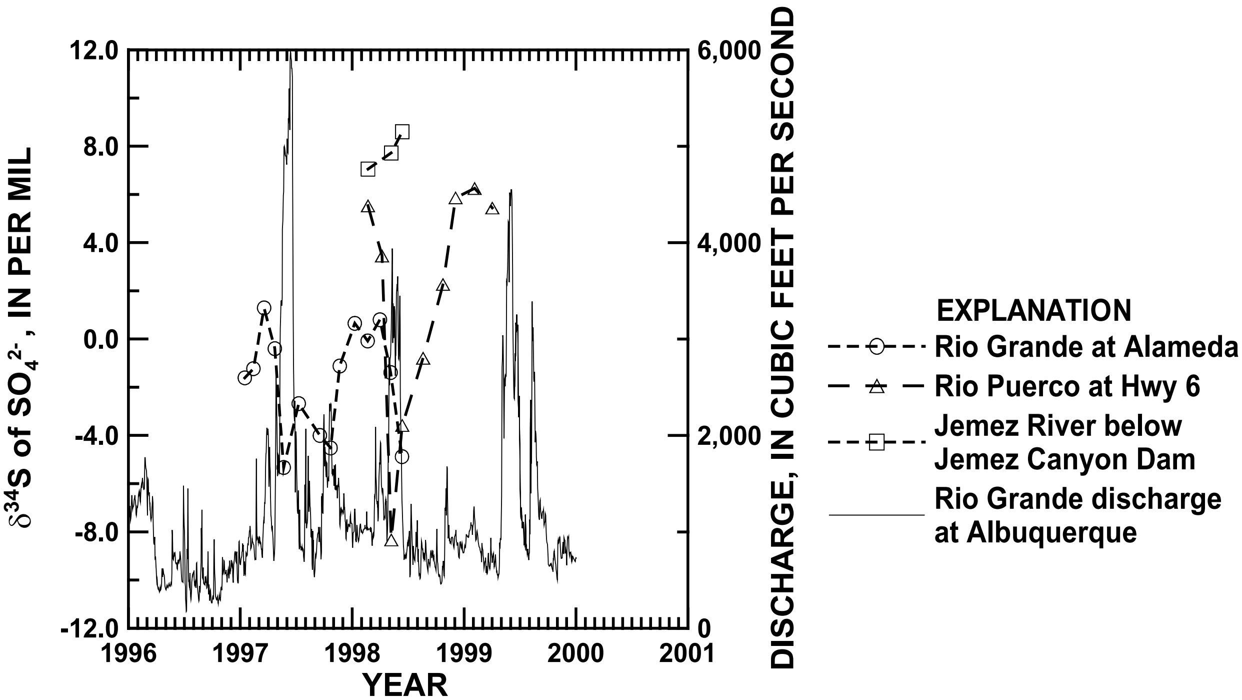



**Figure 26.** Stable S isotopic composition, $\delta^{34}S$, of sulfate in surface waters of the Middle Rio Grande Basin, New Mexico, 1997-99, in relation to discharge of the Rio Grande at Albuquerque.

(site S292 in fig. 11b), yield a median ratio (in meq/L) of 5.8 for $SO_4$ to Cl concentrations and of 6.2 for Ca to Na concentrations, both of which fall within the range of annual ratios obtained from chemical data for precipitation (table 4). The median specific conductance value of 477 µS/cm, however, indicates that substantial evapotranspiration has occurred relative to precipitation. Based on an event-weighted average Cl concentration of 0.21 mg/L in precipitation and a median Cl concentration of 5.1 mg/L in Bear Canyon Arroyo, surface water in the arroyo represents precipitation that has been evaporated to the extent that Cl has been concentrated by a factor of about 24. Two MRGB ground-water samples (NM002 and NM042; table A2) collected from wells near the eastern mountain front yield ratios of 4.8 and 4.7 for $SO_4$ to Cl concentrations and of 5.9 and 5.5 for Ca to Na concentrations, respectively. Again, these ratios are similar to those of modern precipitation, but may reflect a slight shift in precipitation chemistry through time or geochemical reactions occurring in the soil zone or aquifer. The Cl concentrations of 6.5 and 7.0 in water from these wells reflect an evaporation factor of about 30 relative to precipitation.

### Oxygen-18 and Hydrogen-2

Yapp (1985) found that recharge from the Sandia Mountains east of Albuquerque, obtained from an arroyo in Bear Canyon and Embudo Spring in Embudo Canyon, ranged from -80 to -83 per mil in $\delta^2H$. Samples obtained for this study from similar sites (tables A9, B6) support Yapp's conclusion that water derived from the Rio Grande should, on average, be depleted in $^2H$ by at least 10 per mil relative to average recharge from the Sandia Mountain front at Albuquerque. Other data indicate that mountain-front waters from northern margins of the basin have similar isotopic composition to that from the Sandia and Manzano Mountains near Albuquerque (Vuataz and Goff, 1986; Anderholm, 1994).

### Tritium

Tritium concentrations are near values for modern precipitation in ground water along the eastern mountain front. Nine water samples from Embudo (S057) and Embudito (S056) springs, located just outside of the MRGB in the Sandia Mountains east of

Albuquerque, had tritium concentrations between 10.0 and 11.0 TU in April through July 1997. A water sample from Tunnel spring (site S256, NM169) in June 1996 contained 12.2 TU and water samples from private production wells in the Sandia Mountains east of the basin boundary (sites S249-S251, NM163, NM165, NM166, respectively, table A11) contained 10.6, 0.9, and 9.6, TU in June 1996. Water from a domestic well in Bear Canyon (S007, NM002) contained 10.6 TU in June 1996 and water at the base of the Sandia Mountains on the east edge of Albuquerque (S229, NM515) had a tritium concentration of 8.3 TU in July 1998. During the period 1996 through 1997, precipitation at Albuquerque averaged 9.9 ± 3.1 TU, with the highest tritium concentrations occurring in spring-early summer precipitation.

Ground-water samples containing more than 0.2 TU always contained detectible concentrations of chlorofluorocarbons, especially CFC-12. The mountain-front ground-water samples containing appreciable concentrations of tritium also contained 137 to 1,100 pg/kg of CFC-12. As a means of detecting recently recharged water or water samples containing fractions of young water, samples for chlorofluorocarbon analysis were routinely collected wherever a closed path could be established between the source and the sampling equipment. Samples where CFCs were not collected included some seeps, wells, and windmills that, for various reasons, introduced air into the sample prior to discharge. For these samples, tritium was routinely measured. Because of the low detection limit for CFCs and the stability of CFC-12, CFC-12 provided a useful tracer of young water (post-1940's water) or of samples containing a fraction of young water. The absence of CFC-12 and/or tritium provided a useful criterion for identifying water samples in which the $^{14}C$ activity had not been contaminated with $^{14}C$ from atmospheric testing of nuclear bombs.

### Sulfur-34

Five ground-water samples in which $\delta^{34}S$ of $SO_4$ was measured are probably representative of modern mountain-front recharge. All samples are from the Sandia Mountains on the eastern margin of the Basin. These samples are from Embudo (S057) and Embudito (S056) springs (NM044, NM043, respectively), and private wells (sites S055, S249, S007, and samples NM042, NM163, NM002). The five samples have tritium concentrations from 7.8 to 10.8 TU, and CFC-12 concentrations from 207 to 886 pg/kg. The $SO_4$/Cl ratio (meq/meq) in the five mountain-front ground-water samples averaged 5.4 ± 2.3, with an average $SO_4$ concentration of 62 ± 32 mg/L. The sulfur isotopic composition, $\delta^{34}S$, of the dissolved $SO_4$ averaged 4.4 ± 1.1 per mil. Annual $SO_4$/Cl ratios (meq/meq) in precipitation from the NADP Cuba and Bandelier stations, and from the Sevilleta National Wildlife Refuge, were similar to that of the mountain-front ground-water samples, averaging 5.9 ± 0.9 with average $SO_4$ concentrations of 0.8, 0.7, and 1.4 mg/L, respectively, in the years 1989 through 1995, indicating an evapotranspiration factor in the ground water of more than 20-fold. The observed range in the average $\delta^{34}S$ of $SO_4$ in ground water from mountain-front areas, after concentration by evapotranspiration, is within the range of average $\delta^{34}S$ values of sulfur in $SO_4$ of snowpack from the Rocky Mountains of northern New Mexico and southern Colorado that averaged 4.4 ± 0.7 per mil between 1993 and 1999 (Mast and others, 2001), and is consistent with an atmospheric source.

## Ground-Water Inflow

### Inorganic Chemical Composition

Ground-water inflow appears to be an important source of recharge to the MRGB along the western margin and in the area of the Hagan Embayment (fig. 5). Historical NWIS data are available for several wells and springs located along the western margin of the basin. These data indicate that the chemical composition of ground-water inflow varies from north to south. From about the Rio Salado (the northern one that flows into the Jemez River) north (fig. 1), the available data for specific conductance range from about 530 to more than 11,000 µS/cm. The median ratio (in meq/L) of $SO_4$ to Cl concentrations is 0.56 and of Ca to Na concentrations is 0.28. Most of these samples are from the Triassic Chinle Formation or from Quaternary alluvium. From about the Rio San Jose north to the Rio Salado, the available data for specific conductance range from about 1,650 to 41,500 µS/cm. The median ratio of $SO_4$ to Cl concentrations is 1.2 (although it ranges as high as about 110) and of Ca to Na concentrations is 0.09. These samples are from Cretaceous, Jurassic, and Triassic rocks. From about the Rio San Jose south, the available data for specific conductance range from about 3,000 to 45,000 µS/cm. The median ratio of $SO_4$ to Cl concentrations is 0.58 and of Ca to Na concentrations is 0.13. These samples are primarily from Permian and Pennsylvanian rocks.

NWIS ground-water samples for the area of the Hagan Embayment come from Quaternary and Cretaceous deposits. The median specific conductance value is 1,220 µS/cm. The median ratio of $SO_4$ to Cl concentrations is 3.5 and of Ca to Na concentrations is 1.1.

#### Oxygen-18 and Hydrogen-2

Stable-isotope data are limited for wells and springs located along the western margins of the basin. Data available from Goff and others (1983) for about five sites near the margins of the MRGB in the area of the Lucero Uplift indicate that $\delta^2H$ varies from about –83.6 to –63.8 per mil. Samples collected for the current MRGB investigation (NM265, NM330, NM335, and NM485 in table A9) indicate that $\delta^2H$ of water along the western margins typically ranges from about –65 to –60 per mil, although one sample had a value of –99.7 per mil. No stable isotope data are known to be available for waters located along the northeastern margin of the basin in the area of the Hagan Embayment.

#### Tritium

All indications are that inflow along the basin margins is old (10,000-year (10 ka) time scale) water and free of tritium, chlorofluorocarbons, and any other environmental tracer of anthropogenic origin. Although tritium was detected in water from a few wells in the southwest part of the basin, and in the northeast near the Hagan Embayment, the source can be attributed to surface water.

#### Sulfur-34

Dissolved $SO_4$ in water from seven wells completed in the Permian San Andres Limestone and/or Permian Glorieta Sandstone, located in an area within approximately 50 miles of the southwestern margin of the MRGB had an average $\delta^{34}S$ of 11.8 ± 0.6 per mil (Plummer, L.N. and Anderholm, S.K., U.S. Geological Survey, unpublished data, 1987). Ten samples of Permian anhydrite and gypsum from core and outcrop in the Glorieta Sandstone and San Andres Limestone from the vicinity of Mesa Lucero along the southwestern margin of the MRGB had an average $\delta^{34}S$ composition of 12.6 ± 1.3 per mil (Plummer, L.N. and Anderholm, S.K., U.S. Geological Survey, unpublished data, 1987). The observed sulfur isotopic composition of dissolved $SO_4$, anhydrite, and gypsum is typical of values reported for Permian evaporates of marine origin (Holser and Kaplan, 1966; Claypool and others, 1980).

The sulfur isotopic composition of sedimentary sulfides can vary widely, but when formed accompanying microbially mediated sulfate reduction, is almost always depleted in $^{34}S$ relative to the $SO_4$ source (see for example, Hoefs, 1987; Clark and Fritz, 1997). The kinetic fractionation between dissolved sulfate and hydrogen sulfide is typically from 20 to 30 per mil (Pearson and Rightmire, 1980; Rye and others, 1981; Habicht and Canfield, 1997; Plummer and others, 1990). Gautier (1987) gives extensive data on the sulfur isotopic composition of pyrite from North American Cretaceous shales.

# CHEMICAL AND ISOTOPIC COMPOSITION OF GROUND WATER IN THE MIDDLE RIO GRANDE BASIN

Chemical and isotopic data for ground water of the MRGB were examined for relations and spatial patterns that could be useful in determining recharge sources, directions of ground-water flow, and geochemical processes. Areal distributions of water types and selected chemical and isotopic data are discussed in this section, as are the apparent relations among constituents. The hydrologic and geochemical implications of the observed data characteristics are presented. Saturation indices for selected minerals discussed below were calculated using the geochemical software package PHREEQC (Parkhurst, 1995), (table C4).

Because the majority of ground-water samples used in this investigation were obtained from wells that were drilled and operated to supply water to people or stock, or to monitor the quality of a municipal water resource, the available data are biased toward regions of the MRGB where water appropriate for these uses could typically be found. Nevertheless, overall spatial coverage of the basin is sufficient. Also, the data typically represent conditions in about the upper 1,750 feet of the saturated zone, and in many places in about the upper 600 feet of the saturated zone, so that the data probably are not representative of conditions in deeper parts of the aquifer system. Nevertheless, the data should provide an accurate picture of the part of aquifer system currently used as the primary ground-water resource.

## Field Parameters

Ground water in the MRGB ranges from dilute to highly mineralized. Values of specific conductance vary within the basin from about 128 to 41,400 microsiemens per centimeter at 25°C (µS/cm). This parameter is conservative in that it is not expected to decrease as water moves down a ground-water flow path (unless mixing occurs with a large quantity of water of another source having a lower specific conductance), so that it can be useful in delineating areas of broadly similar ground-water chemistry. Contours of specific conductance in ground water of the MRGB (fig. 27) indicate that the highest values (greater than 2,000 µS/cm) typically occur near the western margin of the basin, where mineralized ground waters are believed to enter the basin from Paleozoic and Mesozoic rocks to the west. Values greater than about 1,000 µS/cm also are observed near the Hagan Embayment in the northeast part of the basin, near the Tijeras Fault Zone along the eastern margin, and at the southern end of the basin. The lowest values of specific conductance (less than 400 µS/cm) occur along parts of the northern and eastern mountain fronts, and in an area extending across Rio Rancho and Albuquerque in the north-central part of the basin. A small area of relatively low-conductance water (relative to other parts of the basin) is present near Ladron Peak in the southwestern part of the basin, where it is surrounded by much higher-conductance water.

Most ground water within the MRGB is slightly alkaline. Contours of pH (fig. 28) indicate that the highest values (greater than 8.0 standard units) are present across much of the western half of the basin. Values of 8.0 or more also are present across a large area in the southeast. Values of 7.5 or less occur along parts of the northern and eastern mountain fronts, near the Hagan Embayment, and in areas along Abo Arroyo and the Rio Puerco.

Dissolved-oxygen concentrations indicate that most ground water in the MRGB is oxidized. Concentrations greater than 2.0 mg/L are common in all parts of the basin except along the Rio Grande and part of the western margin, where concentrations typically are less than 0.5 mg/L (fig. 29). Concentrations also can be low in deeper wells, particularly west of the Rio Grande. Concentrations of greater than 5.0 mg/L are present along much of the northern and eastern mountain fronts, and across much of the western half of the basin.

Water temperatures at the depths sampled in the MRGB generally range between about 15 and 30°C. Most ground-water temperatures are warmer than the modern mean annual temperature at Albuquerque (13.6°C) (fig. 30), and indicate heating under the effect of the local geothermal gradient (Reiter, 2001). Water temperatures exceed 30°C in an area in the west-central part of the basin.

Water temperatures typically are less than 20°C along basin margins, along the Rio Grande, the Rio Puerco, and Abo Arroyo, and across the northernmost section of the basin (fig. 30). The lowest water

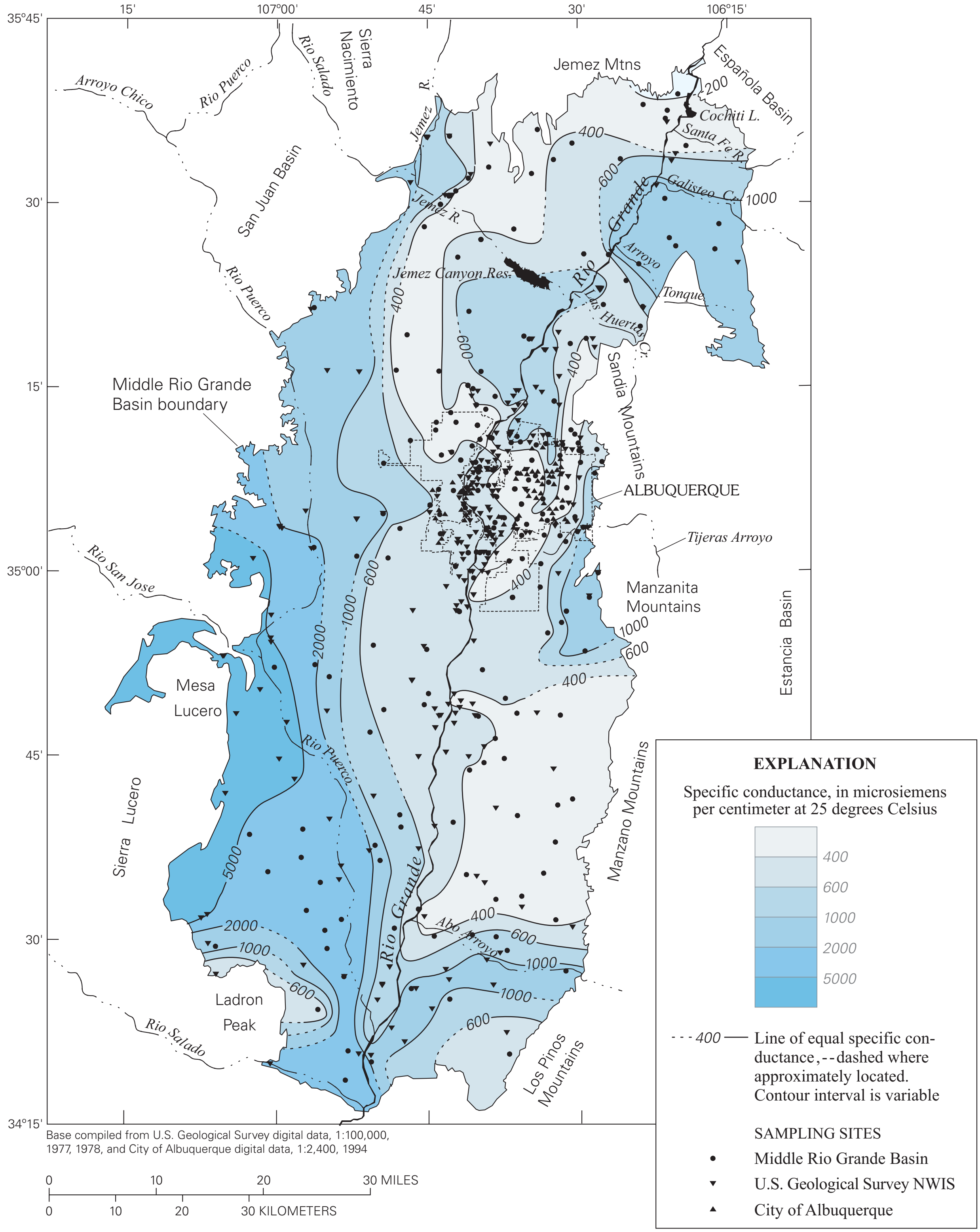



**Figure 27.** Specific conductance for ground water of the Middle Rio Grande Basin, New Mexico. NWIS-- Data from the U.S. Geological Survey National Water Information System.

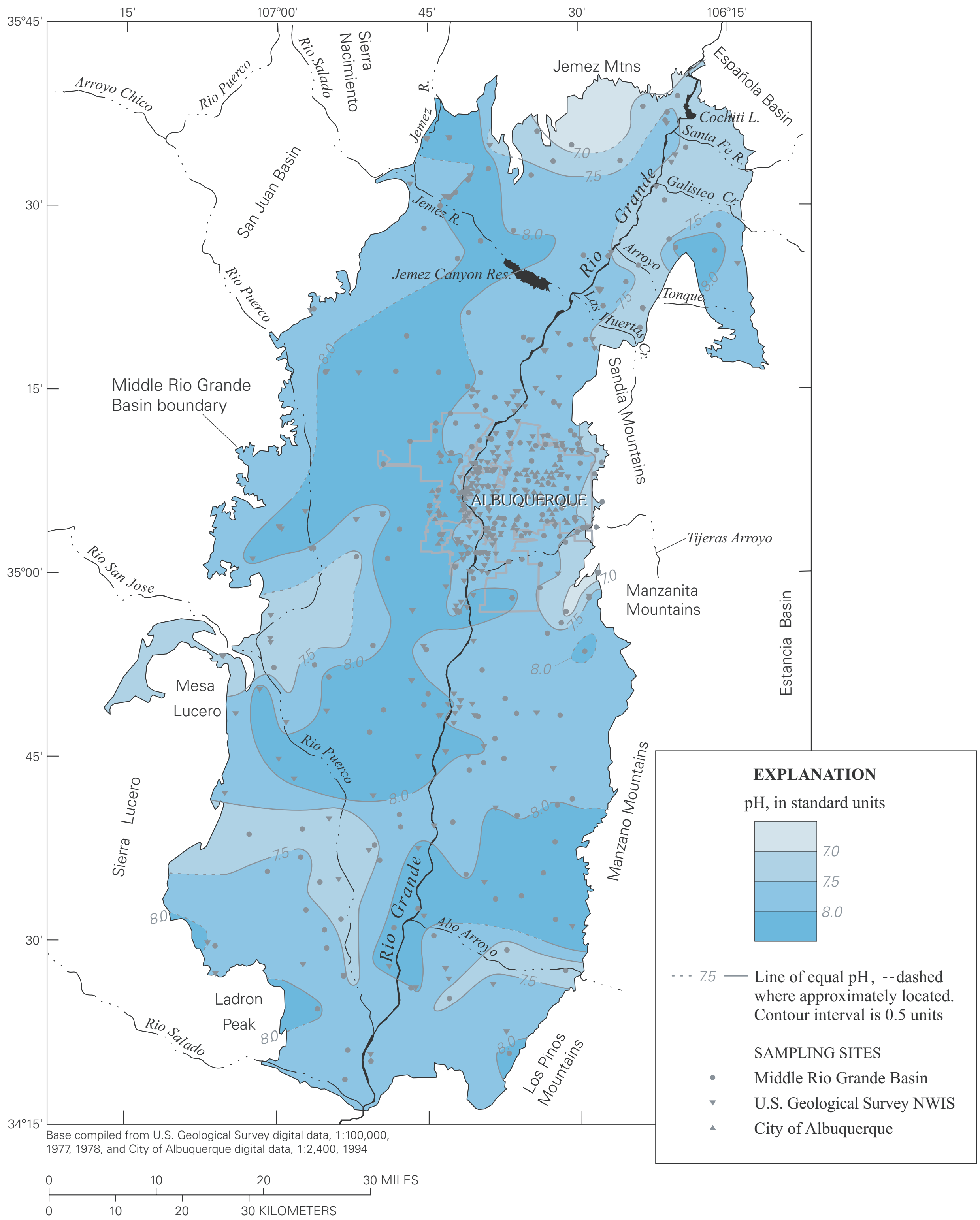



**Figure 28.** pH for ground water of the Middle Rio Grande Basin, New Mexico. NWIS-- Data from the U.S. Geological Survey National Water Information System.

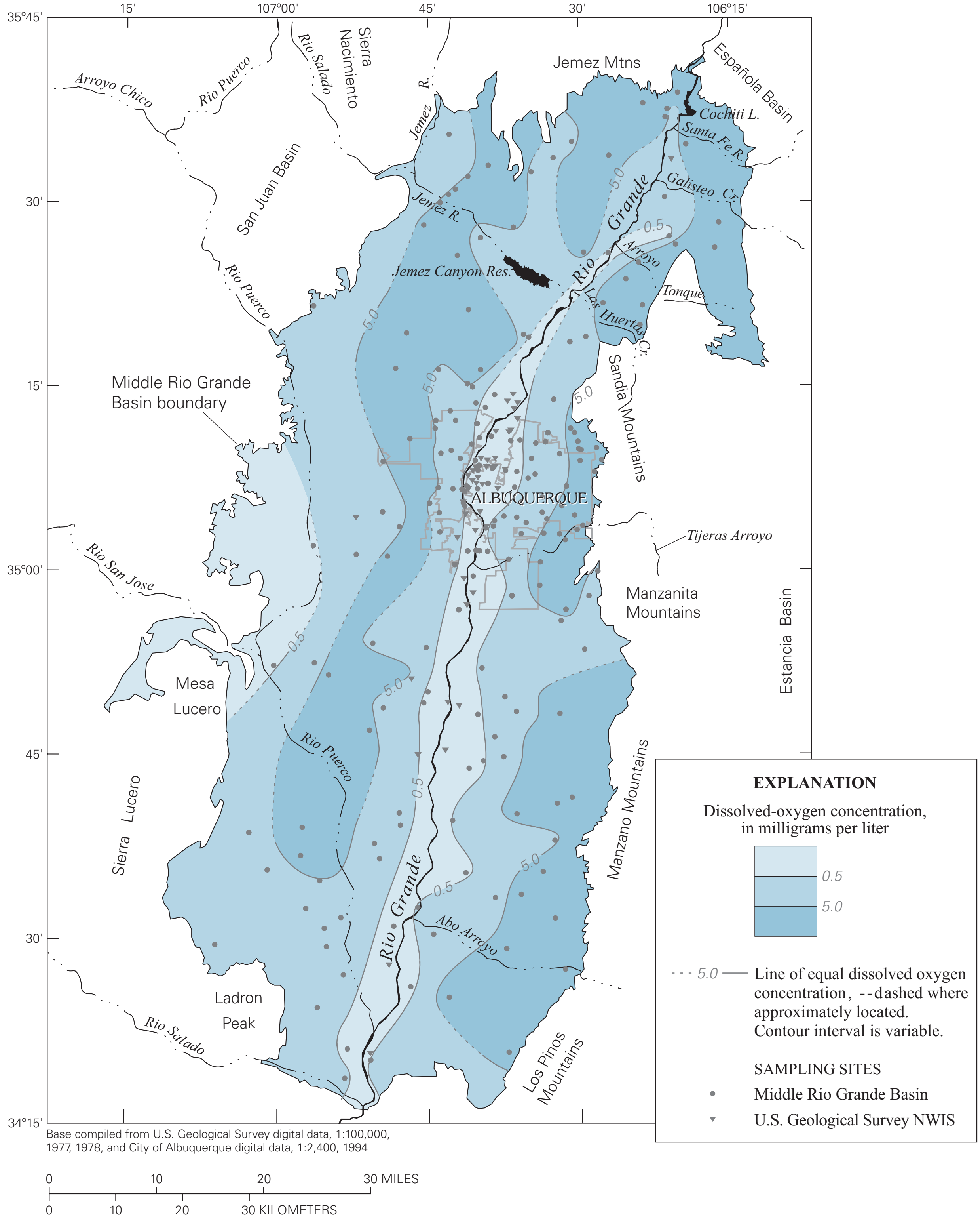



**Figure 29.** Dissolved-oxygen concentration for ground water of the Middle Rio Grande Basin, New Mexico. NWIS--Data from the U.S. Geological Survey National Water Information System.

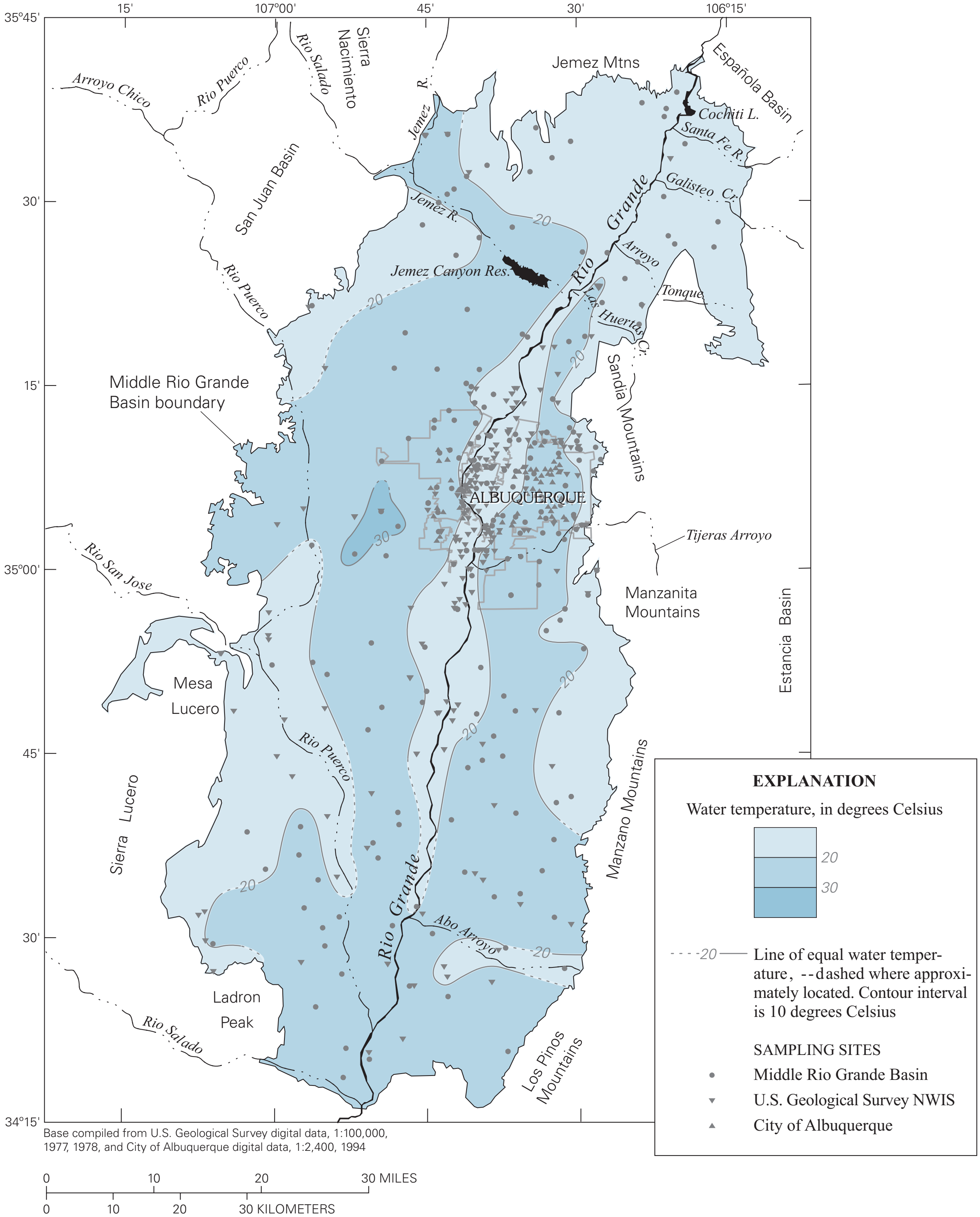



**Figure 30.** Water temperature for ground water of the Middle Rio Grande Basin, New Mexico. NWIS-- Data from the U.S. Geological Survey National Water Information System

temperatures are found in shallow water samples at relatively high altitudes, for example, discharge from Embudo and Embudito springs along the eastern mountain front above Albuquerque (altitudes of 6,600 and 6,440 feet above sea level, respectively) has water temperatures of 8-9$^{o}$C.

## Water Type

Broad differences in water quality among a group of samples can be observed by plotting their chemical compositions on a Piper diagram (fig. 31), which shows the relative proportion of the major ions present in the samples. Of the 12 possible water types (excluding the Mg-containing water types which do not occur in the basin), 11 are represented by waters from the MRGB— all but Ca/Cl waters. The most common water type among the samples analyzed is Ca / $CO_3$ + $HCO_3$, followed by Na + K / $CO_3$ + $HCO_3$ and Mixed-cation / $CO_3$ + $HCO_3$ (fig. 31). Because sample sites are not distributed evenly across the basin, the most common water type among the samples analyzed does not necessarily represent the most common water type by volume for ground water in the basin.

Different water types tend to group in distinct areas of the basin. With respect to cations, the Na + K type generally dominates west of the Rio Grande (except near the northern end of the basin), whereas the Ca type generally dominates east of the Rio Grande (fig. 32). Mixed-cation samples are relatively common near the Rio Puerco, in the southeastern part of the basin, and in some parts of Albuquerque. With respect to anions, the $CO_3$ + $HCO_3$ type dominates across much of the eastern and northern parts of the basin (fig. 32). The $SO_4$ type dominates in areas near Abo Arroyo and the Hagan Embayment, as well as across much of the western part of the basin; the mixed-anion type also is relatively common west of the Rio Grande. The Cl type occurs primarily in the southwestern part of the basin.

## Major-Element Chemistry

### Anions

The following sections present data on concentrations of chloride, sulfate, the $^{34}$S isotopic composition of dissolved sultate, bicarbonate, the $^{13}$C isotopic composition of bicarbonate, nitrate, dissolved nitrogen gas, and dissolved fluoride in ground water from the MRGB.

#### *Chloride*

Chloride typically is a conservative constituent in ground water. Contours of Cl concentration in the MRGB (fig. 33) indicate that concentrations of greater than 1,000 milligrams per liter (mg/L) occur along the western margin of the basin, south of the Rio San Jose. Concentrations of 50 mg/L or greater are present across much of the southwestern part of the basin and near the Tijeras Fault Zone. These concentrations also occur in isolated areas northwest of Bernalillo and in the northeastern part of Albuquerque. Chloride concentrations of less than 10 mg/L are present along much of the northern and eastern mountain fronts. These low concentrations also extend across large areas southward from the Jemez mountain front and westward from the Manzano mountain front.

In general, Cl concentrations in the basin likely reflect the amount of evapotranspiration that water has undergone during recharge through mountain-front areas or rivers/arroyos. However, in some parts of the basin, these concentrations appear to indicate mixing between local recharge and old, mineralized waters sourced from adjacent basins or from depth within the MRGB, such as from hydrothermal fluids (Rao and others, 1996). In the southwestern part of the basin, high Cl concentrations probably indicate Na-Cl brine entering the basin from Paleozoic rocks to the west. Near the Tijeras Fault Zone, high Cl concentrations could be associated with the leakage of mineralized waters upward and/or basinward along the major faults of the area. The anomalously high Cl concentrations near Bernalillo and in northeastern Albuquerque appear consistent with the upward movement of deep, mineralized waters along faults, or possibly over structural highs, as has been suggested by previous investigators (Anderholm, 1988; Trainer and others, 2000; Bexfield and Anderholm, 2002a; Bexfield and Plummer, 2002). Water-quality data collected from piezometer nests (discussed below) support the presence of more mineralized waters at depth in these areas.

Anderholm (2001) used Cl concentrations from ground water near the mountain front and from bulk precipitation to estimate the amount of mountain-front recharge along the eastern side of the basin. Results from this chloride mass-balance method (Dettinger,

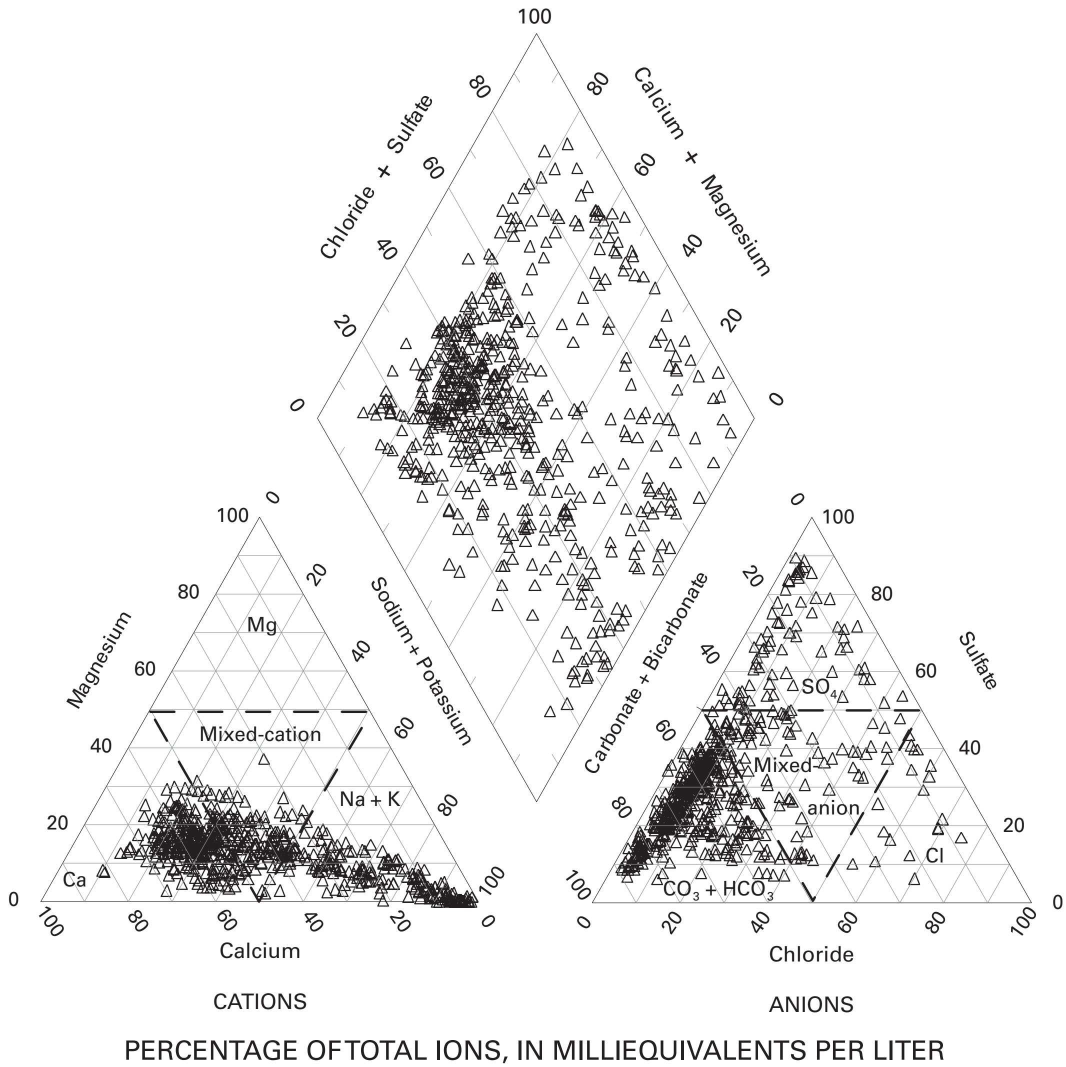



**Figure 31.** Piper diagram showing water types for all ground-water samples from the Middle Rio Grande Basin, New Mexico.

1989) yielded estimates of total mountain-front recharge along the eastern side of about 11,000 acre-feet per year, as opposed to estimates of about 36,000-38,000 acre-feet per year based on water-yield regression equations (Anderholm, 2001).

*Sulfate and Sulfur-34 of Dissolved Sulfate*

Although $SO_4$ concentrations are not necessarily conservative because of common rock-water interactions and biological processes, these concentrations indicate useful patterns in ground water of the MRGB. Contours of $SO_4$ concentration (fig. 34) show that the highest values (greater than 1,000 mg/L) tend to occur along the western margin of the basin and along much of the Rio Puerco. Concentrations of greater than 200 mg/L are present across much of the western and southern parts of the basin, as well as near the Hagan Embayment and the Tijeras Fault Zone. Concentrations of less than 50 mg/L are common along much of the northern and eastern mountain fronts and extend outward from these margins across substantial areas of the basin.

A map of the ratios of $SO_4$ to Cl concentrations (meq/L) shows that these ratios (unitless) exceed 10 in areas along part of the western margin, near the Hagan Embayment in the vicinity of Galisteo Creek, and near Abo Arroyo (fig. 35). As discussed above in the section on sources of water to the basin, ratios of this magnitude are consistent with infiltration through Abo

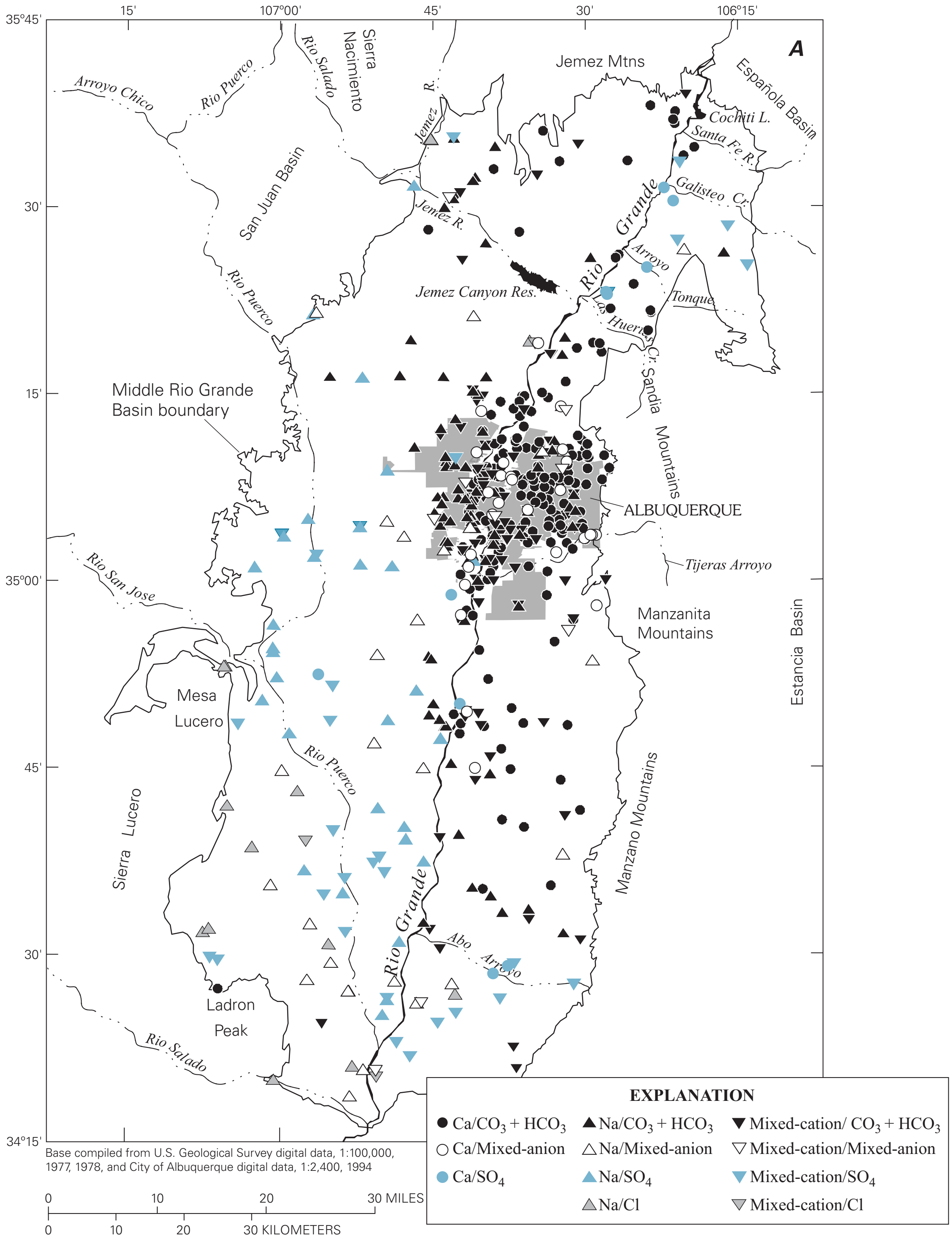



**Figure 32a.** Water types of ground-water samples throughout the Middle Rio Grande Basin. (Water types based on the Piper diagram of figure 31.)

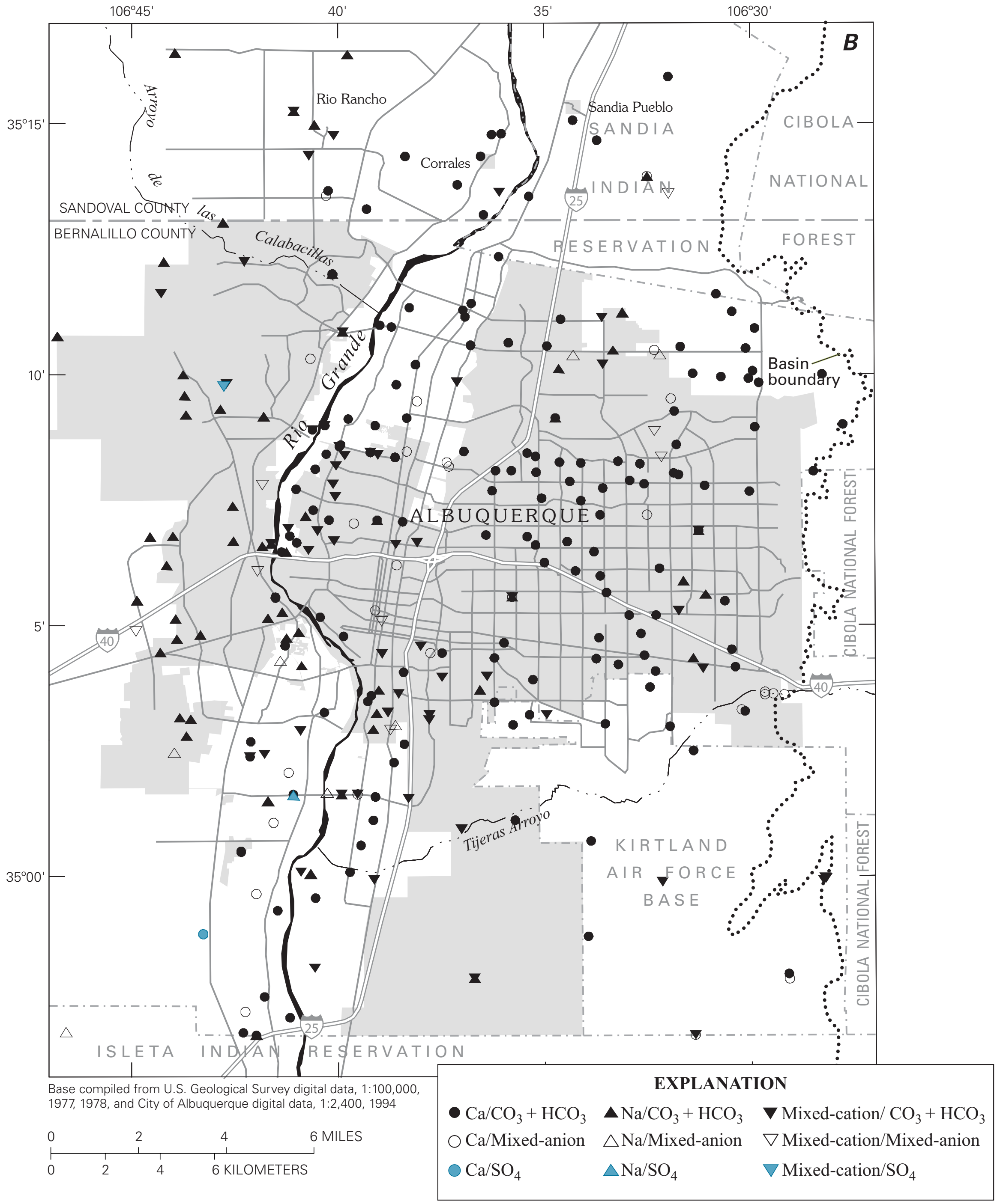



**Figure 32b.** Water types of ground-water samples inside the Albuquerque area, New Mexico. (Water types based on the Piper diagram of figure 31.)

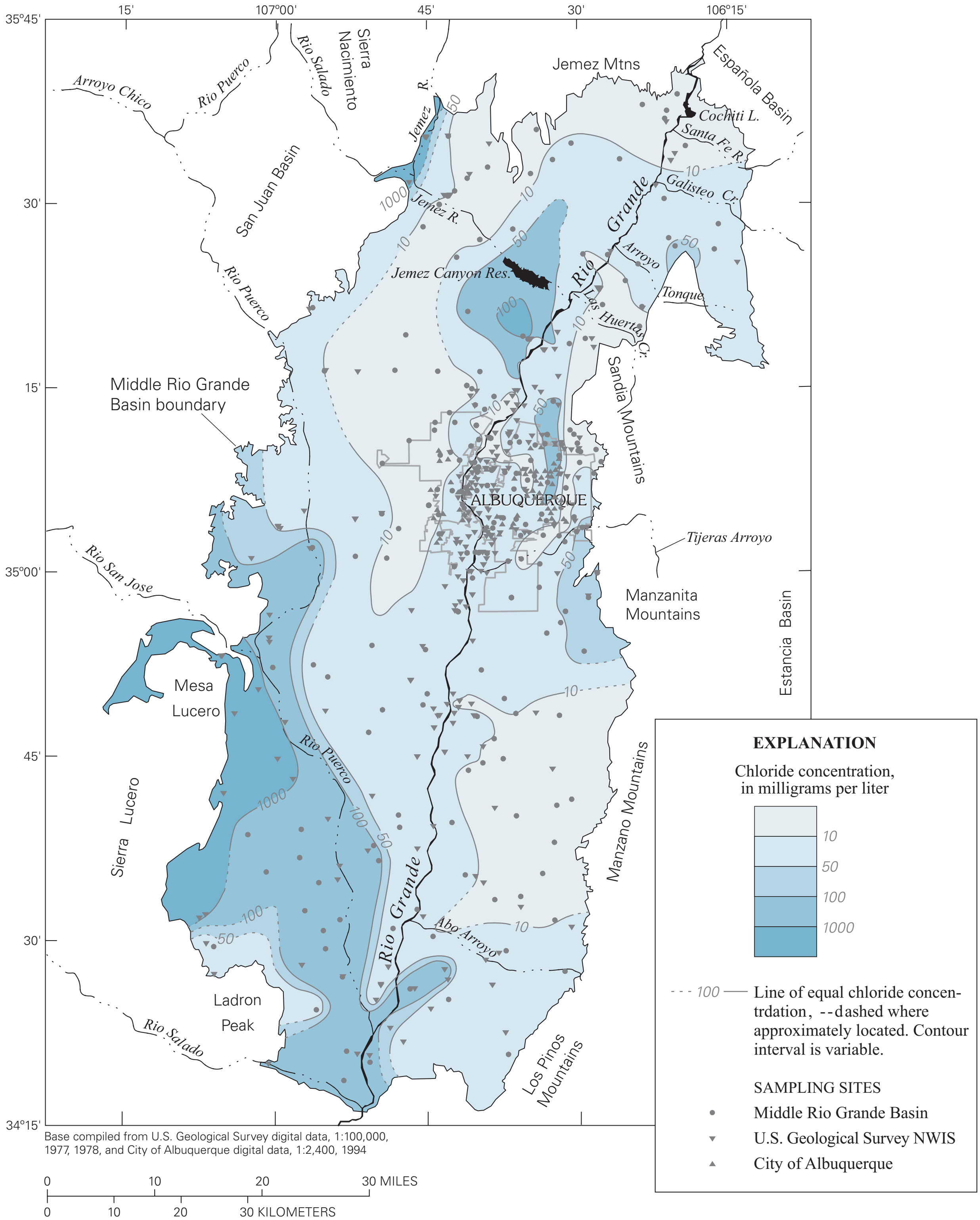



**Figure 33.** Chloride concentration for ground water of the Middle Rio Grande Basin, New Mexico. NWIS-- Data from the U.S. Geological Survey National Water Information System.

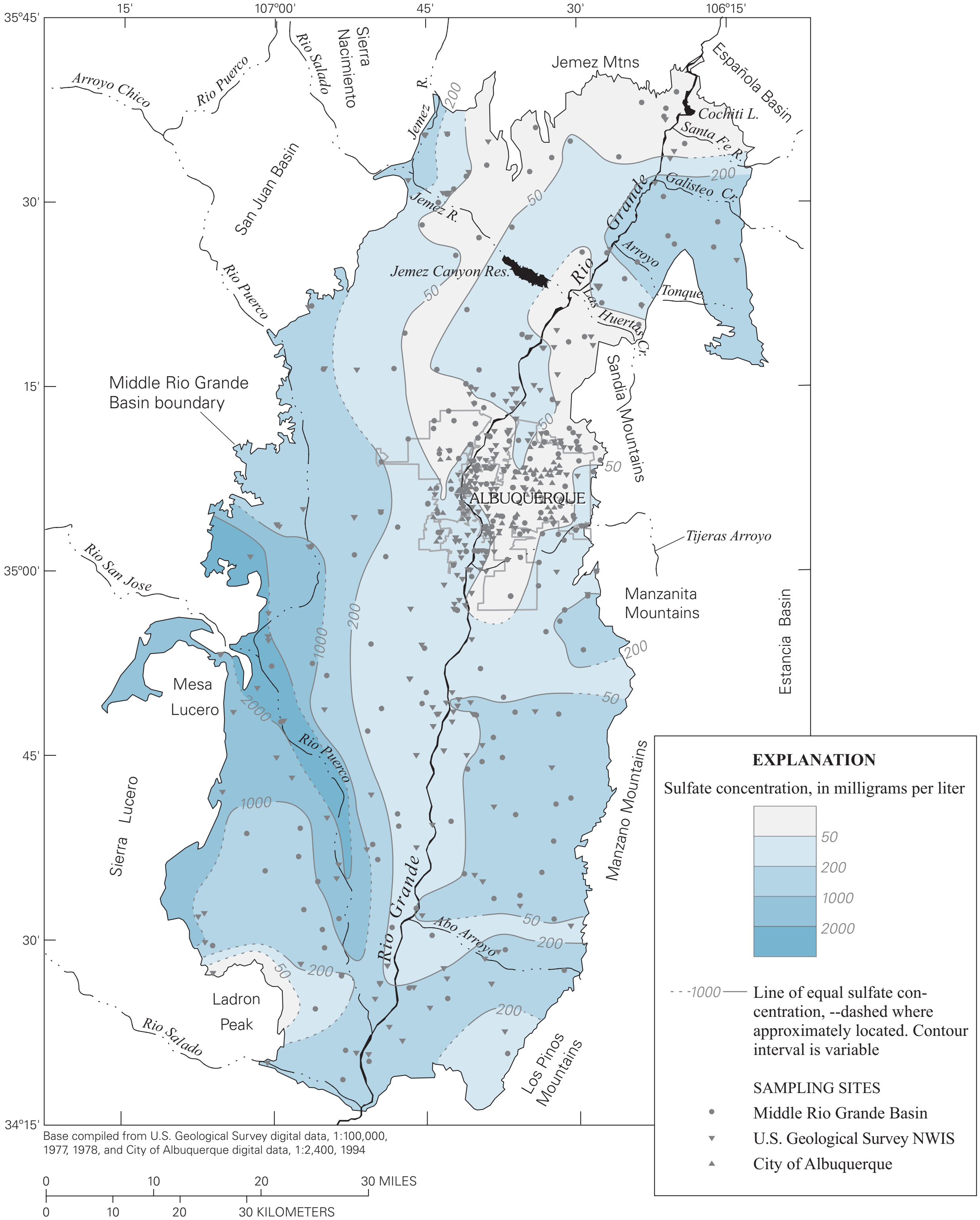



**Figure 34.** Sulfate concentration for ground water of the Middle Rio Grande Basin, New Mexico. NWIS-- Data from the U.S. Geological Survey National Water Information System.

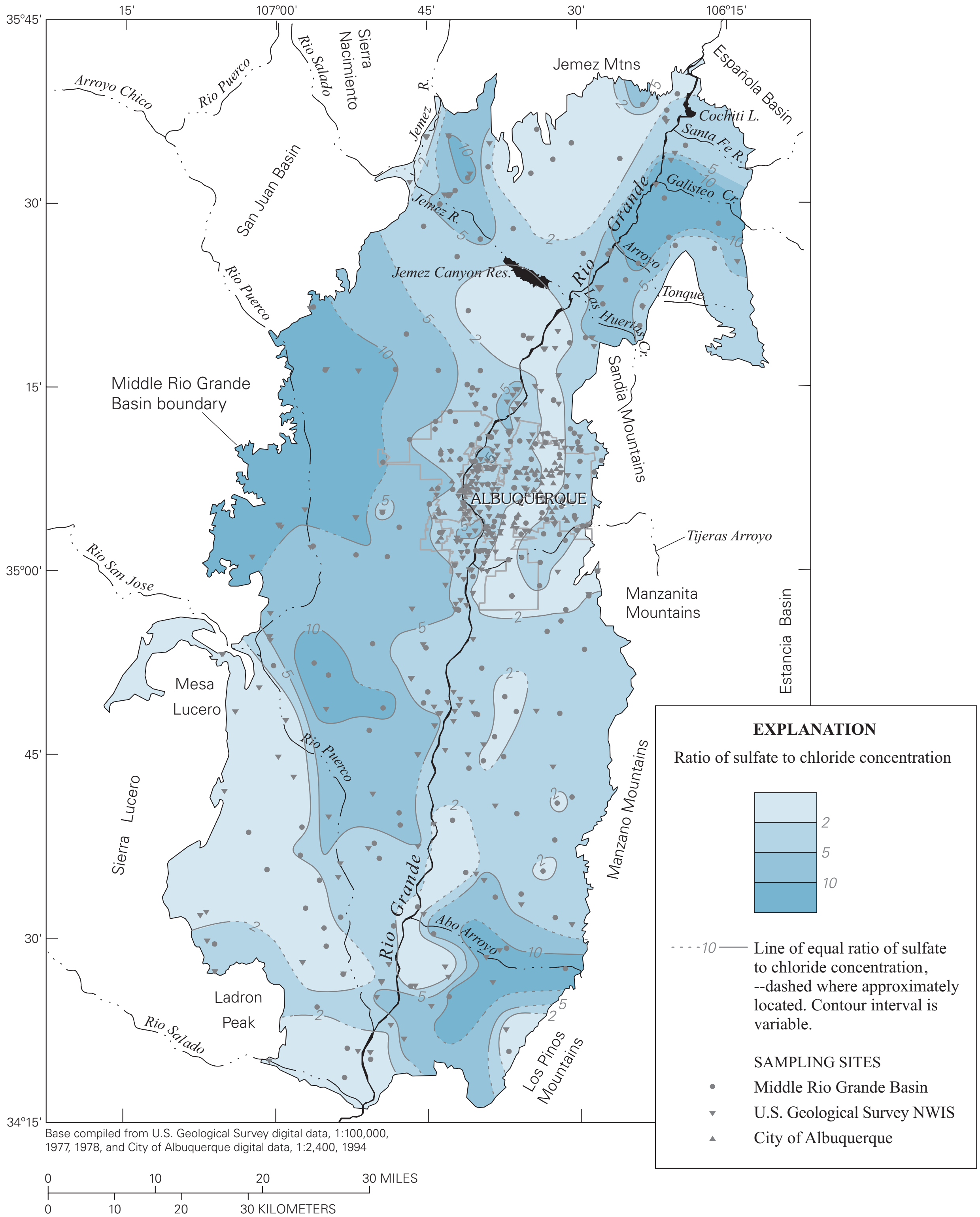



**Figure 35.** Ratio of sulfate to chloride concentration (concentrations in milliequivalents per liter) for ground water of the Middle Rio Grande Basin, New Mexico. NWIS-- Data from the U.S. Geological Survey National Water Information System.

Arroyo or possibly the Rio Puerco and are found in some ground-water samples obtained along the western margin. These relatively high $SO_4$ concentrations in ground water of the basin generally appear to be associated with waters from areas where gypsum is present. In particular, Mesozoic and/or Paleozoic rocks along the western margin of the basin and in the drainage areas for the Rio Puerco and Abo Arroyo contain gypsum deposits. Gypsum also is present in Mesozoic rocks in the area of the Hagan Embayment, probably resulting in the high $SO_4$ to Cl ratios found in ground water of this area. Even in these areas of high $SO_4$ to Cl ratio, nearly all ground-water samples are undersaturated with respect to gypsum.

Sulfate to Cl ratios between 2 and 10 are common in ground water throughout a large part of the basin (fig. 35). Among potential recharge waters, ratios of this magnitude are most consistent with precipitation and seepage from the Rio Grande. Therefore, it appears that mountain-front and/or river recharge may be important across large areas of the basin. Along with Cl concentrations, $SO_4$ concentrations in these areas probably can be used to estimate the amount of evapotranspiration resulting as precipitation recharged along basin margins or as surface water infiltrated and recharged the aquifer system.

Sulfate to Cl ratios less than 2 occur along parts of the western margin, in an area extending from the central Jemez Mountains into northeastern Albuquerque, and in isolated areas throughout the rest of the basin (fig. 35). These areas are generally coincident with those of elevated Cl discussed above, where brine entering the basin from Paleozoic rocks to the west or mineralized water moving upward from depth are believed to affect water chemistry in the upper several hundred feet of the aquifer system.

The isotopic composition of sulfur in dissolved $SO_4$ of the MRGB is a function of the isotopic composition of the sulfur source(s) and the extent of sulfate reduction and/or sulfide oxidation within the aquifer system. Some waters along the southwestern basin margin have elevated $SO_4$ concentrations, and may have sulfur isotopic compositions dominated by dissolution of Permian evaporite-mineral sources. For example, water from a windmill at site S201 on the southwestern basin margin (NM329) has a dissolved $SO_4$ concentration of 936 mg/L with a $\delta^{34}S$ value of 9.4 per mil, a value only slightly lower than average values of Permian gypsum sources (Holser and Kaplan, 1966; Claypool and others, 1980). As discussed earlier, 10 samples of anhydrite and gypsum from Permian rocks along the southwestern margin of the basin had an average $\delta^{34}S$ composition of 12.6 ± 1.3 per mil.

The average value of $\delta^{34}S$ from the 152 measurements of ground-water $SO_4$ from throughout the MRGB is 0.5 ± 6.0 per mil, spanning a range of nearly 43 per mil, from -23.0 to 19.7 per mil. Many of the water samples from the MRGB seem to have sulfur isotopic compositions that reflect mixed sources of sulfur. Aerobic samples probably have not been affected by sulfate reduction, but may contain sulfur from oxidation of sulfide minerals, which are typically depleted in $^{34}S$. Oxidation of sulfide minerals (alone) would lead to waters with $\delta^{34}S$ isotopic compositions less than that of sulfur in precipitation (less than approximately 4 per mil in $\delta^{34}S$). Water samples with $\delta^{34}S$ values greater than approximately 4 per mil represent samples that have dissolved an excess of Permian evaporates relative to sulfide-oxidation sources of S, and/or have been affected by incomplete sulfate reduction. Water samples with $\delta^{34}S$ values greater than approximately 12.6 per mil (the average isotopic composition of Permian sulfates) represent samples where the dissolved $SO_4$ has undergone incomplete sulfate reduction. For example, samples from the SWAB-3 well (NM158-NM159) have $\delta^{34}S$ values of dissolved $SO_4$ that range from 16.2 to 19.7 per mil.

Although there is considerable data on the sulfur isotopic composition of sulfur in modern precipitation, sulfur of recent atmospheric origin is at least, in part, derived from anthropogenic sources (Mast and others, 2001), and may not be entirely representative of atmospheric sulfur in the past.

Most of the sulfur isotopic data were obtained in the vicinity of Albuquerque in an attempt to determine if, on the basis of $\delta^{34}S$ values of dissolved $SO_4$, waters derived from mountain-front sources could be separated from waters derived from Rio Grande sources. Analysis of the sulfur isotope data proved only marginally successful in this effort. In the section "Tracing Sources of Water in the Middle Rio Grande Basin—Definition of Hydrochemical Zones and Water Sources", a variety of isotopic and chemical parameters are used to recognize and classify water of mountain-front and Rio Grande source. Using the resulting classification (see discussion of hydrochemical zones in the the section "Tracing Sources of Water in the Middle Rio Grande Basin"), the mountain-front waters (spanning an age range of modern to approximately 20 ka) have an average $\delta^{34}S$ composition of 3.6 ± 3.3 per mil, whereas the Rio Grande source waters (spanning an age range of modern to 27 ka) average -0.9 ± 6.4 per mil. The mountain-front waters contain sulfur predominantly of atmospheric source. Two processes primarily account for variations in $\delta^{34}S$ in the Rio Grande sources: (1) the seasonal variations in the isotopic composition of Rio Grande water (fig. 26), and (2) following infiltration, release of sulfur depleted in $^{34}S$ during oxidation of sulfide minerals in sediment of the inner valley of the Rio Grande. Dissolved $SO_4$ concentrations and $\delta^{34}S$ for all waters analyzed of apparent mountain-front and Rio Grande origin are compared in figure 36. Although there is considerable overlap in the more enriched samples, the highest $\delta^{34}S$ values (except for those from S244 and S245 which have undergone sulfate reduction) are in mountain-front waters and the lowest in waters apparently of Rio Grande origin. The waters most depleted in $^{34}S$ also contain the highest concentrations of dissolved $SO_4$ (fig. 36), and are from wells located in the inner valley of the Rio Grande. These samples depleted in $^{34}S$ are apparently of Rio Grande origin, and have been appreciably affected by oxidation of sulfide minerals. The two dashed lines that bracket the $SO_4$ and $\delta^{34}S$ values on figure 36 were determined assuming a hypothetical initial dissolved $SO_4$ concentration of 30 mg/L with $\delta^{34}S$ of 2.0 per mil accompanying oxidation of sulfides of -30 per mil with evapotranspiration factors from 1.0 to 5.0.

Apparently, the separation in average $\delta^{34}S$ of $SO_4$ of Rio Grande origin from that of mountain-front origin results from sulfide oxidation in parts of the inner valley of the Rio Grande where Rio Grande

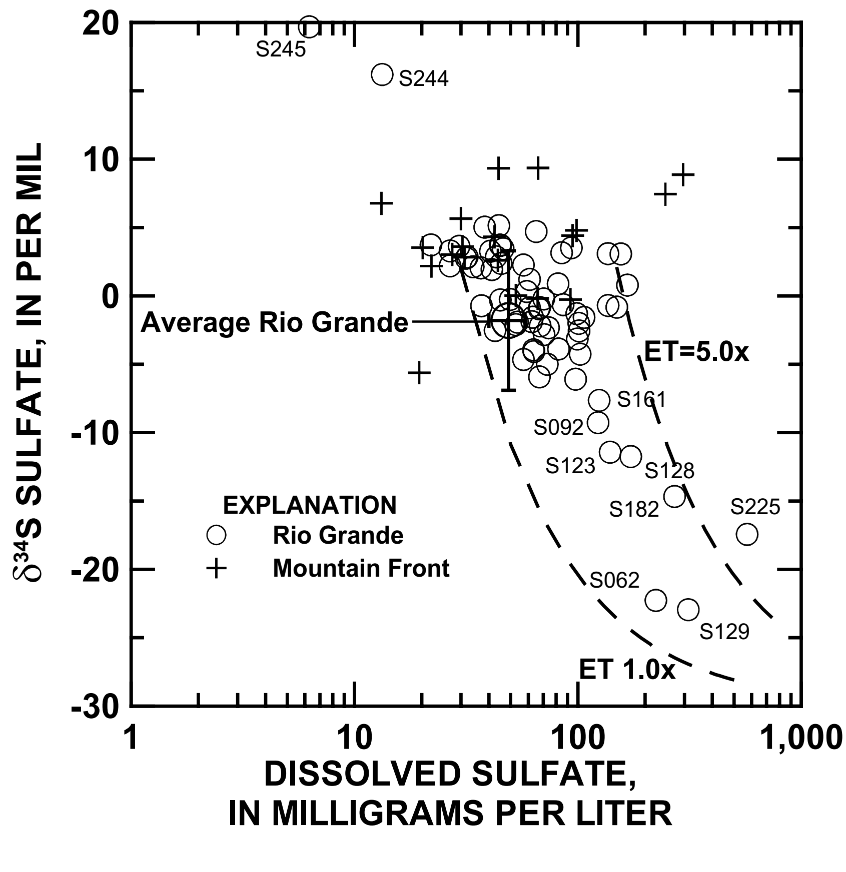



**Figure 36.** Comparison of dissolved sulfate concentrations and stable S isotopic composition of dissolved sulfate, $\delta^{34}S$, for waters of mountain-front recharge and Rio Grande origin. The highest $\delta^{34}S$ values occur in mountain-front waters and the lowest in waters of Rio Grande origin. The waters most depleted in $\delta^{34}S$ also contain the highest concentrations of dissolved sulfate, and are from wells located in the inner valley of the Rio Grande. The two dashed lines bracket the range of sulfate and $\delta^{34}S$ values that would result from a hypothetical initial dissolved sulfate concentration of 30 mg/L with $\delta^{34}S$ of 2.0 per mil accompanying oxidation of sulfides of -30 per mil with evapotranspiration factors (ET) from 1.0 to 5.0.

source waters predominate. This sulfide oxidation results in dissolved-$SO_4$ concentrations that are depleted in $^{34}S$ relative to that in waters of mountain-front origin. For example, ground-water samples of either a mountain-front or Rio Grande source that contain more than 0.1 mg/L of dissolved oxygen tend to be located outside the inner valley of the Rio Grande and have similar $\delta^{34}S$ values (fig. 37). In contrast, samples from the inner valley, where dissolved oxygen concentrations are less than 0.1 mg/L, tend to have $SO_4$ concentrations that are depleted in $^{34}S$ relative to $SO_4$ of mountain-front origin. Because the depleted sulfur occurs predominantly in the relatively young, inner-valley ground water, sulfide oxidation in the inner valley of the Rio Grande may be a relatively recent phenomenon. With the installation of drains and canals along the Rio Grande, and in response to lowered water levels accompanying ground-water withdrawals near Albuquerque, dissolved oxygen has apparently been introduced to greater depths in the inner valley of the Rio Grande in the 20th century, which has permitted oxidation of sedimentary sulfide minerals that have formed previously in otherwise anoxic sediments.

The $^{34}S$ isotopic composition of dissolved sulfur can be used in recognizing Permian sources of $SO_4$ ($\delta^{34}S$ of $SO_4$ in the range of 9 to 12 per mil). Permian sources of sulfur probably affect waters in Abo Arroyo, the Rio Puerco, ground-water inflow to the western side of the MRGB, and inflow from the northeast in the vicinity of the Hagan Embayment. The contrast in sulfur isotopic compositions is useful in recognizing water samples probably affected by oxidation of sulfide minerals ($\delta^{34}S$ of $SO_4$ generally less than 0 per mil). However, it is probably not possible to separate waters of Rio Grande origin from those of mountain-front origin in the MRGB on the basis of sulfur isotopic composition.

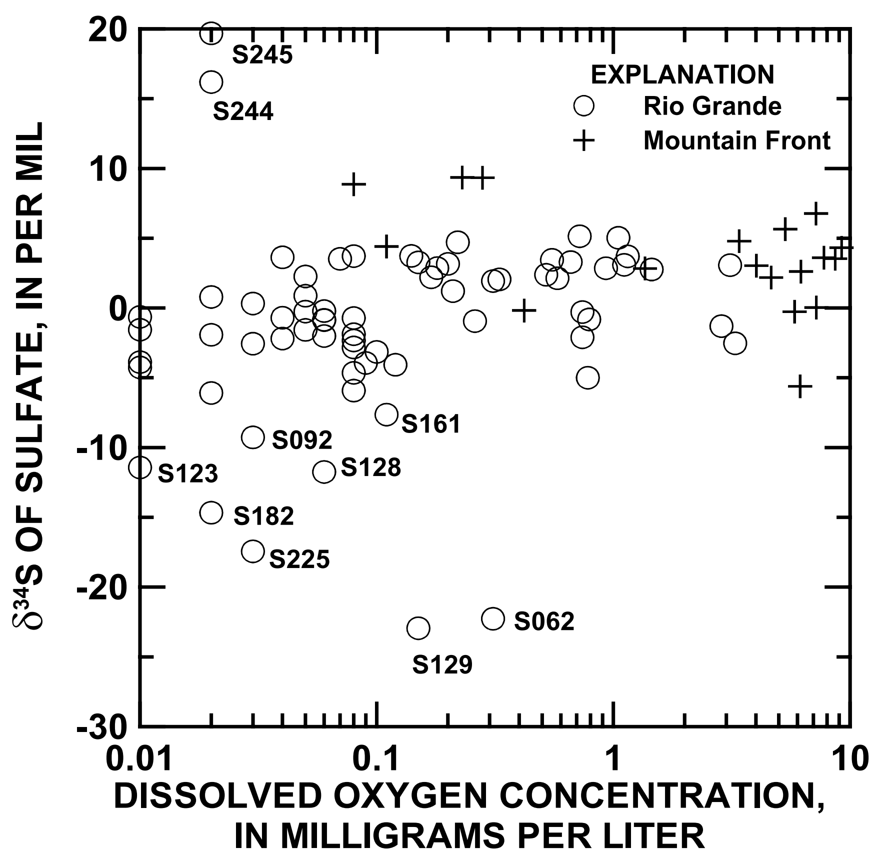



**Figure 37.** Comparison of stable S isotopic composition of dissolved sulfate, $\delta^{34}S$, with dissolved-oxygen concentration for water of Rio Grande and mountain-front origin, New Mexico. The range of $\delta^{34}S$ values is similar in mountain-front and Rio Grande waters in aerobic samples, but $\delta^{34}S$ generally becomes more depleted in $^{34}S$ in low-oxygen waters.

*Bicarbonate and Carbon-13 of Dissolved Inorganic Carbon*

Total alkalinity as $HCO_3$ through most of the center of the basin is less than 200 mg/L, and commonly less than 150 mg/L (fig. 38). High values of alkalinity are present along much of the eastern mountain front and near the western margin of the basin. Particularly high values can be indicative of areas of extensive carbonate-mineral reactions, and if occurring in the aquifer following recharge, can have an appreciable effect on interpretation of radiocarbon age. Even in areas of lower alkalinity, calculations indicate that most ground-water samples are near or at saturation with respect to calcite.

Approximately 250 measurements of $\delta^{13}C$ of the dissolved inorganic carbon, DIC, in ground water from the MRGB average -7.9 ± 2.0 per mil. The $\delta^{13}C$ values show only small variations spatially throughout the basin (fig. 39). Waters relatively enriched in $^{13}C$ in the southwestern part of the basin probably reflect values of $^{13}C$ from the source water, rather than the effects of reactions within the basin. $\delta^{13}C$ values of approximately -10 to -12 per mil can be traced along parts of the northern and eastern mountain fronts where, over short distances (several miles), they increase to approximately -8 per mil (fig. 39). Over large sections of the basin, from approximately the Jemez River to the southern extent of the basin, $\delta^{13}C$ values are nearly constant along the general north to south direction of regional ground-water flow. This result suggests that geochemical reactions that could affect the dissolved inorganic carbon are not extensive.

There are, however, small differences in $\delta^{13}C$ values among some waters. For example, $\delta^{13}C$ values of DIC are slightly more negative in waters near the Rio Grande than in other parts of the basin, probably reflecting the oxidation of organic carbon as redox reactions occur in the fluvial sediments of the inner valley of the Rio Grande.

In order to use $^{13}C$ data to recognize geochemical reactions that affect the DIC in the MRGB, the various $\delta^{13}C$ compositions of the carbon sources must be appreciably different. Carbon sources within the basin include limited occurrences of carbonate minerals (mainly calcite cement, lithic fragments of limestone, and caliche), organic carbon (plants and soil organic matter), and soil-gas $CO_2$.

A limited number of measurements of $\delta^{13}C$ of calcites were made for this study (Appendix C, table C2). Ten samples of Pennsylvanian limestones that cap the Sandia and Manzano Mountains on the eastern side of the basin had $\delta^{13}C$ values of -0.9 ± 1.9 per mil. Eleven specimens of caliche from soils and drill cuttings from throughout the basin had $\delta^{13}C$ values of -4.3 ± 0.9 per mil. Three of the eleven caliche samples were radiocarbon dated and had $\delta^{13}C$ values of -2.9, -3.8, and -5.3 per mil, with Conventional Radiocarbon Ages of 27.4, 7.2, and 2.3 ka B.P., respectively. Although the data are limited, the isotopic values for the three caliche samples are consistent with a possible decrease in the proportion of $C_4$ plants in late Holocene ecosystems, as discussed in more detail below (Grover and Musick, 1990; Liu and others, 1996).

Twenty-six plant specimens were collected in late April-early May 1997 at Embudo and Embudito Arroyos, and from the base of the Manzano Mountains on Kirtland Air Force Base. Plants included grasses, chamisa, willow, juniper, and apache plume. Various parts of the plants were analyzed for $\delta^{13}C$, including foliage, stems, roots, and wood (table C3). Two distinct groups of $\delta^{13}C$ values were evident, with median $\delta^{13}C$ values of -26.4 and -14.5 per mil (fig. 40). Plants utilizing the $C_3$ photosynthetic cycle include most trees, shrubs, and herbs, and grasses that prefer cool, wet-growing seasons, whereas $C_4$ plants are almost entirely grasses that can tolerate hot, dry growing seasons (Morgan and others, 1994). Plants undergoing the $C_3$ and $C_4$ photosynthetic pathways are recognized today by average $\delta^{13}C$ values typically -26.5 ± 2.5 and -12.5 ± 1.2 per mil, respectively (Morgan and others, 1994; Deines, 1980); thus, the two groups of plants analyzed from the eastern mountain front at Albuquerque are characteristic of plants utilizing the $C_3$ and $C_4$ photosynthetic pathways. The $\delta^{13}C$ of pre-industrial atmospheric $CO_2$ was about 1.5 per mil more positive than modern air (Peng, 1985; Francey and others, 1999); therefore, pre-industrial $\delta^{13}C$ values of $C_3$ and $C_4$ plants would have been about -25 and -11 per mil, respectively.

Twenty-two samples of unsaturated-zone air were collected from June 1996 through October 1997 from shallow depths (approximately 3 feet) and analyzed for gas composition and $\delta^{13}C$ isotopic composition of the $CO_2$. The soil-gas samples were from Bear Canyon, Kirtland Air Force Base, and Tijeras Arroyo vicinities along the eastern mountain front near Albuquerque (table C1). The median isotopic composition of the soil-gas samples was -14.8 per mil in $\delta^{13}C$ (fig. 40). The soil gas had a range in $\delta^{13}C$ values that was greater than that of either of the

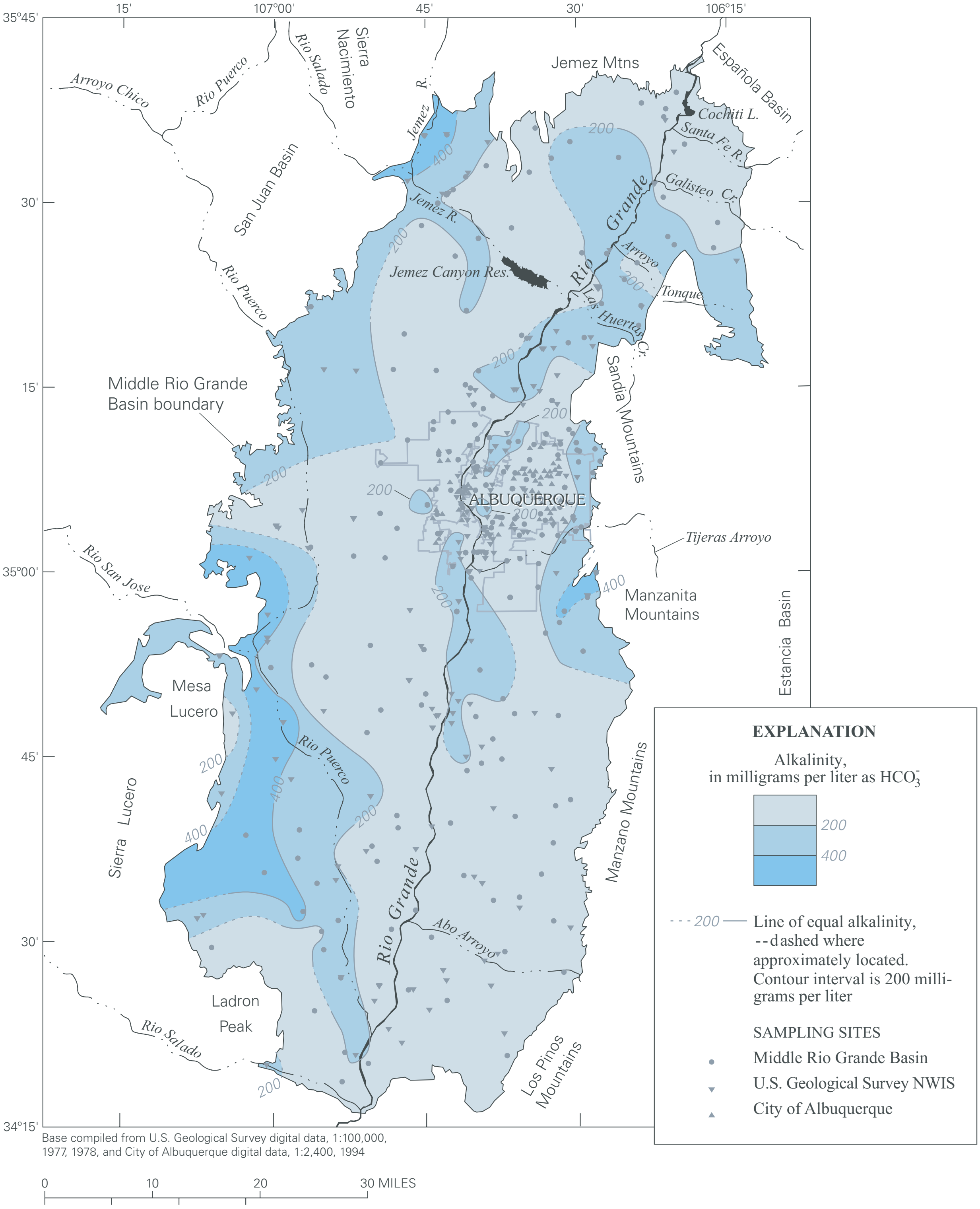



**Figure 38.** Alkalinity for ground water of the Middle Rio Grande Basin, New Mexico. NWIS-- Data from the U.S. Geological Survey National Water Information System.

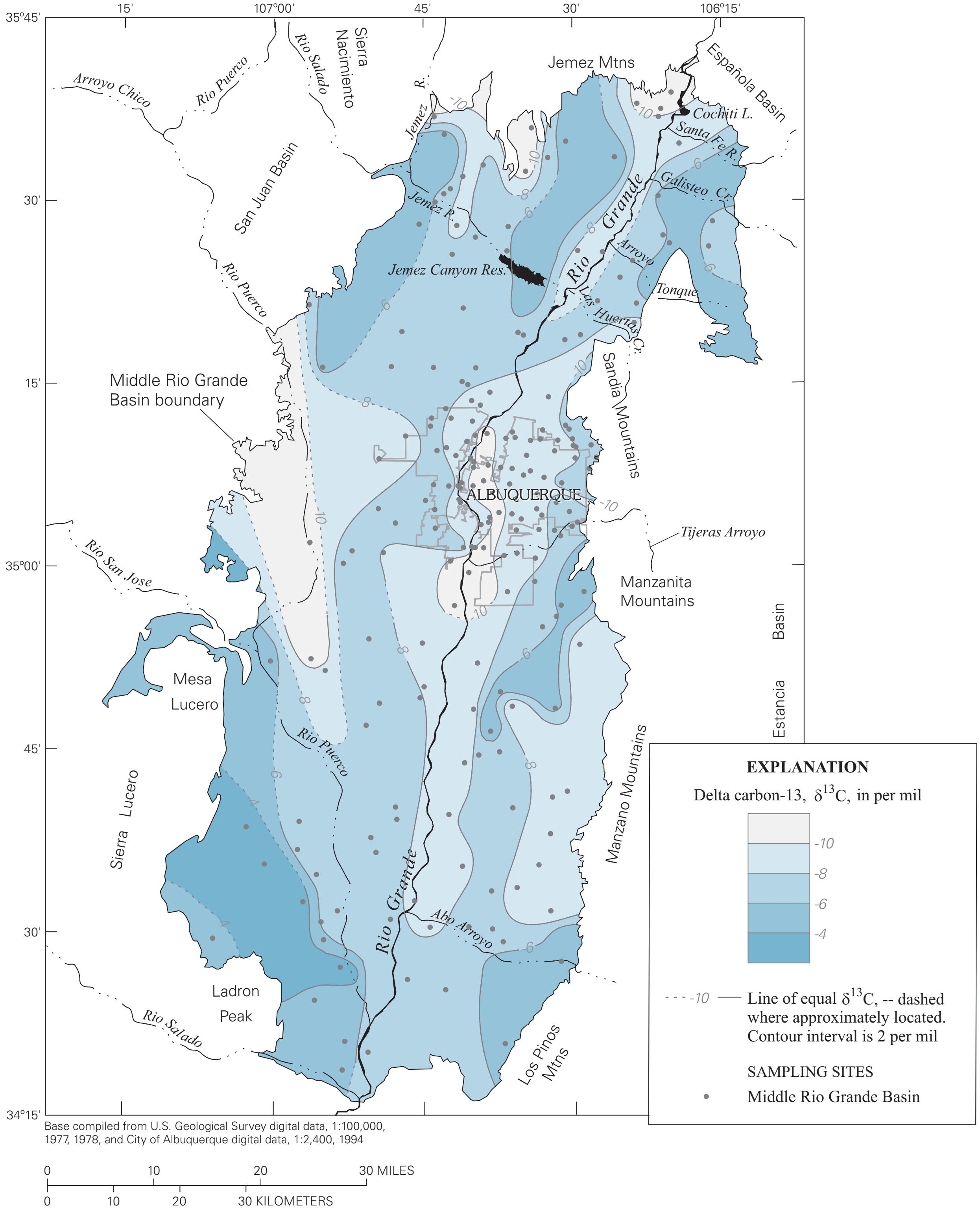



**Figure 39.** Stable carbon isotopic composition, $\delta^{13}C$, of dissolved inorganic carbon for ground water of the Middle Rio Grande Basin, New Mexico.

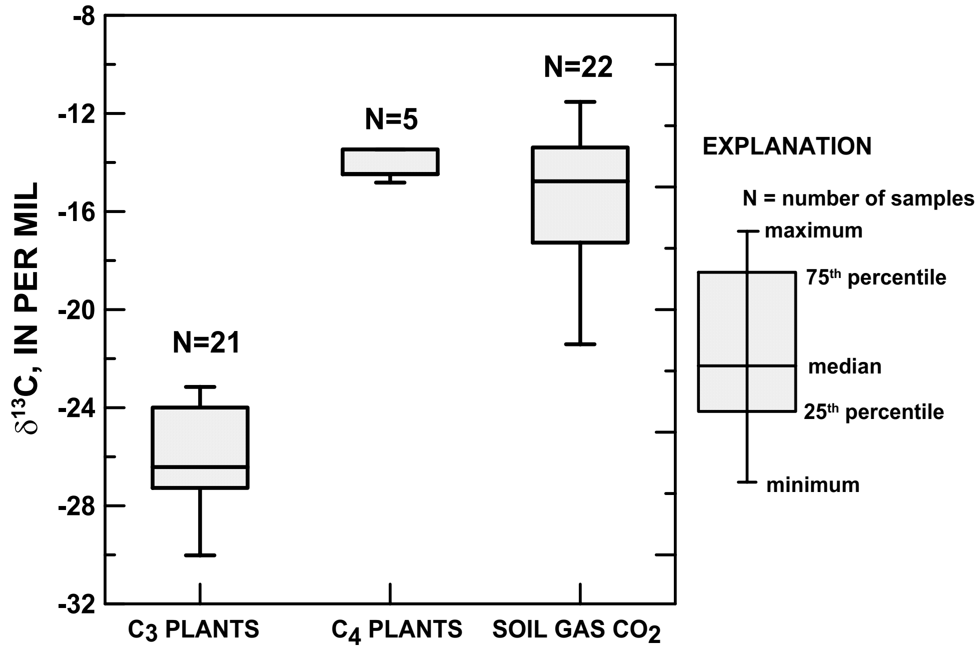



**Figure 40.** Comparison of $\delta^{13}C$ isotopic composition of plant matter and shallow unsaturated zone $CO_2$ gas from the eastern mountain front in the vicinity of Albuquerque, New Mexico.

two individual plant groups, varying from -11.5 to -21.4 per mil.

The sampling of plants and unsaturated-zone gas was not sufficient to permit generalization regarding the distribution of plant types throughout the basin, or even the distribution in the eastern mountain front environment, but does indicate that: (1) both $C_3$ and $C_4$ plants are present in the MRGB, (2) the soil-gas $CO_2$ sampled is likely a mixture of $CO_2$ from both $C_3$ and $C_4$ plants, and (3) most of the soil-gas samples collected had $CO_2$ predominantly from $C_4$ plants, even though most of the actual plant specimens collected and analyzed were from $C_3$ plants. Possible historical variations in $C_3$-$C_4$ plant distributions in the MRGB are discussed in the section "Historical Variations in Carbon-13 Isotopic Composition of Dissolved Inorganic Carbon".

#### Nitrate and Dissolved Nitrogen Gas

Nitrate concentration (as N) is less than 0.5 mg/L along much of the Rio Puerco and Rio Grande, and along parts of the Jemez River and the western margin of the basin (fig. 41). The median $NO_3$ concentration throughout the MRGB is 0.3 mg/L, with a mean value of 1.0 ± 2.0 mg/L. In most areas where ground water contains more than 1.0 mg/L of dissolved oxygen, $NO_3$ concentration is between 0.5 and 2 mg/L. Concentrations exceeding 2 mg/L are common in the northwestern part of the basin, and reach a maximum of 11.5 mg/L (as N) in water from one well (sample NM180) along the northwestern margin of the basin. Elevated concentrations of $NO_3$ can be traced from the northwestern margin of the basin in a generally south-southeast direction to the Lincoln piezometer nest (NM497-NM499), where $NO_3$ concentrations in ground water are from 4.7 to 5.8 mg/L (see region marked ">2.0" extending from the northwestern part of the basin to the western side of Albuquerque, fig. 41).

Natural accumulations of $NO_3$ at the land surface have been observed in arid regions (Böhlke and others, 1997) and may be a source of $NO_3$ to ground water in parts of the MRGB. During wet climatic periods, the accumulated $NO_3$ is apparently dissolved and recharged to ground water. Other elevated $NO_3$ concentrations in the MRGB are found in ground water near some test facilities on Kirtland Air Force Base (samples NM010, NM059), or in other areas where ground water may be affected by discharge from septic tanks and other domestic sources.

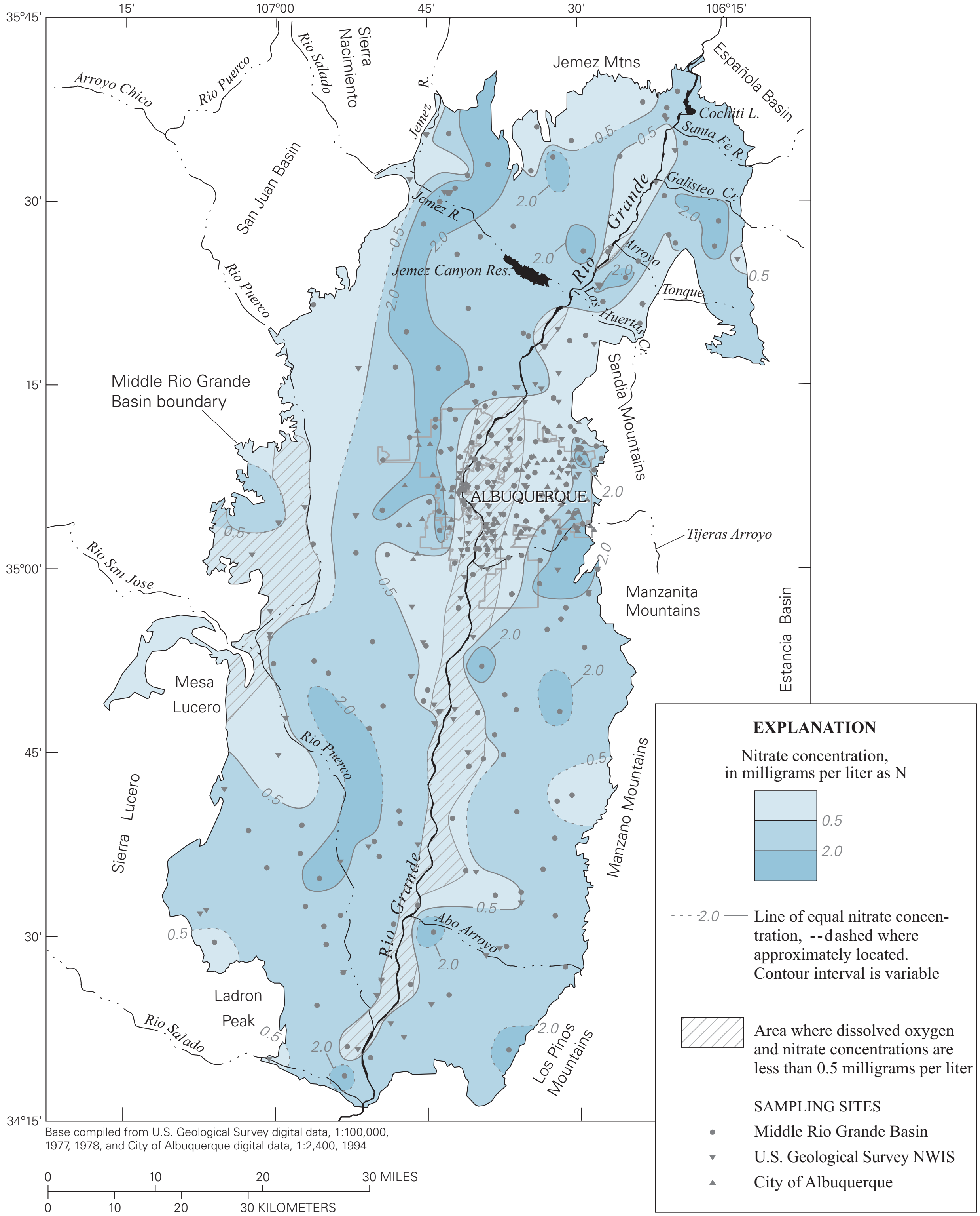



**Figure 41.** Nitrate concentration for ground water of the Middle Rio Grande Basin, New Mexico.

Denitrification, whereby $NO_3$ is converted to molecular nitrogen through a series of biological processes, is possible in those areas of the basin where dissolved-oxygen concentrations are low (typically less than 0.5 mg/L). Areas where low dissolved-oxygen and low $NO_3$ concentrations coincide are shown in figure 41. Evidence of denitrification can be found in some measured concentrations of dissolved nitrogen gas that exceed $N_2$ concentrations derived from equilibrium with air and dissolution of excess air (Heaton, 1981; Heaton and Vogel, 1981; Busenberg and others, 1993) during recharge. Of the 284 analyses of dissolved gases, 30 percent contained estimated excesses of $N_2$ gas that were attributed to denitrification (tables A5 and A6). In the samples affected by denitrification, the average calculated amount of denitrification was 1.5 ± 1.0 mg/L, with a maximum value of 4.0 mg/L as N.

#### Fluoride

Fluoride concentrations are less than 1.0 mg/L throughout large areas of the MRGB (fig. 42). However, concentrations typically exceed 1.0 mg/L along the western and southern margins of the basin, where concentrations greater than 2.0 mg/L also are common. Concentrations greater than 1.0 mg/L also are present across broad areas in the west-central part of the basin, near the Tijeras Fault Zone, along the Sandia mountain front, and near the Hagan Embayment. Nearly all ground-water samples in the basin are undersaturated with respect to fluorite ($CaF_2$), indicating that equilibrium reactions with this mineral probably are not the dominant control on F concentrations. Weathering of volcanic rocks and pH-dependent exchange and sorption reactions also can release F into solution (Robertson, 1991), and are potential controls on F concentrations in the MRGB. However, no relationship between pH and F concentrations is evident in the basin for the data set as a whole.

### Cations

The following sections present data on concentrations of calcium, sodium, magnesium, potassium, and silica in ground water from the MRGB.

#### Calcium

Although Ca concentrations generally are not conservative as a result of rock-water interactions, including calcite dissolution/precipitation, gypsum dissolution/precipitation, and cation exchange, they do demonstrate useful patterns in the MRGB. The highest Ca concentrations (greater than 100 mg/L) are throughout most of the southwestern area of the basin and along parts of the Rio Puerco, Abo Arroyo, and the Sandia mountain front; high concentrtations also are present in the area of the Hagan Embayment (fig. 43). Calcium concentrations of less than 20 mg/L are present across areas extending southward from the western Jemez Mountains past Los Lunas and westward from the southern Manzano Mountains.

#### Sodium

Similar to Ca, Na concentrations generally are not conservative (because of processes such as feldspar weathering and cation exchange) but do show useful patterns in the basin. The highest Na concentrations (greater than 100 mg/L) are present across much of the western part of the basin, as well as near the Tijeras Fault Zone (fig. 44). Concentrations less than 20 mg/L occur mainly along parts of the northern and eastern mountain fronts.

A map of the ratios of Ca to Na concentrations (in meq/L) shows that these (unitless) ratios are less than 5 throughout the entire basin, with the exception of a small area near the eastern mountain front at Albuquerque (fig. 45). Therefore, whereas the ratios of $SO_4$ to Cl concentrations are consistent with precipitation even at large distances from the mountain fronts, the ratios of Ca to Na concentrations are not. Near mountain fronts, these cation ratios indicate the occurrence of reactions within the soil zone or aquifer that increase concentrations of Na relative to Ca, even at relatively short distances from the recharge source. In the MRGB, such reactions are likely to include weathering of silicate minerals—particularly plagioclase feldspar—and/or cation exchange. Locally, the Ca to Na ratios between 2 and 5 that are common from the eastern mountain front to just west of the Rio Grande also could indicate areas of infiltration from the Rio Grande or from Abo or Tijeras Arroyos, which have ratios in this range. Ratios between 0.5 and 2 in ground water near the Rio Puerco are consistent with infiltration from this stream. Ratios between 0.5 and 2 in the area of northeastern Albuquerque where elevated Cl concentrations have been observed could indicate that the deep, mineralized water believed to mix with shallow ground water in this area has high Na concentrations relative to Ca.

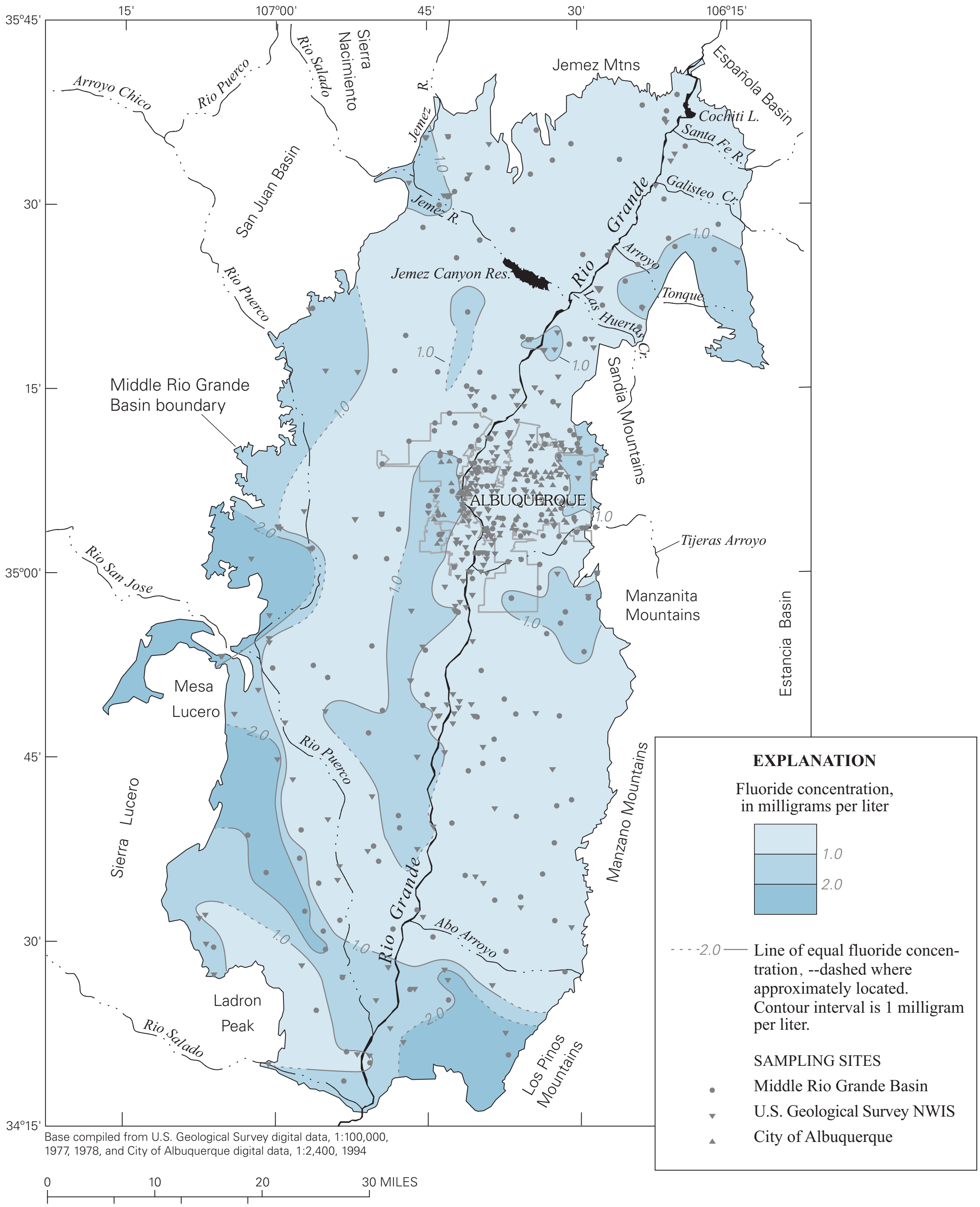



**Figure 42.** Fluoride concentration for ground water of the Middle Rio Grande Basin, New Mexico

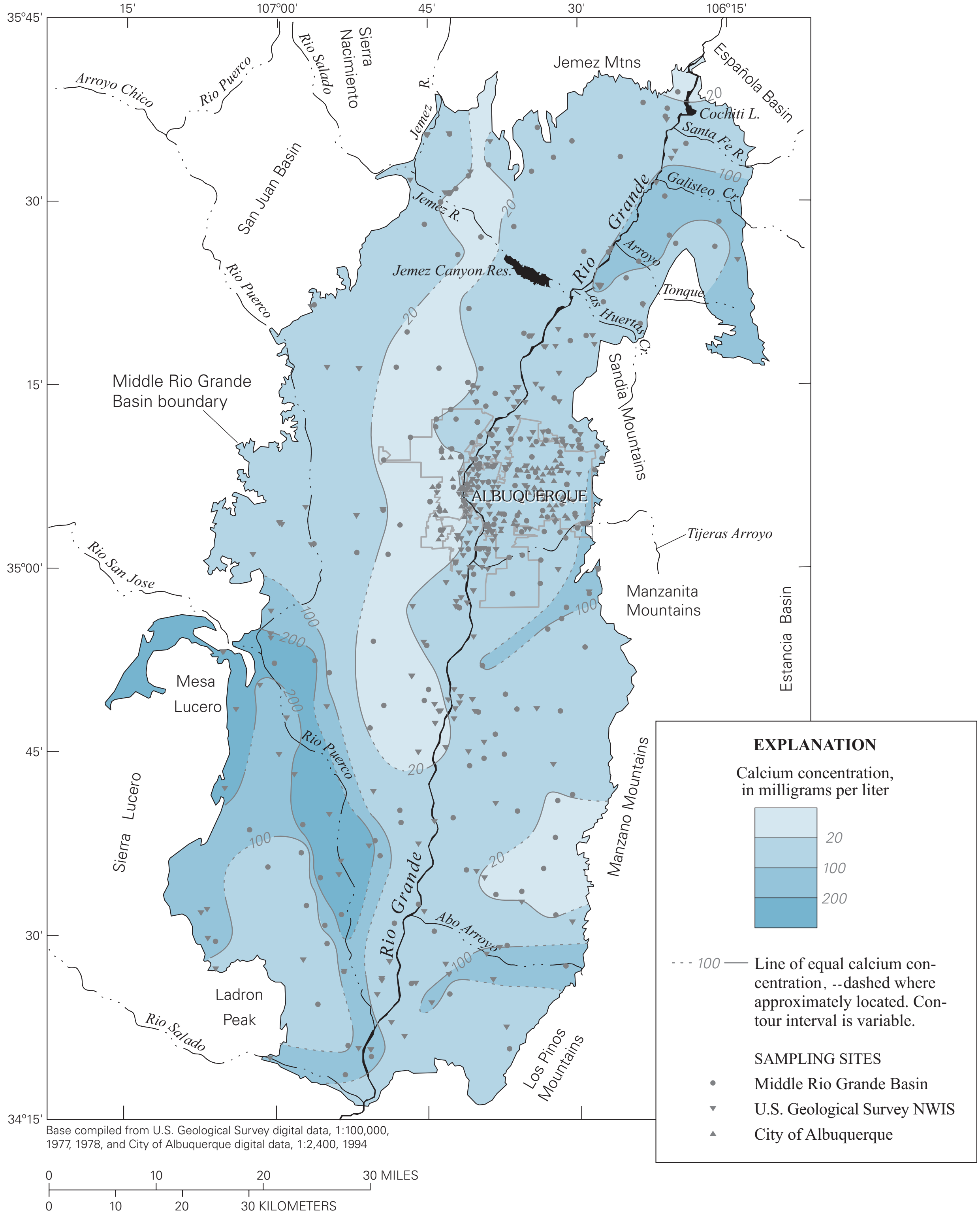



**Figure 43.** Calcium concentration for ground water of the Middle Rio Grande Basin, New Mexico.

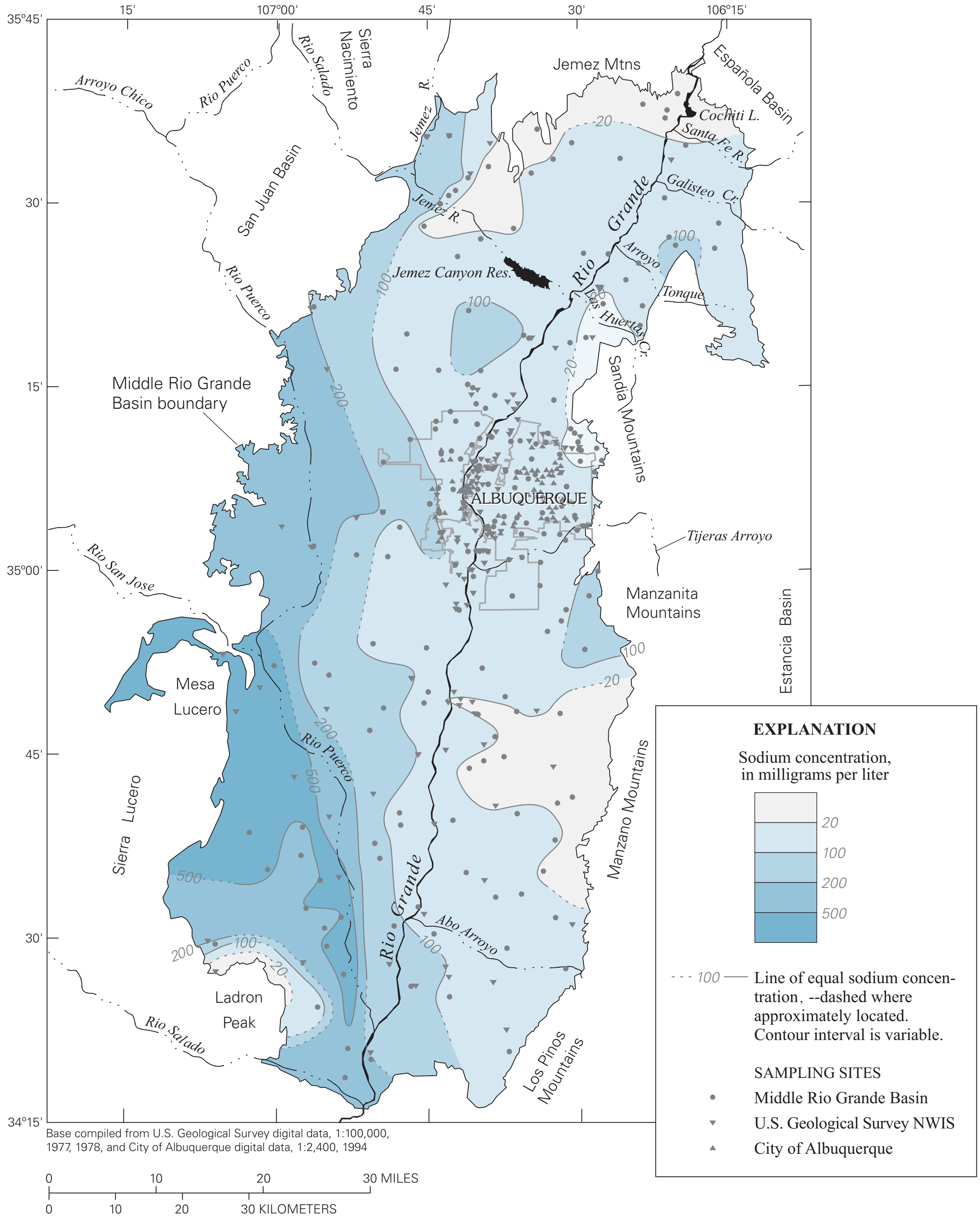



**Figure 44.** Sodium concentration for ground water of the Middle Rio Grande Basin, New Mexico.

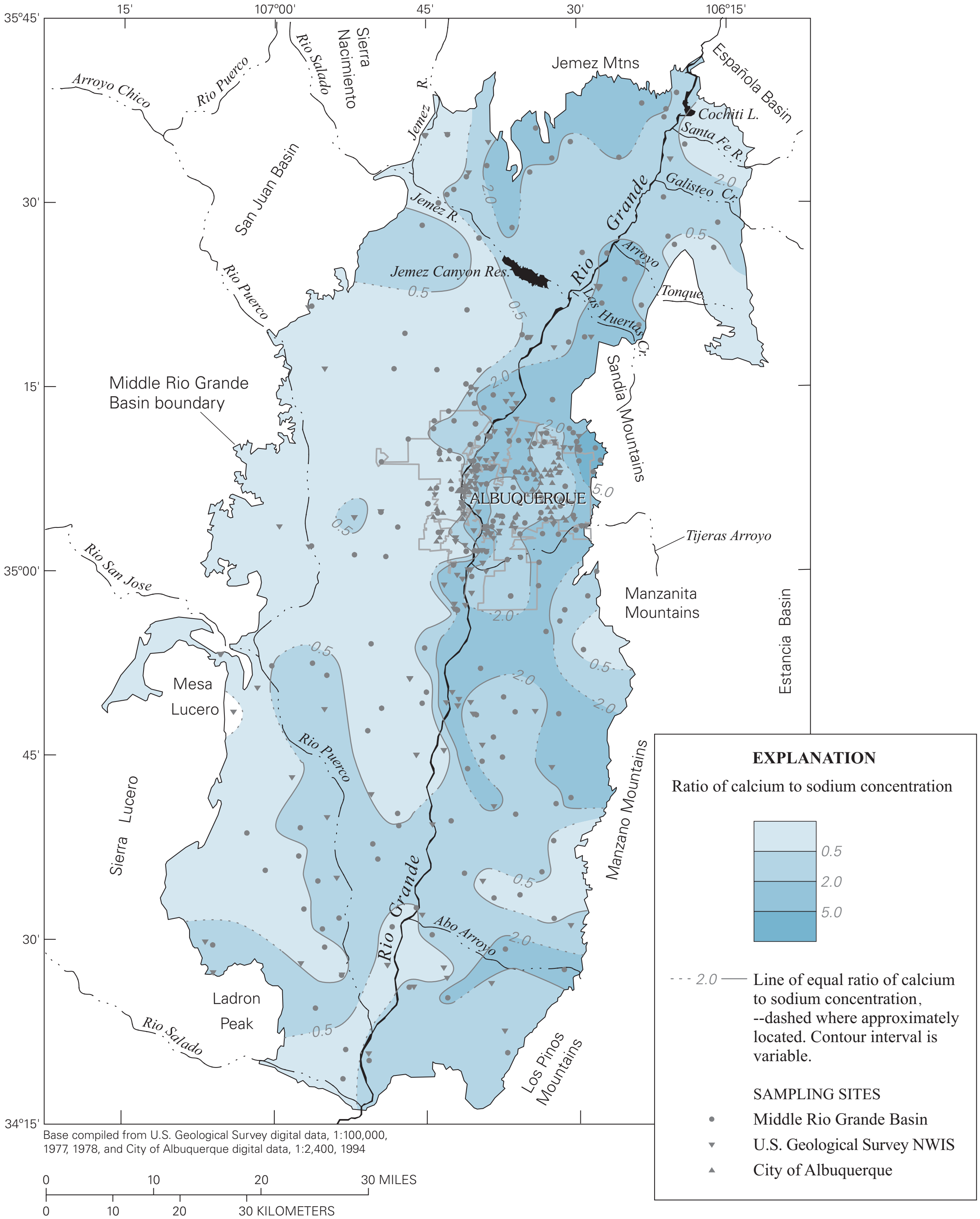



**Figure 45.** The ratio of calcium to sodium concentration (concentrations in milliequivalents per liter) for ground water of the Middle Rio Grande Basin, New Mexico.

Ca to Na ratios of 0.5 or less are widespread in the western part of the MRGB (fig. 45). In the southwestern part of the basin, these ratios are consistent with the presence of Na-Cl brine leaking into the aquifer system from Paleozoic rocks to the west. Farther north, where $SO_4$ to Cl ratios generally indicate recharge sources associated with precipitation or seepage from the Rio Grande, high concentrations of Na relative to Ca may be the result of cation exchange. Anderholm (1988) used a generalized material-balance model to show that silicate weathering could not account for the high Na concentrations observed in this area, and that Ca concentrations were lower than would be expected from the amounts of carbonate dissolution, gypsum dissolution, and silicate weathering indicated by other constituents. The occurrence of cation exchange in the western part of the basin is consistent with the presence of fine-grained sediments in the area, including calcium smectite and mixed layer illite-smectite clays with high ion-exchange capacities (Anderholm, 1985; Hawley and Haase, 1992; Stone and others, 1998).

*Magnesium*

Magnesium concentrations in ground water of the MRGB usually are less than 10 mg/L across broad areas, but exceed 10 mg/L in some parts of the basin (fig. 46). Concentrations greater than 10 mg/L occur across the entire southwestern part of the basin, much of the southeastern part (south of about Abo Arroyo), and along the far western margin of the basin north of the Rio San Jose (but data here are sparse). Within these areas, concentrations along the Rio Puerco and just north of Ladron Peak typically exceed 50 mg/L; the concentration for one well sample near the mouth of Abo Arroyo also exceeds 50 mg/L. Additional areas with Mg concentrations exceeding 10 mg/L include the northeastern part of the basin (near the Hagan Embayment) and an area extending along the eastern mountain front from Albuquerque to the Tijeras Fault Zone. In most of these areas of relatively high Mg concentration (as opposed to most other areas of the basin), ground-water samples generally are saturated with respect to dolomite. Most of these areas could receive water from Paleozoic and Mesozoic rocks located along basin margins, which may contain more dolomite than rocks in other source areas. Relatively high Mg concentrations also occur in part of the Rio Grande inner valley, but probably are not associated with waters sourced in Paleozoic or Mesozoic rocks; evapotranspiration could be the cause of higher concentrations in this area.

*Potassium*

Contours of K concentration throughout the MRGB (fig. 47) indicate that concentrations generally are less than 10 mg/L. The primary area where concentrations exceed 10 mg/L is the southwestern part of the basin, where brine from Paleozoic rocks to the west is present. Concentrations less than 3 mg/L are present along much of the eastern mountain front, except for a small area extending from Albuquerque to the Tijeras Fault Zone. Concentrations less than 3 mg/L also are present over limited areas of the western half of the basin. Weathering of silicate minerals, including potassium feldspar, mica, and volcanic glass, probably is the most likely source of K in ground water of the basin.

*Silica*

Dissolved $SiO_2$ concentrations are not conservative because of rock-water interactions, and indicate a general pattern of increasing concentration with distance away from the eastern and western margins of the MRGB (fig. 48). The highest $SiO_2$ concentrations (greater than 50 mg/L) are present primarily down the center of the basin. The lowest concentrations (< 20 mg/L) are mainly along the eastern mountain front, along the western margin of the basin, and near Ladron Peak. Anderholm (1988) suggested that $SiO_2$ concentrations greater than about 30 mg/L in the basin could result from dissolution of volcanic glass in sediments derived from the Jemez volcanic field. This conclusion is consistent with the observation by Hawley and Haase (1992) that glassy pumice from the Jemez area is present in fluvial deposits beneath Albuquerque. Silica concentrations of approximately 50 mg/L ($SiO_2$) are common in waters associated with weathering of silicate minerals such as plagioclase feldspars (Davis, 1964; Langmuir, 1997).

## Minor-Element Chemistry

The processes that affect minor-element chemistry in ground water often are complex and poorly understood. Nevertheless, concentrations of

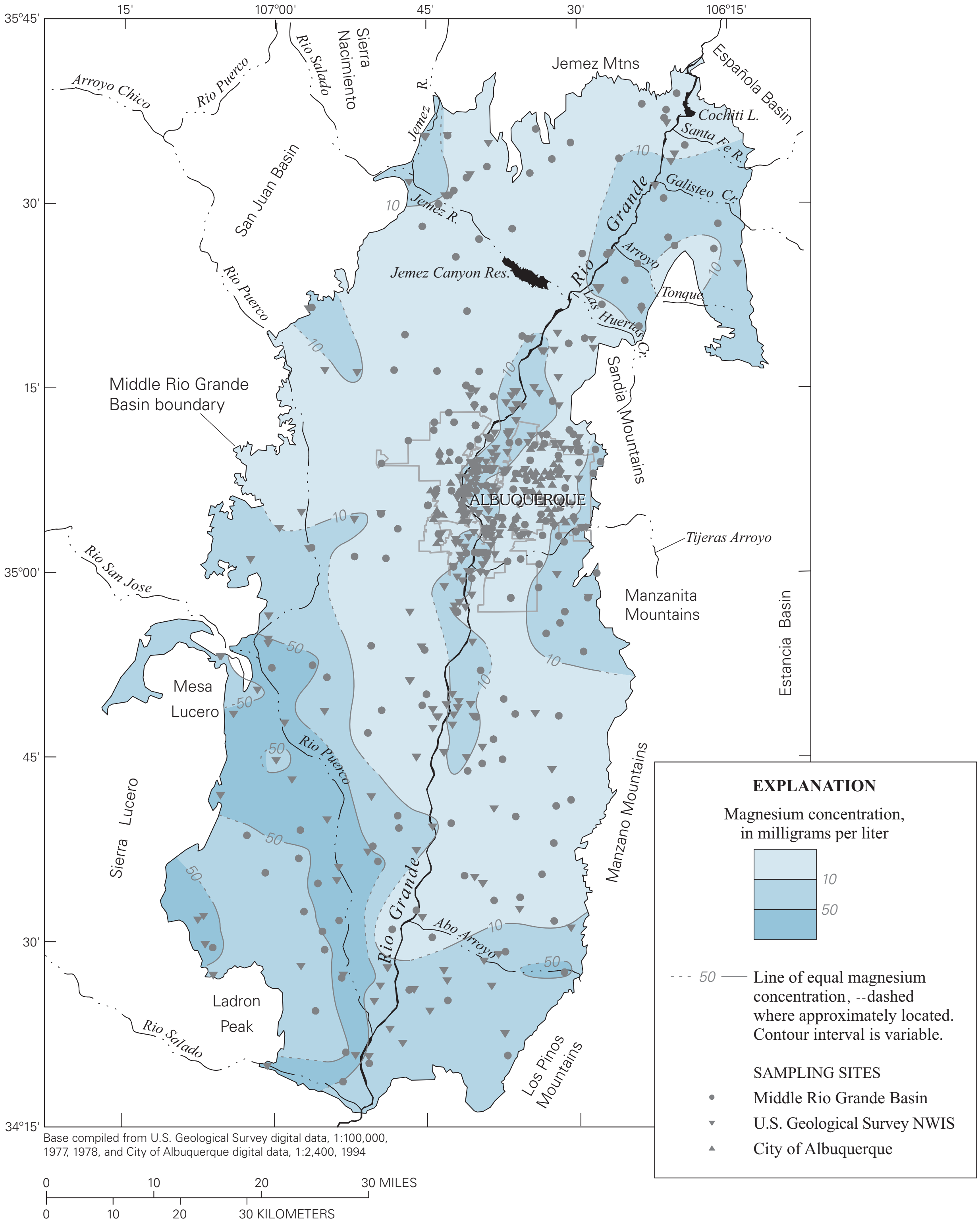



**Figure 46.** Magnesium concentration for ground water of the Middle Rio Grande Basin, New Mexico.

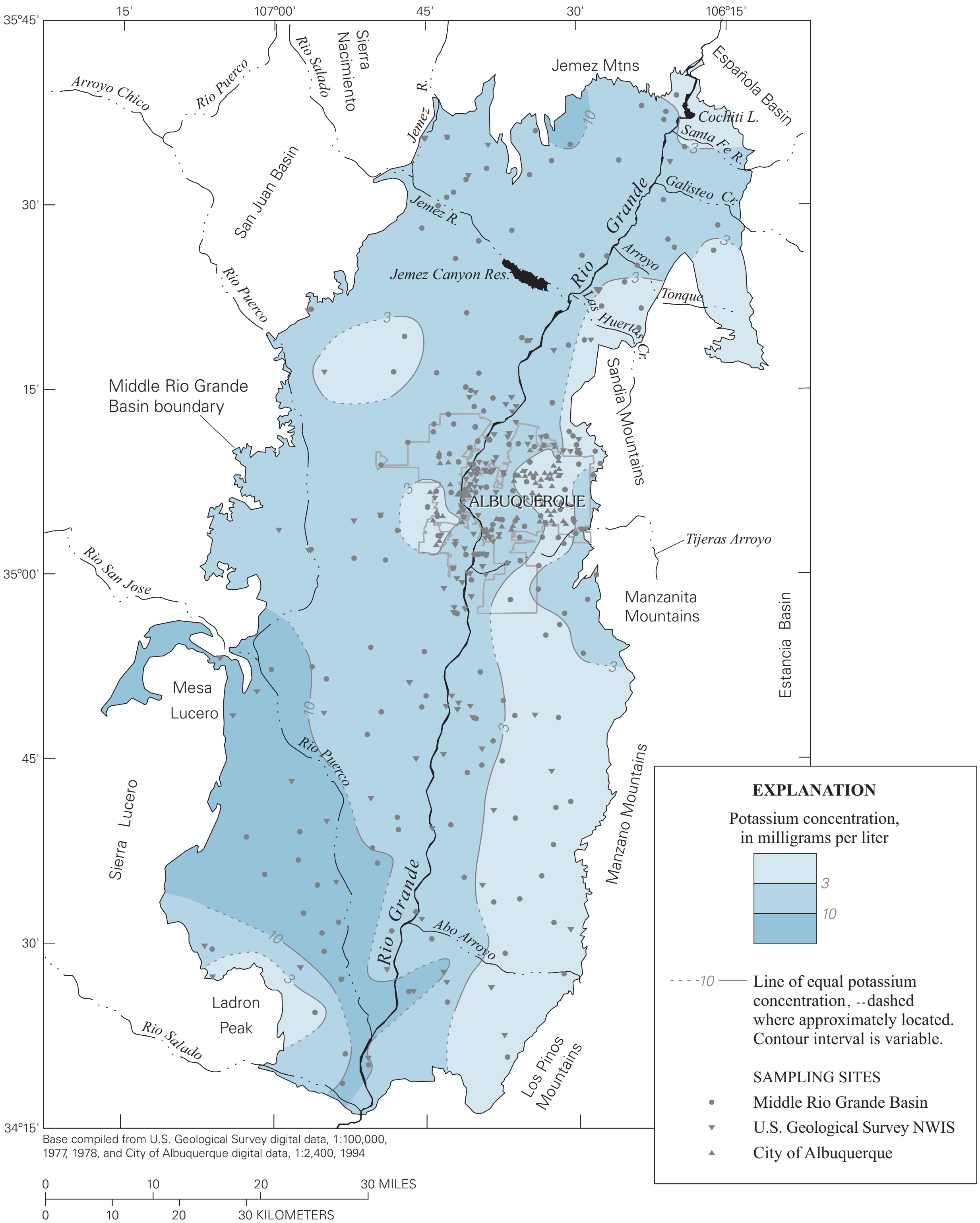



**Figure 47.** Potassium concentration for ground water of the Middle Rio Grande Basin, New Mexico.

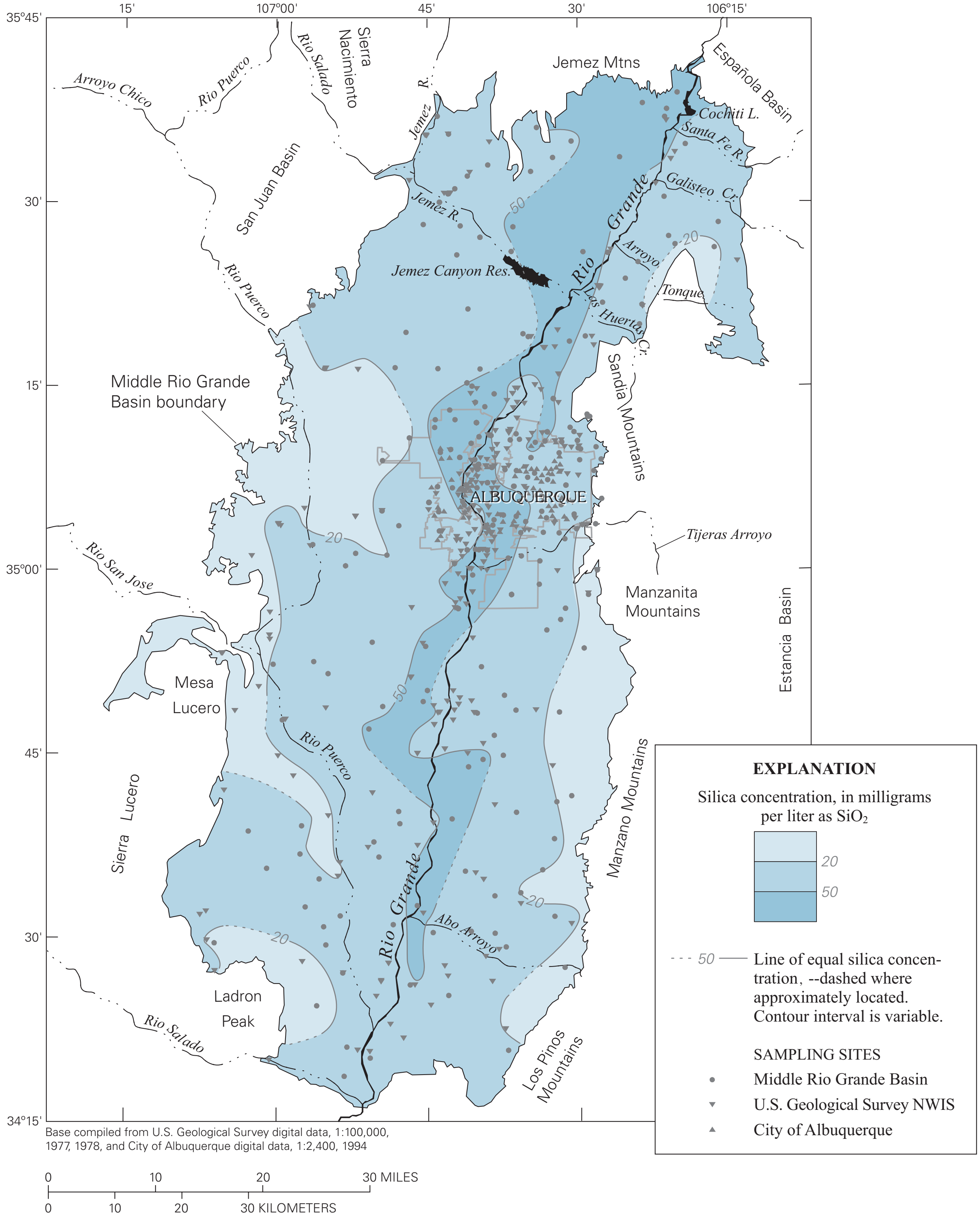



**Figure 48.** Silica concentration for ground water of the Middle Rio Grande Basin, New Mexico.

minor elements can still provide useful information about areas where water sources are likely to differ or where particular chemical processes are likely to be occurring. This section discusses aspects of the concentrations of arsenic, barium, boron, lithium, molybdenum, strontium, uranium, and vanadium in ground water of the MRGB. Concentration data for other minor or trace elements in ground water of the MRGB are given in tables A3 and A4.

Arsenic concentrations in ground water of the MRGB generally are lowest (< 3 µg/L) along the eastern and western margins of the basin (fig. 49). Concentrations greater than 20 µg/L are present across much of the northwestern part of the basin and the western part of Albuquerque. Smaller areas of elevated As concentration occur in the northeastern part of Albuquerque and the southern half of the basin. Bexfield and Plummer (2002) showed that elevated As is associated with two primary sources. One source is mineralized water of deep origin (thousands of feet), the distribution of which was discussed above with respect to anomalous Cl concentrations. Geologic structure likely controls the geographic distribution of this mineralized water by allowing upwelling along major faults or as the result of structural highs (Bexfield and Plummer, 2002). Mixing with this water elevates the As concentrations of ground water at shallower depths of the aquifer system in parts of the central and eastern areas of the basin. The other high-As source affects ground water in the northwestern part of the basin and is associated with silicic volcanism in the Jemez Mountains to the north. Recharge of water through rocks that have been altered by contact with geothermal fluids could account for the high As in ground water of the area. Adsorption/desorption processes involving metal oxides and clays also appear to affect As concentrations along flow paths in the northwestern part of the basin, where the highest As concentrations typically occur for samples with pH values of 8.5 or higher.

Barium concentrations are relatively high throughout much of the central and eastern parts of the basin, commonly exceeding 100 µg/L (fig. 50). Concentrations in other areas usually are less than 20 µg/L. Potassium feldspar, in which Ba commonly substitutes for K, may be the major source of Ba to ground water of the basin. Most ground-water samples in the basin are near or at saturation with respect to barite, $BaSO_4$; therefore, mineral equilibrium is likely an important control on Ba concentrations. Sorption to clay minerals also could be an important control.

Boron concentrations show fairly consistent patterns in ground water of the basin. The highest concentrations (greater than 0.5 mg/L) typically are along the western margin of the basin (fig. 51), primarily in the southwest. Concentrations of less than 0.1 mg/L occur across broad areas east of the Rio Grande and along much of the northern margin of the basin, indicating that mountain-front recharge water probably is relatively low in B. Boron commonly is enriched in evaporite minerals, such as those present along the western margin of the basin. Boron also tends to be enriched in hydrothermal systems, such as that found in the Jemez Mountains, which may help to explain relatively high B concentrations that extend south from the Jemez Mountains, on the west side of the Rio Grande.

Bromide concentrations are less than 0.2 mg/L throughout much of the MRGB (fig. 52). However, concentrations exceeding 0.2 mg/L, and in some cases 0.5 mg/L, are along the western basin margin, at the southern end of the basin, near the Hagan Embayment in the northeast, and near the Tijeras Fault Zone. These higher concentrations may be associated with high-Cl source waters to these parts of the basin, which receive recharge from Paleozoic and Mesozoic sedimentary rocks. A few additional concentrations exceeding 0.2 mg/L appear likely to result from mixing with high-Cl water of deep origin, as discussed above.

Lithium concentrations exceed 200 µg/L primarily in the southwestern part of the MRGB and near the Tijeras Fault Zone (fig. 53). Brenner-Tourtelot and Machette (1979) showed that Li-rich brine has moved through sediments in the southwestern part of the MRGB and that clays of the Popotosa Formation (respresenting basin-fill deposits of early to late Miocene age) exposed in the area are consequently associated with large quantities of Li. Lithium-rich brine also may be present in the area of the Tijeras Fault Zone; Li also is elevated in some high-Cl waters that appear to upwell in particular locations around the basin. Lithium concentrations generally appear to be lowest (< 20 µg/L) along much of the eastern mountain front.

Molybdenum concentrations are less than 5 µg/L across broad areas of the basin (fig. 54). Concentrations exceeding 10 µg/L are present along the western margin of the basin, extending eastward for up to 14

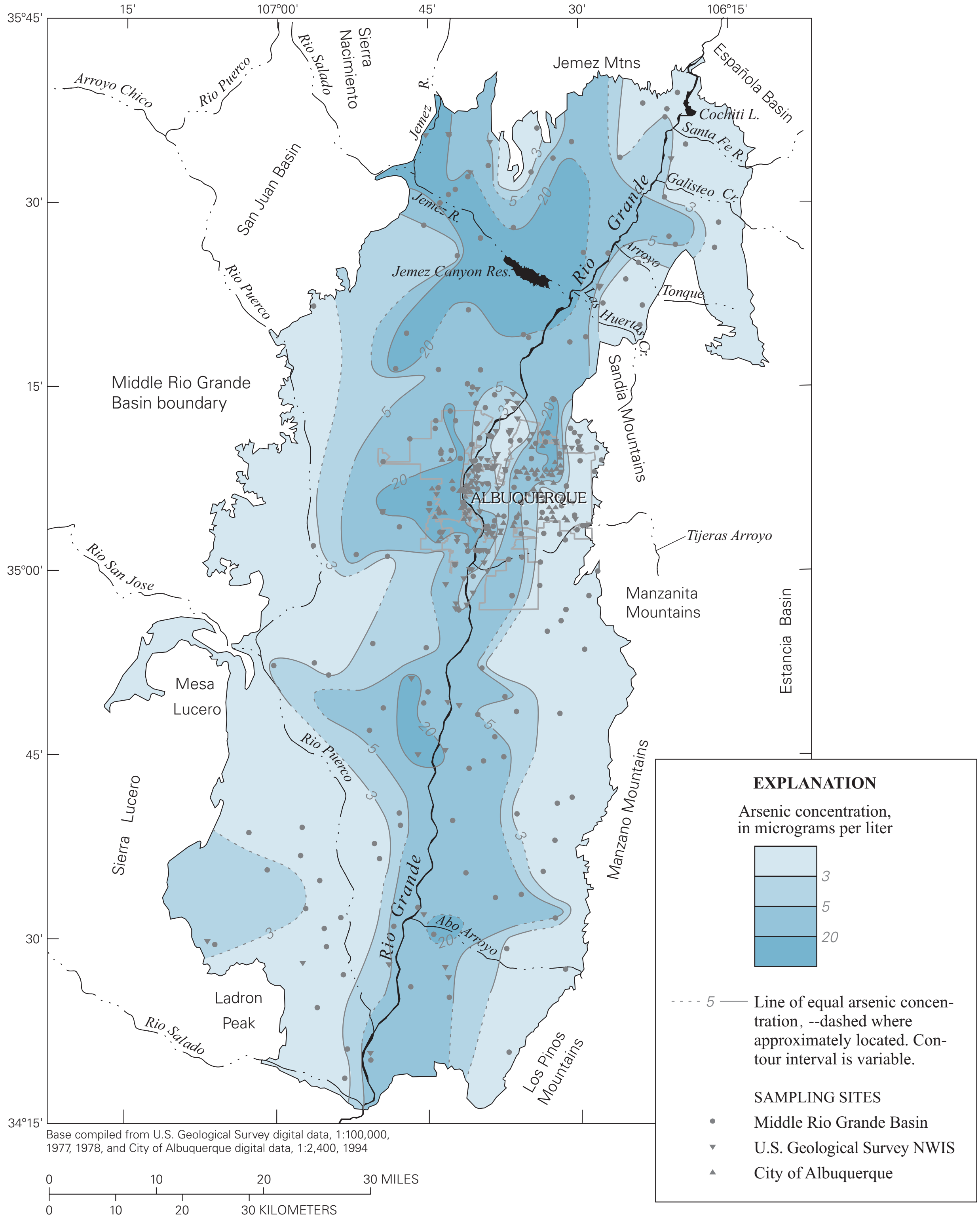



**Figure 49.** Arsenic concentration for ground water of the Middle Rio Grande Basin, New Mexico.

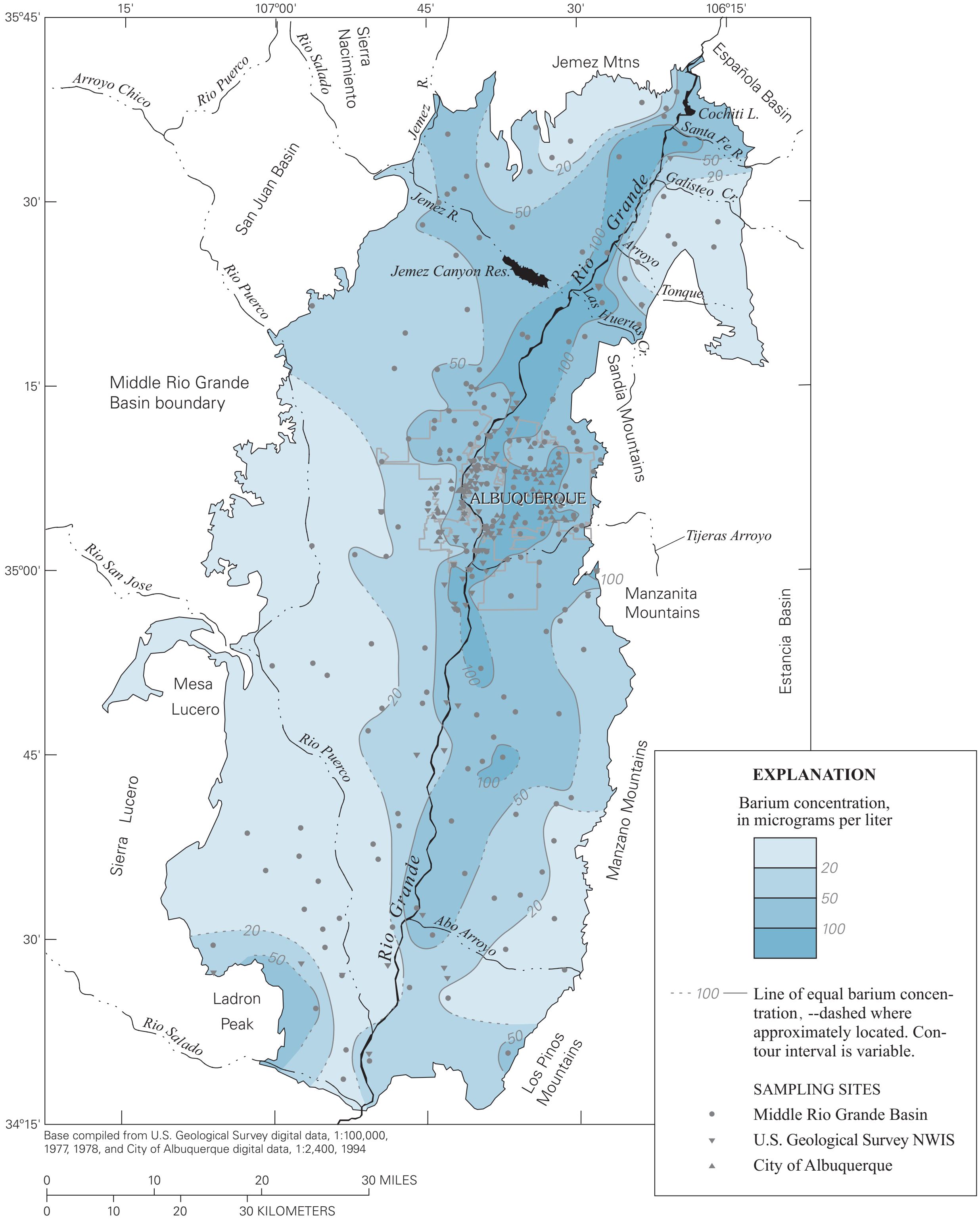



**Figure 50.** Barium concentration for ground water of the Middle Rio Grande Basin, New Mexico.

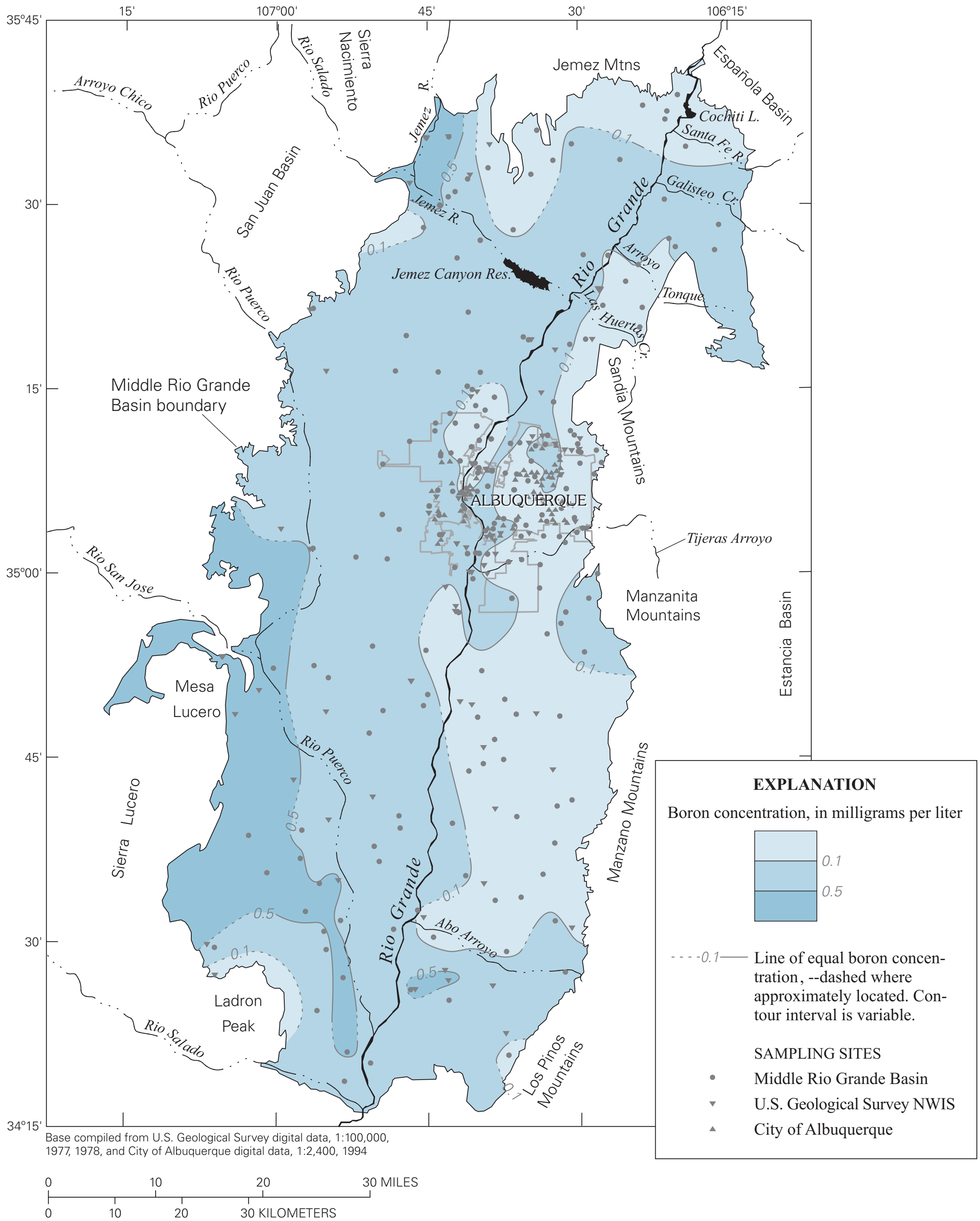



**Figure 51.** Boron concentration for ground water of the Middle Rio Grande Basin, New Mexico.

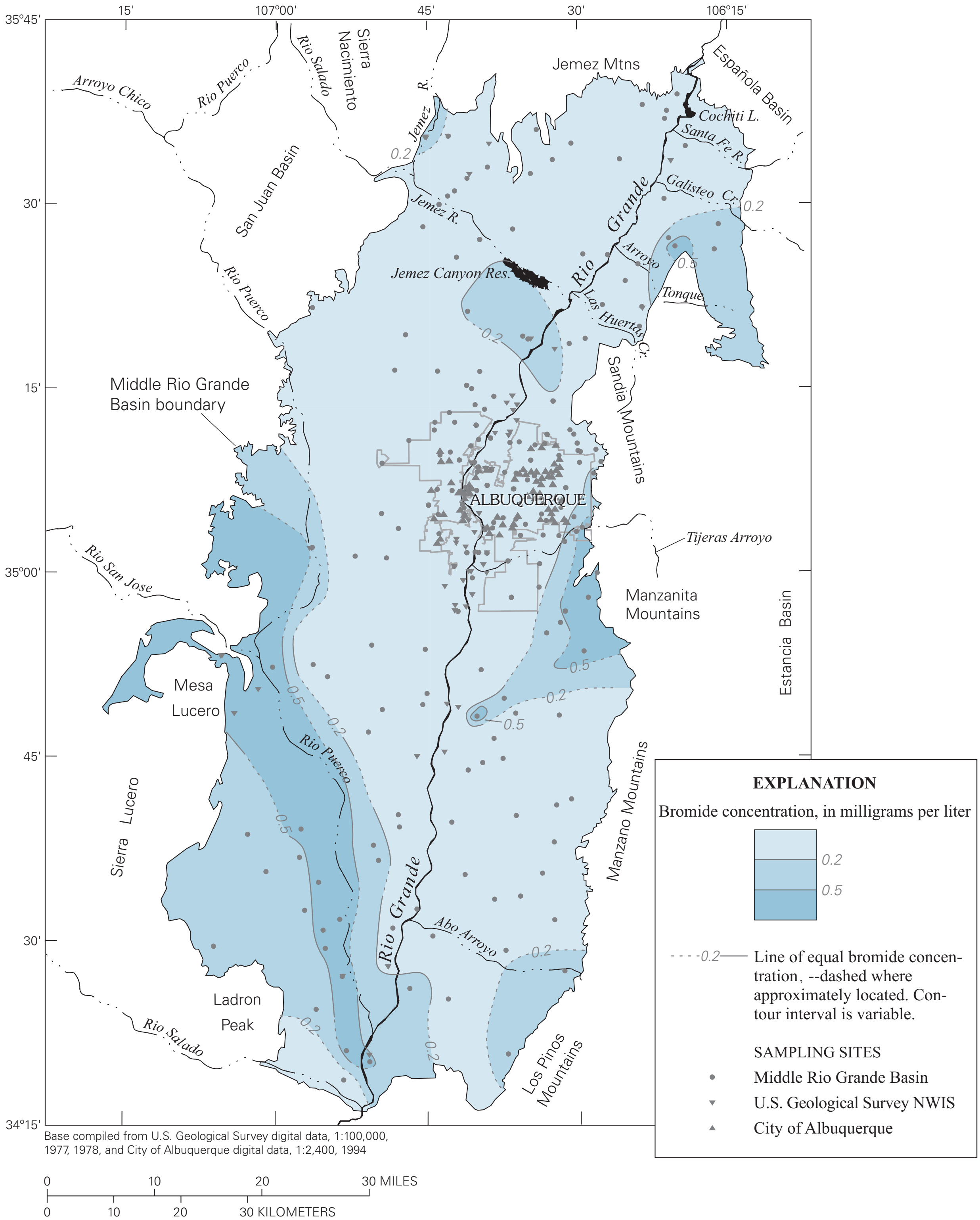



**Figure 52.** Bromide concentration for ground water of the Middle Rio Grande Basin, New Mexico.

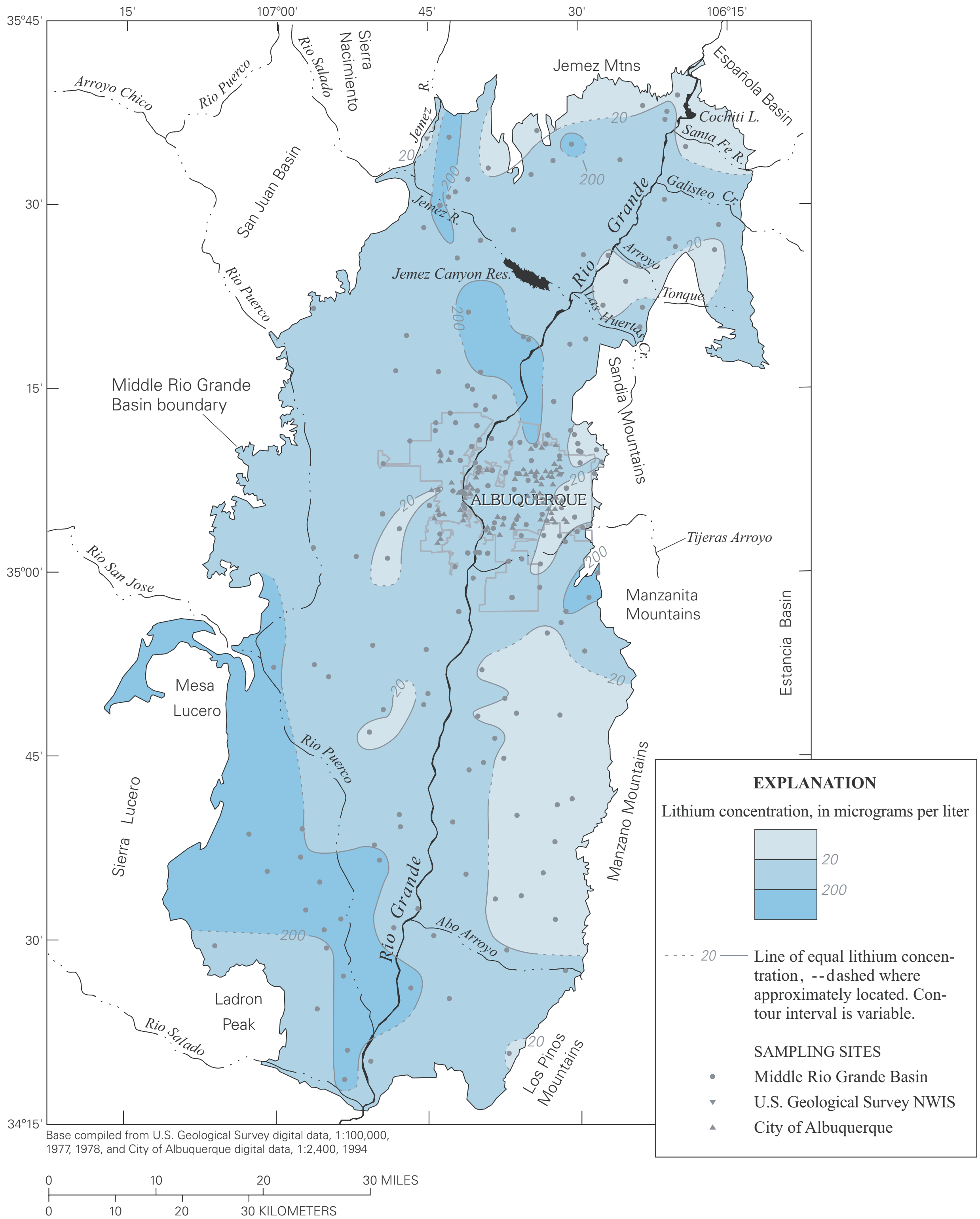



**Figure 53.** Lithium concentration for ground water of the Middle Rio Grande Basin, New Mexico.

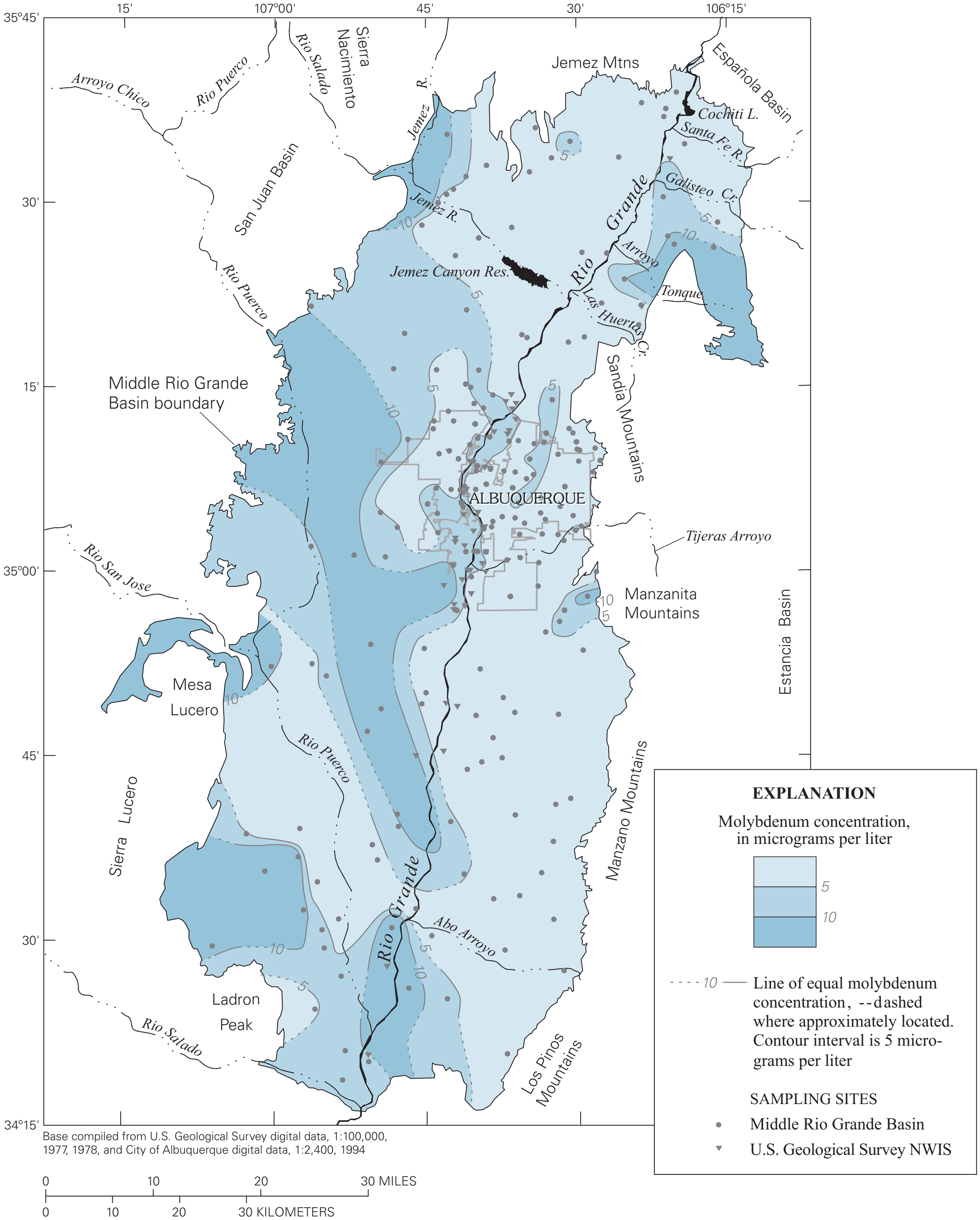



**Figure 54.** Molybdenum concentration for ground water of the Middle Rio Grande Basin, New Mexico.

miles in places. Concentrations of this magnitude also are at the south end of the basin and in the northeastern area, near the Hagan Embayment. The source of Mo in ground water of the basin is not known.

Strontium concentrations vary substantially throughout the MRGB. The highest concentrations (> 1,000 µg/L) generally are along the western margin of the basin and throughout the southwestern and southeastern parts of the basin (fig. 55). Concentrations of this magnitude also are present in the northeastern part of the basin (near the Hagan Embayment) and near the Tijeras Fault Zone. Concentrations substantially less than 500 µg/L are found along most of the eastern mountain front and throughout large sections of the central part of the basin. Strontium commonly replaces Ca in mineral structures, so that the higher concentrations may indicate greater contact with carbonate rocks, such as those along the western margin of the basin, in the Hagan Embayment, and in the vicinity of the Tijeras Fault Zone. Other sources of strontium include plagioclase feldspars and gypsum that can contain strontium in substitution for calcium.

Uranium concentrations are low (< 5 µg/L) in ground water throughout much of the basin (fig. 56). However, concentrations of about 10 µg/L or greater are in some ground water along the Rio Puerco, near the Tijeras Fault Zone, near Abo Arroyo, in the northeastern part of the basin, and near the Rio Grande. Some of the higher concentrations of U may be associated with the infiltration of surface water; U has been detected in water of the Rio Puerco, Abo Arroyo, and Tijeras Arroyo at concentrations exceeding 10 µg/L (table B4).

Similar to As, vanadium concentrations generally tend to be lower along the eastern and western margins than through the center of the basin (fig. 57). Concentrations along the margins typically are less than 5 µg/L, whereas concentrations exceed 10 µg/L across broad areas in the southeastern part of the basin and extending south from the Jemez Mountains. Adsorption/desorption processes may affect concentrations of V, which (like As) is present primarily as a negative oxyanion under the redox conditions of ground water in the MRGB.

Other minor elements for which ground-water samples were analyzed include Fe, Mn, Cr, Cu, Pb, Al, Rb, Co, Se, and Zn (tables A3 and A4). Because of contact with steel well casings, concentrations of Fe, Mn, Cr, Cu, Pb, and Zn in some samples may not be representative of concentrations present in ground water of the aquifer system. Samples from steel windmills may have been appreciably affected because of the small quantities of water pumped from these wells and the large amount of time during which pumping may not occur. These factors can allow for long contact times between ground water and the well casing (especially relative to steel-cased municipal-supply wells). Therefore, the use of these data in this investigation was limited. Examination of the data indicates that Zn and Fe concentrations in ground-water samples from windmills may have been most severely affected by corrosion of galvanized pipe.

## Variations in Chemical Composition of Ground Water with Depth

Monitoring-well nests screened at substantially different depths are located at several sites across the MRGB, primarily in the vicinity of Albuquerque. Twenty such monitoring-well nests are shown in figure 58 and identified in table A1. In all of these nests, the deepest completion is at least 450 feet below the water table and the difference between the shallowest and deepest completions is at least 250 feet, and generally is more than 400 feet. Most of the nests are among those installed as part of a program started in 1996 by the City of Albuquerque, the New Mexico Office of the State Engineer, Bernalillo County, and the USGS to obtain water-level and water-quality information from multiple parts of the aquifer system, including from depths rarely reached by other wells. These nests typically contain three piezometers that are screened at the water table, near the middle of the pumped zone of the closest municipal supply wells, and near the bottom of or below the pumped zone (up to about 1,500 feet below the water table).

The data shown in tables A1-A4 for selected chemical parameters indicate that, although chemical variations are observed within the upper 2,000 feet of the aquifer system, areal variations on a basin-wide scale are generally higher than vertical variations in a particular location. The data also show that chemical parameters do not tend to vary in the same manner with depth in all areas of the basin. For example, specific conductance values for the Garfield piezometer nest (nest N, fig. 58) are lower in water from the deep completion than the shallow completion, but values for the 98$^{th}$ Street nest (nest F, fig. 58) are higher in water from the deep completion than the shallow completion.

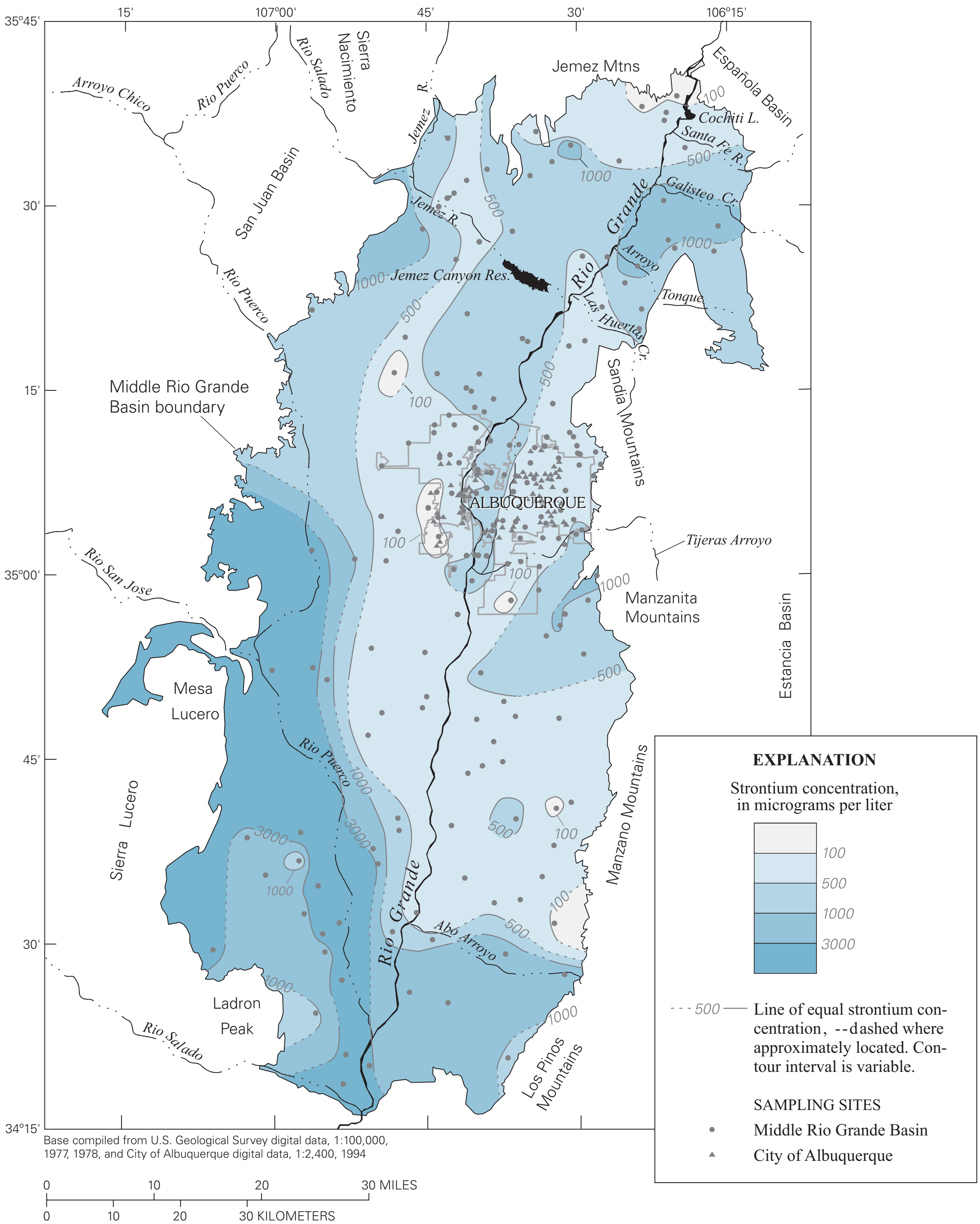



**Figure 55.** Strontium concentration for ground water of the Middle Rio Grande Basin, New Mexico.

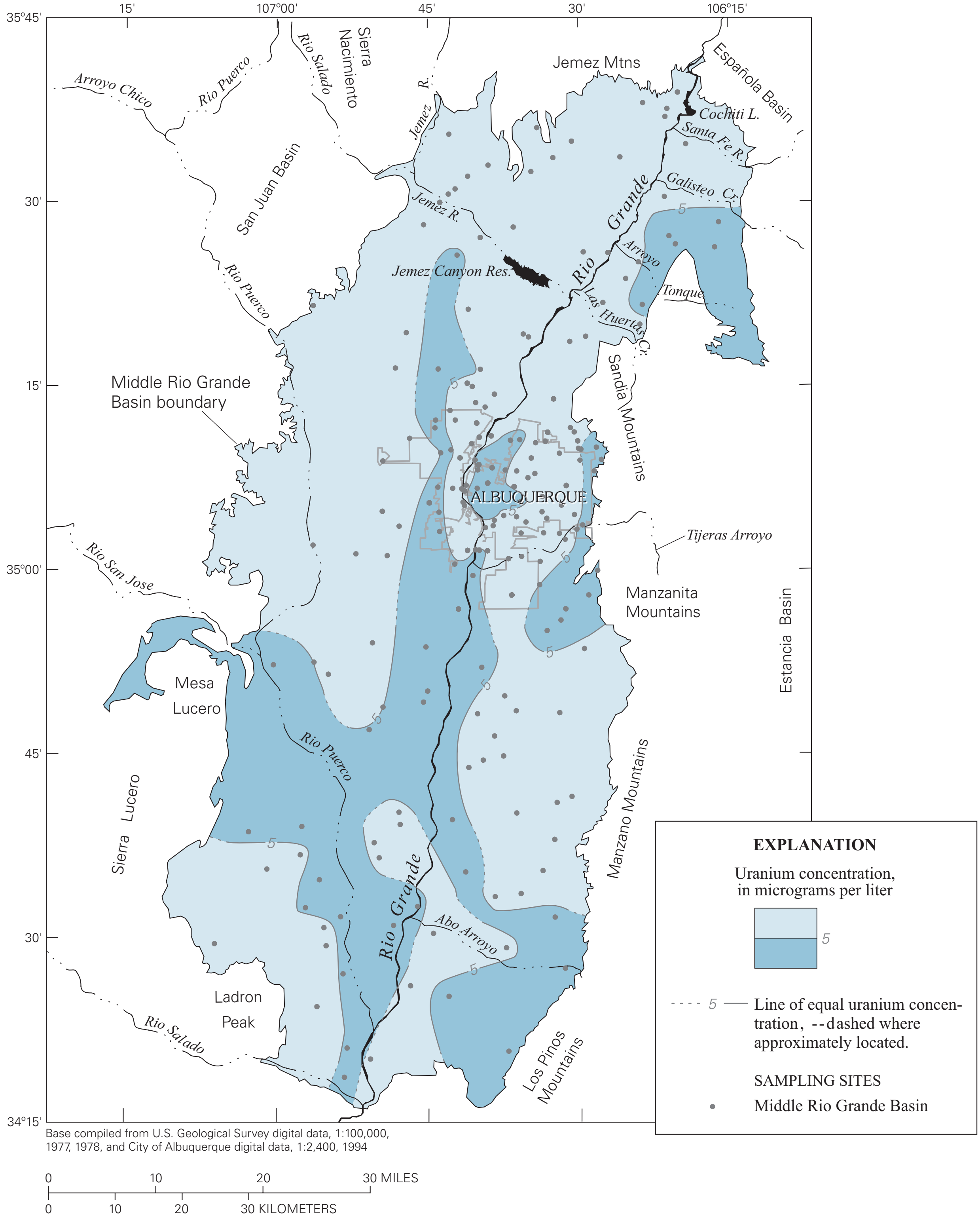



**Figure 56.** Uranium concentration for ground water of the Middle Rio Grande Basin, New Mexico.

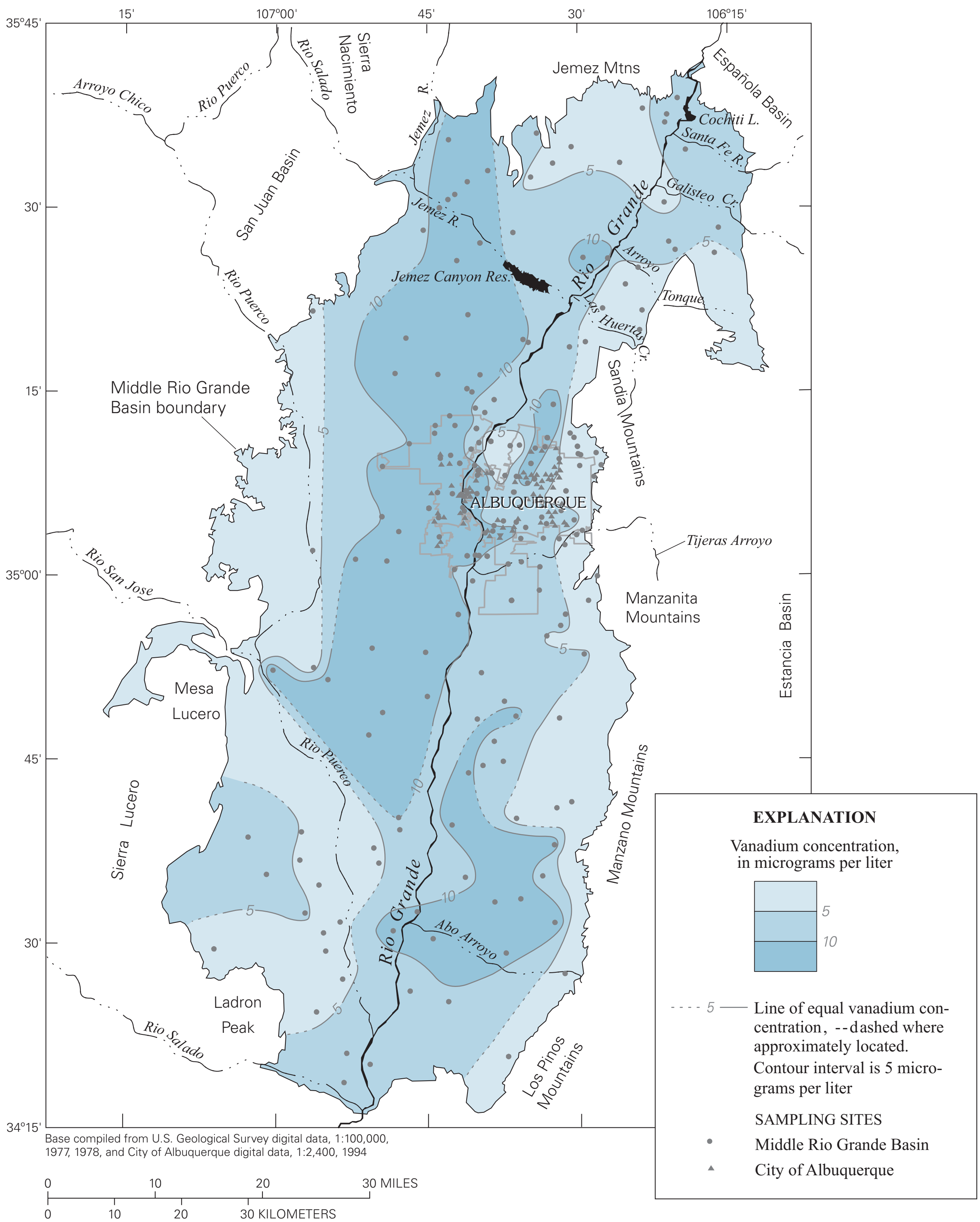



**Figure 57.** Vanadium concentration for ground water of the Middle Rio Grande Basin, New Mexico.

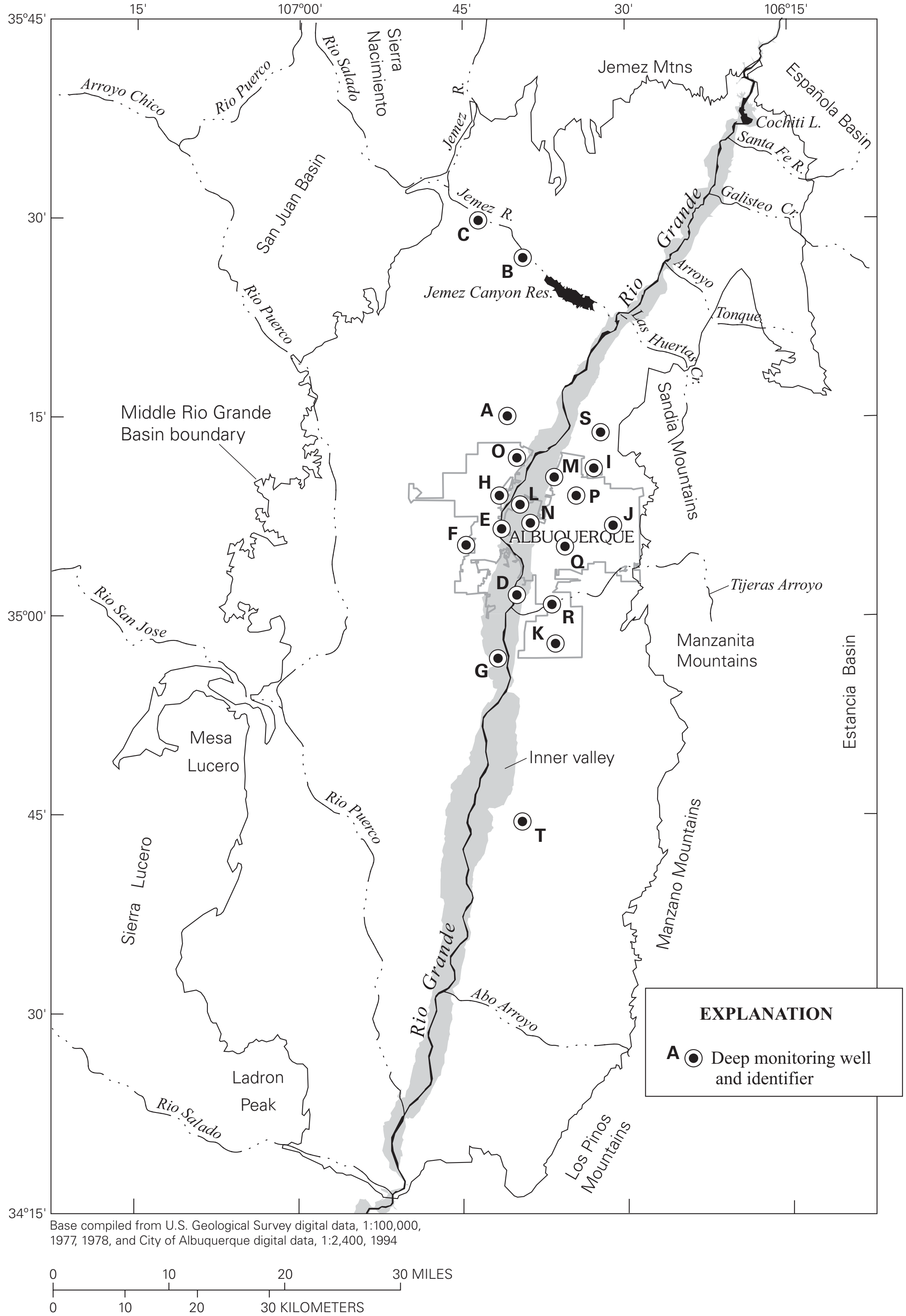



**Figure 58.** Locations of deep monitoring wells included in the data set for the Middle Rio Grande Basin, New Mexico (see table A1 for well identification).

Therefore, vertical variations in water chemistry probably do not result from the same processes at all locations. Bexfield and Anderholm (2002a) discuss the variation observed in data collected by the City of Albuquerque Environment Department from several of the well nests listed in table A1. They conclude that evapotranspiration, land-use practices, different water sources, and longer flow paths/times at depth likely contribute to variations observed with depth in different well nests.

Some well nests are located in the flood plain of the Rio Grande or the Jemez River, where the water table is within about 50 feet of land surface. In these areas, evapotranspiration and land use can reasonably be expected to affect water quality at shallow depths. Factors such as these probably contribute to higher specific conductance values and Cl concentrations in shallow relative to deep completions of the Garfield (nest N in figure 58), Isleta (nest G), Paseo 3 (nest M), and Zia Ball Park (nest C) well nests (fig. 59). The effects of evapotranspiration and land use are likely to be important only in the shallow completions of wells located in areas where the water table is near the land surface.

Other well nests are located in areas that previously have been identified as potential sites of upwelling of deep, mineralized water having high Cl and As concentrations (Bexfield and Plummer, 2002). Upwelling of mineralized water probably contributes to higher specific conductance values and Cl concentrations in deep relative to shallow completions of the Nor Este (nest I) and Sister Cities (nest P) well nests (fig. 59). The same process also may affect other well nests located near major structural features (faults and/or structural highs). Mixing of deep, mineralized water with water in shallower parts of the aquifer system may be important over broad areas of the basin.

Other regional factors that could cause substantial vertical variation in water chemistry in the MRGB include differences in recharge area, ground-water travel times, or geologic materials along flow paths at different depths. Because the sediments of the Santa Fe Group aquifer system at the depths studied for this investigation consist primarily of alluvium of granitic and metamorphic derivation, the geologic materials that water contacts do not differ substantially with depth and are not likely to be a major factor in chemical variation. The importance of differences in recharge area and travel times for water at various depths within the basin will be discussed in greater detail below. Overall, the most common and consistent (but not ubiquitous) changes in water chemistry with increasing depth in the aquifer system appear to be increases in temperature, Na, As, and B concentrations, and decreases in Ca concentration. Additional information on variations in stable isotopic composition of water and $^{14}C$ activity of DIC with depth is given below.

## Hydrogen-2 and Oxygen-18 Isotopes in Ground Water

In most cases, it is likely that the stable isotopic composition of ground water in the MRGB records the isotopic composition of the source water, as has been observed in other semiarid regions (Vogel and Van Urk, 1975). As identified previously, the likely sources of water to the basin include recharge from precipitation along mountain fronts, seepage from rivers and arroyos (including the Rio Grande, the Rio Puerco, the Jemez River, and Tijeras and Abo Arroyos), and subsurface ground-water inflow from adjacent basins. Following recharge, few processes can affect the isotopic composition of ground water within the MRGB. Except for thermal waters discharging along fault zones or in geothermal areas such as the Jemez Mountains, most ground-water temperatures do not exceed 30$^{o}$C in the MRGB and the stable isotope composition can be regarded as unaffected by water-rock interaction or geothermal isotope exchange processes (Panichi and Gonfiantini, 1981). In the recharge process, soil water taken up by plants is not fractionated (White and others, 1985; Ehleringer and Dawson, 1992; Dawson, 1993), and, thus, the stable isotopic composition of ground water is insensitive to plant uptake, even though the dissolved solutes can be concentrated by a factor of two or more during the growing season in shallow ground-water environments such as the inner valley of the Rio Grande (Anderholm, 1988).

### Previous Studies

Stable isotope data for waters from the MRGB and vicinity can be found in Goff and others (1983), Yapp (1985), Vuataz and Goff (1986), Logan (1990), Anderholm (1994), and Lambert and Balsley (1997). Yapp (1985) first recognized most of the prominent features of the isotopic composition of precipitation, surface water, and ground water in the vicinity of

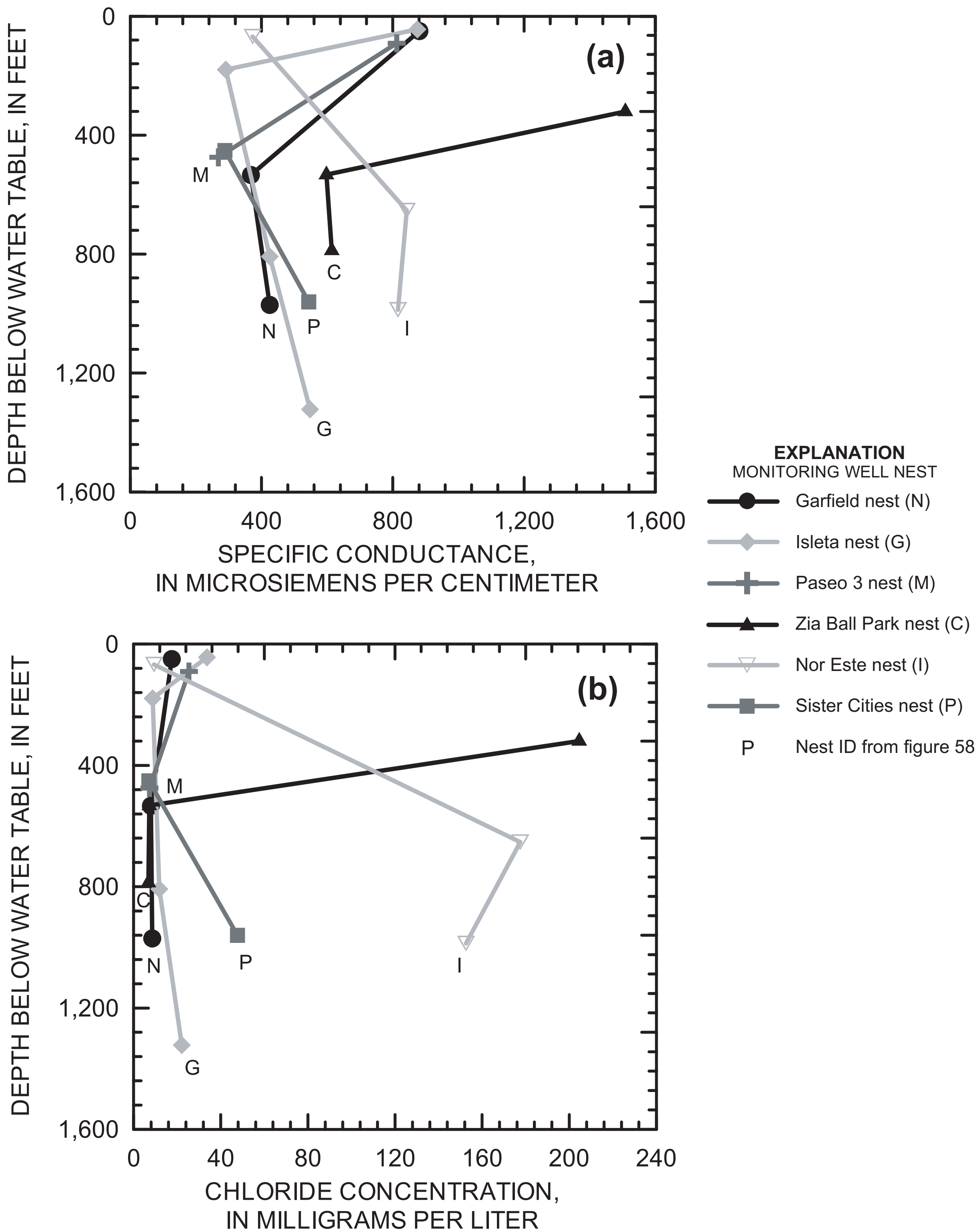



**Figure 59.** (a) Specific conductance values, and (b) chloride concentrations with depth for selected deep monitoring well nests in the Middle Rio Grande Basin, New Mexico. The monitoring well nests are located on figure 58 and identified in table A1.

Albuquerque. Yapp (1985) tabulates and/or plots approximately 147 measurements of $\delta^2H$ (VSMOW scale) of waters from the vicinity of Albuquerque collected between October 1980 and October 1982. The $\delta^{18}O$ composition of the water samples was not determined by Yapp.

Yapp (1985) found that ground water from City of Albuquerque production wells varied widely between -77 and -104 per mil in $\delta^2H$ over a lateral distance of only 12 miles at Albuquerque. Because none of the local ground-water samples were as enriched in $^2H$ as the average local precipitation sampled (-60 per mil), Yapp (1985) suggested that little of the ground water at Albuquerque can be recharged locally by direct infiltration of precipitation; however, the possibility of seasonally-weighted direct infiltration could not be excluded. The possibility of seasonal weighting of direct infiltration favoring the winter months was also considered unlikely by Yapp (1985) because the amount of winter precipitation is generally the lowest of any season of the year in an already arid climate. Yapp (1985) concluded that runoff from the Sandia and Manzano Mountains and recharge from the Rio Grande were the most likely modern contributions to ground water in the Albuquerque area.

Three distinct groups of waters were recognized in the Albuquerque vicinity based on their $\delta^2H$ isotopic composition (Yapp, 1985). Ground water along the eastern side of Albuquerque nearest the Sandia Mountains (referred to by Yapp as "Eastern domain" waters) was consistently enriched in $^2H$ ($\delta^2H$ of -75 to -86 per mil), and was attributed to recharge from precipitation that fell in the Sandia Mountains. Over a narrow transition striking north-northeast, and of horizontal width of only about 1 to 2 miles, the $\delta^2H$ isopleths of ground water at Albuquerque became distinctly depleted in $^2H$, to a composition similar to that of Rio Grande water (approximately -92 to -94 per mil). Yapp (1985) referred to the depleted waters as "Western domain" waters, which ranged in $\delta^2H$ from -90 to -104 per mil, and suggested that they represented waters recharged by infiltration of Rio Grande water. Within the "Western domain" waters, Yapp (1985) recognized a third group of waters on the west side of the Rio Grande, southwest of Albuquerque, that were even more depleted than modern Rio Grande water; these waters were referred to by Yapp as "Deuterium-depleted Deep water", with $\delta^2H$ values of -102 to -104 per mil. Yapp (1985) suggested that the "Deuterium-depleted Deep water" could be waters recharged from the Rio Grande at a time when the river was, on average, about 10 per mil more depleted in $^2H$ than at present. Further evidence was presented showing that $\delta^2H$ values of ground water actually decreased further east of the Rio Grande to -98 per mil, suggesting that the production wells discharged ground-water mixtures containing appreciable fractions of the "Deuterium-depleted Deep water", which presumably occurred at some depth beneath the zone of modern Rio Grande water east of the river. As is shown below, all but one of the conclusions of Yapp (1985) are strongly supported by the findings of this study. The exception is the actual origin of the "Deuterium-depleted Deep water", which was tentatively suggested by Yapp (1985) to represent infiltration from the Rio Grande, possibly during the "Little Ice Age" (extending from approximately A.D. 1450 to 1620). The present study also recognizes the "Deuterium-depleted Deep water" of Yapp (1985), and documents its eastern extent at depth beneath Albuquerque, but its age is on the order of 20,000 radiocarbon years, and it represents a predominant water type in the MRGB extending north to south through most of the west-central part of the basin. The source of the "Deuterium-depleted Deep water" can still be debated, but as shown below from many lines of evidence, the "Deuterium-depleted Deep water" is not derived from the Rio Grande.

In spring of 1995 Sandia National Laboratories (SNL) collected water samples from 25 municipal-supply wells in Albuquerque and analyzed these waters for $\delta^2H$ and $\delta^{18}O$. The results are reported in Lambert and Balsley (1997) on the VSMOW scale and compared with values of $\delta^2H$ reported by Yapp (1985) for the same wells sampled in the early 1980's. The $\delta^2H$ values of most of the samples were similar to those reported by Yapp (1985), but were shifted to more depleted values, by as much as 5 per mil in the 1995 samples relative to the $\delta^2H$ values reported by Yapp (1985). The prominent patterns in isotopic variation in the vicinity of Albuquerque observed by Yapp (1985) were confirmed in the 1995 samples. "Eastern domain" water was defined by Lambert and Balsley (1997) as $\delta^2H > -86$ per mil and $\delta^{18}O > -12.1$ per mil, and a "central domain" water, presumably derived predominantly from the Rio Grande, had $\delta^2H < -95$ per mil and $\delta^{18}O < -13.2$ per mil. Lambert and Balsley (1997) noted that samples from only a few wells had $\delta^2H$ values near the "baseline" value for Rio Grande water defined by Yapp (1985) of -92 per mil. They suggested that the apparent shift to slightly more depleted $\delta^2H$ in 1995 relative to the early 1980's may reflect the response of the aquifer system to pumping in the eastern domain and southwest areas, resulting in an expansion of the central-basin region. In comparing stable isotope results for samples from the same wells collected over a span of approximately 15 years, the assumption was made that both laboratories, reporting on the VSMOW scale, would find identical results if the same sample of water were analyzed in either laboratory. This assumption was not, however, investigated by Lambert and Balsley (1997), and left open the question of whether there are temporal shifts in the $\delta^2H$ composition of water pumped from some municipal wells in Albuquerque, or whether the differences reflect some artifact of the analytical procedures between the two laboratories. This question is addressed below.

### Comparability of Results

Analyses from the USGS Stable Isotope Laboratory, Yapp (1985), Lambert and Balsley (1997), and the contract laboratory for the City of Albuquerque production wells (Logan, 1990, and City of Albuquerque, unpublished data) were examined for comparability. As discussed in the "Methods" section, analyses were performed at the USGS Stable Isotope Laboratory for newly collected ground- and surface-water samples, archived precipitation samples, and archived water samples that had been collected and previously analyzed by Yapp (1985). Values of $\delta^2H$ reported by Yapp (1985) and the re-analyzed values from the USGS Stable Isotope Laboratory are compared in figure 60. Apparently, there is a small but systematic bias between the two sets of $\delta^2H$ values, with the values reported by Yapp (1985) being more enriched in $^2H$ than those determined by the USGS laboratory. In only two samples, $\delta^2H$ measured in the USGS laboratory was more enriched in $^2H$ than the value reported by Yapp (1985). Excluding these two samples (Love 3 and Volcano Cliffs 2, both sampled on August 18, 1981) as being possibly evaporated on storage, the remaining 38 samples average 2.0 ± 1.1 per mil more depleted in $^2H$ in the analyses from the USGS laboratory than reported by Yapp (1985). Although 15-17 years elapsed between measurements, the differences shown in figure 60 for the remaining 38 samples are small and in the opposite direction to that expected for evaporation (evaporation would cause an enrichment in $^2H$). The difference between $\delta^2H$ values reported by Yapp (1985), and those of the re-analyzed waters indicates that for the most depleted waters, the bias between Yapp (1985) and the USGS laboratory is greater than for the more enriched waters (fig. 60). The least squares slope of the correlation between the USGS re-analyzed values and the Yapp (1985) reported values is 0.965, representing a difference of 3.5 per mil over a range of 100 per mil, or 3.5 percent of the reported value.

No significant offset was found in $\delta^2H$ values reported by SNL and the USGS (fig. 61a). Although the identical water samples collected in 1995 and analyzed by Lambert and Balsley (1997) were not available, 19 of the 25 wells sampled by SNL in 1995 were re-sampled in either 1996 or 1997, with stable isotopes analyzed by the USGS. The average deviation in $\delta^2H$ between the SNL and USGS ($\delta^2H_{SNL}$ - $\delta^2H_{USGS}$) analyses of the 19 samples was 0.3 ± 1.5 per mil. This result suggests that $\delta^2H$ values from SNL can be compared directly to the USGS values without further correction, but that 2.0 per mil, on average, should be subtracted from $\delta^2H$ values reported by Yapp (1985) in order to compare Yapp's $\delta^2H$ values with those measured as a part of this study. Although Yapp (1985) did not measure $\delta^{18}O$, values of $\delta^{18}O$ were measured by Lambert and Balsley (1997) and also can be compared without correction to the USGS values determined on waters sampled from the same 19 wells. In this case, there is a slight deviation in $\delta^{18}O$ between the two sets of samples, with the SNL values averaging 0.12 per mil ± 0.08 per mil more depleted in $\delta^{18}O$ than those values determined by the USGS (fig. 61b). The difference is small and, on average, within the analytical uncertainties, yet apparently systematically biased to slightly more negative $\delta^{18}O$ values in the SNL analyses reported by Lambert and Balsley (1997).

It is possible that in the case of Lambert and Balsley (1997), the differences in $\delta^{18}O$ reflect real temporal differences in the isotopic composition of water pumped from Albuquerque municipal wells, but if so, depletion in $^2H$ on the order of 1.0 per mil in the SNL samples relative to the USGS samples would be expected. Instead, a small enrichment of 0.3 per mil was found in the $^2H$ values of the SNL samples relative to the USGS samples. Therefore, it is likely that the SNL values are slightly depleted in $^{18}O$ relative to the USGS values, with an average bias of 0.12 per mil in $\delta^{18}O$.

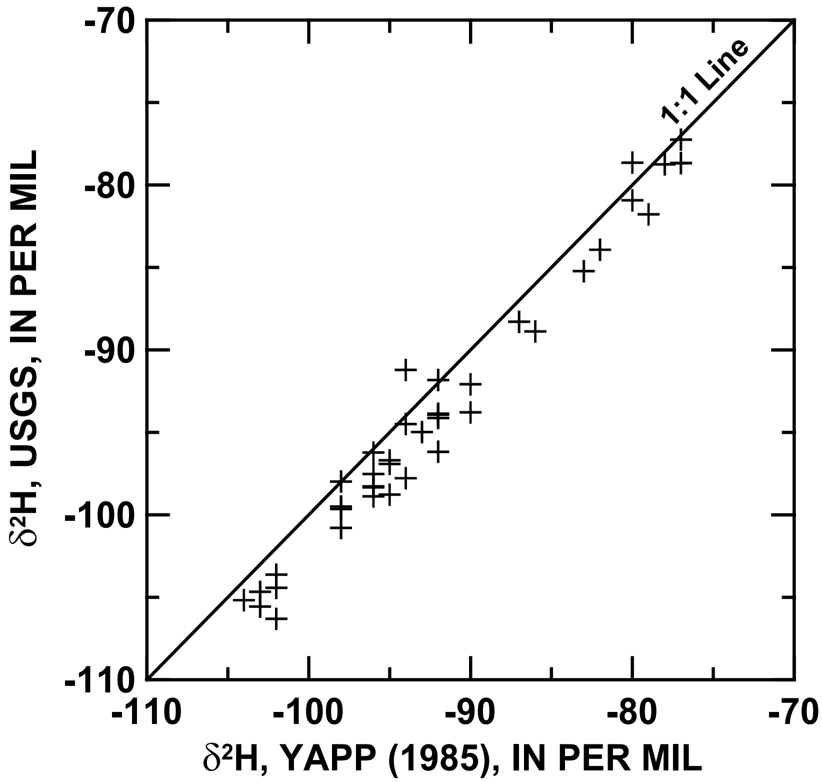



**Figure 60.** Comparison of $\delta^2H$ isotopic composition of water samples reported by Yapp (1985) with U.S. Geological Survey (USGS) re-analyzed values from the archived water samples, determined as a part of this study in the Middle Rio Grande Basin, New Mexico. The values reported by Yapp (1985) are slightly enriched in $^2H$ relative to those values determined by the USGS laboratory.

The results from the contract laboratory for samples from the City of Albuquerque production wells were compared to the USGS results for the re-analyzed Yapp samples from 1980 to 1982, and the USGS samples from 1996 to 1997. The stable isotope analyses from the contract laboratory are in reasonably good agreement with the other data sets, as shown by Logan (1990), but do not appear to have been determined with sufficient precision or accuracy to permit recognition of possible temporal variations in the isotopic composition of water discharged from City of Albuquerque production wells. As mentioned in the "Methods" section, the average standard deviation of $\delta^{18}O$ values from all replicate analyses provided by the contract laboratory was 0.22 per mil, as compared to 0.12 and 0.06 per mil in $\delta^{18}O$ for the average of the standard deviations from the re-analyzed Yapp samples (1980-82) and the USGS samples (1996-97). The maximum difference in $\delta^{18}O$ from a set of representative samples (samples all from the same well) analyzed by the contract laboratory ranged over more than 1 per mil, but was only 0.10 per mil in the USGS samples and 0.28 per mil in the re-analyzed Yapp samples (removing samples from West Mesa 3 (site S272) that apparently show considerable natural variation). Although part of the remaining variation in standard deviation in replicate samples is attributed to real variations in the isotopic composition of water pumped from the municipal wells, the relative differences between the sources of stable isotope data indicate that the most precise data were obtained from the USGS laboratory, either of samples collected by Yapp in the early 1980's and re-analyzed by the USGS, or of samples collected as a part of this study (1996-97) and analyzed by the USGS laboratory.

In addition to the problems with precision of measurements between the contract laboratory and the USGS laboratory, there are more fundamental problems in the accuracy of the analyses from the contract laboratory. To demonstrate these problems, the average $\delta^{18}O$ value was computed for water from each well, as reported for each sample set: (1) the

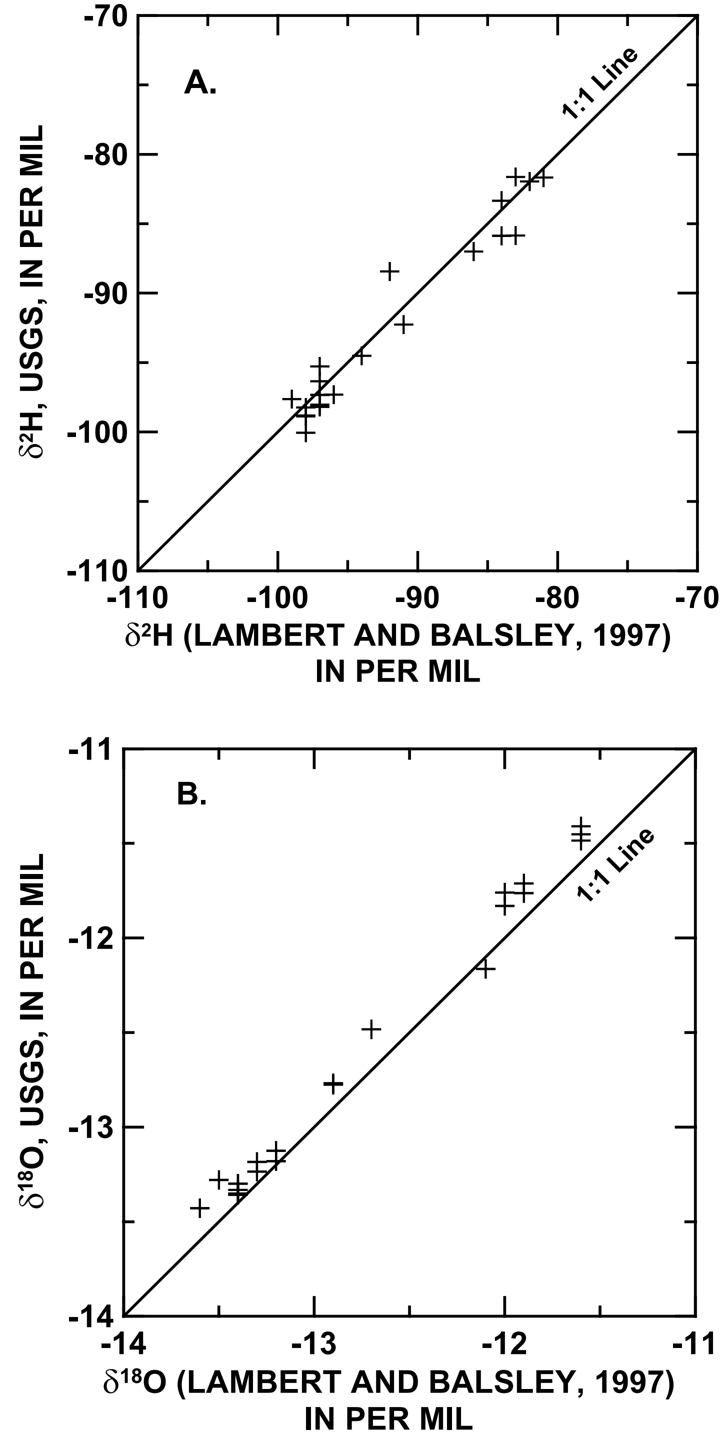



**Figure 61.** Comparison of $\delta^2H$ and $\delta^{18}O$ isotopic compositions of water from City of Albuquerque, New Mexico, production wells reported by Lambert and Balsley (1997) and the U.S. Geological Survey (USGS). (A) Comparison of $\delta^2H$ isotopic composition of water samples reported by Lambert and Balsley (1997) for water samples collected in 1995 with USGS analyses of water samples collected from the same wells in 1996 and 1997. (B) Comparison of $\delta^{18}O$ isotopic composition of water samples reported by Lambert and Balsley (1997) for water samples collected in 1995 with USGS analyses of water samples collected from the same wells in 1996 and 1997.

contract laboratory (1987-90), (2) the Yapp samples from 1980 to 1982 re-analyzed by the USGS, and (3) the USGS samples from 1996 to 1997. The difference in the average $\delta^{18}O$ values between the contract lab and the USGS analyses (contract lab 1987-90 analytical values minus USGS 1996-97 analytical values), and between the Yapp samples and the USGS analyses (re-analyzed Yapp samples 1980-82 minus USGS 1996-97) was -0.23 and -0.01 per mil in $\delta^{18}O$. That is, for the population of municipal wells as a whole, the contract lab $\delta^{18}O$ results are more depleted in $^{18}O$ relative to the USGS results of either the re-analyzed Yapp samples from the early 1980's or the samples from 1996-1997 (fig. 62). As seen in a following section of this report ("Temporal Variations"), the stable isotopic composition of water from some wells in the Albuquerque vicinity has shifted since the early 1980's (West Mesa 3, Ponderosa 2, Ponderosa 3, Leavitt 1, College 1, College 2, and Charles 4). Removing these samples from the averaging, the average standard deviation of the differences between the contract laboratory (1987-90) and the USGS Laboratory (1996-97) was -0.25 ± 0.18 per mil at 74 wells, and the differences between the re-analyzed Yapp samples (early 1980's) and the USGS samples (1996-97), at 19 City of Albuquerque municipal wells, spanning nearly 17 years, was -0.05 ± 0.10 per mil in $\delta^{18}O$ (fig. 63).

Unfortunately, no water samples analyzed by the contract laboratory (1987-90) were retained and, therefore, they cannot be re-analyzed. However, given the stated differences between the results from the contract laboratory and results from the USGS laboratory, all stable isotope results from the contract laboratory were disregarded in comparison of historical data in this report, because the results from the re-analyzed Yapp samples from the early 1980's and the analyses from 1996 to 1997 span the range of historical data.

Finally, if the adjustment of 2.0 per mil in $\delta^{2}H$ is applied to the original analyses of Yapp (1985), the baseline for the $\delta^{2}H$ composition of ground water derived from the Rio Grande at Albuquerque, proposed by Yapp (1985), is shifted from -92 per mil to -94 per mil. Water from Bear Canyon in the Sandia Mountains, indicative of "Eastern Domain" water, is then shifted from -83 to -85 per mil. These adjusted values for "baseline" Rio Grande water and "Eastern Domain" water are nearly identical to the $\delta^{2}H$ values reported by Lambert and Balsley (1997), of -95 and -86 per mil, respectively. These values leave little possibility for historical shifts in stable isotopic composition of most ground water pumped from wells in the vicinity of Albuquerque.

#### Hydrogen-2 and Oxygen-18 Isotopic Composition of Ground Water in the Albuquerque Area

Approximately 380 stable isotope measurements of ground water in the vicinity of Albuquerque have been made as a part of this study. The data include re-analysis of 132 ground-water samples collected by C. Yapp in the early 1980's, analysis of 91 water samples from City of Albuquerque production wells from summer 1997, and analysis of approximately 150 water samples collected as a part of this investigation in the period 1996-98 from the vicinity of Albuquerque (tables A9-A10). The samples collected as a part of this study include samples from City of Albuquerque production wells, domestic wells, and a network of monitoring wells. Samples from the monitoring-well network provide details of the vertical variation in chemical and isotopic composition of ground water to depths of more than 1,000 feet below the water table. These monitoring wells give the most representative stable isotope analyses of ground water in the MRGB because they sample relatively narrow intervals of aquifer, minimizing mixing of waters in the well bore. Comparison of the results from the re-analyzed water samples from the early 1980's with the isotopic analyses of water from the mid- to late- 1990's provides new information on possible ground-water flow during approximately the past 20 years in the Albuquerque area in response to withdrawal from municipal-supply wells.

Although there are variations in stable isotopic composition of ground water with depth in the Albuquerque vicinity, horizontal variations across the basin are greater than most vertical variations, permitting stable isotope variations to be contoured (fig. 64). Most ground water beneath the eastern-most third of Albuquerque and north of Tijeras Arroyo has $\delta^{2}H$ values of -80 to -85 per mil (fig. 64). This water is similar in isotopic composition to mountain-front recharge along the western side of the Sandia Mountains at Albuquerque, as seen at Bear Canyon and Embudo and Embudito Springs (table 5). South of Tijeras Arroyo in the region beneath most of Kirtland Air Force Base, the stable isotopic composition of ground water is enriched in $^{2}H$ by typically 10 per mil or more relative to mountain-front recharge at

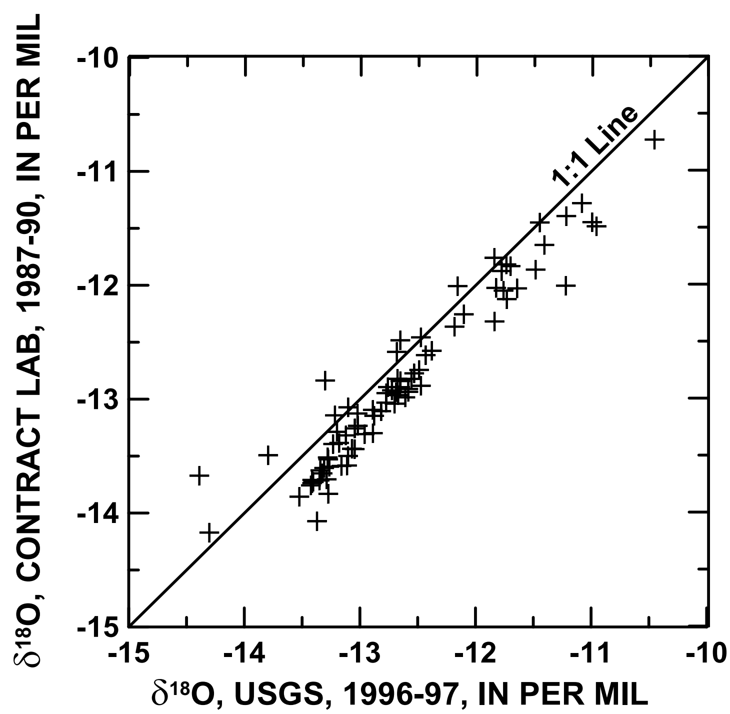



**Figure 62.** Comparison of $\delta^{18}O$ isotopic composition of water samples from City of Albuquerque, New Mexico, production wells collected in 1987-90 and analyzed by a private contract laboratory with analyses of water samples collected in 1996-97 and analyzed by the U.S. Geological Survey.

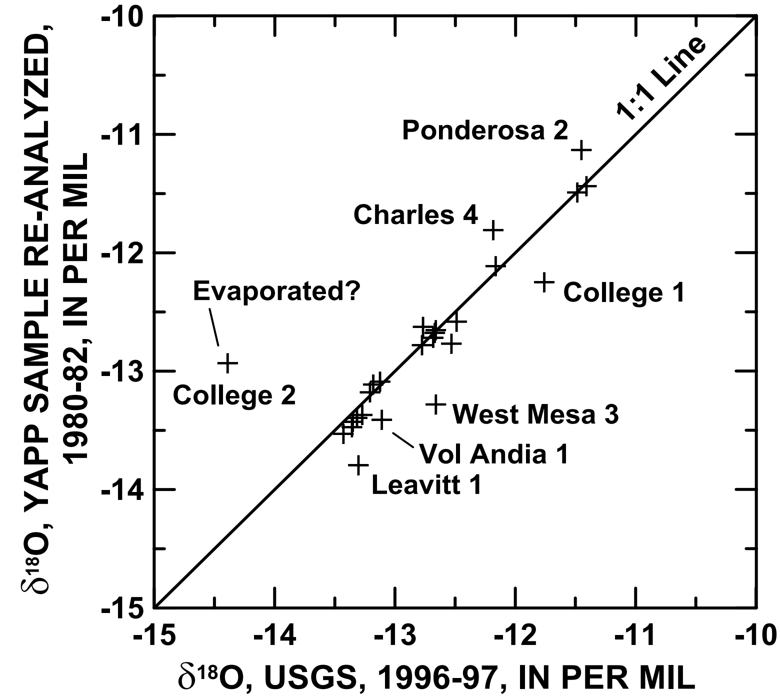



**Figure 63.** Comparison of $\delta^{18}O$ isotopic composition of water samples from City of Albuquerque, New Mexico, production wells collected in 1980-82 and re-analyzed by the U.S. Geological Survey (USGS) with water samples collected from the same wells in 1996-97 and analyzed by the USGS.

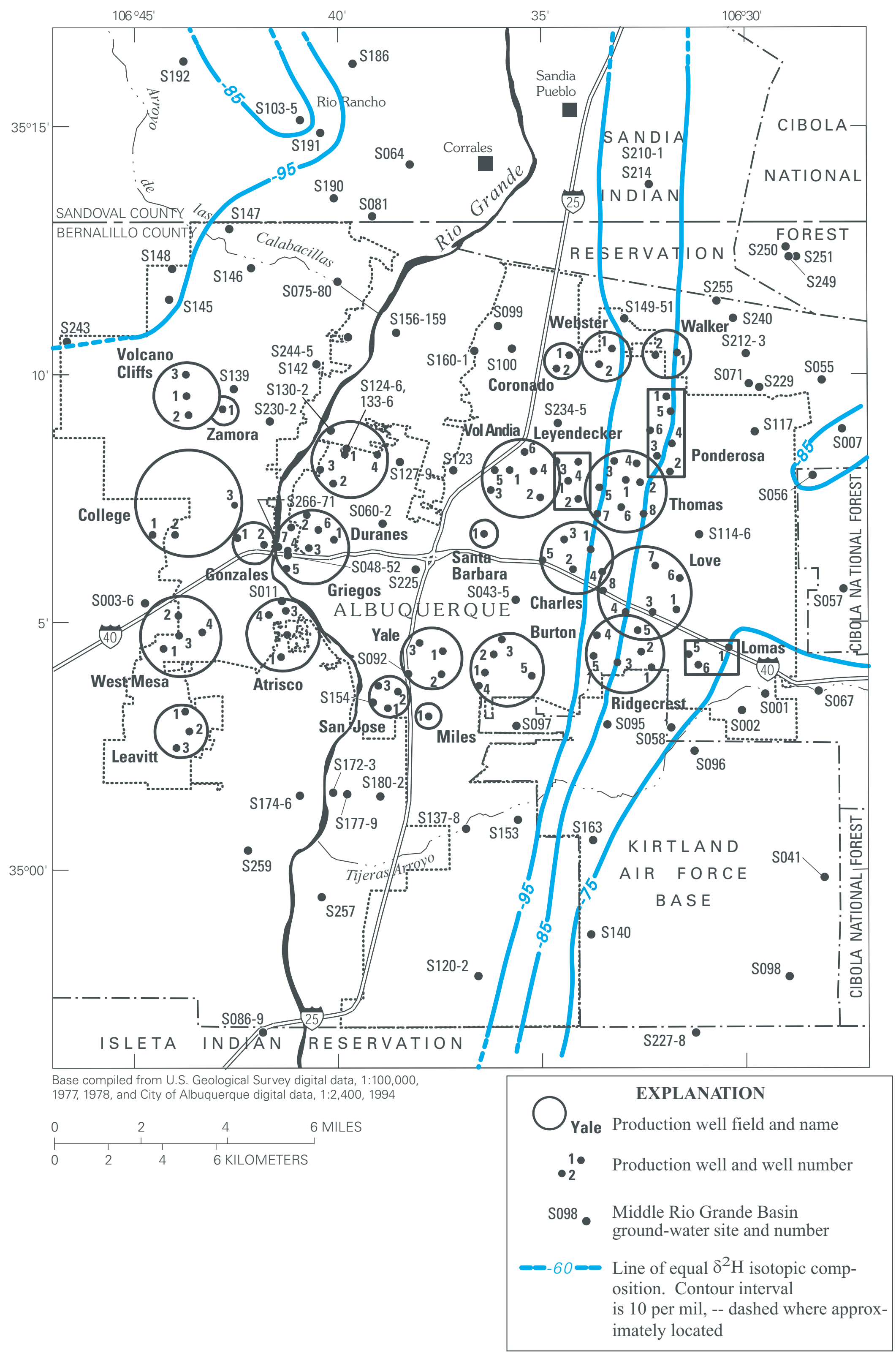



**Figure 64.** $\delta^2$H isotopic composition of ground water in the vicinity of Albuquerque, New Mexico.

Albuquerque, and is similar in isotopic composition to many of the surface-water samples from Tijeras Arroyo (table 5) and water associated with the Tijeras Fault Zone southeast of Albuquerque (fig. 64). To the west of these two regions, and beneath approximately the western two-thirds of the City of Albuquerque, the stable isotopic composition of ground water becomes appreciably depleted in $^{2}H$. The transition to isotopically-depleted water occurs over a narrow zone, of width less than approximately 1 mile, and strikes approximately north-south (fig. 64). West of the transition zone, the $\delta^{2}H$ values of water are typically more negative than -90 per mil, in the range of -90 to -100 per mil. Some waters, in an area south and southwest of Albuquerque, have $\delta^{2}H$ values more negative than -100, reaching -110 per mil at the mid-depths of the 98th Street well nest (sites S004 and S005) (fig. 64). Waters in the range of -90 to -100 per mil are similar in isotopic composition to that of the Rio Grande, as pointed out by Yapp (1985). Also, the "Deuterium-depleted Deep water" recognized by Yapp (1985) discharges from wells in the College, Leavitt and West Mesa well fields in the southwestern part of Albuquerque (table A10) and from the mid-depths of the monitoring wells at 98th Street west of Albuquerque and Mesa Del Sol (site S121) east of the Rio Grande, in the southern part of Albuquerque (table A9) (fig. 64).

In sharp contrast to the relatively depleted waters throughout most of the vicinity of Albuquerque, some of the most enriched ground-water samples of the entire MRGB occur in the Lincoln nest (sites S103-S105), west of Corrales, and northwest of Albuquerque, where $\delta^{2}H$ values of -56.6, -56.5, and -67.3 per mil were found at the shallow, medium, and deep completions, respectively (fig. 64). The samples from the Lincoln nest do not appear evaporated and were probably recharged at relatively low altitudes in the northern part of the basin.

*Temporal Variations*

Temporal variations in the stable isotope composition of ground water in the vicinity of Albuquerque were examined as a means to estimate the extent to which the patterns mapped in figure 64 are representative of predevelopment conditions, and to investigate areas where ground-water flow in response to withdrawals can be identified in the vicinity of Albuquerque. Here, the stable isotopic composition of water pumped from specific wells at Albuquerque is compared for samples collected in 1996 to 1997 with those re-analyzed from the C. Yapp set of samples that were collected in the early 1980's. Values of $\delta^{18}O$ in water from many of the production wells in Albuquerque that were in operation in the early 1980's and the late 1990's are compared in figure 65. Values of $\delta^{18}O$ are plotted instead of $\delta^{2}H$ because the $\delta^{18}O$ measurements have higher precision than $\delta^{2}H$ measurements. It is apparent that the $\delta^{18}O$ range of isotopic composition for water from all City of Albuquerque production wells spans approximately 3 per mil. Water from most individual wells sampled over several years' time varies in $\delta^{18}O$ by $\pm$ 0.2 per mil or less. Apparently, then, most water pumped from City wells has been nearly constant in isotopic composition from the early 1980's through the late 1990's (fig. 65). Wells (with sufficient records from the early 1980's) that have produced water nearly constant in isotopic composition since the early 1980's can be found in the Atrisco, Burton, Duranes, Griegos, Leyendecker, Love, Ridgecrest, Santa Barbara, Thomas, Volandia, Volcano Cliffs, West Mesa (fig. 66), and Yale well fields (fig. 65).

Waters from only a few wells clearly show a shift in stable isotopic composition between the early 1980's and the late 1990's, and these tend to be located along the boundaries between differing water sources. These wells include Ponderosa 2 and Charles 4, which were producing water more depleted in stable isotopes in the late 1990's than in the early 1980's, and wells 1-3 in the Leavitt field, which were producing water somewhat more enriched in stable isotopic composition in the late 1990's than in the early 1980's (figs. 64-65). The shifts in stable isotopic composition over time are detected because the wells indicating changes in isotopic composition over time are located near boundaries between source waters of appreciably different isotopic composition. Apparently, old ground water of Rio Grande origin has moved slightly in response to hydraulic gradients created by pumping along the boundaries between the various water sources at Albuquerque. Ponderosa 2 and Charles 4 are located in the eastern part of Albuquerque, along the boundary between the depleted water, presumably derived from the Rio Grande, and the enriched water from mountain-front recharge. Apparently, resident ground water of (paleo) Rio Grande origin is moving eastward over time to mix with mountain-front recharge withdrawn from the Ponderosa and Charles fields. The Leavitt Field is located west of the Rio Grande and southwest

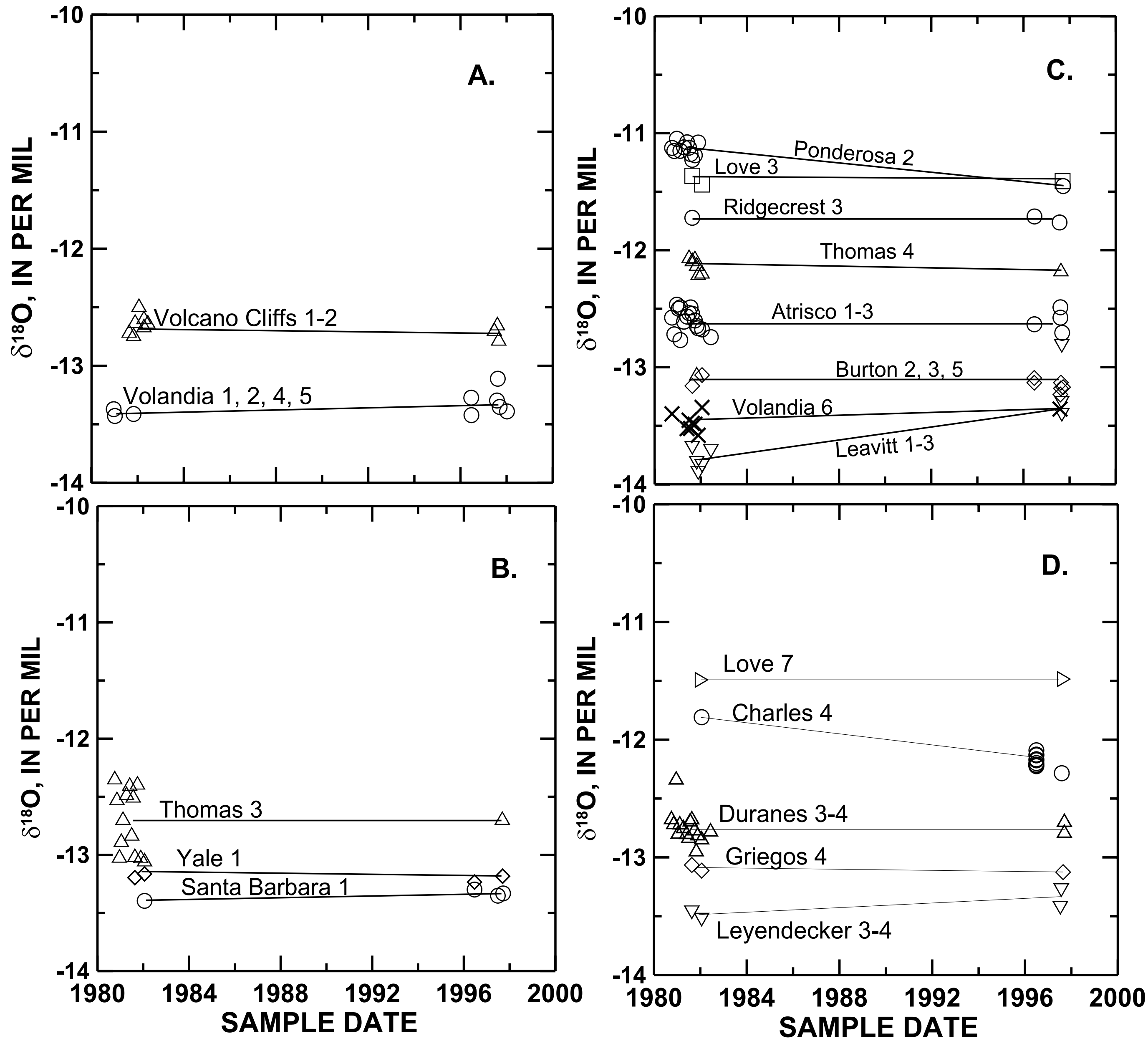



**Figure 65.** $\delta^{18}O$ isotopic composition of water from City of Albuquerque, New Mexico production wells collected in the early 1980s and 1996-97. Water samples from the early 1980s were collected by C. Yapp and re-analyzed by the U.S. Geological Survey. (A) Volcano Cliffs 1 and 2, Volandia 1, 2, 4, and 5. (B) Thomas 3, Yale 1, and Santa Barbara 1. (C) Ponderosa 2, Love 3, Ridgecrest 3, Thomas 4, Atrisco 1, 2, and 3, Burton 2, 3, and 5, Volandia 6, and Leavitt 1, 2, and 3. (D) Love 7, Charles 4, Duranes 3 and 4, Griegos 4, and Leyendecker 3 and 4.

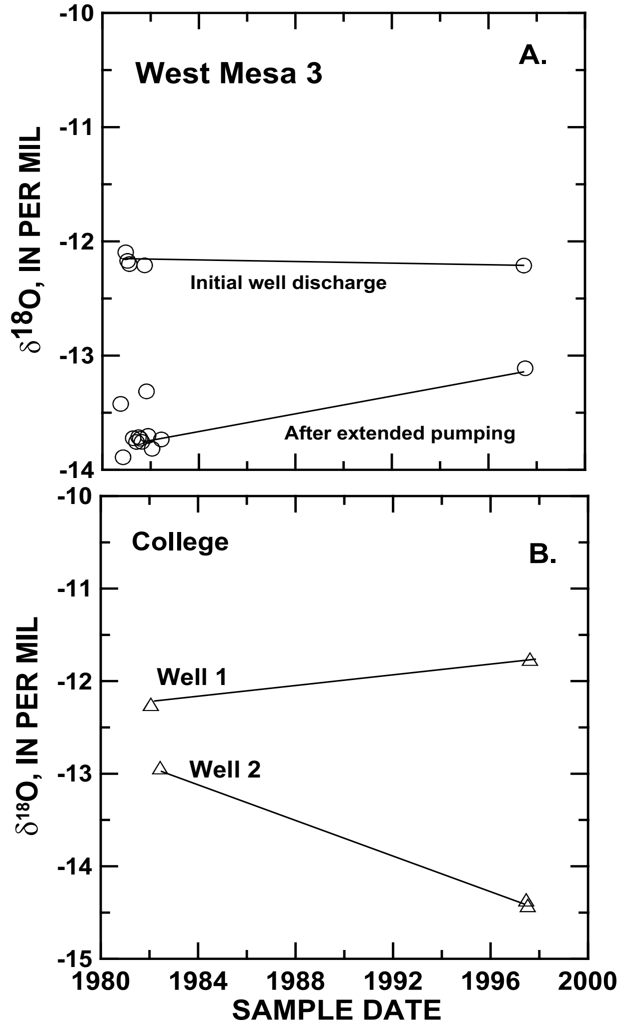



**Figure 66.** Comparison of $\delta^{18}O$ isotopic composition of water from City of Albuquerque, New Mexico production wells (A) West Mesa 3 and (B) College 1 and 2. Water samples from the early 1980's were collected by C. Yapp and re-analyzed by the U.S. Geological Survey.

of Albuquerque in an area of the "Deuterium-depleted Deep water" water of Yapp (1985). This water typically is more depleted in stable isotopic composition than the "Western Domain" water from the Rio Grande. Extended movement of the (paleo) Rio Grande source water westward is apparent in the Leavitt field, as seen in a shift to slightly more enriched waters, relative to the "Deuterium-depleted Deep water", toward the composition of Rio Grande water during the period from the early 1980's to the late 1990's (fig. 64).

Changes in the isotopic compositions of discharge from several wells also may be related to changes in the relative amounts of waters differing vertically in isotopic composition that intercept well screens. Yapp (1985) pointed out that water from West Mesa 3 was depleted in stable isotopic composition when the well had produced continuously for periods of days, and was more enriched when initially run following extended dormant periods. These two water types were found in the 1997 sampling at West Mesa 3 and suggest shallow inflow of the Rio Grande source water as the well recovers following periods of pumping (fig. 66) and discharge of the deeper, more depleted "Deuterium-depleted Deep water" after extended periods of pumping. Water pumped from College 2 is apparently withdrawing greater proportions of "Deuterium-depleted Deep water" today than in the early 1980's (fig. 66). College 2 is slightly deeper than West Mesa 3.

#### Purge Test

The stable isotope composition of discharge from two wells (Charles 4 and Duranes 1) was measured approximately hourly over a period of 6 hours, and compared with results from the same wells from single samples taken 1 week earlier in 1996 and one sample taken a year later in 1997 (fig. 67). Prior to the 6-hour purge test, each well had not been pumped for approximately 12 hours. The variations in $\delta^{18}O$ over 6 hours of pumping (fig. 67a) at these two wells were small, but probably reflect real changes in sources of water being pumped from the aquifer system, as the withdrawal of ground water from different parts of the aquifer system approaches steady state. The variations in $\delta^{2}H$ in part reflect real variations over time, but also are subject to higher analytical uncertainty than those in $\delta^{18}O$, as indicated by decreasing $\delta^{2}H$ and increasing $\delta^{18}O$ in Duranes 1 (fig. 67b).

#### Variations with Depth

Water from many of the monitoring wells in the Albuquerque vicinity is nearly constant in stable isotope composition to depths of at least 1,200 feet below the water table (fig. 68). Well nests with total depths greater than 500 feet below the water table and contain water most likely affected by infiltration from the Rio Grande include Del Sol, Garfield, Hunter Ridge, Isleta, Montaño 6, Montesa, Sierra Vista, Sister

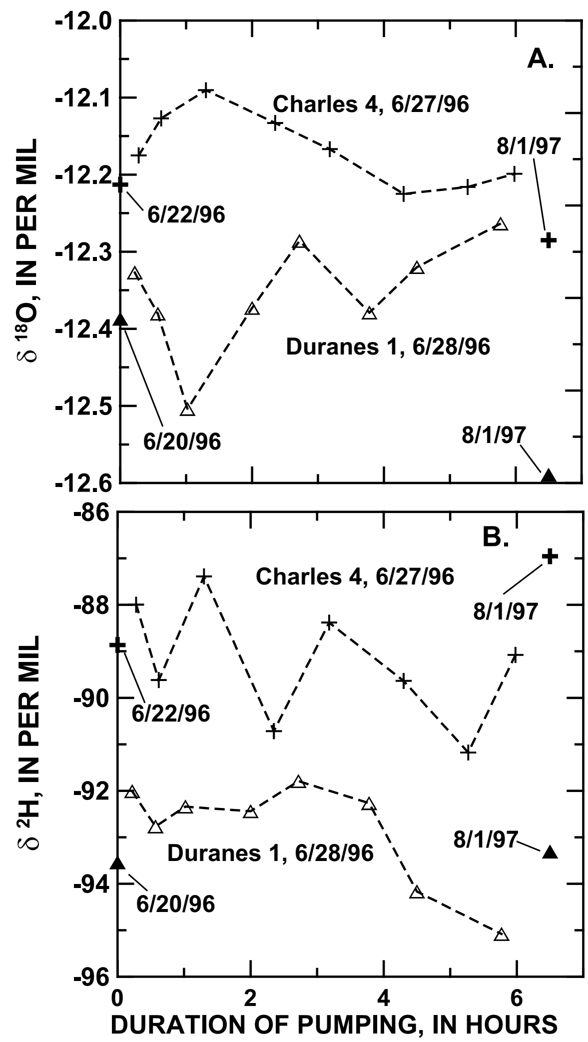



**Figure 67.** Short-term variations in (A) $\delta^{18}O$ and (B) $\delta^{2}H$ isotopic composition of water pumped from the City of Albuquerque, New Mexico, production wells, Charles 4 and Duranes 1.

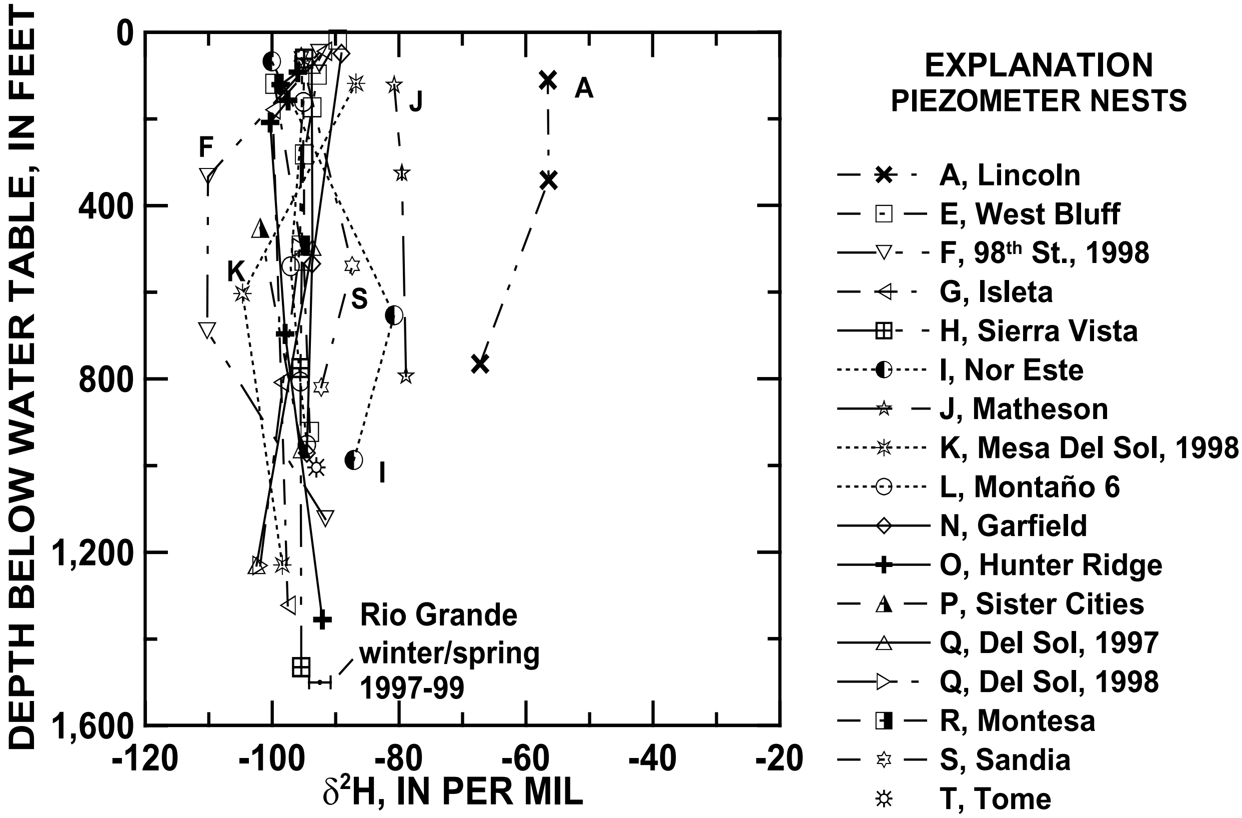



**Figure 68.** Variations in $\delta^2$H isotopic composition of water from selected monitoring wells in the vicinity of Albuquerque, New Mexico (see figures 58 and 69 for location, and appendix A1 for well-construction information).

Cities, and West Bluff (fig. 69). The average $\delta^2$H and $\delta^{18}$O stable isotopic composition of water from these selected monitoring wells is -95.6 ± 3 and -12.88 ± 0.5 per mil, respectively. As shown in a later section of this report, the average radiocarbon ages of these waters exceed 10 ka (range of nearly modern to more than 20 ka). The $\delta^2$H value of -95.6 ± 3 per mil that could be assumed for historical Rio Grande water from ground water in these wells is nearly identical to the adjusted "baseline" value for Rio Grande water from Yapp (1985) (see previous discussion), the "baseline" value for Rio Grande water suggested by Lambert and Balsely (1997), and the average $\delta^2$H value (-95.5 per mil) for the re-analyzed Yapp samples of Rio Grande water from the early 1980's. The average $\delta^2$H of Rio Grande water from the period 1997 to 1999, (-89.9 per mil) is higher than the historical "baseline" values from ground water, and higher than stable isotope values of Rio Grande water from the early 1980's, and may reflect changes in meteorological and/or environmental factors since the early 1980's.

Several well nests indicate significant deviations in stable isotopic composition from that of "baseline" Rio Grande water (fig. 68). Water from the Lincoln nest in Rio Rancho northwest of Albuquerque (point "A" on fig. 69) has $\delta^2$H values of -56.5 per mil at the shallow and intermediate depths, and -67.3 per mil at nearly 800 feet below the water table. Enriched water of this type has not been recognized before in the Albuquerque area, and may represent water that was recharged at lower altitudes in the northern part of the basin (see the section "Tracing Sources of Water in the Middle Rio Grande Basin— Definition of Hydrochemical Zones and Water Sources"). The Matheson nest (point "J" on fig. 68) is characteristic of eastern mountain-front recharge. Two nests in the northern part of the area (Sandia (S) and Nor Este(I)) seem to be affected by eastern mountain-front recharge at their intermediate depths and by more isotopically depleted water at the shallow and deep sampling intervals. [Note: The stable isotope data raise some question as to whether the water from the mid-depth of the Sandia

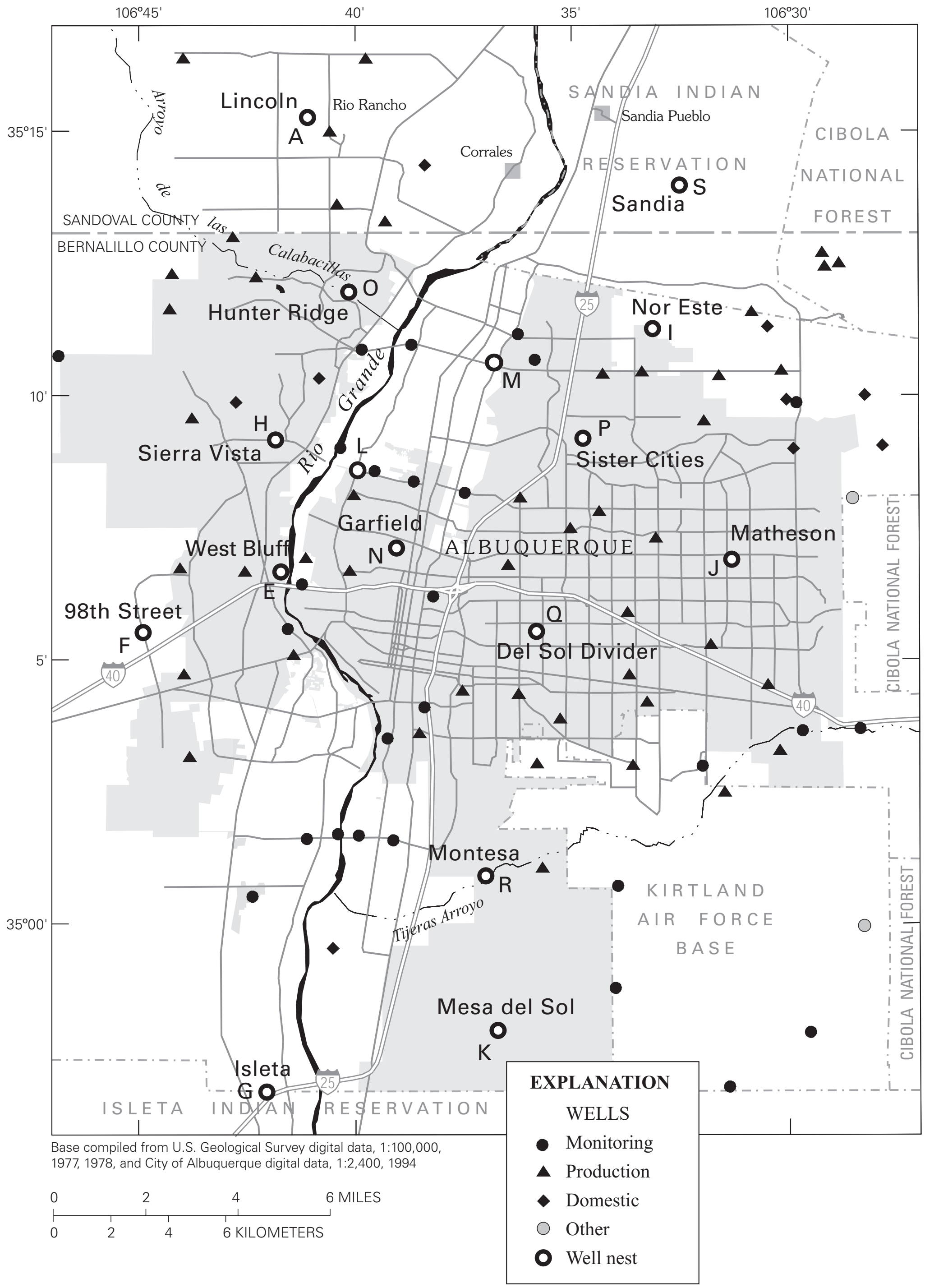



**Figure 69.** Location of monitoring wells in the vicinity of Albuquerque, New Mexico.

nest (S211) belongs in the sub-set of *exotic* samples (table A1). Following completion of this investigation, field tests confirmed the depth and identification of the Sandia piezometers.] The presence of "Deuterium-depleted Deep water" is evident in the intermediate depths of the 98th Street nest (F) west of Albuquerque and the Mesa Del Sol nest (K) in the southern part of Albuquerque (fig. 68). Some of the depleted water may also be present in the deepest piezometer of the Del Sol Divider (also referred to as Del Sol in this report, point Q) well nest (fig. 68). The shallow piezometer of Mesa Del Sol well nest probably contains portions of water from the eastern mountain front and/or Tijeras Arroyo. The shallow piezometer of the 98th Street well nest probably intercepts water from the Rio Grande.

Three cross sections were constructed along east-west lines through the Albuquerque area based on Hawley (1996) and information provided by Sean Connell (New Mexico Bureau of Geology and Mineral Resources, written commun., 2002). Well-construction information was extrapolated to each section along lines normal to the section lines. The northern-most section is aligned approximately along Paseo del Norte Boulevard, across northern Albuquerque, whereas the central and southern-most sections are, respectively, aligned approximately along Menaul Boulevard and the Los Padillas area, south of Albuquerque (fig. 70). Each cross section shows the approximate location of major faults, stratigraphic boundaries, land-surface altitude, the water table, and depths of the open intervals of the selected wells. Symbols show ranges of $\delta^2$H values of water with labels in $\delta^2$H values shown for each well, plotted at the depth of the open interval, or, in the case of production wells, plotted in the middle of the open interval. The most definitive information is provided by the monitoring wells, which are open to narrow intervals of the aquifer system (typically 5 to 10 feet). On the Paseo del Norte section (fig. 71), the wells providing the most definitive depth information include Nor Este (S149-51), Sister Cities (S234-5), Paseo 3 (S160-1), SWAB 3 (S244-5), Hunter Ridge (S075-80), Sierra Vista (S231-2), SWAB 2 (S243), and SAF (S236). Along the Menaul section (fig. 72) the most important wells are Matheson (S114-6), Del Sol (S043-5), Garfield (S060-2), West Bluff (S266-71), and 98th Street (S003-6). Only two wells provide definitive depth information on the Los Padillas section (fig. 73), Mesa Del Sol (S120-22) and Isleta (S086-89). Even though samples from most of the production wells produce mixtures of water over intervals of typically 500 to 1,000 feet of aquifer system, the monitoring wells show that, in many areas, vertical variations in isotopic composition are small (fig. 68) and, therefore, production wells usually produce waters consistent in isotopic composition with areal patterns determined by samples from the monitoring wells.

The predominant features recognized in the stable isotope data in map view in the Albuquerque area (fig. 64) are evident in greater detail in the cross sections (figs. 71-73). Enriched eastern mountain front recharge is evident in all three cross sections. Along the northernmost section (fig. 71), the mountain-front recharge crosses the Sandia Fault Zone and extends beneath more depleted Rio Grande water at Nor Este (S149-51). Further north of the Paseo del Norte section, eastern mountain front water occurs at the middle depth in the Sandia piezometer nest on Sandia Pueblo (figs. 68-69). In the Menaul section (fig. 72), eastern mountain front water reaches depths of more than 1,000 feet below the water table at the Matheson nest (S114-6), with nearly constant $\delta^2$H values of -80.8, -79.6, and -78.9 per mil at the shallow, intermediate and deep piezometers, respectively. The boundary between eastern mountain-front recharge and water derived from the Rio Grande occurs between the Thomas well field and the Matheson nest (figs. 64 and 72). Along the southern-most section (fig. 73), water enriched in $^2$H from the eastern mountain front, Tijeras Arroyo, and the Tijeras Fault Zone occurs at Hubbell Spring (S072), the monitoring wells SFR-3 (S227-8) and MRN-1 (S140) on Kirtland Air Force Base, and possibly the shallow well in the Mesa Del Sol nest (S120-2).

Water with $\delta^2$H values in the range from -90 to -100 per mil is beneath most of the Albuquerque area and probably represents water derived from the Rio Grande. Some water at intermediate depths beneath Albuquerque is more depleted in $^2$H than at either the shallow or deep depths. This depletion is seen at the intermediate depth at Sister Cities (S235; $\delta^2$H of -102 per mil) and Hunter Ridge (S078; $\delta^2$H of -100 per mil), and in discharge from production wells Leyendecker 1 (S107; $\delta^2$H of -99.1 per mil), and Santa Barbara 1 (S220; $\delta^2$H of -98.8 per mil). The "Deuterium-depleted Deep water" of Yapp (1985) appears in the two intermediate depths at 98th Street (S004-5; $\delta^2$H of -110 and -110 per mil), in discharge from production wells College 2 (S037; $\delta^2$H of -109 per mil), West Mesa 4 ($\delta^2$H of -104.2 per mil), and the intermediate depth at

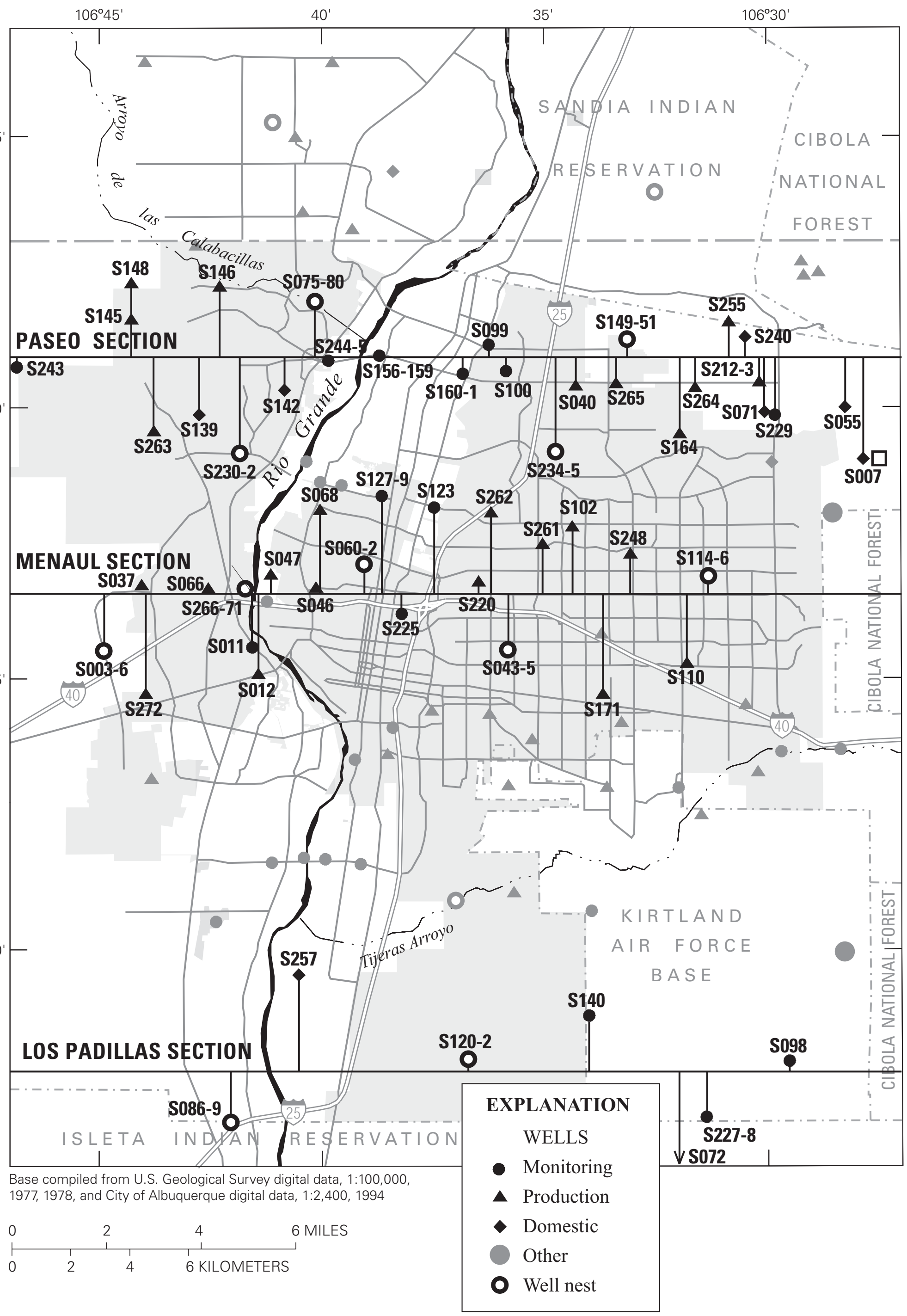



**Figure 70.** Location of the Paseo del Norte, Menaul, and Los Padillas cross-section lines and locations of wells shown on the cross sections, Albuquerque, New Mexico. See figure 11b and table A1 for identification of wells.

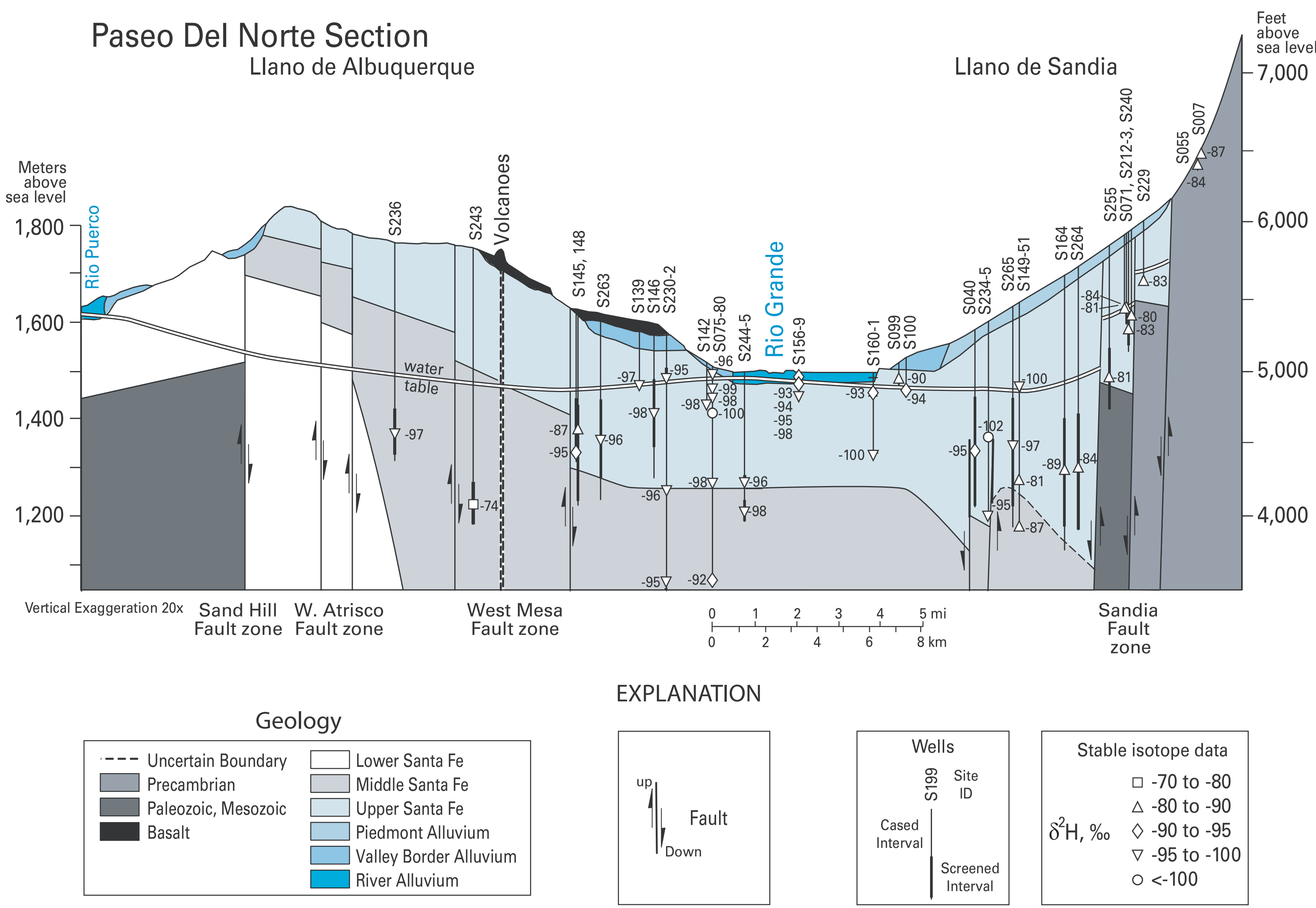



**Figure 71.** Schematic hydrogeologic cross section of the Middle Rio Grande Basin aligned with Paseo del Norte Boulevard, Albuquerque, New Mexico (based on Hawley, 1996, and Sean Connell, New Mexico Bureau of Geology and Mineral Resources, written commun., 2002) showing ranges of $\delta^2H$ for ground water. The cross-section line is shown on figure 70.

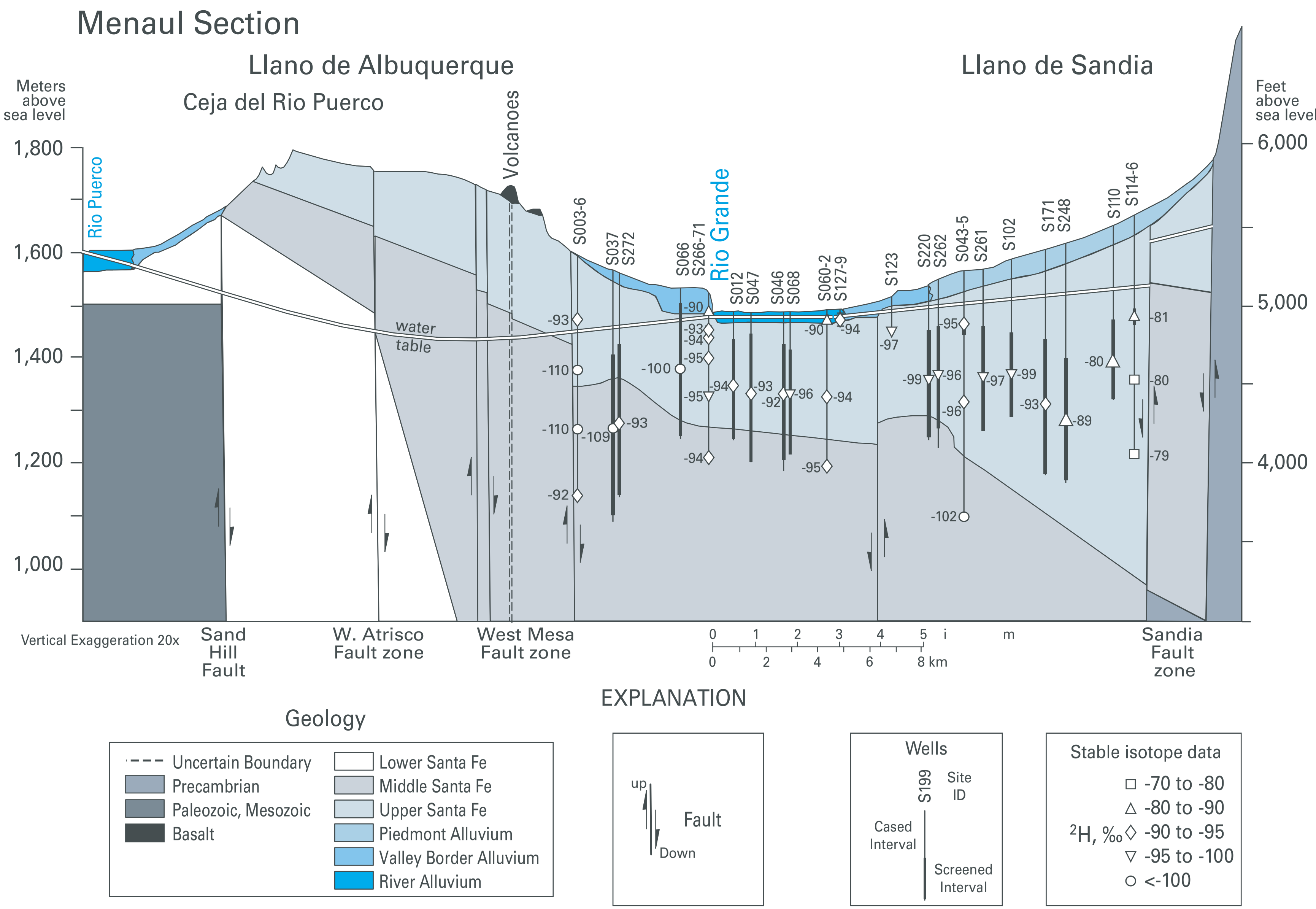



**Figure 72.** Schematic hydrogeologic cross section of the Middle Rio Grande Basin aligned with Menaul Boulevard, Albuquerque, New Mexico (based on Hawley, 1996, and Sean Connell, New Mexico Bureau of Geology and Mineral Resources, written commun., 2002) showing ranges of $\delta^2H$ for ground water. The cross-section line is shown on figure 70.

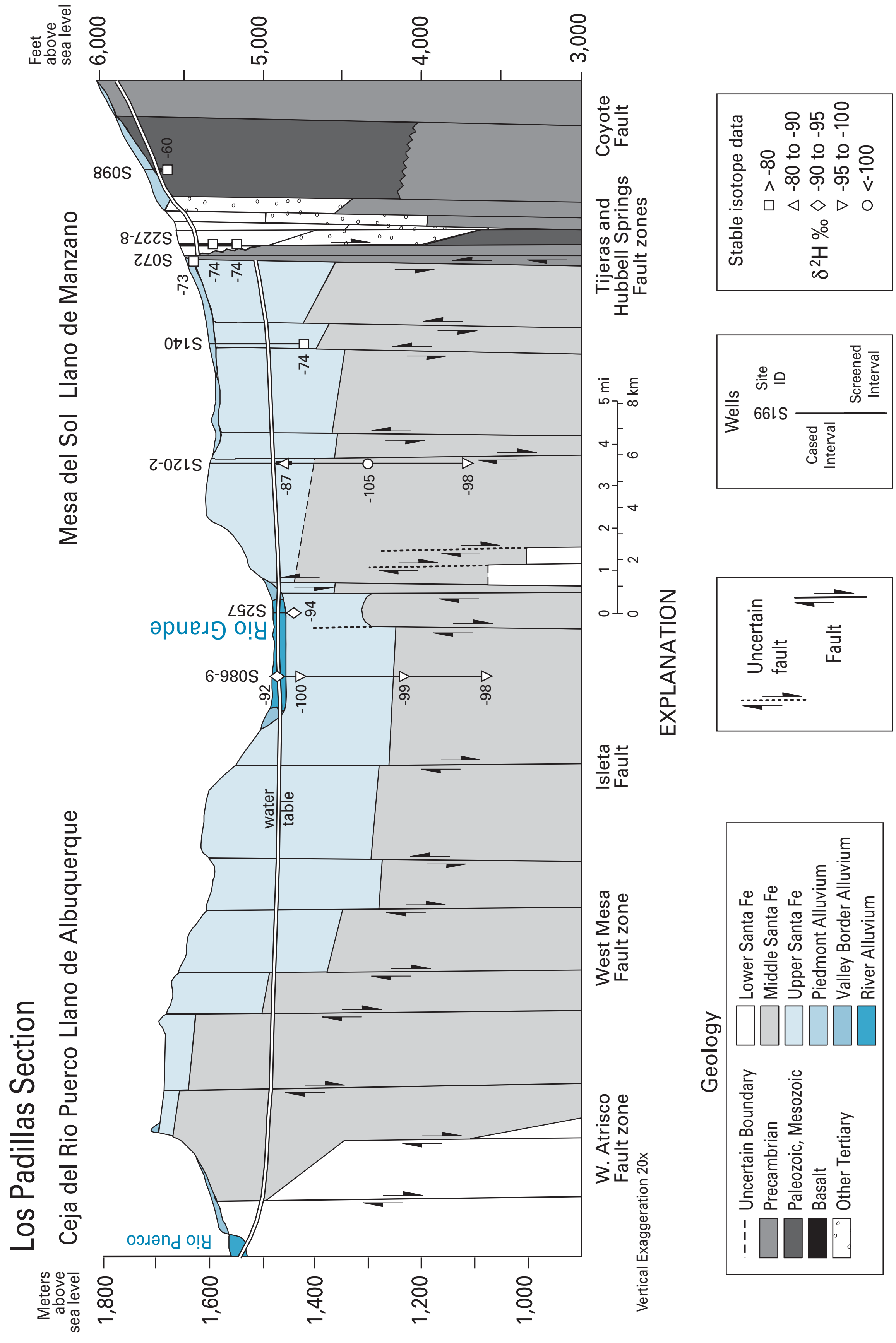



**Figure 73** Schematic hydrogeologic cross section of the Los Padillas vicinity, New Mexico (based on Hawley, 1996, and Sean Connell, New Mexico Bureau of Geology and Mineral Resources, written commun., 2002) showing ranges of $\delta^2H$ for ground water.

Mesa Del Sol (S121; $\delta^2H$ of -105 per mil). Some of this depleted water may also occur at the deepest interval of Del Sol Divider (S043; $\delta^2H$ of -102 per mil) and may be mixed with water from the Rio Grande at the intermediate depths at Isleta (S087-8; $\delta^2H$ of -99.9 and -98.6 per mil). Finally, water somewhat enriched in $^2H$ at SWAB 2 (S243; $\delta^2H$ of -73.6 per mil) and New Mexico Utilities 1 (S145; $\delta^2H$ of -87.3 per mil) may contain fractions of the enriched water found at the Lincoln nest (S103-5) approximately 7 miles further north.

### Hydrogen-2 and Oxygen-18 Isotopic Composition of Ground Water Basin-Wide

Only a few monitoring wells with narrow sampling intervals and depths of more than 200 feet below the water table were available for sampling outside of the Albuquerque area. Ground-water sampling points outside of the Albuquerque area were, for the most part, either windmills, stock wells, or domestic wells that provided samples from shallow parts of the aquifer system. Still, nearly 250 wells were sampled basin-wide outside of the Albuquerque area that provide an overall consistent pattern in stable isotopic composition of ground water, predominantly in the upper 200 feet of the aquifer system. Results from the monitoring wells outside of the Albuquerque area, such as the wells at Santa Ana Boundary (S217), Zia BMT (S288), Zia Ball Park (S283), and Tome (S253), indicate that in parts of the basin, the patterns established in the upper 200 feet of the aquifer system are representative of water to depths of at least 1,000 feet below the water table, as was found in many of the monitoring wells in the Albuquerque area. The lack of variation in stable isotopic composition with respect to depth indicates that the flow directions determined from water-quality data in the shallow wells (most wells sampled) may extend some 1,500 feet or more below the water table throughout much of the MRGB.

The average $\delta^2H$ composition of water from the wells sampled outside the vicinity of Albuquerque is -82.1 per mil, compared to waters sampled from the Albuquerque vicinity, which average -92.4 per mil in $\delta^2H$. Water in the vicinity of Albuquerque is more depleted in comparison to waters basin-wide because most ground water in the vicinity of Albuquerque is derived from the relatively depleted Rio Grande, whereas many of the waters outside the Albuquerque area were derived form sources more enriched in $^2H$ than that of the Rio Grande. The range of $\delta^2H$ values of all the water sampled outside the Albuquerque area is 65 per mil (-118.3 to -52.9 per mil), compared to 38 per mil (-111.3 to -73.7 per mil) in the Albuquerque area.

Similar to many of the major water-quality parameters, the stable isotopic composition of ground water can be contoured throughout most of the MRGB (fig. 74). Important features of the stable isotope contour map include: (1) contours in stable isotope composition tend to align north to south in the central part of the basin, parallel to the direction of the general north to south flow of ground water, (2) a zone of isotopically depleted water extends over the central part of the northern two-thirds of the basin, and is found beneath relatively-enriched water in the northern part of the basin, (3) an area of isotopically enriched water extends along the western and southwestern parts of the basin, along Abo Arroyo, and in a narrow band that extends southward from the northern margin of the basin, (4) a zone of water with $\delta^2H$ values in the -90s per mil range extends north-south along both sides of the Rio Grande throughout most of the basin, and (5) water with $\delta^2H$ values in the -70s and -80s per mil range extends along the eastern and northern margins of the basin (fig. 74).

Based on stable isotope data, it appears that the "Deuterium-depleted Deep water" recognized by Yapp (1985) in southwestern parts of Albuquerque is part of a regional pattern in depleted stable isotope composition of water that extends through the west-central part of the basin from the northernmost boundary (at depth) south to an area in the vicinity of Belen. The "Deuterium-depleted Deep water" water occurs in Rio Rancho wells 9 (site S193) and 13 (site S188) approximately 20 miles northwest of Albuquerque, and is found in deep monitoring wells in the northern part of the basin (Zia BMT (S288), Zia Ball Park (S283-S284), and Santa Ana Boundary (S217-S219) monitoring wells; samples NM186, NM181-NM182, and NM144-NM146, respectively) to depths of more than 1,000 feet below the water table. The "Deuterium-depleted Deep water" water is present beneath a relatively thin zone of somewhat enriched water ($\delta^2H$ values in the -80s per mil range), along the northern margin of the basin at sites S288, S283-S284, and S217-S219. Along the Rio Grande in the central part of the basin, the "Deuterium-depleted Deep water" is present beneath water of Rio Grande composition ($\delta^2H$ values in the -90s per mil range) such as at the 98th St. (sites S004-S005) and Mesa Del Sol (sites S120-S121) nests. The

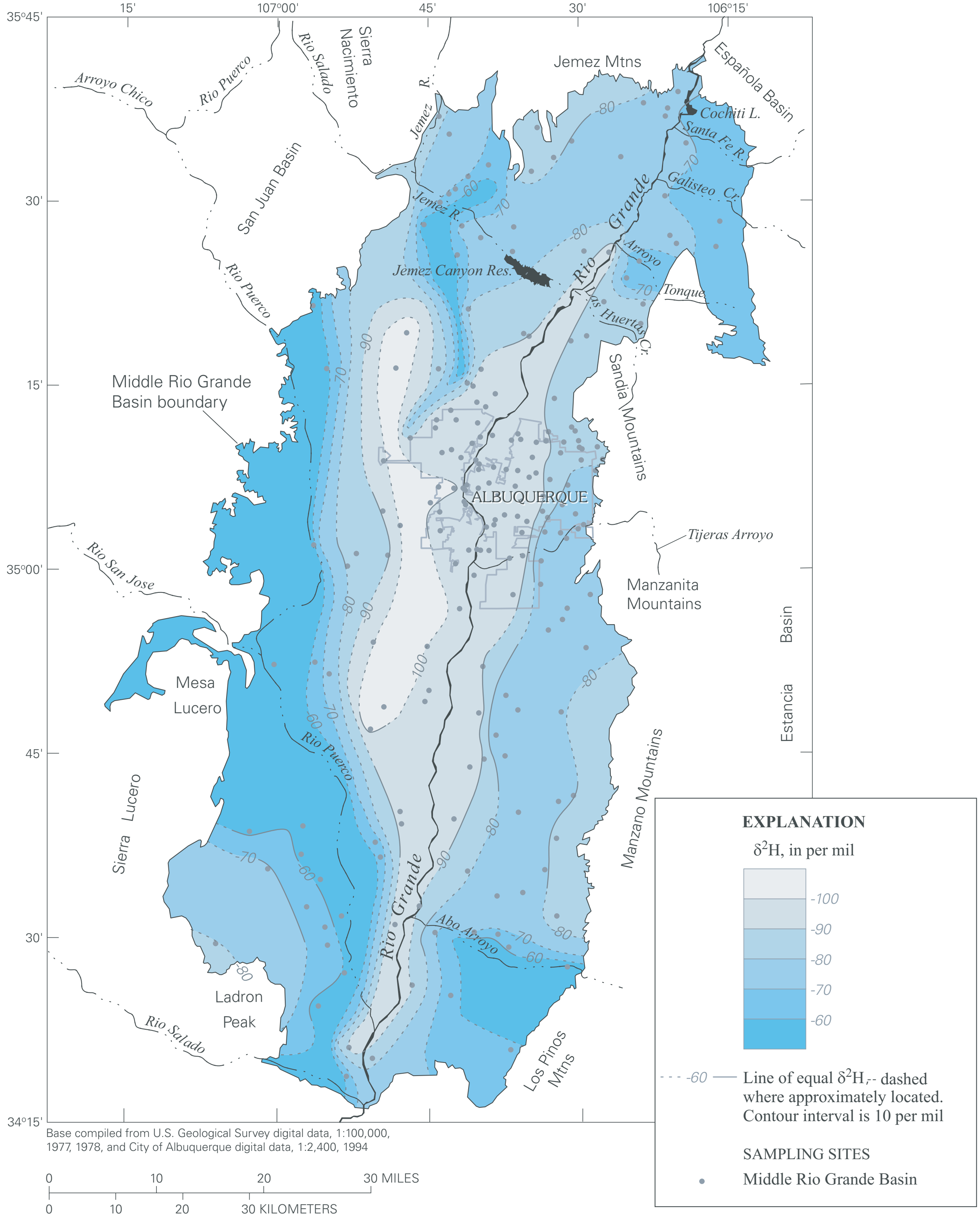



**Figure 74.** Stable H isotopic composition, $\delta^2H$, for ground water in the Middle Rio Grande Basin, New Mexico.

“Deuterium-depleted Deep water” appears to merge with multiple sources of ground water in the southern part of the basin.

West of the central area of “Deuterium-depleted Deep water”, the stable isotopic composition of ground water is greatly enriched by comparison. The presence of the enriched western waters parallels the Rio Puerco in the western and southwestern parts of the basin. The isotopic composition of this ground water is similar to values measured for water from the Rio Puerco (table 5), and it is likely that infiltration from the Rio Puerco contributes part of the water found in the western and southwestern parts of the basin.

Water along the northern, eastern, and southwestern margins of the basin tends to have values of $\delta^2H$ in the range of -80s per mil that are indicative of mountain-front recharge.

The sharp boundary between mountain-front recharge ($\delta^2H$ values in the -80s per mil) and Rio Grande water ($\delta^2H$ values in the -90s per mil) found at Albuquerque (fig. 64) appears to extend north through Sandia Pueblo to San Felipe Pueblo, where depleted Rio Grande water pinches out at the Rio Grande. The stable isotope pattern is consistent with the suggestion of Yapp (1985) that, north of San Felipe, there may be net discharge of ground water to the Rio Grande, but further south from San Felipe, there is net loss of Rio Grande water to the aquifer system. Based on stable isotope data, the zone of influence of infiltration from the Rio Grande is approximately 10 miles in width just north of Albuquerque, remains about 10-miles wide through most of Albuquerque, and then narrows south of Albuquerque parallel to the Rio Grande (fig. 74). Waters with stable isotopic composition similar to the Rio Grande appear to mix with other western, northern, and eastern sources of water in the southernmost part of the basin.

In comparison to surrounding waters, some of the most anomalous waters in the MRGB are the enriched waters at the Lincoln Middle School monitoring nest (S103-105) northwest of Albuquerque, where the shallow, medium, and deep completions have $\delta^2H$ values of -56.6, -56.5, and -67.3 per mil, respectively. This enriched water may originate as low-altitude recharge from arroyos in the northern parts of the basin, but insufficient spatial coverage of samples hampered tracing of the source further north and northeast of the Lincoln well nest. The samples from the Lincoln nest have relatively low deuterium excess of 3.7 to 4.2 per mil, compared to the average deuterium excess of 6.8 per mil for waters basin-wide outside of the Albuquerque area and 7.2 per mil for waters within the vicinity of Albuquerque.

Values of $\delta^2H$ and $\delta^{18}O$ for all ground-water samples from the MRGB are shown in figure 75. The samples generally plot parallel to the global meteoric water line, with a slope slightly less than 8.0. The ground waters (n=335) are correlated according to the least squares fit,

$$\delta^2H = 7.62\ \delta^{18}O + 2.48 \qquad (18)$$

The deuterium excess of all ground-water samples, computed assuming a slope of 8.0, averages 6.9 per mil.

Although stable isotopes can be extremely useful in recognizing sources or water to the MRGB, it could be misleading to base such interpretation solely upon stable isotope data, without considering all the available chemical and isotopic data. The section “Tracing Sources of Water in the Middle Rio Grande Basin—Definition of Hydrochemical Zones and Water Sources” discusses interpretations of hydrologic information based on all chemical and isotopic data collected as a part of this study.

## Carbon-14 Activity of Dissolved Inorganic Carbon in Ground Water from the Middle Rio Grande Basin

### Variations with Depth

The various piezometer nests throughout the MRGB (predominantly in the Albuquerque vicinity) provide useful information on the $^{14}C$ activity gradients with depth in the basin (fig. 76). Activities at the water table vary from 6 percent modern carbon (pmC) at 98$^{th}$ Street (S006) to nearly 120 pmC in the inner valley of the Rio Grande, such as at the shallow depth of the Isleta well nest (S089; 118 pmC). In general, $^{14}C$ activities measured in the piezometer nests decrease with increasing depth below the water table (fig. 76). Selected piezometer nests and/or other wells with depth information were used to estimate the $^{14}C$ activity gradients with depth in the aquifer system of the MRGB (table 7). The lowest $^{14}C$ activity gradients were found in wells completed in the west-central parts of the basin, just west of Albuquerque; these gradients vary from about 0.003 to 0.02 pmC per foot. Higher $^{14}C$ activity gradients can occur in northern parts of the

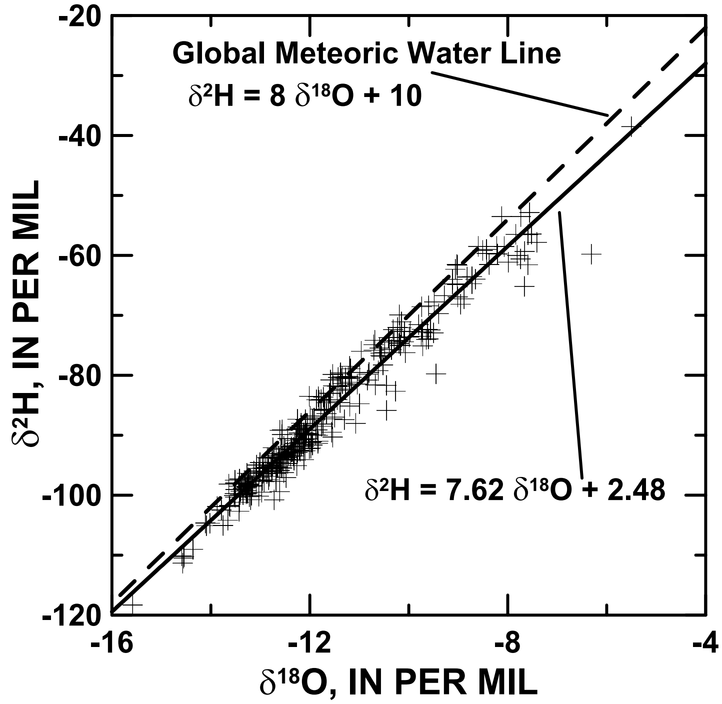



**Figure 75.** Values of $\delta^2H$ and $\delta^{18}O$ isotopic composition for all ground water from the Middle Rio Grande Basin, New Mexico, sampled as a part of this study in relation to the global meteoric water line. The solid line shows a least squares fit to the ground-water data.

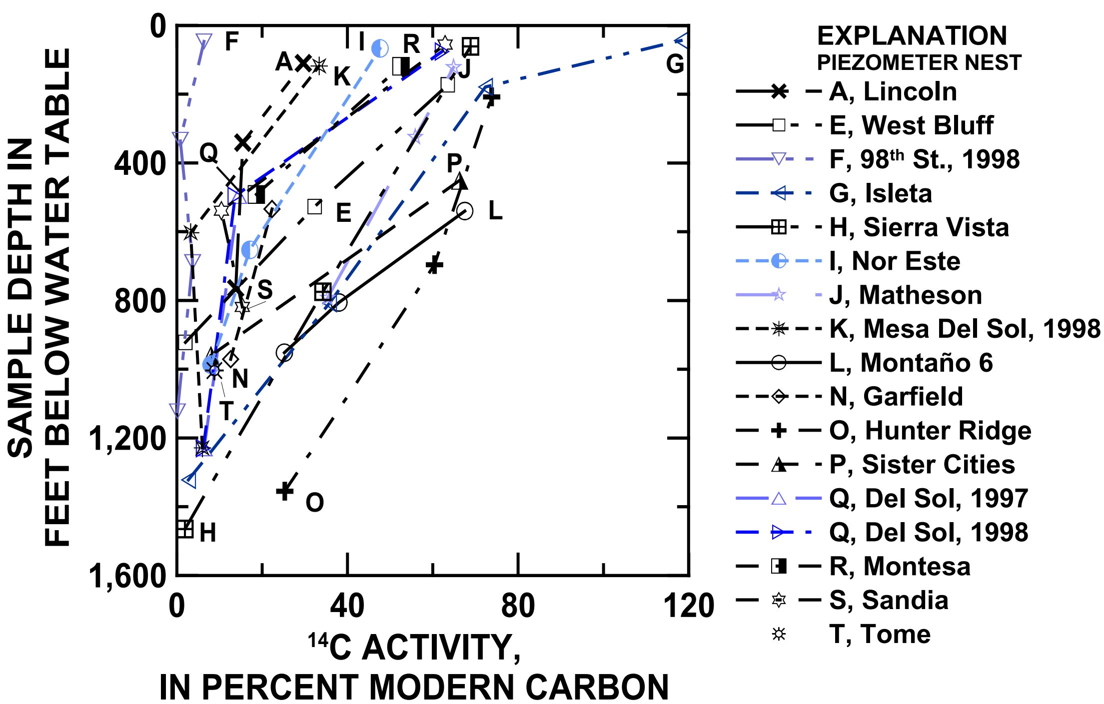



**Figure 76.** $^{14}C$ activity as a function of depth below the water table in narrow-screened piezometers in the vicinity of Albuquerque, New Mexico (see figures. 58 and 69 for location, and table A1 for well-construction information).

basin, such as at the Zia Ball Park (sites S283-S285) and Windmill #12 (S276) wells (table 7). Vertical $^{14}C$ activity gradients vary from about 0.03 to 0.08 pmC per foot in areas where recharge is from the eastern mountain front and/or from the Rio Grande.

### Areal Variations

Maps showing spatial variations in chemical and isotopic properties of water on a basin-wide scale are considered representative of average values for the saturated upper-most 500 feet of the aquifer system. In the vicinity of Albuquerque, the upper 500 feet of the aquifer system is consistent with the primary depth interval intercepted by many of the City of Albuquerque production wells. In constructing a map showing spatial variations of $^{14}C$ activity throughout the MRGB (fig. 77), approximately 200 measurements of $^{14}C$ activity of DIC were plotted on a map; in the cases of multi-depth monitoring wells, values were plotted that were from the mid-depths of the piezometers, typically from about 300 to 500 feet below the water table. This choice in sample depth from piezometers was preferable to plotting $^{14}C$ data from the shallow depth of piezometers that, in some cases, intercepts the water table and can contain fractions of anthropogenic $^{14}C$, and preferable to the deep sample depths of piezometer nests, that typically are below the maximum depth of most of the other wells sampled throughout the basin.

The measured $^{14}C$ activities of DIC of ground water from 211 sites (excluding redundant samples) in the MRGB range from 0.62 to 123.1 pmC. The average $^{14}C$ activity for all the sites sampled was 44.0 ± 31.6 pmC with a median value of 39.7 pmC. The average $^{14}C$ activity varies in different parts of the basin. For example, along the eastern mountain front, $^{14}C$ activity averages 50.9 ± 33.0 pmC, and in areas receiving recharge from the Rio Grande (as defined in the section "Tracing Sources of Water in the Middle Rio Grande Basin— Definition of Hydrochemical Zones and Water Sources"), $^{14}C$ activity of DIC averages 61.6 ± 28.0 pmC. In contrast, DIC in water in the region extending nearly the length of the west-central part of the basin has an average $^{14}C$ activity of 13.9 ± 12.1 pmC.

A smooth continuum of $^{14}C$ activity is apparent throughout the basin (fig. 77). Most of the contours in $^{14}C$ activity align in a north-south direction. $^{14}C$ activities are highest along the eastern mountain front, along the northern margin of the basin, and along the inner valley of the Rio Grande, corresponding to areas where recharge has most likely occurred in the past 5-10 ka. Relatively high $^{14}C$ activities also are present near areas where Abo Arroyo, the Rio Puerco, and the Jemez River enter the basin (fig. 77). Waters with low values of $^{14}C$ activity of DIC are present along the western and southwestern basin margins. A zone of low $^{14}C$ activity extends through nearly the entire

**Table 7.** Estimated $^{14}C$ gradients with depth for ground water from the Middle Rio Grande Basin, New Mexico

[Monitoring Well ID, Monitoring well identification number, see fig. 58; pmC, percent modern carbon; Hydrochemical zones: 2, Northwestern; 3, West-Central; 8, Eastern Mountain Front; 12, Central]

| Site no. | Monitoring well ID | Well nest | Hydro-chemical zone | $^{14}C$ gradient (pmC/ foot) |
|---|---|---|---|---|
| S103-S104 | A | Lincoln | 2 | 0.017 |
| S285, S276 | C | Zia Ball Park (S) to Windmill #12 | 3 | 0.06 |
| S003-S006 | F | 98th Street | 3 | 0.003 |
| S241-S242 | na | SWAB 1 | 3 | 0.023 |
| S114-S115 | J | Matheson | 8 | 0.05 |
| S149-S150 | I | Nor Este | 8 | 0.04 |
| S212-S213 | na | Sandia Peak | 8 | 0.03 |
| S043-S044 | Q | Del Sol | 12 | 0.03 |
| S060-S061 | N | Garfield | 12 | 0.04 |
| S075-S077 | O | Hunter Ridge | 12 | 0.05 |
| S234-S235 | P | Sister Cities | 12 | 0.07 |
| S266-S268 | E | West Bluff | 12, 3 | 0.08 |
| S230-S232 | H | Sierra Vista | 12, 3 | 0.05 |

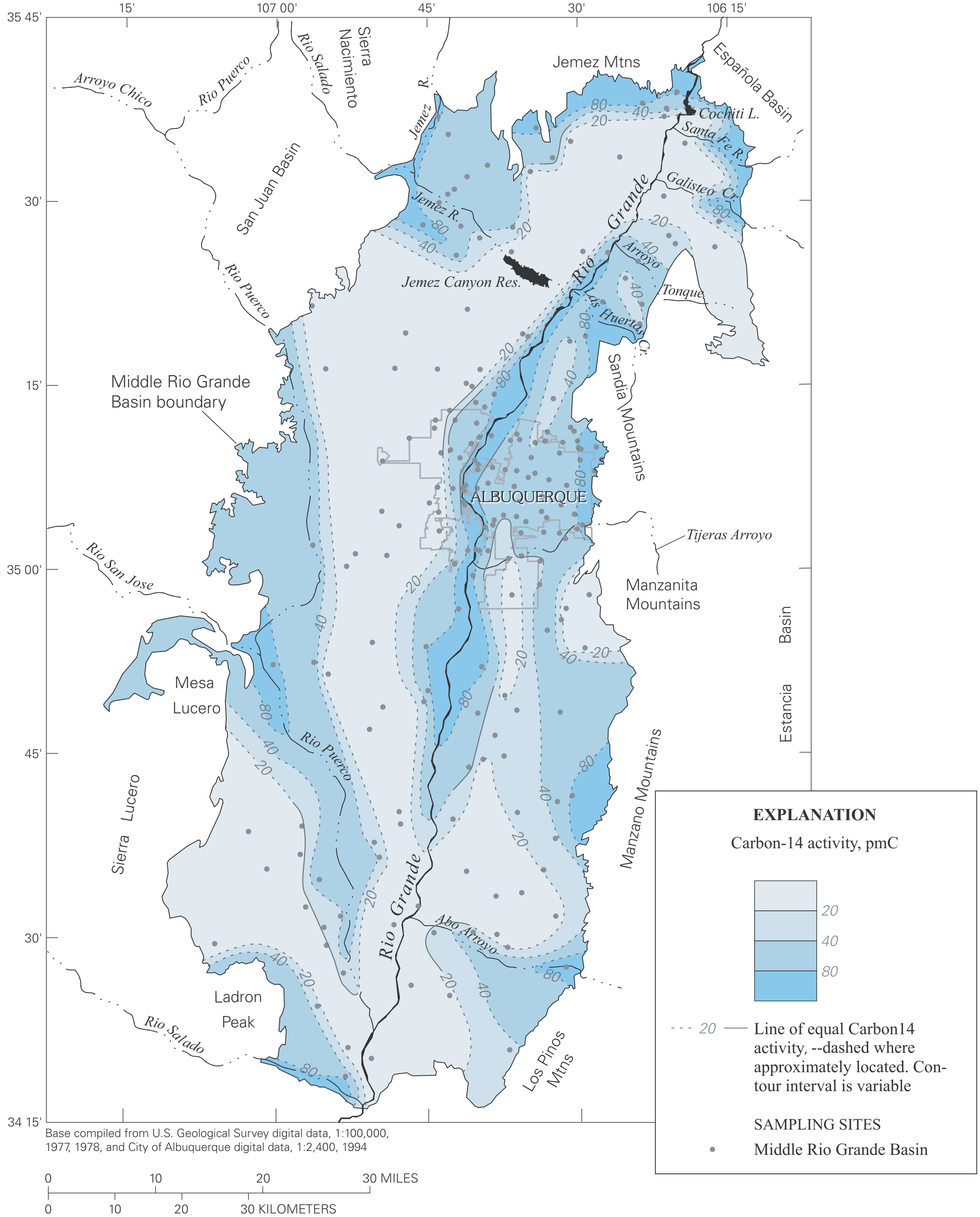



**Figure 77.** $^{14}C$ activity in percent modern carbon, pmC, for dissolved inorganic carbon from ground water throughout the Middle Rio Grande Basin, New Mexico.

length of the west-central part of the basin. The $^{14}C$ activities generally indicate that waters in the MRGB have ages on a time scale of 10s of thousands of years. Interpretation of radiocarbon age requires consideration of recharge conditions and geochemical processes affecting $^{14}C$ activity within the basin. Radiocarbon ages are interpreted in the section "Interpretation of Radiocarbon Age of Dissolved Inorganic Carbon in Ground Water".

As a means of estimating the uncertainty of contours in $^{14}C$ activity drawn on figure 77, which is based on data from a variety of wells completed in the upper 500 feet of the aquifer system, the $^{14}C$ gradients of table 7 were applied to estimated depth variations of ± 200 feet. Consequently, for contours drawn in $^{14}C$ activity along mountain-front recharge areas and near parts of the Rio Grande where infiltration from the river recharges the aquifer system (with $^{14}C$ activity gradients of 0.03 to 0.07 pmC per foot), variations of ± 200 feet indicate maximum uncertainties of ± 6 to ± 14 pmC in values plotted on figure 77. In the west-central parts of the basin, where $^{14}C$ activity gradients are low (0.003 to 0.02 pmC per foot), variations of ± 200 feet could result in maximum uncertainties of ± 0.6 to ± 4 pmC in values of $^{14}C$ activity plotted on the map. These uncertainties are relatively small compared to the large spatial variations in $^{14}C$ activity shown in figure 77 throughout the MRGB.

## TRACING SOURCES OF WATER IN THE MIDDLE RIO GRANDE BASIN-- DEFINITION OF HYDROCHEMICAL ZONES AND WATER SOURCES

The chemical and isotopic parameters discussed in the section "Chemical and Isotopic Composition of Ground Water in the Middle Rio Grande Basin", and mapped in figures 27-30, 33-35, 38-39, 41-57, 64, 74, and 77 reveal areas of ground water of distinctly different chemical and isotopic character in the MRGB, with boundaries that can be defined clearly in most cases. These areal patterns are evident even though water chemistry and isotopic composition has been observed to differ with depth, and ground-water pumpage has recently altered the hydraulic-head distribution of the aquifer system, primarily in the vicinity of Albuquerque. The chemical and isotopic patterns along with information on sample location within the basin have been used to define 13 hydrochemical zones (fig. 78) that represent 12 sources of recharge and an area of discharge for the basin (Plummer and others, 2000). For reference purposes, the zones were assigned names that either reflect a geographical location within the basin (Northeastern (11), Northwestern (2), Western Boundary (4), West-Central (3), Central (12), Northern Mountain Front (1), Eastern Mountain Front (8), Southwestern Mountain Front (6), and Discharge (13) zones) or a major hydrologic or geologic feature of the area (Rio Puerco (5), Abo Arroyo (7), Tijeras Arroyo (10), and Tijeras Fault Zone (9) zones). A unique number was assigned to each hydrochemical zone, shown in parentheses after each zone name above and on figure 78. The hydrochemical zone names are used throughout the text, but to save space, zone numbers are used in some of the tables of this report. Although water chemistry within each zone is broadly similar, localized effects from evapotranspiration, contamination, possible mixing with geothermal waters, or other factors have been observed in parts of the basin. Areas with indications of these localized effects have not been separated from the broader zones.

The hydrochemical zones defined in this study provide insight into likely recharge sources, flow paths, and aquifer properties. Although the zones are broadly similar to those defined by previous investigators in the basin (Anderholm, 1988; Logan, 1990), they are not identical. The hydrochemical zones of Anderholm (1988) are more generalized than those defined in this study, probably largely because fewer data points were available, and with fewer analytes. The regions of Logan (1990) also were defined using fewer data points and are based on proximity to suspected recharge sources and on aquifer permeability in addition to geochemistry. A recent study of water chemistry in the Albuquerque area by Bexfield and Anderholm (2002a) used detailed hydrochemical regions that are generally consistent with those defined in this study. The previous studies have not had the benefit of the extensive stable isotope and radiocarbon data obtained as a part of this study.

Each ground-water sample in the data set for the basin was assigned to a particular hydrochemical zone based on location and chemistry (appendix A). The boundaries between hydrochemical zones are known most precisely in areas where sample sites of differing chemistry were located in close proximity. In areas where fewer sampling sites were available, the boundaries between zones are less well defined. In addition, whereas figure 78 provides a reasonable two-dimensional representation of zone boundaries, these boundaries are not strictly vertical within the aquifer system. For example, the chemical and isotopic data indicate that the West-Central zone actually extends at depth beneath essentially the entire Northwestern zone and may extend beneath parts of the Northern Mountain Front and Central zones. In some instances, samples from different depths within the same well nest were assigned to different zones. Therefore, a sample assigned to a particular zone can appear to be located in an adjacent zone because of depth considerations (fig. 78). Finally, the boundaries shown between zones are not meant to indicate extremely sharp shifts in water chemistry, but rather areas of greatest transition between two water types. Various individual samples were recognized as apparent mixtures of water from different zones. With this recognition, the sample was categorized as belonging to the zone with the chemical characteristics that appeared most dominant within the sample, and the sample was characterized as having properties of both a primary and secondary hydrochemical zone (appendix A).

The general chemical characteristics of each hydrochemical zone are discussed below, particularly as they relate to the primary source of water to the zone. Although some variability results within each hydrochemical zone, the median values of selected parameters given in table 8 show that the "typical" chemistry for each zone is distinct, as do the

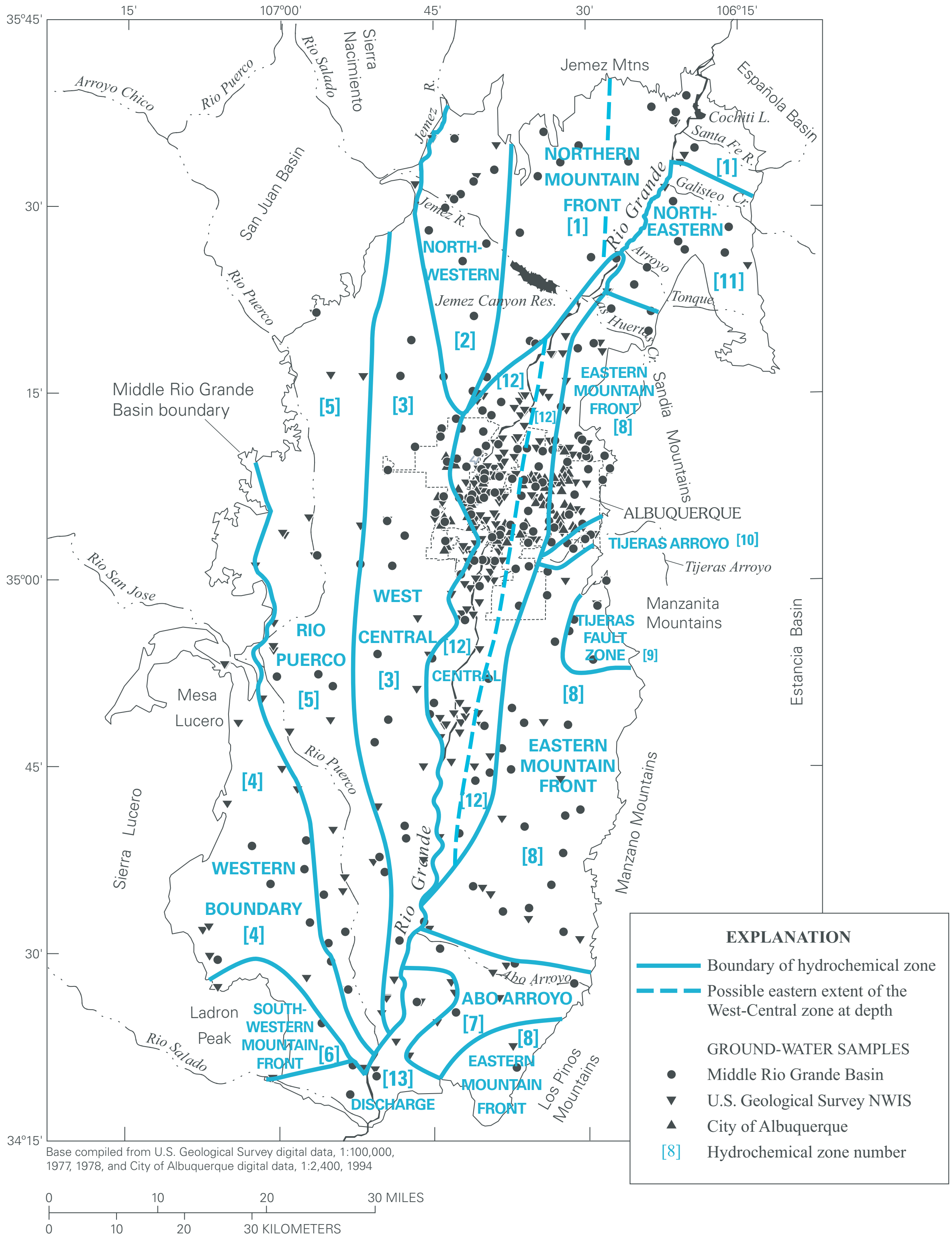



**Figure 78.** Hydrochemical zones defined for ground water in the Middle Rio Grande Basin, New Mexico. The dashed line represents the possible extent of the West-Central zone at depth beneath other zones.

**Table 8.** Median values of selected water-quality parameters by hydrochemical zone for the Middle Rio Grande Basin, New Mexico

[nd, not determined; µS/cm, microsiemens per centimeter at 25 degrees Celsius; deg. C, degrees Celsius; mg/L, milligrams per liter; mg/L, micrograms per liter; pmC, percent modern carbon]

| Hydrochemical zone | Hydro-chem-ical zone no. | Specific conduc-tance (µS/cm) | Field pH | Water temper-ature (ºC) | Dis-solved oxygen (mg/L) | Ca (mg/L) | Mg (mg/L) | Na (mg/L) | K (mg/L) | Alka-linity (mg/L as $HCO_3$) | $SO_4$ (mg/L) | Cl (mg/L) | F (mg/L) | Br (mg/L) | $SiO_2$ (mg/L) | Nitrate (mg/L as N) | Al (µg/L) | As (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Northern Mountain Front | 1 | 340 | 7.49 | 18.9 | 5.1 | 38.5 | 6.1 | 20.0 | 4.9 | 137. | 19.5 | 5.6 | 0.35 | 0.08 | 53.3 | 0.56 | nd | 3.2 |
| Northwestern | 2 | 400 | 7.84 | 20.6 | 6.7 | 33.9 | 4.2 | 49.9 | 5.7 | 160. | 44.8 | 8.5 | 0.61 | 0.07 | 30.1 | 2.44 | nd | 9.8 |
| West Central | 3 | 535 | 8.22 | 23.8 | 3.0 | 12.0 | 2.5 | 103. | 4.2 | 174. | 92.0 | 13.4 | 0.99 | 0.11 | 34.5 | 1.24 | 6.76 | 23.2 |
| Western Boundary | 4 | 4,572 | 7.70 | 22.0 | 4.1 | 135. | 56.4 | 589. | 15.2 | 300. | 793. | 820. | 1.64 | 0.38 | 22.5 | 0.86 | 5.00 | 1.8 |
| Rio Puerco | 5 | 2,731 | 7.50 | 20.0 | 3.7 | 135. | 42.7 | 290. | 10.4 | 190. | 1,080. | 185. | 0.63 | 0.64 | 21.8 | 0.88 | 5.00 | 1.0 |
| Southwestern Mountain Front | 6 | 462 | 8.11 | 19.1 | 4.4 | 52.6 | 13.5 | 27.8 | 2.5 | 202. | 53.0 | 15. | 1.02 | 0.21 | 17.6 | 1.12 | 3.31 | 0.2 |
| Abo Arroyo | 7 | 1,055 | 7.45 | 20.7 | 6.2 | 92.5 | 34.4 | 49.2 | 3.1 | 148. | 346. | 25.9 | 0.90 | 0.17 | 24.0 | 1.40 | 4.14 | 5.2 |
| Eastern Mountain Front | 8 | 382 | 7.67 | 22.0 | 5.2 | 45.0 | 5.1 | 29.2 | 2.2 | 157. | 31.0 | 10.5 | 0.60 | 0.17 | 28.4 | 0.31 | 5.56 | 2.0 |
| Tijeras Fault Zone | 9 | 1,406 | 7.42 | 18.5 | 4.7 | 171. | 36.0 | 95.0 | 6.1 | 599. | 100. | 139. | 1.27 | 0.69 | 18.9 | 1.09 | 5.22 | 2.2 |
| Tijeras Arroyo | 10 | 677 | 7.39 | 16.1 | 7.0 | 89.4 | 24.5 | 29.3 | 3.8 | 240. | 115. | 56.6 | 0.60 | 0.35 | 19.5 | 3.79 | 4.09 | 1.0 |
| Northeastern | 11 | 1,221 | 7.50 | 19.4 | 6.4 | 141. | 29.5 | 81.8 | 4.8 | 208. | 390. | 22.7 | 0.51 | 0.19 | 38.5 | 0.64 | 4.34 | 2.7 |
| Central | 12 | 436 | 7.74 | 18.1 | .1 | 42.9 | 8.0 | 31.0 | 6.4 | 158. | 66.0 | 16.6 | 0.44 | 0.09 | 47.0 | 0.08 | 6.00 | 5.4 |
| Discharge | 13 | 1,771 | 7.70 | 20.6 | .1 | 93.0 | 31.0 | 190. | 10.5 | 157. | 290. | 280. | 1.40 | 0.47 | 39.0 | 0.42 | 4.50 | 9.9 |

| Hydrochemical Zone | Hydro-chem-ical zone no. | Ba (mg/L) | B (mg/L) | Cr (µg/L) | Cu (µg/L) | Fe (mg/L) | Pb (µg/L) | Li (mg/L) | Mn (mg/L) | Mo (µg/L) | Sr (mg/L) | U (µg/L) | V (µg/L) | Zn (µg/L) | δD (per mil) | $\delta^{18}O$ (per mil) | $\delta^{13}C$ (per mil) | $^{14}C$ (pmC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Northern Mountain Front | 1 | 0.062 | 0.043 | 1.2 | 0.8 | 0.060 | 0.20 | 0.058 | 0.005 | 1.7 | 0.31 | 1.0 | 6.4 | 258. | -77.7 | -10.9 | - 8.5 | 33.4 |
| Northwestern | 2 | 0.056 | 0.118 | 2.0 | 0.4 | 0.030 | 0.10 | 0.068 | 0.002 | 3.4 | 0.57 | 2.7 | 15.6 | 9.0 | -64.7 | - 8.7 | - 6.9 | 29.6 |
| West Central | 3 | 0.032 | 0.239 | 5.7 | 0.5 | 0.028 | 0.11 | 0.045 | 0.002 | 8.2 | 0.20 | 3.7 | 27.9 | 5.0 | -96.7 | -12.7 | - 7.2 | 8.8 |
| Western Boundary | 4 | 0.014 | 0.900 | 10.6 | 3.0 | 0.213 | 0.12 | 0.251 | 0.041 | 9.9 | 2.09 | 4.4 | 5.7 | 118. | -64.4 | - 9.1 | - 4.7 | 6.2 |
| Rio Puerco | 5 | 0.014 | 0.291 | 3.0 | 3.4 | 0.130 | 0.10 | 0.253 | 0.015 | 7.0 | 3.92 | 6.0 | 3.4 | 117. | -61.6 | - 8.5 | - 7.7 | 36.4 |
| Southwestern Mountain Front | 6 | 0.045 | 0.094 | 1.9 | 9.3 | 0.030 | 0.41 | 0.041 | 0.007 | 3.0 | 0.86 | 0.9 | 1.0 | 252. | -53.5 | - 7.7 | - 5.8 | 40.0 |
| Abo Arroyo | 7 | 0.017 | 0.130 | 4.4 | 2.0 | 0.105 | 0.10 | 0.031 | 0.004 | 3.4 | 1.48 | 5.4 | 9.5 | 8.1 | -65.2 | - 9.1 | - 6.7 | 24.1 |
| Eastern Mountain Front | 8 | 0.084 | 0.050 | 1.0 | 1.7 | 0.031 | 0.27 | 0.020 | 0.003 | 2.0 | 0.32 | 3.6 | 7.5 | 6.7 | -81.0 | -11.4 | - 8.7 | 47.2 |
| Tijeras Fault Zone | 9 | 0.046 | 0.347 | 1.7 | 4.3 | 0.111 | 0.34 | 0.227 | 0.023 | 3.7 | 1.11 | 7.3 | 6.3 | 61.5 | -74.2 | -10.3 | - 1.0 | 9.7 |
| Tijeras Arroyo | 10 | 0.057 | 0.060 | 1.1 | 1.0 | 0.050 | 0.10 | 0.017 | 0.005 | 1.9 | 0.47 | 3.7 | 3.0 | 4.5 | -75.7 | -10.3 | - 6.8 | 72.8 |
| Northeastern | 11 | 0.018 | 0.215 | 3.2 | 3.7 | 0.170 | 0.11 | 0.040 | 0.004 | 6.7 | 1.72 | 8.5 | 3.8 | 99.5 | -68.6 | - 9.7 | - 6.4 | 28.5 |
| Central | 12 | 0.083 | 0.085 | 1.0 | 0.8 | 0.041 | 0.10 | 0.040 | 0.015 | 5.0 | 0.40 | 3.6 | 9.3 | 5.0 | -95.4 | -12.8 | - 8.9 | 61.0 |
| Discharge | 13 | 0.030 | 0.630 | 10.2 | 1.7 | 0.080 | 0.15 | 0.326 | 0.010 | 10.3 | 3.02 | 3.9 | 7.1 | 16.2 | -90.8 | -12.1 | - 7.0 | 10.8 |

major-element compositions plotted for each zone on the Piper diagram of figure 79. Spatial patterns (hydrochemical zones) were defined on basin-scale maps by comparing all the chemical and isotopic data from one well with that from adjacent wells. The process of assigning wates to particular hydrochemical zones took into account also a conceptualization of likely sources of recharge to the basin, their chemical and isotopic composition, knowledge of the predevelopment water levels, and well location. This process resulted in recognition of areas that seem to have similar chemical and isotopic properties, and could be related to a particular source of recharge. After all samples were assigned to hydrochemical zones, the Mann-Whitney statistical test (also known as the Wilcoxon rank-sum test) was used between adjacent zones for several water-quality parameters to determine whether the samples actually could have come from separate populations. The test calculates whether the median values from the two groups being compared are statistically different, or whether they could represent the medians of two groups drawn from the same population. The test is nonparametric and so does not require the statistical distributions of the groups being compared to have the same shape or variability (Helsel and Hirsch, 1995). The test was used to compare only those hydro-chemical zones that contained at least 10 samples for most constituents, which included every zone except the Southwestern Mountain Front and Discharge zones. Selected parameters for which the test showed statistically different medians between zones at the 95-percent confidence level are listed in table 9 and discussed briefly below.

## Northern Mountain Front Zone

The Northern Mountain Front zone includes areas located on both sides of the Rio Grande (fig. 78). West of the river, the zone extends from the base of the Jemez Mountains in the north to the vicinity of the Rio Grande on the south and east. East of the river, the zone extends from the basin boundary on the north and east to a few miles south of the Santa Fe River. No major surface-water drainages are located in the upgradient parts of the zone. Therefore, potential sources appear to be limited primarily to mountain-front recharge, particularly the infiltration of precipitation, and intermittent streamflow in upland areas. Other sources of recharge could contribute water to the aquifer system locally, such as by infiltration through the Rio Grande, Jemez River, or Santa Fe River, or by underflow from the Española Basin to the north. Based on the extent of this zone as defined by water chemistry, ground water of the zone probably discharges to the Rio Grande in some areas and mixes with ground water of downgradient zones in other areas at its southern extent.

Ground water of the Northern Mountain Front zone is characterized by low values of specific conductance relative to all other zones (table 8). Ground water in this zone tends to have particularly low concentrations of Na, $SO_4$, Cl, F, Br, B, Mo, Sr, and U, but particularly high $SiO_2$ concentrations. The dominant water type is Ca / $CO_3$ + $HCO_3$ (fig. 79). The median deuterium content and carbon-14 activity are -77.7 per mil and 33.4 pmC, respectively.

To look for samples with similar composition, the concentrations of selected major ions in ground water of the zone were plotted against Cl concentrations (expected to be conservative) on graphs that included the theoretical evaporation trends of average bulk precipitation collected on Sevilleta National Wildlife Refuge and average Jemez River water collected from the sample site below Jemez Canyon Dam (figs. 80a and b). On these graphs and similar graphs for subsequent hydrochemical zones, the theoretical surface-water evaporation trend is shown for both more concentrated and more dilute compositions than the average composition calculated from available data. Surface-water compositions can be expected to be more dilute than “typical” during periods of high runoff from precipitation events or snowmelt, which are periods when infiltration may be greatest. During these times, the chemical composition of water in some streams might be expected to approach the average chemical composition of precipitation. However, for the graphs presented in this report, the surface-water compositions were allowed to approach the graph origin at their dilute ends, which is negligibly different from the average composition of precipitation for the purposes of data analysis performed here.

Graphs of $SO_4$ and Ca against Cl (figs. 80a and b) indicate that the general composition of most ground-water samples from the Northern Mountain Front zone are fairly similar to those of bulk precipitation, which is consistent with recharge through the infiltration of precipitation or intermittent streamflow. Based on the Cl concentration of precipitation, most

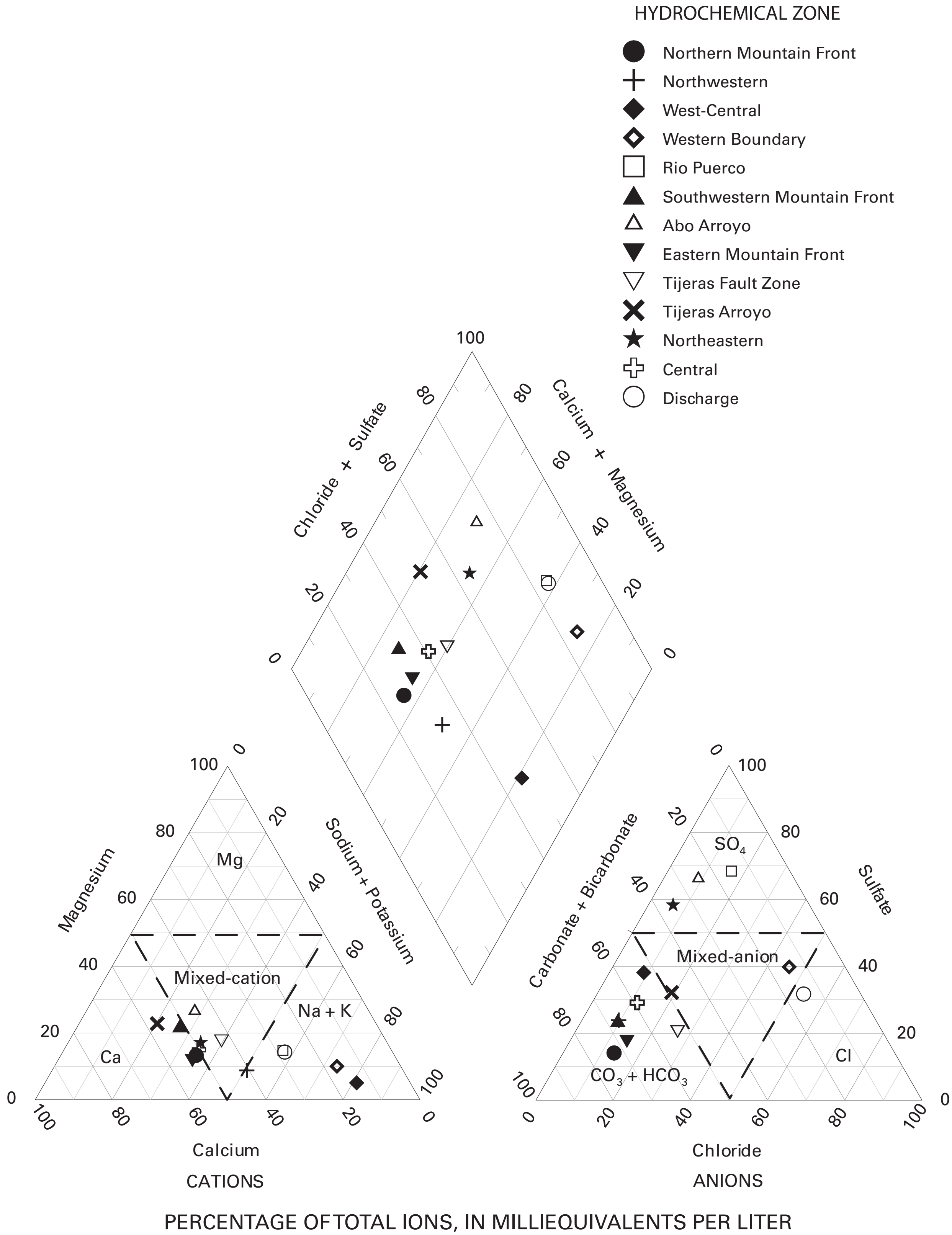



**Figure 79.** Representative major-element compositions for ground water from the various hydrochemical zones in the Middle Rio Grande Basin, New Mexico.

**Table 9.** Parameters for which the Mann-Whitney test indicated statistically different medians between adjacent hydrochemical zones at the 95-percent confidence level for ground-water samples from the Middle Rio Grande Basin, New Mexico

["X" indicates that medians for that parameter were statistically different for the zones listed]

| Hydrochemical zones compared | Hydro-chemical zone numbers | Specific conduc-tance | pH, field | Water temper-ature | Dis-solved oxygen | Cal-cium | Magne-sium | Sodium | Potas-sium | Alka-linity | Sulfate | Chlo-ride | Fluo-ride | Bro-mide | Silica | Nitrate | Alumi-num |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Northern Mountain Front and Northwestern | 1 - 2 | | X | | X | | | | | | X | | X | | X | X | |
| Northwestern and West Central | 2 - 3 | X | X | X | X | X | X | X | | | X | | X | X | | X | X |
| West Central and Rio Puerco | 3 - 5 | X | X | X | | X | X | X | X | | X | X | | X | X | | |
| Western Boundary and Rio Puerco | 4 - 5 | X | | | | | | X | X | X | | X | X | | | | |
| Abo Arroyo and Eastern Mountain Front | 7 - 8 | X | | | | X | X | X | | | X | X | | | | X | |
| Eastern Mountain Front and Tijeras Fault Zone | 8 - 9 | X | X | X | | X | X | X | X | X | X | X | X | X | X | X | |
| Eastern Mountain Front and Tijeras Arroyo | 8 - 10 | X | X | X | | X | X | | X | X | X | X | | | X | X | |
| Tijeras Fault Zone and Tijeras Arroyo | 9 - 10 | X | | | X | | X | X | | X | | X | X | | | X | |
| Northeastern and Eastern Mountain Front | 8 - 11 | X | | X | | X | X | X | X | X | X | X | | | X | | X |
| Northeastern and Northern Mountain Front | 1 - 11 | X | | | | X | X | X | | X | X | X | X | X | | | |
| Central and Eastern Mountain Front | 8 - 12 | X | | X | X | | X | | X | | X | X | X | X | X | X | |
| Central and Northern Mountain Front | 1 - 12 | X | X | | X | X | X | | | | X | X | | | | X | X |
| Central and West Central | 3 - 12 | X | X | X | X | X | X | X | X | | X | X | X | | X | X | |

| Hydrochemical zones compared | Hydro-chemical zone numbers | Arsenic | Barium | Boron | Chrom-ium | Copper | Iron | Lead | Lith-ium | Manga-nese | Molyb-denum | Stron-tium | Ura-nium | Vana-dium | Zinc | Deute-rium | Carbon-14 | Carbon-13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Northern Mountain Front and Northwestern | 1 - 2 | | | X | | | X | | | | | X | | X | | X | | |
| Northwestern and West Central | 2 - 3 | X | X | X | X | | | | | | X | X | | X | | X | X | |
| West Central and Rio Puerco | 3 - 5 | X | X | | | X | X | | X | X | X | X | | X | X | X | X | |
| Western Boundary and Rio Puerco | 4 - 5 | | | X | | | | | | | | | | | | | X | X |
| Abo Arroyo and Eastern Mountain Front | 7 - 8 | | X | X | X | | | X | | | | X | | | | X | | X |
| Eastern Mountain Front and Tijeras Fault Zone | 8 - 9 | | | X | | | X | | X | X | | X | X | | | | X | X |
| Eastern Mountain Front and Tijeras Arroyo | 8 - 10 | X | | | | | | X | | | | X | | | | X | | X |
| Tijeras Fault Zone and Tijeras Arroyo | 9 - 10 | X | | X | | | | | X | X | X | X | | | | | X | |
| Northeastern and Eastern Mountain Front | 8 - 11 | | X | X | X | | X | | | | X | X | | | X | X | | X |
| Northeastern and Northern Mountain Front | 1 - 11 | | | X | | X | | | | | X | X | X | | | X | | X |
| Central and Eastern Mountain Front | 8 - 12 | X | | X | | X | X | X | X | X | X | X | | | X | X | | |
| Central and Northern Mountain Front | 1 - 12 | | | X | | | | | | X | X | | X | | X | X | | |
| Central and West Central | 3 - 12 | X | X | X | X | | | | | X | X | X | | X | | | X | X |

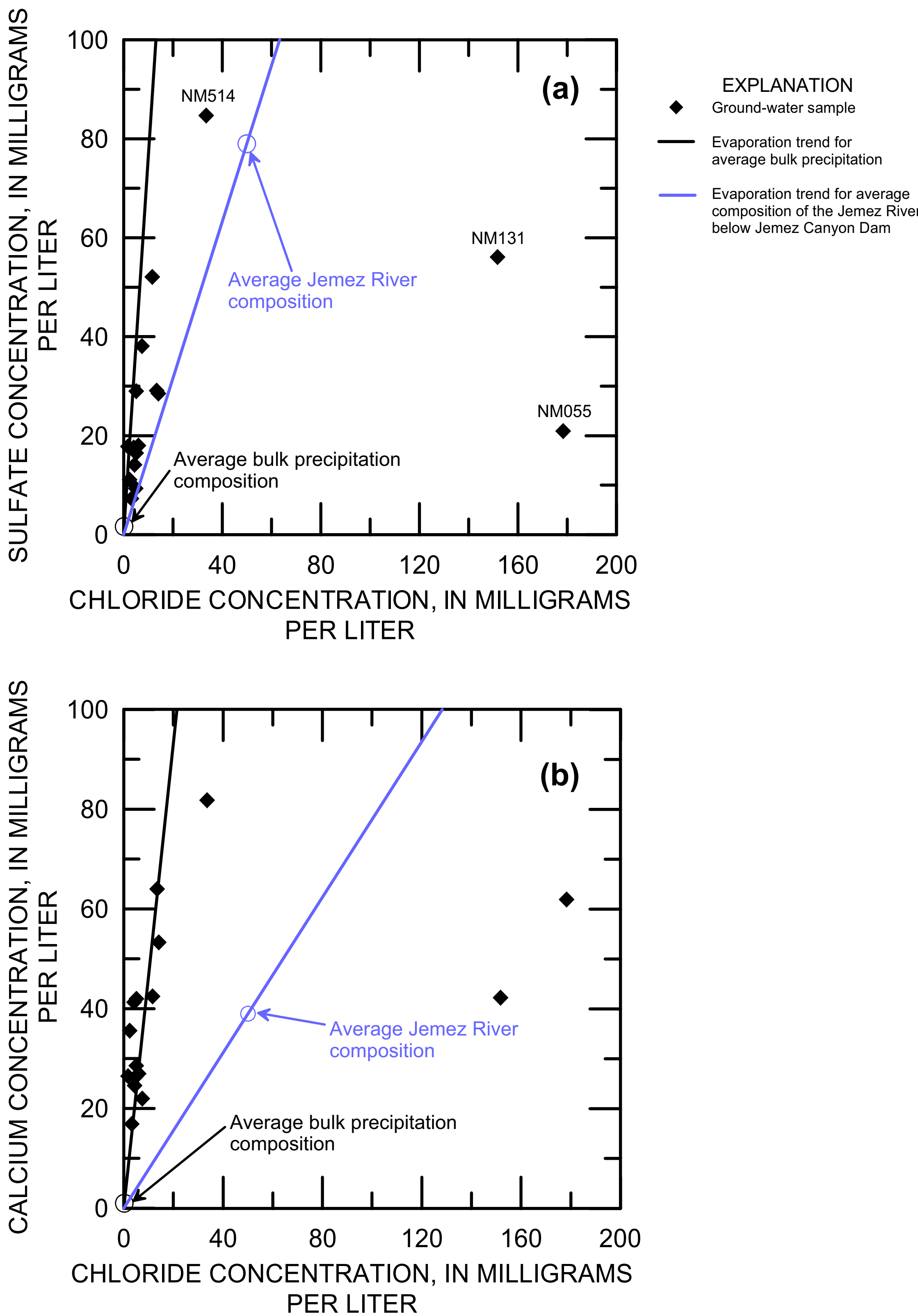



**Figure 80a-b.** Relation of (a) sulfate to chloride and (b) calcium to chloride concentrations in ground water of the Northern Mountain Front zone, Middle Rio Grande Basin, New Mexico, and area precipitation and surface water.

samples appear to have been concentrated up to about 66-fold during recharge. However, there are a few samples that show Cl concentrations substantially higher than expected based on the ion ratios of precipitation. Two of these samples (NM055 and NM131) are from sites located at the southern end of the zone (south of the Jemez River) and one sample (NM514) is from a site located near the base of the Jemez Mountains. The two samples from sites located downgradient of the Jemez River have substantial excess Cl relative even to the discharge-weighted average Jemez River chemistry determined from NWIS. Therefore, it appears most likely that all three high-Cl samples could be affected by mixing with deep, mineralized water having a high concentration of Cl relative to $SO_4$.

Interestingly, although most of the ground-water samples from the Northern Mountain Front zone plot fairly close to the precipitation evaporation line on the graph of $SO_4$ and Cl (fig. 80a), nearly all plot slightly to the Cl side of the line. These same samples plot closely along or almost evenly on either side of the precipitation evaporation line for Ca and Cl (fig. 80b), but nearly all plot far to the Ca side of the precipitation evaporation line for Ca and $SO_4$ (fig. 80c). If the samples were affected by appreciable amounts of calcite dissolution, Ca would plot above the precipitation line relative to Cl (fig 80b). Therefore, these plots indicate that the $SO_4$ concentrations of modern precipitation samples are slightly higher relative to Cl than the concentrations present during recharge of the ground-water samples. This conclusion is consistent with the modern release of sulfur into the atmosphere as a result of industrial activities.

In summary, the generally dilute nature of ground water in the Northern Mountain Front zone,

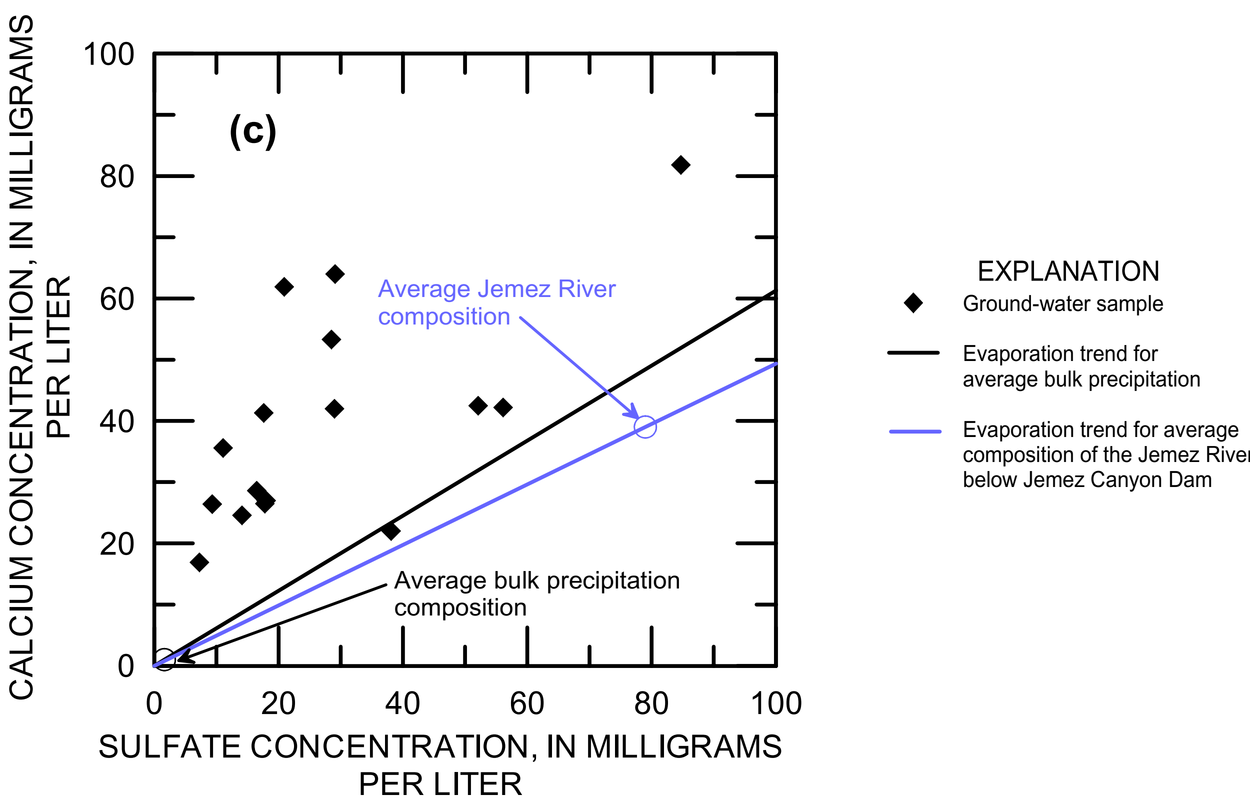



**Figure 80c.** Relation of calcium to sulfate concentrations in ground water of the Northern Mountain Front zone, Middle Rio Grande Basin, New Mexico, and area precipitation and surface water.

along with constituent ratios, the low concentrations of most minor elements, and the moderately light deuterium contents, are consistent with mountain-front recharge processes. However, some samples indicate mixing with a high-Cl source, such as a deep, mineralized water. The high $SiO_2$ concentrations characteristic of the zone may reflect weathering of silicic volcanic rocks associated with Jemez Mountain volcanism in the area.

## Northwestern Zone

The Northwestern zone extends in a relatively narrow band from the base of the Jemez and Nacimiento Mountains on the north and west to boundaries with other zones near Albuquerque to the south (fig. 78). Potential recharge sources in upgradient areas include mountain-front recharge processes, infiltration through the Jemez River, and possibly ground-water inflow from north of the basin. Based on the extent of this zone as defined by water chemistry, ground water of the zone probably mixes at its southern end with greater quantities of water from other, downgradient zones.

Similar to the Northern Mountain Front zone, ground water of the Northwestern zone generally has relatively low specific conductance compared to other zones (table 8). Compared to most other zones, ground water in this zone also has relatively low concentrations of Ca, Mg, $SO_4$, Cl, Br, and U, but relatively high concentrations of dissolved oxygen, $NO_3$, As, and V, and relatively high pH. The dominant water types are Na + K / and mixed-cation / $CO_3$ + $HCO_3$ (fig. 79). The median deuterium content and carbon-14 activity are –64.7 per mil and 29.6 pmC, respectively. The Mann-Whitney test indicates that ground water of the Northern Mountain Front and the adjacent Northwestern zone differs in the median values of 11 water-quality parameters, including 4 major constituents (as defined above, the major constituents are Ca, Mg, Na, K, $HCO_3$, $SO_4$, Cl, F, $SiO_2$, and $NO_3$), pH, and deuterium content (table 9).

For selected parameters, ground-water samples from the zone were plotted against the evaporation trends for bulk precipitation and the Jemez River (fig. 81). Similar to the Northern Mountain Front zone, most samples fall close to (but slightly to the Cl side of) the precipitation evaporation trend for $SO_4$ and Cl (fig. 81a), which is consistent with recharge through the infiltration of precipitation or intermittent streamflow. Based on the Cl concentration of precipitation, most of these samples appear to have been concentrated up to about 60-fold during recharge. However, three samples (DB427, DB429, and NM133) fall close to the Jemez River evaporation trend and one sample (DB428) is clearly distinct from either trend. Samples DB427-9 are from wells located within about 1 mile of the Jemez River and could reasonably be expected to include some fraction of infiltration from the river. In contrast, sample NM133 is from a well screened deep (at depths of greater than 820 feet) and located several miles south of the river. Therefore, it seems unlikely that infiltration from the Jemez River would provide the highest fraction of water in this sample. Deep, mineralized water could be a more reasonable source of high-Cl water to the well. Several widely scattered samples from the zone, including samples from wells more than 800 feet deep, show $NO_3$ concentrations of greater than 5 mg/L. These samples fall along the precipitation evaporation trend for $NO_3$ and Cl concentration (fig. 81b) and contain fairly high dissolved-oxygen concentrations, which is consistent with a natural source of $NO_3$ and the relative lack of $NO_3$ reduction.

Samples from a few wells located near the Jemez River were removed from the data set, and, therefore, removed from consideration as part of this hydrochemical zone, because of high specific conductance values and compositions that indicated the samples represented primarily the local infiltration of Jemez River water that had been greatly evapotranspired. Because such samples appeared to represent local processes and occurred infrequently, they also were not combined into a separate hydrochemical zone.

In summary, the chemical composition of water in the Northwestern zone generally is consistent with mountain-front recharge processes, although some samples show evidence of local mixing with infiltration from the Jemez River. Compared with adjacent hydrochemical zones, the enriched $^2H$ content of most ground water in the zone indicates that recharge occurred at relatively low altitudes along the Jemez Mountains. In addition, the presence of relatively high concentrations of some minor elements indicates that ground water of this zone may have contacted geothermally altered rocks in the area of the Jemez Mountains during or subsequent to recharge (Bexfield and Plummer, 2002).

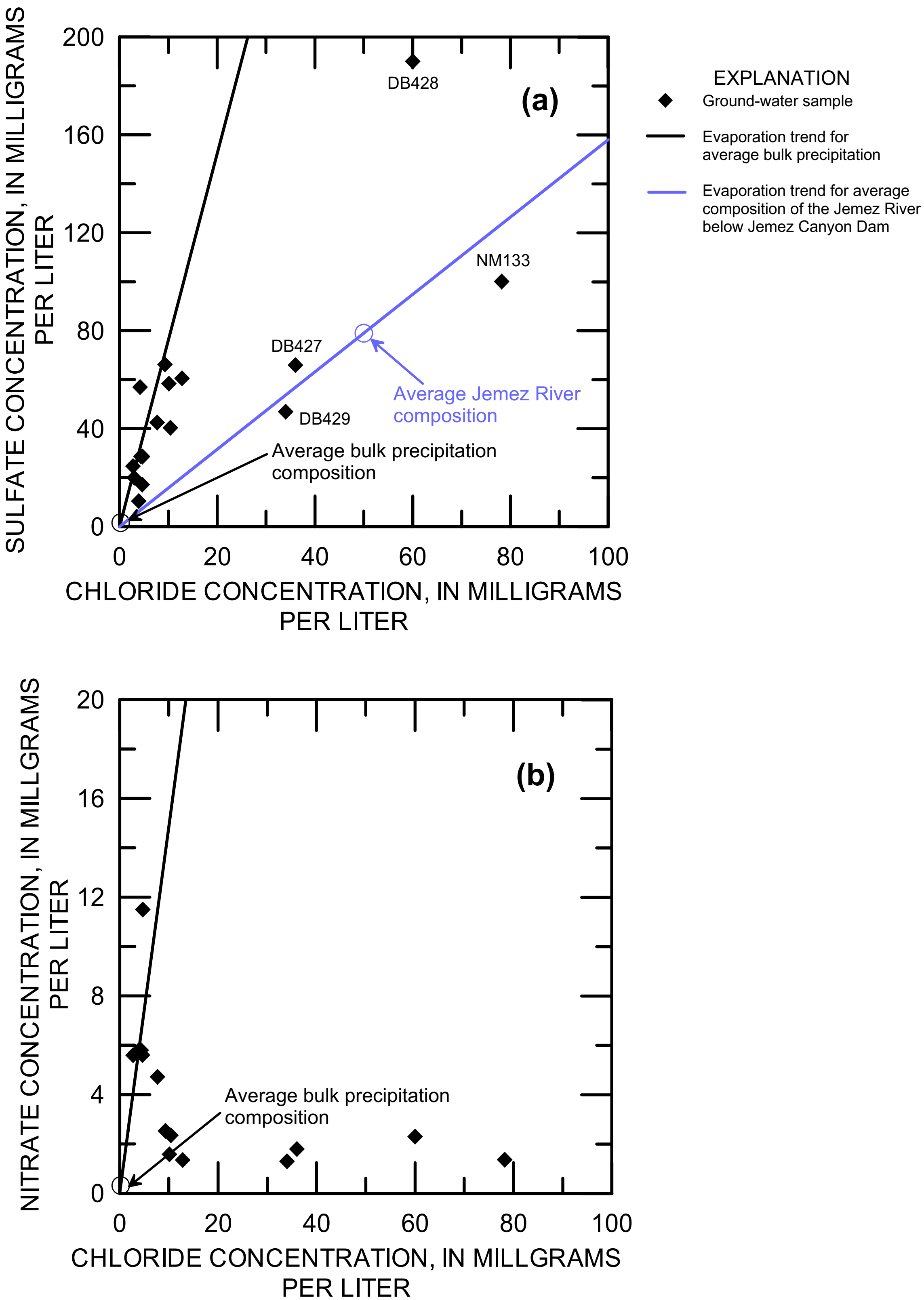



**Figure 81.** Relation of (a) sulfate to chloride and (b) nitrate to chloride concentrations in ground water of the Northwestern zone, Middle Rio Grande Basin, New Mexico, and area precipitation and surface water.

## West-Central Zone

The West-Central zone begins at the base of the Jemez and Nacimiento Mountains (at depth beneath the Northwestern zone) in the northwestern part of the MRGB (fig. 78). The West-Central zone extends south through much of the western portion of the basin between the Rio Puerco and the Rio Grande until it ends at the Rio Grande south of Belen. In some areas, the zone may also extend eastward under the Rio Grande to the east side of the basin at depth, but its full extent is unclear (fig. 78). Potential sources of ground-water recharge to the zone include mountain-front recharge processes and possibly ground-water inflow from north of the basin. Based on the extent of this zone as defined by water chemistry, ground water of the zone probably discharges to the Rio Grande at its southern end and may mix with water of the Central zone along its eastern boundary and with water of the Rio Puerco zone along its western boundary.

Ground water of the West-Central zone typically has moderate specific conductance relative to other zones (table 8). Ca, Mg, and Sr concentrations are low, whereas pH values and As and V concentrations are high. Compared to other zones, concentrations of Na and Mo also are relatively high. The dominant water type is Na + K / $CO_3$ + $HCO_3$ (fig. 79), although Na + K / mixed-anion and Na + K / $SO_4$ water types also are common. The median deuterium content and carbon-14 activity are –96.7 per mil and 8.8 pmC, respectively. The limited data as a function of depth along the northern margin of the basin indicate that ground water of the West-Central zone extends under ground water of the Northwestern zone at depth, and may extend under parts of the Northern Mountain Front and Central zones. The Mann-Whitney test indicates that ground water of the West-Central and the adjacent Northwestern zone differs in the median values of 21 water-quality parameters, including 6 major constituents, specific conductance, pH, deuterium content, and carbon-14 activity (table 9).

Ground-water samples from the zone generally plot along the precipitation evaporation trend for $SO_4$ and Cl concentrations (fig. 82), which is consistent

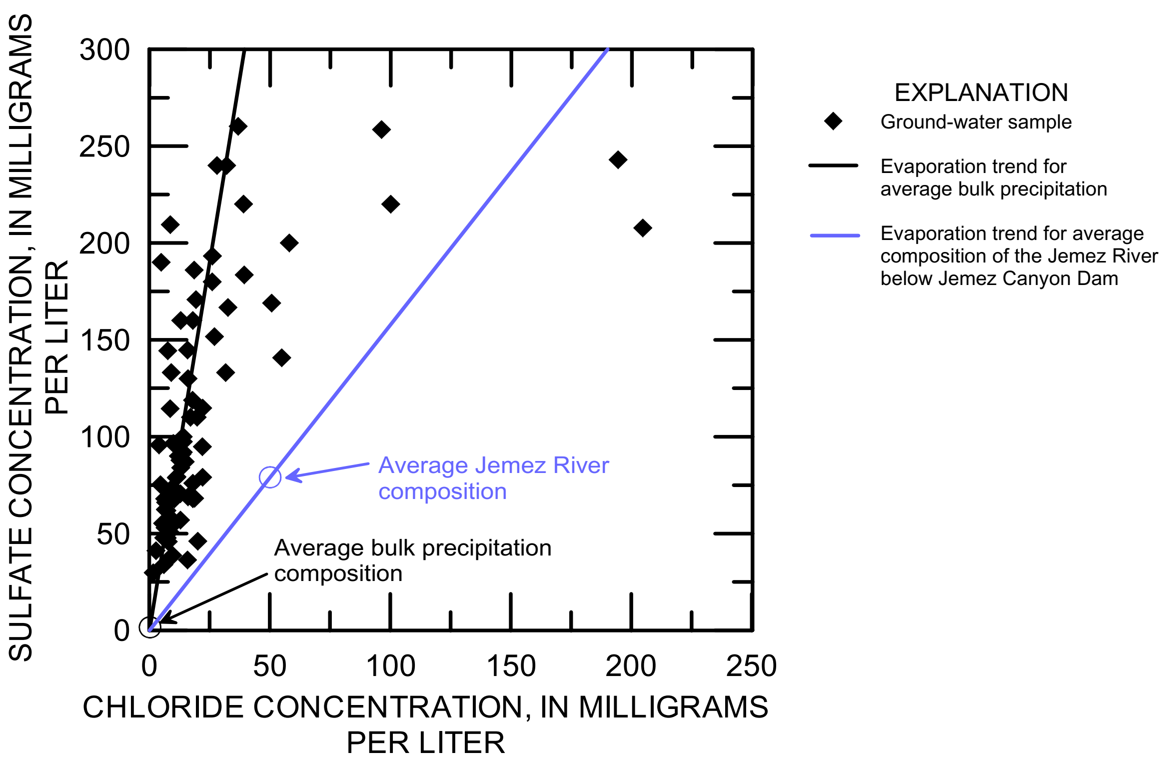



**Figure 82.** Relation of sulfate to chloride concentrations in ground water of the West-Central zone, Middle Rio Grande Basin, Middle Rio Grande Basin, New Mexico, and area precipitation and surface water.

with recharge through infiltration of precipitation or intermittent streamflow in upland areas. Only a low percentage of samples show substantial “excess” $SO_4$ or Cl. These sampling sites are scattered across the zone and may indicate localized mixing with deep, mineralized water. Based on the Cl concentration of precipitation, most ground-water samples in the zone appear to have been concentrated between about 8- and 270-fold during recharge.

The major-element composition of most ground-water samples from the West-Central zone indicate that the primary source of water is the infiltration of precipitation in or near the Jemez Mountains, either directly or as intermittent streamflow. The depleted $^{2}H$ content of most samples indicates that recharge occurred at high altitude and/or during a time when the local climate was colder than today. Also, the generally low carbon-14 activity, along with the observation that West-Central zone water is present at depth beneath the adjacent Northwestern zone water, indicates that recharge to this zone may occur farther north than recharge to the Northwestern zone and generally travel longer, deeper flow paths into the basin. High-altitude parts of the Jemez Mountains appear to be the most likely recharge area that could explain depleted $^{2}H$ content and long travel times, although the possibility of a recharge area even farther north cannot be completely ruled out. Bexfield and Plummer (2002) concluded that the high concentrations of some trace elements, including As, in the zone were probably the result of contact of local recharge water with geothermally altered rocks and subsequent control by pH-dependent adsorption/desorption processes.

## Western Boundary Zone

The Western Boundary zone extends along much of the western margin of the MRGB. The zone generally extends eastward into the basin to within a few miles of the Rio Puerco and may extend to the Rio Grande at its far southeastern tip (fig. 78). The likely sources of recharge to the zone include ground-water inflow from Mesozoic to Paleozoic rocks west of the basin and local arroyo recharge. Based on the extent of this zone as defined by water chemistry, ground water of the zone probably discharges to the Rio Grande at its southern end and mixes with water of the Rio Puerco zone along its eastern boundary.

Ground water of the Western Boundary zone typically has the highest specific conductance of any zone (table 8). Concentrations of Mg, Na, K, Cl, F, and B are high. Concentrations of Ca, $SO_4$, and Li and alkalinity values are also high relative to most other regions. Concentrations of $SiO_2$, As, and Ba are relatively low. The typical water types are Na + K / Cl and Na + K / mixed-anion (fig. 79). The median deuterium content and carbon-14 activity are –64.4 per mil and 6.2 pmC, respectively.

Ground-water samples from the zone generally plot far to the Cl side of the precipitation evaporation trend for $SO_4$ and Cl concentrations (fig. 83). Only three samples plot close to the evaporation trends for either precipitation or the Rio Puerco (using the discharge-weighted average from historical NWIS data, table 4). The two samples (NM329 and DB036) that plot near the Rio Puerco evaporation trend are from sites located near the basin margin just northwest of the Ladron Mountains and could represent ground-water inflow from different rock types than are present along most of the rest of the western basin boundary. The sample (NM167) that plots closest to the precipitation-evaporation trend is from a site located near the boundary between the Western Boundary and Rio Puerco hydrochemical zones and may represent a mixture of both waters, rather than a water derived from local infiltration of precipitation.

The observation that most samples from the zone plot far to the Cl side of the precipitation and surface-water evaporation trends for $SO_4$ and Cl indicates that some fraction of the ground water is saline water that has been affected by processes other than infiltration and evapotranspiration of local sources. Spring sample NM485 (S009), which shows particularly elevated concentrations of Cl and Na that probably are associated with halite dissolution, along with a low carbon-14 activity and an enriched $^{2}H$ content, likely is representative of the composition of brine leaking into the basin in the area of the Lucero Uplift. (This sample was excluded from the final data set for the MRGB because the spring falls outside of the basin boundary.) Goff and others (1983) also sampled high-Cl ground water in the zone and concluded that the water probably originates at depth in the vicinity of the Comanche fault zone and has dissolved halite, gypsum, limestone, and dolostone. These origins could explain the elevated levels of Li, which replaces Na in small quantities in evaporite minerals such as halite

(Rankama and Sahama, 1950). The study by Goff and others did not find evidence of high-temperature origins for the high concentrations of Cl, Na, and Li.

Because ground-water samples from within the basin generally show substantially lower specific conductance and higher carbon-14 values than water from spring sample NM485, the brine must be mixing with younger, more dilute water from another source as it enters the basin. Goff and others (1983) found evidence of mixing between high-Cl water and dilute surface meteoric water in the zone based on relations between selected constituents. The most likely source for dilute meteoric water probably is infiltration of arroyo flow from runoff because of storm events, although direct infiltration of precipitation also may be possible in areas, or in the past during climatic periods wetter than today. These processes would occur at relatively low altitudes along the western basin margin that would be consistent with the observed deuterium contents of the ground water. Calculations using the Cl concentrations from NM485 and Sevilleta bulk precipitation indicate that the Cl concentration at site S074 (fig. 11a; sample NM285, table A2) would result from a mixture of about 11-percent brine with about 89-percent precipitation, assuming no other sources or sinks for Cl. These calculations indicate that the quantity of brine leaking into the basin along the western boundary is likely to be substantially lower than the quantity of precipitation entering the aquifer system within the basin. Nevertheless, ground-water samples do not plot along the precipitation evaporation trend because the concentrations of major constituents in the brine are so high that the chemical signature of the brine dominates that of the precipitation.

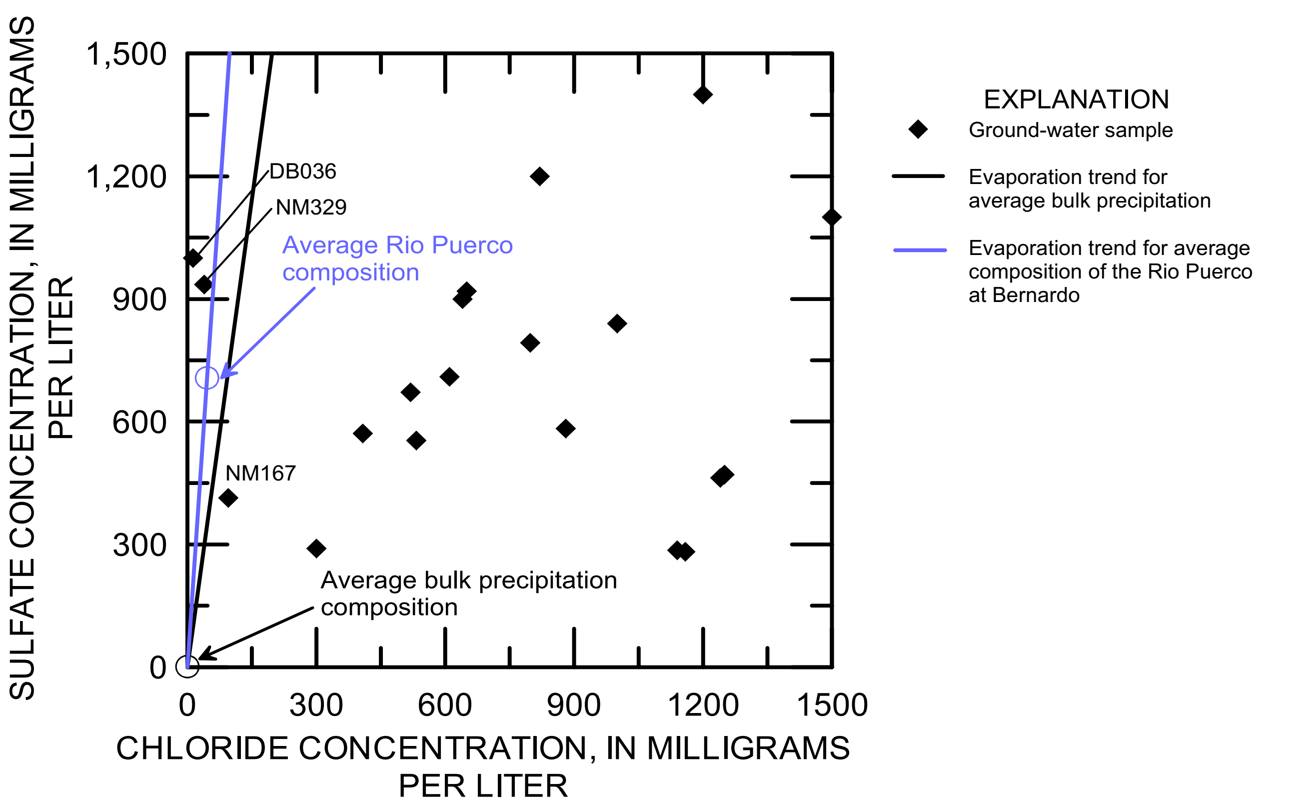



**Figure 83.** Relation of sulfate to chloride concentrations in ground water of the Western Boundary zone, Middle Rio Grande Basin, New Mexico, and area precipitation and surface water.

## Rio Puerco Zone

The Rio Puerco zone stretches along the Rio Puerco throughout its length within the MRGB (from the western boundary of the basin to the Rio Grande) and generally extends for a few miles east and west of the river (fig. 78). Possible sources of recharge to the zone include infiltration from the Rio Puerco and ground-water inflow from Mesozoic and/or Paleozoic rocks along the western margin of the basin. Based on the extent of this zone as defined by water chemistry, ground water of the zone probably discharges to the Rio Grande in the southern part of the basin, and possibly mixes with some water of the West-Central zone along its eastern boundary.

Ground water of the Rio Puerco zone typically has the second-highest specific conductance of any zone (table 8). Concentrations of $SO_4$ and Sr are high. Concentrations of Ca, Mg, Na, K, Cl, Br, Li, and U also are relatively high compared to most other zones. Concentrations of $SiO_2$, As, Ba, and V are relatively low. The dominant water types are mixed-cation / and Na + K / $SO_4$ (fig. 79). The median deuterium content and carbon-14 activity are –61.6 per mil and 36.4 pmC, respectively. The Mann-Whitney test indicates that ground water of the Rio Puerco and the adjacent West-Central zone differs in the median values of 23 water-quality parameters, including 7 major constituents, specific conductance, pH, deuterium content, and carbon-14 activity (table 9). The test indicates that ground water of the Western Boundary and the Rio Puerco zone differs in the median values of 9 water-quality parameters, including 5 major constituents, specific conductance, carbon-13 content, and carbon-14 activity (table 9).

Ground water in the zone shows a wide range of ratios between $SO_4$ and Cl concentrations (fig. 84). Some samples fall along the evaporation trend for the Rio Puerco (using the discharge-weighted average from historical NWIS data) (table 4), whereas others fall near the precipitation evaporation trend, or even to the right of both evaporation trends (toward the Cl axis). Samples from the Rio Puerco zone that are farthest right of the evaporation trends approach the composition of samples from the Western Boundary zone. This range of ratios between $SO_4$ and Cl concen-

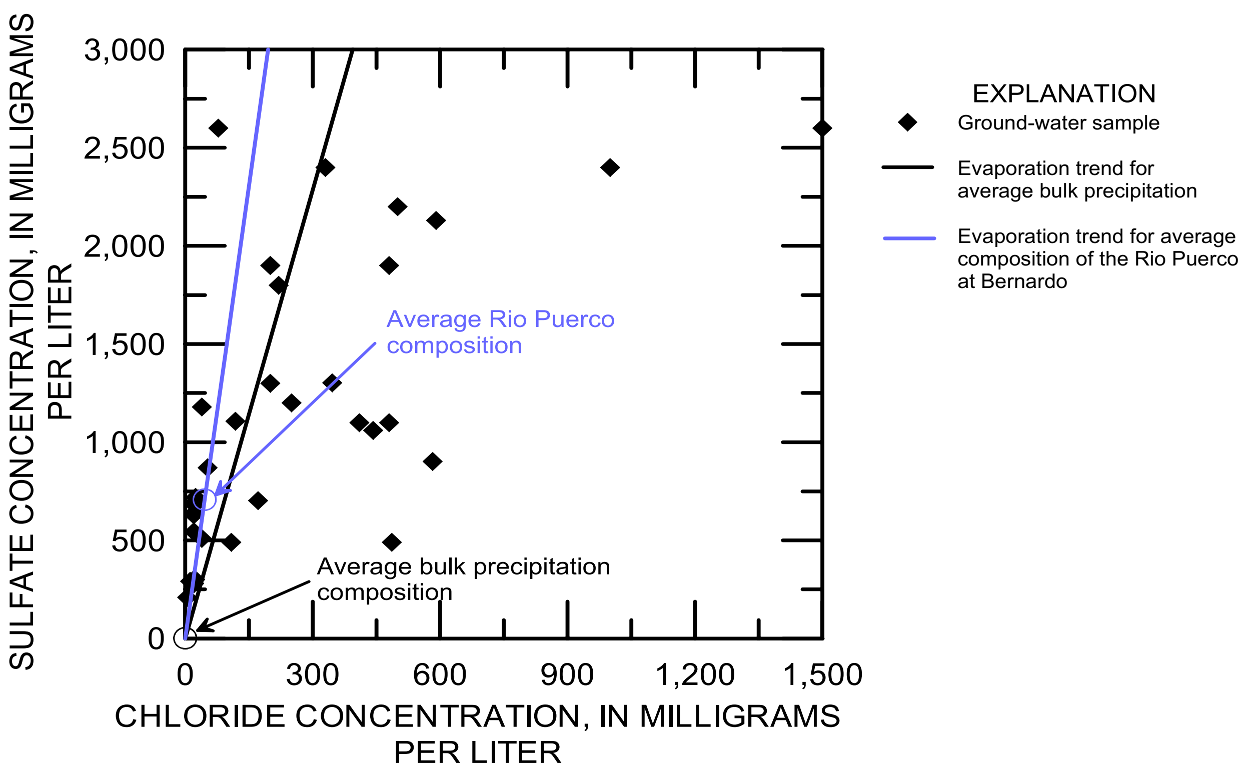



**Figure 84.** Relation of sulfate to chloride concentrations in ground water of the Rio Puerco zone, Middle Rio Grande Basin, New Mexico, and area precipitation and surface water.

trations for water in the Rio Puerco zone may represent a mixing continuum between surface water infiltrating from the Rio Puerco (or ground water leaking from the same rock types drained by the Rio Puerco) and water from the Western Boundary zone. Water samples that fall near the precipitation evaporation trend, then, probably would represent intermediate mixtures of Rio Puerco zone and Western Boundary zone waters rather than ground water closely associated with the infiltration of precipitation.

Several samples that fall near the Rio Puerco evaporation trend for $SO_4$ and Cl concentrations have lower concentrations of both constituents than the discharge-weighted average concentrations calculated for the Rio Puerco. This observation could indicate that more infiltration occurs during higher flows of the Rio Puerco when the water is more dilute, or that the composition of the Rio Puerco has changed somewhat through time. Alternatively, these samples could represent the inflow of ground water from Mesozoic rocks along the northwestern border of the basin. This inflow would come from rock types similar to those drained by the Rio Puerco, but could be more dilute than the surface water in the river because of less evapotranspiration. Goff and others (1983) sampled similar ground waters of high $SO_4$ relative to Cl in the area of the Lucero uplift, particularly west and northwest of the Lucero monocline. They proposed that these waters are of low-temperature origin and are dissolving gypsum, limestone, dolostone, and evaporite minerals (not including substantial amounts of halite). However, the generally higher carbon-14 activities in ground water from the Rio Puerco zone as compared to the Western Boundary zone are consistent with a greater component of younger water, such as infiltration through the arroyo, rather than just a greater contribution of old ground water of different composition.

## Southwestern Mountain Front Zone

The Southwestern Mountain Front zone, which is defined by only two samples (S022 and DB027, figs. 11a and 17a), extends from the base of the Ladron Mountains on the south and west to boundaries with other zones a few miles within the basin (fig. 78). Potential sources of recharge to the zone include mountain-front recharge processes along the Ladron Mountains and possibly ground-water inflow along the basin margins. Based on the extent of this zone as defined by water chemistry, ground water of the zone probably mixes with greater quantities of water from the downgradient Western Boundary zone, although some water may discharge to the Rio Grande.

The Southwestern Mountain Front zone is delineated on the basis of only two samples, so that a comparison with the ground-water chemistry of other zones is difficult. The average values of the two samples in the zone (table 8) indicate that specific conductance is moderately low, as are concentrations of Na and K. Concentrations of $SiO_2$, As, U, and V are particularly low, while pH values are quite high. Water types of the two samples are mixed-cation / $CO_3$ + $HCO_3$ and Ca / $CO_3$ + $HCO_3$ (fig. 79). The one sample analyzed for deuterium content and carbon-14 activity had values of –53.5 per mil and 40.0 pmC, respectively. Although the Mann-Whitney test could not be performed between the Southwestern Mountain Front and Western Boundary zones, the difference in chemistry is evident from the values of most chemical parameters.

The two ground-water samples from the Southwestern Mountain Front zone plot quite close to the precipitation evaporation trend for $SO_4$ and Cl concentrations (fig. 85). Therefore, their major-element compositions appear consistent with the infiltration of precipitation or intermittent streamflow along the mountain front. The generally low concentrations of minor elements also support this recharge source, although the single known deuterium content indicates recharge at a relatively low altitude. Based on the Cl concentration of precipitation, the samples appear to have been concentrated about 33- to 110-fold during recharge.

## Eastern Mountain Front Zone

The Eastern Mountain Front zone extends along most of the Sandia, Manzanita, Manzano, and Los Pinos mountain fronts at the eastern boundary of the MRGB (fig. 78). The zone is broken up, however, by the occurrence of other, smaller hydrochemical zones in the areas of Tijeras Arroyo, the Tijeras Fault Zone, and Abo Arroyo. The Eastern Mountain Front zone typically does not stretch all the way from the mountain front to the Rio Grande, except just north of Abo Arroyo. The most likely source of recharge to the zone is mountain-front recharge processes, although ground-water inflow along the eastern basin margin

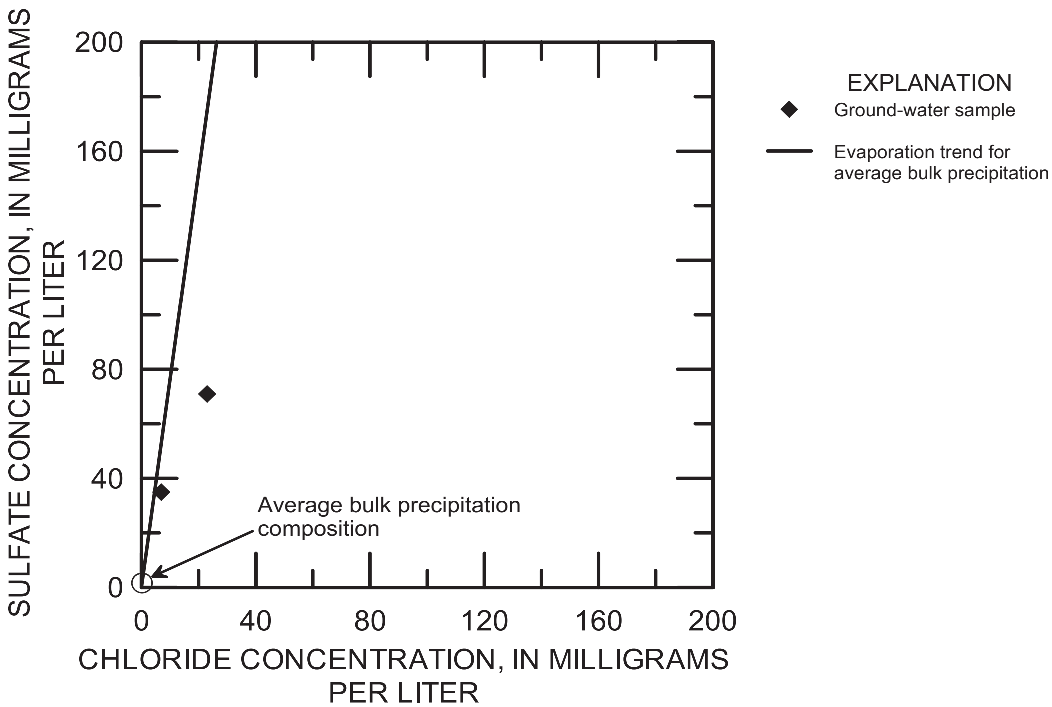



**Figure 85** Relation of sulfate to chloride concentrations in ground water of the Southwestern zone, Middle Rio Grande Basin, New Mexico, and area precipitation.

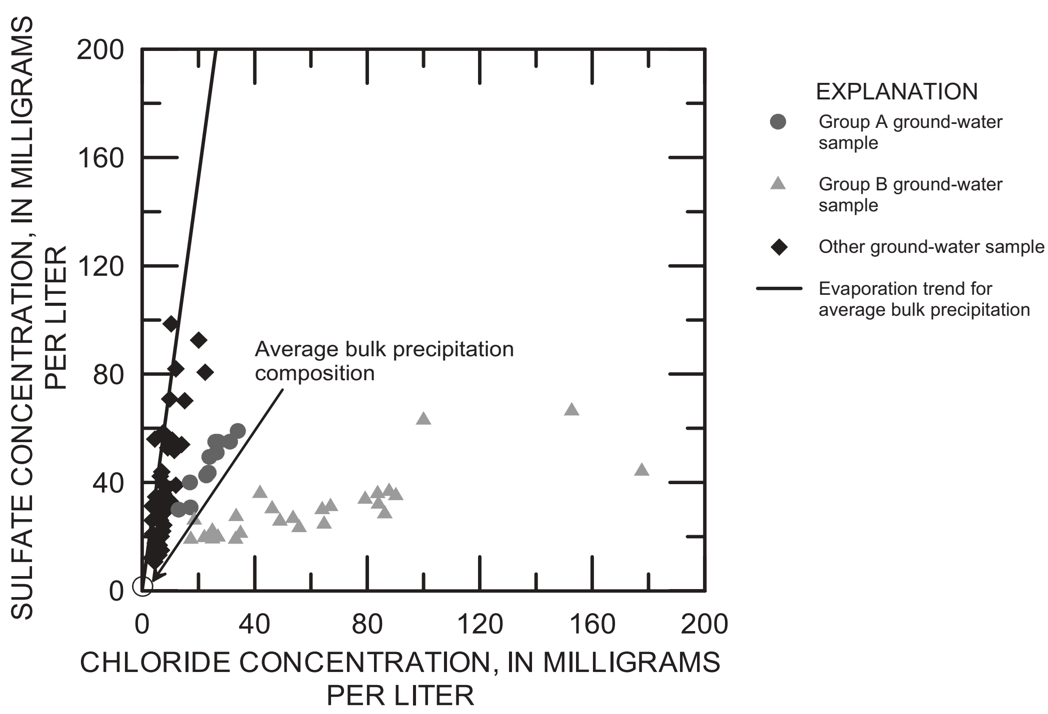



**Figure 86.** Relation of sulfate to chloride concentrations in ground water of the Eastern Mountain Front zone, Middle Rio Grande Basin, New Mexico, and area precipitation.

also may contribute substantial amounts of water. Based on the extent of this zone as defined by water chemistry, ground water of the zone probably discharges to the Rio Grande at its southern end and possibly mixes with water of the Central zone along its western boundary.

Typical ground water of the Eastern Mountain Front zone has the second-lowest conductance of any zone (table 8). Compared to other zones, concentrations of Mg, Na, $SO_4$, Cl, F, $NO_3$, As, B, Li, Mo, and Sr are relatively low; K concentrations are particularly low. Concentrations of Ba are particularly high. The dominant water type is Ca / $CO_3$ + $HCO_3$ (fig. 79). The median deuterium content and carbon-14 activity are -81.0 per mil and 47.2 pmC, respectively.

Many ground-water samples from the zone plot close to the precipitation evaporation trend for $SO_4$ and Cl concentrations (fig. 86). Based on the Cl concentration of precipitation, most of these samples appear to have been concentrated about 16- to 75-fold during recharge. However, several other samples plot in one of two apparent groups that show relatively high amounts of Cl. Samples in Group A of figure 86 are scattered across the entire hydrochemical zone, but samples in Group B are nearly all located in a similar area of Albuquerque (fig. 87a and b). Most Group B samples have previously been discussed by Bexfield and Anderholm (2002a) and Bexfield and Plummer (2002), who conclude that water with elevated Cl flows upward from deeper parts of the aquifer system in this area, either along faults or as the result of a structural high located at the north end of Albuquerque. Mixing with such water also appears to contribute to elevated concentrations of some minor constituents. Logan (1990) suggested that this area of high Cl concentrations could be associated with strong effects of wetting/drying cycles upon infiltration of recharge water through alluvial fans and arroyos. However, the north-south orientation of the area (extending north of the Sandia Mountains), its presence only some distance away from the mountain front, and the persistence of—and increase in—high Cl concentrations with depth in piezometer nests of the area (fig. 59 and table A2) appear to contradict this idea that shallow, mountain-front processes are responsible for the elevated Cl in the area of Group B. Because most of the Group B samples are from sites located along or near major faults in the basin (fig. 87a), upwelling of deep, mineralized water also appears more likely than shallow mountain-front processes to result in elevated Cl concentrations in these samples.

Overall, the major-element composition of most ground water in this zone is consistent with infiltration of precipitation and intermittent streamflow in upland areas. This conclusion is supported by the generally low concentrations of most minor elements, the moderately depleted deuterium contents of most samples, and the high carbon-14 activities near the mountain front.

## Abo Arroyo Zone

The Abo Arroyo zone stretches between the mountain front and the Rio Grande and extends from just north of Abo Arroyo to boundaries with other hydrochemical zones on the south (fig. 78). Possible sources of recharge to the area include the infiltration of surface water through Abo Arroyo, ground-water inflow from the Abo Arroyo watershed upstream of the MRGB boundary, and mountain-front recharge processes. Based on the extent of this zone as defined by water chemistry, ground water of the zone probably discharges to the Rio Grande in some areas and mixes with, or possibly evolves to, water of the Discharge zone in other areas.

Ground water of the Abo Arroyo zone typically has a moderately high specific conductance (table 8). Compared to other zones, concentrations of K, Ba, and Li are relatively low, whereas concentrations of Mg, $SO_4$, and $NO_3$ are relatively high. The typical water type is mixed-cation / $SO_4$ (fig. 79). The median deuterium content and carbon-14 activity are -65.2 per mil and 24.1 pmC, respectively. The Mann-Whitney test indicates that ground water of the Abo Arroyo and the adjacent Eastern Mountain Front zone differs in the median values of 14 water-quality parameters, including 6 major constituents, specific conductance, and deuterium and carbon-13 contents (table 9).

Sulfate and Cl concentrations for ground-water samples from the Abo Arroyo zone were plotted against evaporation trends for precipitation and for surface water from Abo Arroyo (fig. 88). The surface-water composition used for figure 88 was that of one of the two surface-water samples collected from Abo Arroyo specifically for the MRGB study (table B2). Although this composition does not represent a long-term average, it probably is a reasonable estimate of a typical composition for comparison purposes. The

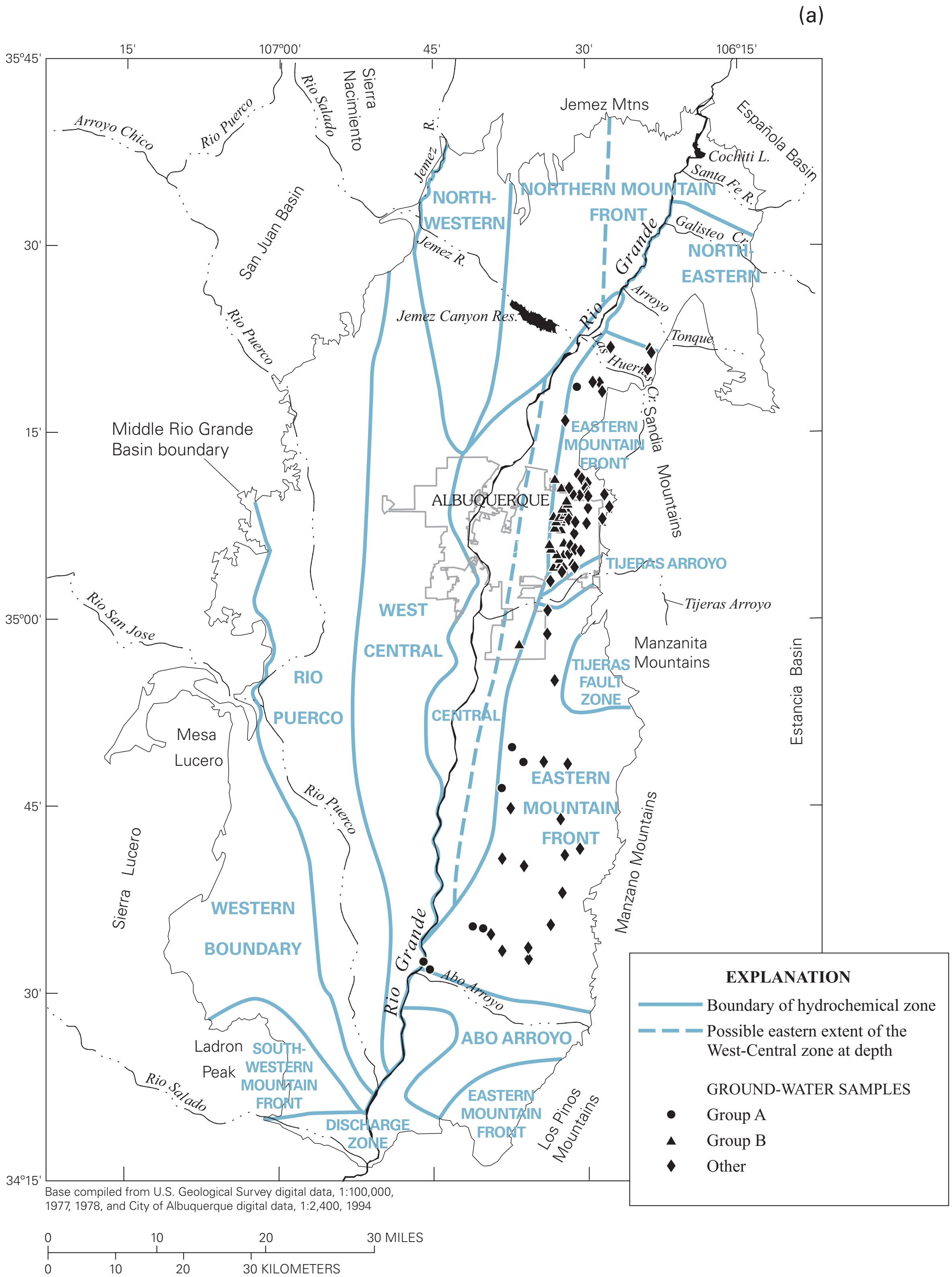



**Figure 87a.** Ground-water samples of the Eastern Mountain Front zone, Middle Rio Grande Basin, New Mexico, outside the Albuquerque area. See figure 86 for definitions of Groups A, B and Other.

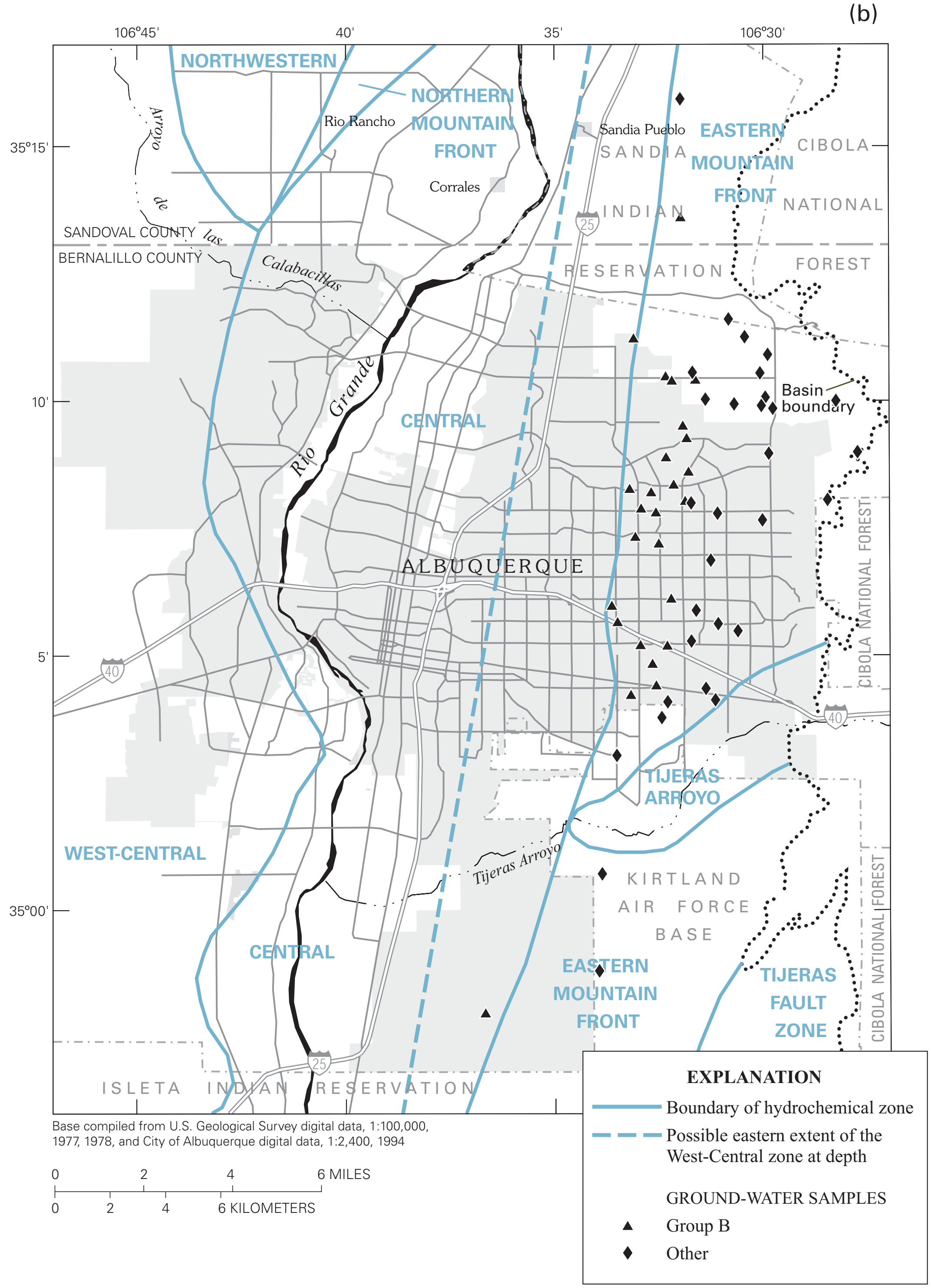



**Figure 87b** Ground-water samples of the Eastern Mountain Front zone, Middle Rio Grande Basin, New Mexico,inside the Albuquerque area. See figure 86 for definitions of Groups B and Other.

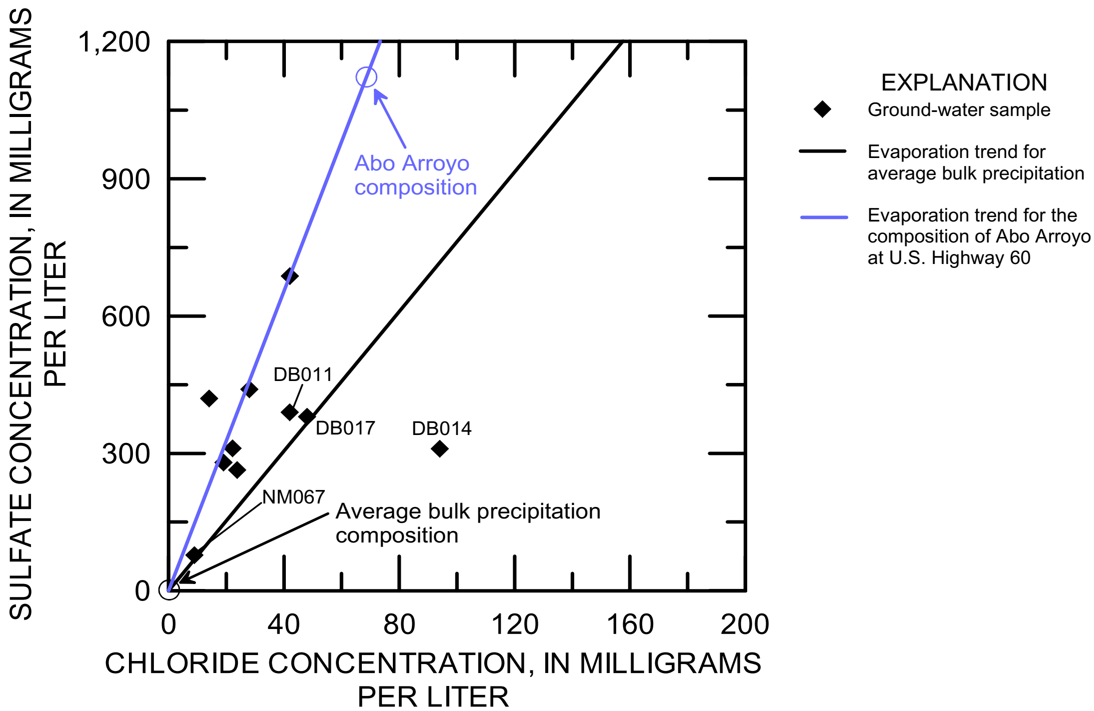



**Figure 88.** Relation of sulfate to chloride concentrations in ground water of the Abo Arroyo zone, Middle Rio Grande Basin, New Mexico, and area precipitation and surface water.

sample shows the dominance of $SO_4$ over Cl in water from the arroyo, which drains gypsum-containing Paleozoic rocks above the basin. Most of the ground-water samples of the zone fall fairly close to the evaporation trend for Abo Arroyo and have deuterium contents that are consistent with infiltration through the arroyo as an important recharge source. All of these samples are more dilute than the compositions observed in Abo Arroyo, which indicates that recharge along the arroyo is most likely to occur during runoff events associated with summer storms. This conclusion is the same reached by Anderholm (2001), who studied Cl concentrations in the area. One sample (NM067) from a well located close to the Rio Grande (where Abo Arroyo contains water only after very heavy storm events) is especially dilute and plots close to the precipitation evaporation trend. This sample probably represents a mixture of dilute water of a mountain-front recharge source with a very low amount of recharge from Abo Arroyo. Three other samples (DB011, DB014, and DB017) also show a higher concentration of Cl relative to $SO_4$ than would be expected from recharge through Abo Arroyo. All three samples are from wells located in the southern part of the Abo Arroyo zone, in an area of transition to the Discharge zone (which has elevated Cl relative to $SO_4$), and probably represent mixtures between water from these two zones.

Several ground-water samples that fall near the Abo Arroyo evaporation trend for $SO_4$ and Cl concentrations have lower concentrations of both constituents than either surface-water sample collected for the MRGB study. This observation could indicate that more infiltration commonly occurs when water in the arroyo is more dilute, such as would be expected during high flows. Alternatively, these samples could represent the inflow of ground water from Paleozoic rocks (particularly gypsum) in the Abo Arroyo watershed upstream of the basin. Such inflow could be more dilute than the surface water in the arroyo because of less evapotranspiration. However, the observation that samples from wells more than 10 miles from (and apparently upgradient of) the potential source and path of ground-water inflow appear to contain a fraction of high-$SO_4$ water indicates that the arroyo (in either its present or a past configuration) may be the more likely source.

## Tijeras Fault Zone Zone

The Tijeras Fault Zone zone encompasses a small area extending a few miles into the basin from the eastern mountain front (fig. 78). The northern and western edges of the zone are located near the Tijeras Fault Zone, which is part of a system of northeast-striking, nearly vertical faults that probably have accommodated rift extension (GRAM, Inc. and William Lettis & Associates, Inc., 1995). In the area, faults of this system apparently juxtapose Precambrian granitic rocks and Precambrian greenstone in some places and Precambrian granitic rocks and Pennsylvanian limestone in other places. Investigations have suggested that these faults have the potential to be substantial barriers to the westward flow of ground water, but also may be conduits for flow in some areas (GRAM, Inc. and William Lettis & Associates, Inc., 1995). Potential sources of recharge to this zone include mountain-front recharge processes along the Manzanita Mountains and inflow of deep ground water across the eastern basin margin. Additional ground-water samples from this area, along with more detailed discussion of individual wells and their chemical compositions, can be found in Rust Geotech (1995).

Ground water of the Tijeras Fault Zone zone typically has a relatively high specific conductance (table 8). Compared to other zones, pH values and $SiO_2$ concentrations are relatively low, whereas alkalinity values and concentrations of Ca, Mg, Cl, F, Br, B, Li and U are relatively high. Mixed-cation / $CO_3$ + $HCO_3$ is the most common water type (fig. 79). The median deuterium content and carbon-14 activity are –74.2 per mil and 9.7 pmC, respectively. The Mann-Whitney test indicates that ground water of the Tijeras Fault Zone zone and the adjacent Eastern Mountain Front zone differs in the median values of 22 water-quality parameters, including all 10 major constituents, specific conductance, pH, carbon-13 content, and carbon-14 activity (table 9).

Most of the 6 ground-water samples from the zone do not plot close to the precipitation evaporation trend for Cl and $SO_4$ concentrations (fig. 89). Instead, most samples show a greater proportion of Cl than would be expected from precipitation. Elevated Cl could indicate that these samples include at least a fraction of high-Cl water from deep fracture systems along the Tijeras Fault Zone, which would be consistent with a generally lower carbon-14 activity than ground water in the Eastern Mountain Front zone. The

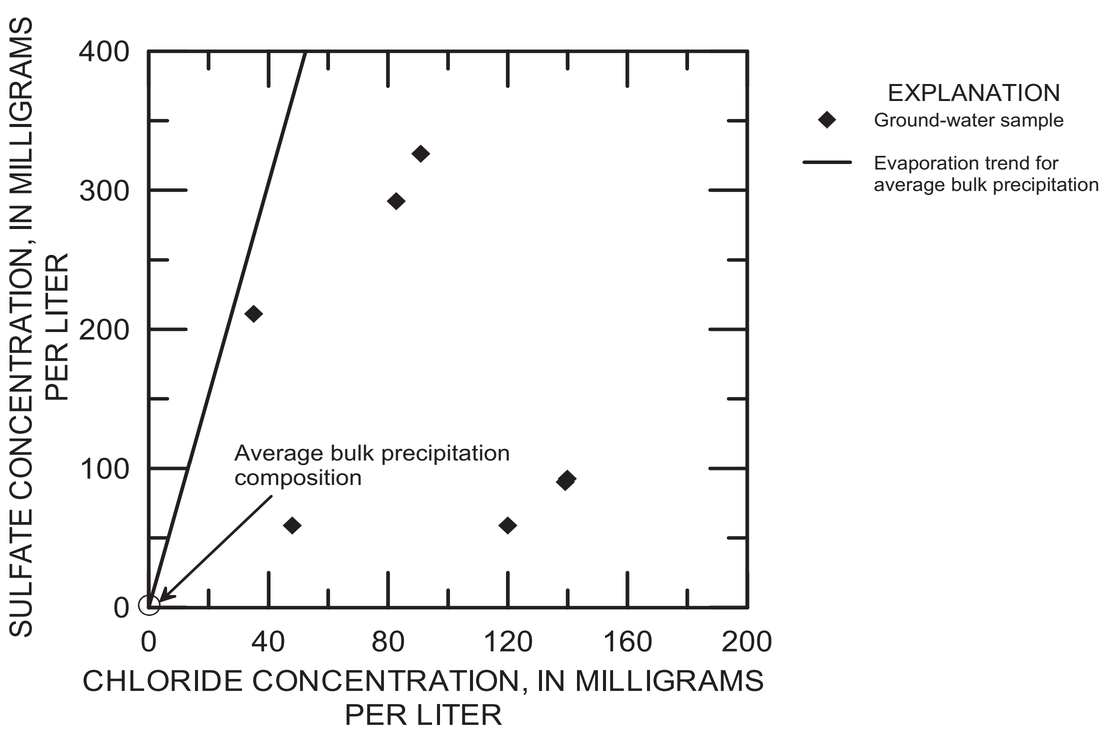



**Figure 89.** Relation of sulfate to chloride concentrations in ground water of the Tijeras Fault Zone zone, Middle Rio Grande Basin, New Mexico, and area precipitation.

fraction of shallow mountain-front recharge water present in the samples in relation to high-Cl is unknown. However, the fraction of dilute mountain-front recharge probably increases downgradient so that the signature of the Tijeras Fault Zone zone water eventually becomes indistinguishable from that of the Eastern Mountain Front zone.

## Tijeras Arroyo Zone

The Tijeras Arroyo zone encompasses a small area stretching along Tijeras Arroyo from where it leaves the mountain front to about 6 miles within the MRGB (fig. 78). Potential sources of recharge to the zone are the infiltration of surface water through the arroyo and ground-water inflow from the Tijeras Arroyo watershed upstream of the basin. Mountain-front recharge processes also are likely to contribute a portion of the water recharging this zone.

Ground water of the Tijeras Arroyo zone typically has a moderate specific conductance (table 8). Compared to other zones, pH values and concentrations of Na, K, $SiO_2$, As, B, Li, Mo, and V are relatively low, whereas alkalinity values and concentrations of dissolved oxygen and $NO_3$ are relatively high. Water types are Ca / $CO_3$ + $HCO_3$ and Ca / mixed-anion (fig. 79). The median deuterium content and carbon-14 activity are –75.7 per mil and 72.8 pmC, respectively. The Mann-Whitney test indicates that ground water of the Tijeras Arroyo and the adjacent Eastern Mountain Front zone differs in the median values of 16 water-quality parameters, including 8 major constituents (table 9). The test also indicates that ground water of the Tijeras Arroyo and nearby Tijeras Fault Zone zone differs in the median values of 15 parameters, including 6 major constituents and carbon-14 activity.

Compositions of ground-water samples from the zone were plotted against evaporation trends for precipitation and Tijeras Arroyo (fig. 90). The composition used for Tijeras Arroyo is the discharge-weighted average calculated from NWIS data (table 4). The plot of $SO_4$ and Cl concentrations indicates that most ground-water samples fall into one of two main groups. Group A is located close to the evaporation trend for precipitation and contains low concentrations of Cl relative to average Tijeras Arroyo water, which

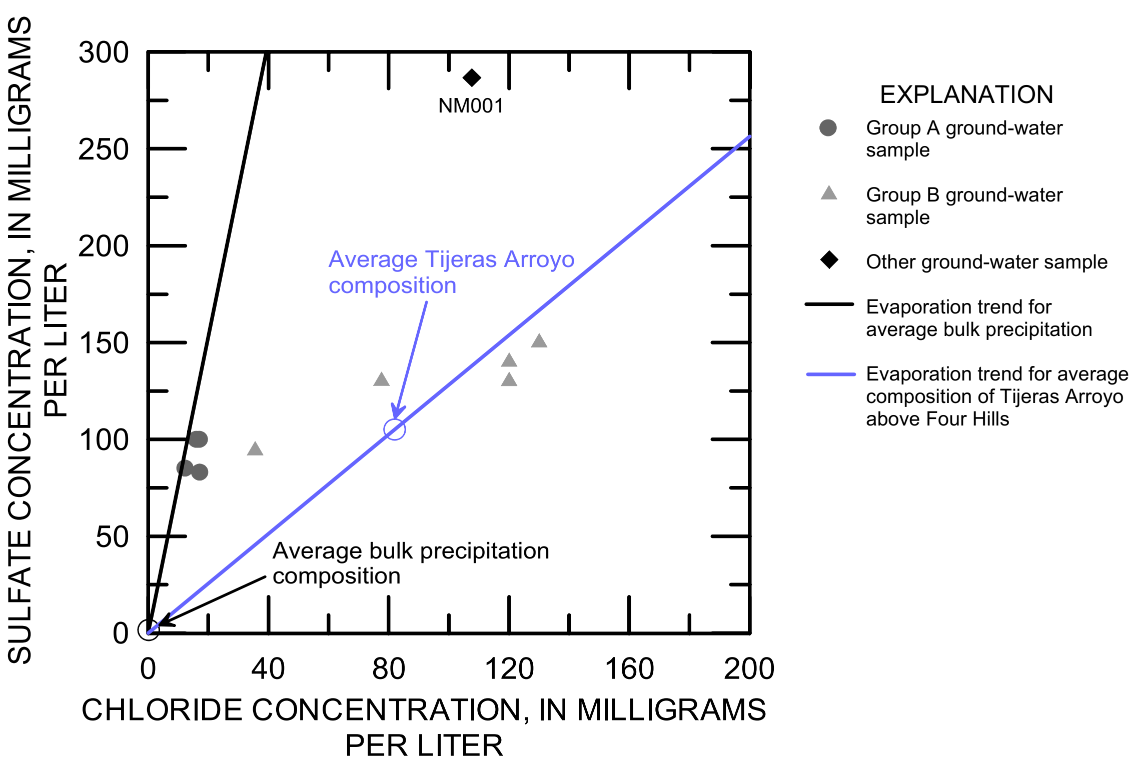



**Figure 90.** Relation of sulfate to chloride concentrations in ground water of the Tijeras Arroyo zone, Middle Rio Grande Basin, New Mexico, and area precipitation and surface water.

would be consistent with a dominant fraction of mountain-front recharge water (fig. 90). Group B is located near the evaporation trend for Tijeras Arroyo and contains Cl concentrations similar to or slightly higher than that of average arroyo water, which would be consistent with a dominant fraction of arroyo recharge (fig. 90). Group B samples also tend to have higher carbon-14 activities. The sampling sites of Group B generally are located closer to the mouth of Tijeras Arroyo (fig. 91), where flow is perennial, and would be likely to receive a higher fraction of young water from arroyo infiltration than Group A waters would receive. One sample (NM001) does not appear to belong to either group. Because the well (S001) is located near the mouth of Tijeras Arroyo, the sample composition would be expected to fall among those of Group B, but the $SO_4$ concentration relative to Cl is unusually high. The source of the excess $SO_4$ in this sample is not known. However, it is possible that ground water from the Tijeras Arroyo watershed flows into the MRGB in this area and contains slightly elevated $SO_4$ relative to the arroyo. Alternatively, this sample may represent substantial evapotranspiration of a mixture of arroyo water and runoff from a precipitation event. As the locations of Group A and Group B sample sites indicates, ground water of the Tijeras Arroyo zone probably mixes with a greater quantity of water from the Eastern Mountain Front and/or Central zone downgradient, until the signature of Tijeras Arroyo zone water is no longer distinguishable.

## Northeastern Zone

The Northeastern zone stretches from just north and east of Galisteo Creek to just south and west of Arroyo Tonque, and from the basin boundary to the Rio Grande (fig. 78). Potential sources of recharge to the zone include ground-water inflow from adjacent areas, including the Hagan Embayment, the infiltration of surface water through arroyo channels, and possibly mountain-front recharge processes, particularly in the southern part of the zone. Based on the extent of this zone as defined by water chemistry, ground water of the zone probably discharges to the Rio Grande.

Ground water of the Northeastern zone typically has a relatively high specific conductance (table 8). Compared to other zones, concentrations of F, Ba, and Li are relatively low, whereas alkalinity values and concentrations of Ca, $SO_4$, $SiO_2$, Sr, and U are relatively high. The dominant water types are Ca / $SO_4$ and mixed-cation / $SO_4$ (fig. 79). The median deuterium content and carbon-14 activity are –68.6 per mil and 28.5 pmC, respectively. The Mann-Whitney test indicates that ground water of the Northeastern and the adjacent Eastern Mountain Front zone differs in the median values of 20 water-quality parameters, including 8 major constituents, specific conductance, and deuterium and carbon-13 contents (table 9). The test also indicates that ground water of the Northeast and the adjacent Northern Mountain Front zone differs in the median values of 16 parameters, including 7 major constituents, specific conductance, and deuterium and carbon-13 contents.

Compositions of ground-water samples from the zone were plotted against evaporation trends for precipitation and Galisteo Creek above Galisteo Reservoir (fig. 92). On the graph of $SO_4$ and Cl concentrations, several ground-water samples plot fairly close to the precipitation evaporation trend (labeled Group A in figure 92), but several others have a higher proportion of $SO_4$ than would be expected from precipitation (labeled Group B). Group B samples tend to plot between the evaporation trends for precipitation and Galisteo Creek, indicating possible mixing between mountain-front recharge water and surface-water infiltration from local arroyos. One sample (S016; NM258) has a higher proportion of Cl than would be expected from precipitation. This sample is located near an intersection of major faults (figs. 93 and 6) and may be receiving a contribution of high-Cl water upwelling along these faults.

Most samples that plot closest to the precipitation evaporation trend for $SO_4$ and Cl are located in the southern or southeastern parts of the zone, closest to the Sandia mountain front and the Hagan Embayment (fig. 93). These samples may represent ground water that was recharged primarily by mountain-front processes, with $SO_4$ and Cl concentrations that have not been highly altered by rock-water interactions. Sample DB421 may also include some water recharged through the Rio Grande. Compared to the Cl in precipitation, these samples appear to have been concentrated about 50- to 260-fold during recharge. The deuterium contents that are available for these samples are only moderately depleted, indicating that the precipitation that resulted in recharge did not occur at particularly high altitude.

The Group B samples that contain excess $SO_4$ relative to Cl are spread across the rest of the

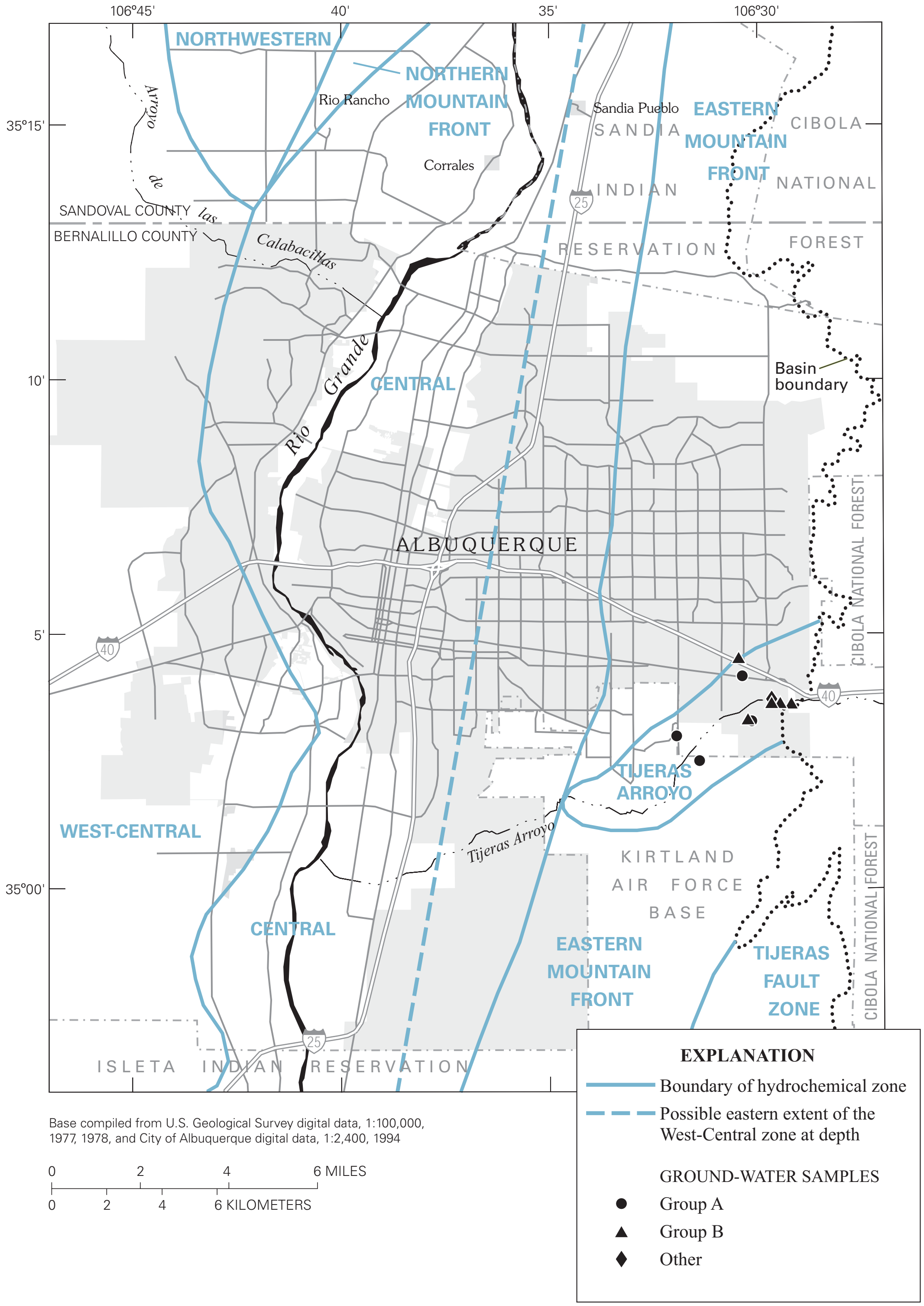



**Figure 91.** Ground-water samples of the Tijeras Arroyo zone, Middle Rio Grande Basin, New Mexico. See figure 90 for definition of Groups A, B, and Other.

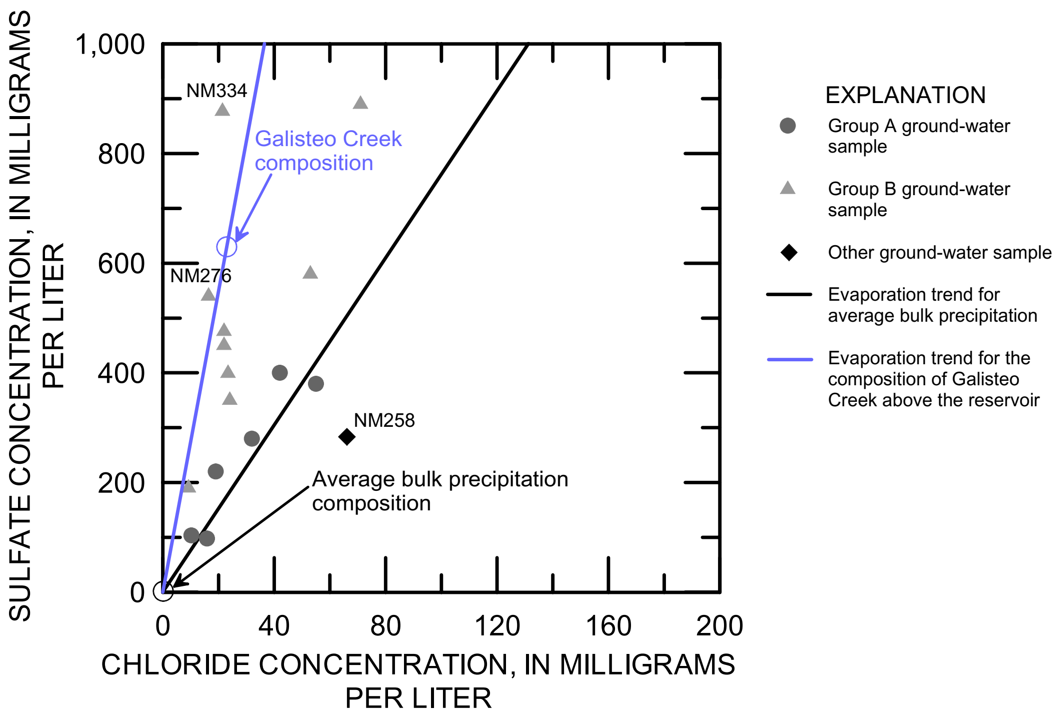



**Figure 92.** Relation of sulfate to chloride concentrations in ground water of the Northeastern zone, Middle Rio Grande Basin, New Mexico and area precipitation and surface water.

ground-water zone (fig. 93). The highest ratio of $SO_4$ to Cl occurs in NM334, which was obtained from a well (S207) located next to Arroyo Tonque. Sample NM276 from a well (S053) located just south of Galisteo Creek also has a relatively high ratio of $SO_4$ to Cl that is consistent with surface water in the creek. Both of these arroyos drain areas that include Mesozoic rocks containing gypsum. Also, both NM334 and NM276 have relatively high carbon-14 activities, indicating that surface water infiltrating through the arroyos of the area probably is the source contributing high concentrations of $SO_4$ to the ground water. Subsurface inflow of ground water that has had contact with gypsum outside the basin also could be occurring along parts of the eastern basin boundary and contributing some high-$SO_4$ recharge to the area. The presence of springs along the eastern basin margin indicates that ground-water inflow probably occurs there.

## Central Zone

The Central zone stretches along the Rio Grande from San Felipe Pueblo (fig. 1) in the north to just north of Abo Arroyo in the south (fig. 78). The zone varies in width from about one to nearly ten miles and generally extends farther away from the river on the east side of the Rio Grande than on the west side. Location alone implies that the Rio Grande is the most likely source of recharge to the zone. The Rio Grande source is strongly supported by the stable isotope data, and geochemical modeling with NETPATH (see the section "Geochemical Mass Transfer Models"). Based on the extent of this zone as defined by water chemistry, ground water of the zone probably discharges back to the Rio Grande.

Ground water of the Central zone typically has a relatively low specific conductance (table 8). Compared to other zones, concentrations of dissolved oxygen, Na, $SO_4$, F, Br, $NO_3$, B, Li, and Sr are relatively low, whereas concentrations of K, $SiO_2$, As, Ba, and V are relatively high. The dominant water types are Ca / $CO_3$ + $HCO_3$ and mixed-cation / $CO_3$ + $HCO_3$ (fig. 79). The median deuterium content and carbon-14 activity are –95.4 per mil and 61.0 pmC, respectively. The Mann-Whitney test indicates that ground water of the Central and the adjacent Eastern Mountain Front zone differs in the median values of 22 water-quality parameters, including 7 major constituents, specific conductance, and deuterium content (table 9). The test indicates that ground water of the

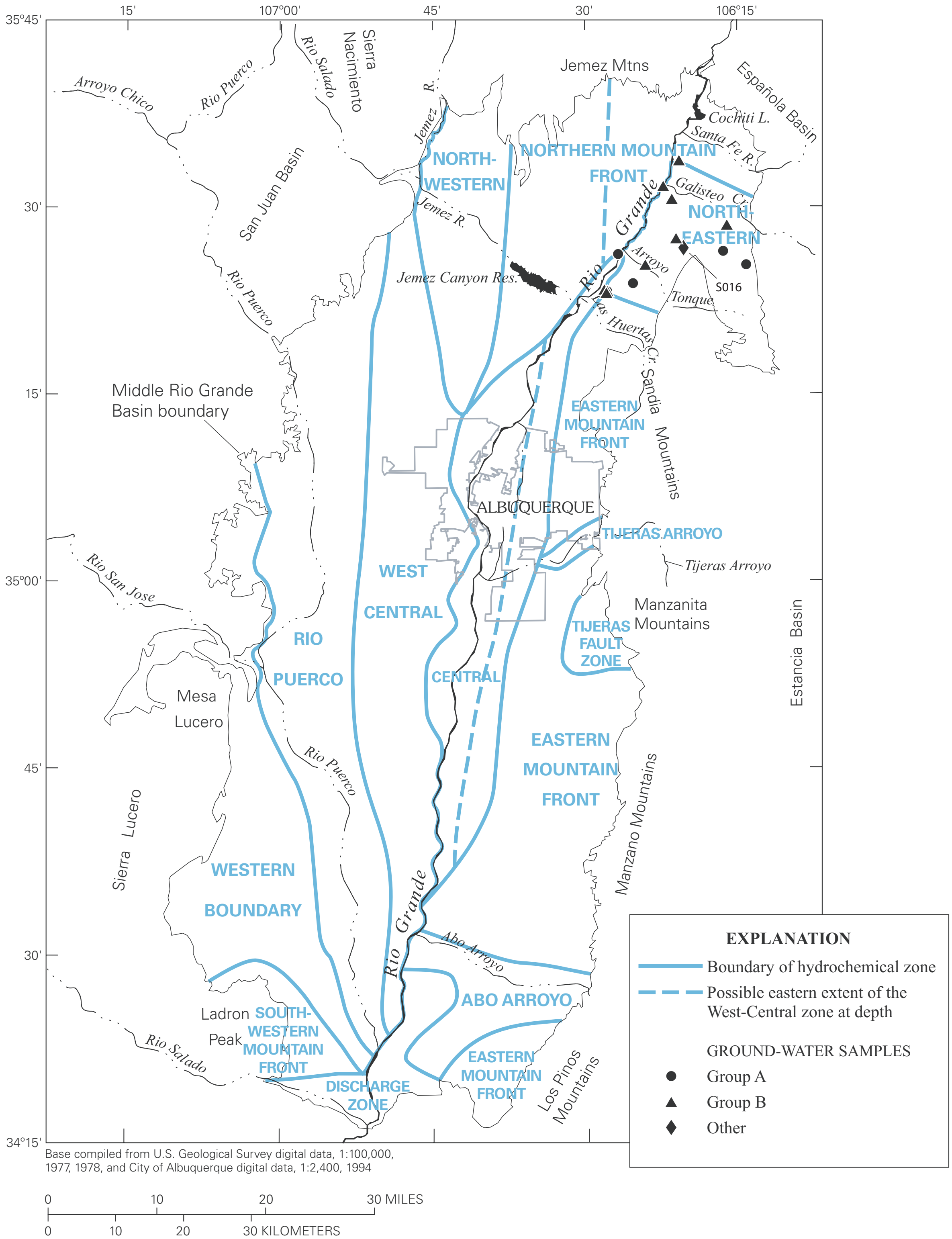



**Figure 93.** Ground-water samples of the Northeastern zone, Middle Rio Grande Basin, New Mexico. See figure 92 for definition of Groups A, B, and Other.

Central zone also differs in the median values of 15 water-quality parameters (including 5 major constituents, specific conductance, and deuterium content) with respect to the Northern Mountain Front zone, and 23 parameters (including 9 major constituents, specific conductance, carbon-13 content, and carbon-14 activity) with respect to the West-Central zone, which are the two other major zones adjacent to the Central zone.

Chemical compositions of ground water from the Central zone were plotted against evaporation trends for precipitation and for the Rio Grande (fig. 94). Discharge-weighted average concentrations from NWIS data were used for the Rio Grande at San Felipe and the Rio Grande at Albuquerque (fig. 17, table 4). Data from the two river sites generally are similar and should provide a reasonable range of potential recharge chemistry for recent river infiltration. The composition of river water may have changed somewhat over the period of time during which the sampled ground water recharged (see the section "Interpretation of Environmental and Climatic Information from Radiocarbon Ages, Stable Isotopes and Dissolved Gases"). Because it is not known how the composition might have changed, the composition of current river water is the most reasonable approximation of the chemistry of past recharge. Furthermore, there are no obvious trends in major-element chemistry of Central-zone waters with radiocarbon age.

The plot of $SO_4$ and Cl concentrations shows that most ground-water samples for the zone fall fairly close to the evaporation trends for both precipitation and the two Rio Grande sites (fig. 94, group B). The evaporation trend for precipitation is actually bracketed by the trends for the two river sites, indicating that the major-element composition of the river is closely related to that of area precipitation and making it difficult to distinguish the primary recharge source from major elements alone. However, the depleted $^2H$ content of ground water in the region, relative to that of Eastern Mountain Front water, indicates that infiltration through the Rio Grande, and not local precipitation, is the primary source of recharge. The conclusion that ground water of the area is derived from infiltration through the river, and not from the recharge of precipitation along the eastern mountain front, is also supported by the relatively high carbon-14 activity of much of the ground water, particularly at shallow depths and near the river. Although several ground-water samples have lower concentrations of Cl

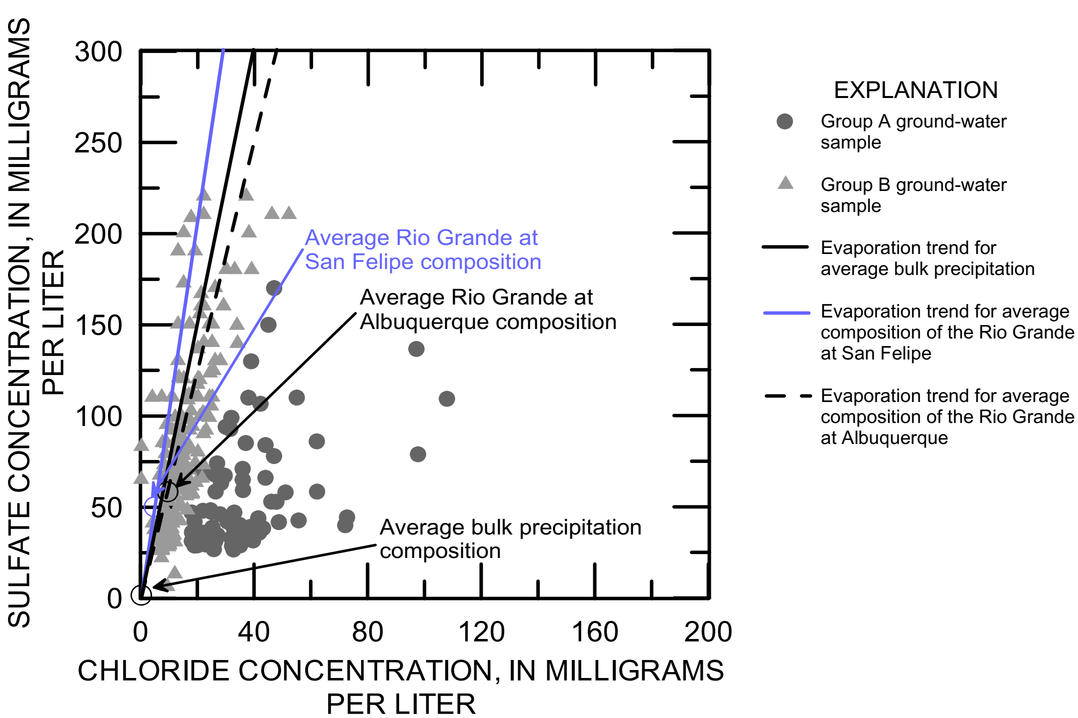



**Figure 94.** Relation of sulfate to chloride concentrations in ground water of the Central zone, Middle Rio Grande Basin, New Mexico, and area precipitation and surface water.

and $SO_4$ than average Rio Grande water at either site, their concentrations almost all fall within the overall range of concentrations observed in individual samples of river water contained in the NWIS database and, therefore, do not eliminate the river as the likely recharge source. The Cl concentrations in most ground water of the zone indicate that typical Rio Grande water is concentrated less than 8-fold during recharge.

Although most ground-water samples in the zone fall near the river evaporations trends for $SO_4$ and Cl, many others show excess Cl (Group A). These wells are located primarily in areas previously identified by Bexfield and Anderholm (2002a) and Bexfield and Plummer (2002) as having unusual chemical compositions, probably because of mixing with upwelling mineralized water from deeper parts of the aquifer system. These areas include the eastern margin of the zone through Albuquerque and an area just north and west of Kirtland Air Force Base (fig. 95). Only a low fraction of high-Cl water would be required to account for most of the Cl concentrations observed. As discussed for high-Cl wells in the Eastern Mountain Front zone, no other likely sources of additional Cl to the area are known. High-Cl water could be moving upward along faults or as the result of structural highs located both at the north end of Albuquerque and near the southern edge of Kirtland Air Force Base (fig. 5). Bexfield and Plummer (2002) indicate that mixing with high-Cl water or with ground water from the West-Central zone are the primary sources of locally elevated concentrations of As, and possibly other minor elements, in ground water of the Central zone.

## Discharge Zone

The Discharge zone is located at the southern tip of the MRGB and extends for several miles both east and west of the Rio Grande (fig. 78). Ground-water flow from the MRGB to the Socorro Basin to the south is restricted to a relatively small cross-sectional area at the “San Acacia constriction”, where the eastern and western structural boundaries of the basin converge (Thorn and others, 1993). Possible sources of water to the Discharge zone include several of the upgradient hydrochemical zones, including the Southwestern, Western Boundary, Rio Puerco, Central, Eastern Mountain Front, and Abo Arroyo zones. Ground water of the Discharge zone probably discharges to the Rio Grande or to the Socorro Basin to the south.

Ground water of the Discharge zone typically has a relatively high specific conductance (table 8). Compared to other zones, concentrations of dissolved oxygen and $NO_3$ are relatively low, whereas concentrations of Na, K, Cl, F, Br, $SiO_2$, As, B, Li, Mo, and Sr are relatively high. Water types vary, but anions tend to be mixed or dominated by Cl (fig. 79). The median deuterium content and carbon-14 activity are -90.8 per mil and 10.8 pmC, respectively. The Mann-Whitney test was not used to compare median values of water-quality parameters with those in other zones because the Discharge zone contains only 7 samples. However, median values for several parameters, including some major constituents, appear to differ substantially from those of surrounding zones (table 8).

A plot of $SO_4$ and Cl concentrations for ground-water samples from the Discharge zone shows that all samples have substantially more Cl relative to $SO_4$ than would be expected from precipitation (fig. 96). Some samples have even higher Cl to $SO_4$ ratios than most samples from the adjacent Western Boundary zone. Therefore, ground water of the zone appears highly altered by rock-water interactions occurring over a long time period (tens of thousands of years), as supported by generally low carbon-14 activities. Although ground-water compositions suggest that the Western Boundary zone may be the primary contributor of water to the Discharge zone, other factors indicate otherwise. The observations that many samples from the Discharge zone have lower specific conductance than those of the Western Boundary zone and that many are located substantially far north and east of the terminus of the Western Boundary zone suggest that the high-Cl chemical signatures usually are the result of another source. However, none of the other adjacent hydrochemical zones show high-Cl signatures, except in certain cases where mixing with deep, mineralized water is suspected. Therefore, ground water of the Discharge zone could be a mixture of fractions of water from the adjacent hydrochemical zones with fractions of high-Cl water moving upward from deeper parts of the aquifer system. Close to the south end of the MRGB, upward movement of deeper water to allow discharge through the constriction to the Socorro Basin would be expected. Phillips and others (2003) showed that the chloride concentration of water in the Rio Grande increased at the southern end of the MRGB corresponding to inflow of saline ground-water discharge from the basin.

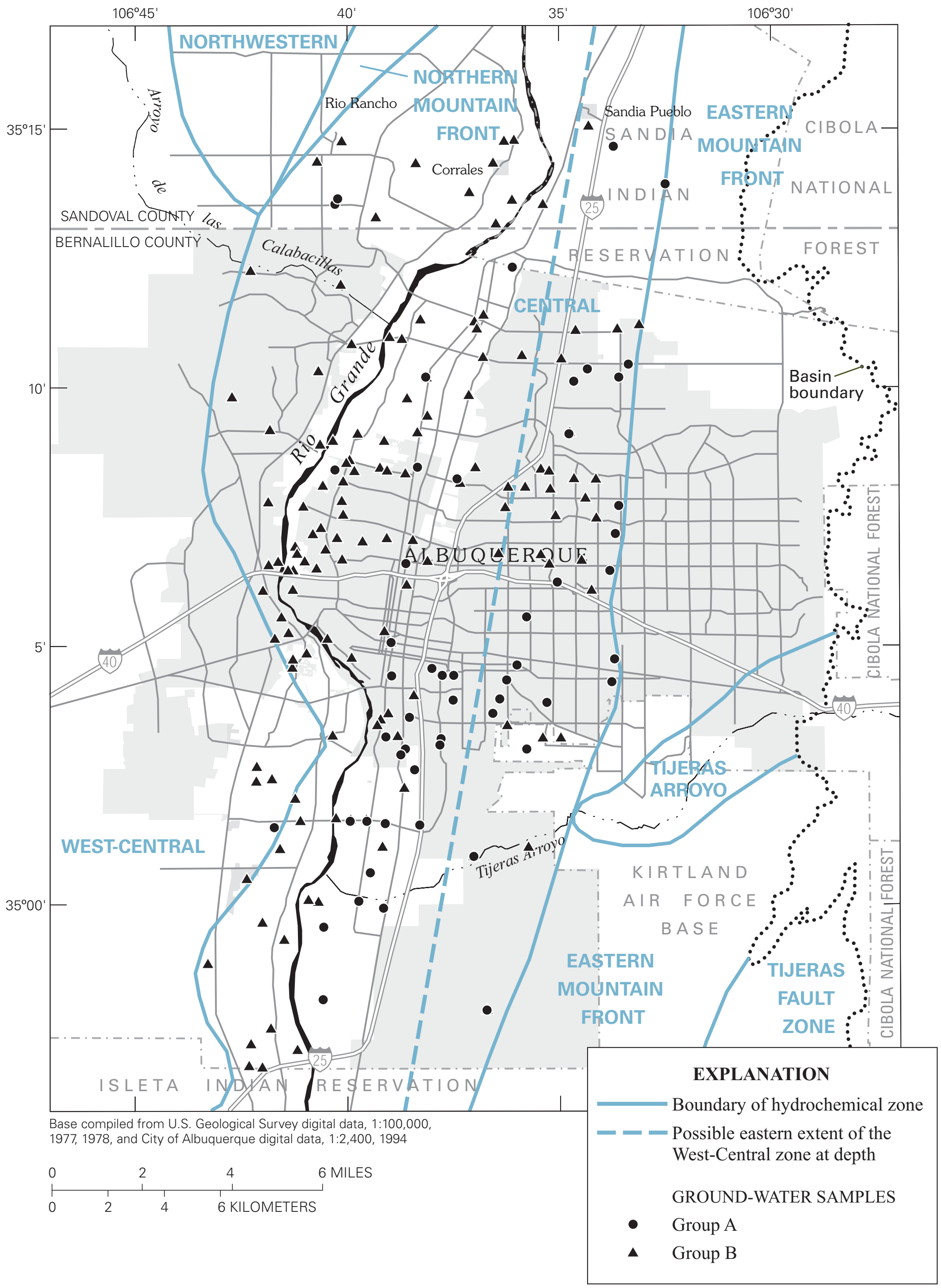



**Figure 95.** Ground-water samples of the Central zone, Middle Rio Grande Basin, New Mexico. See figure 94 for definition of Groups A and B.

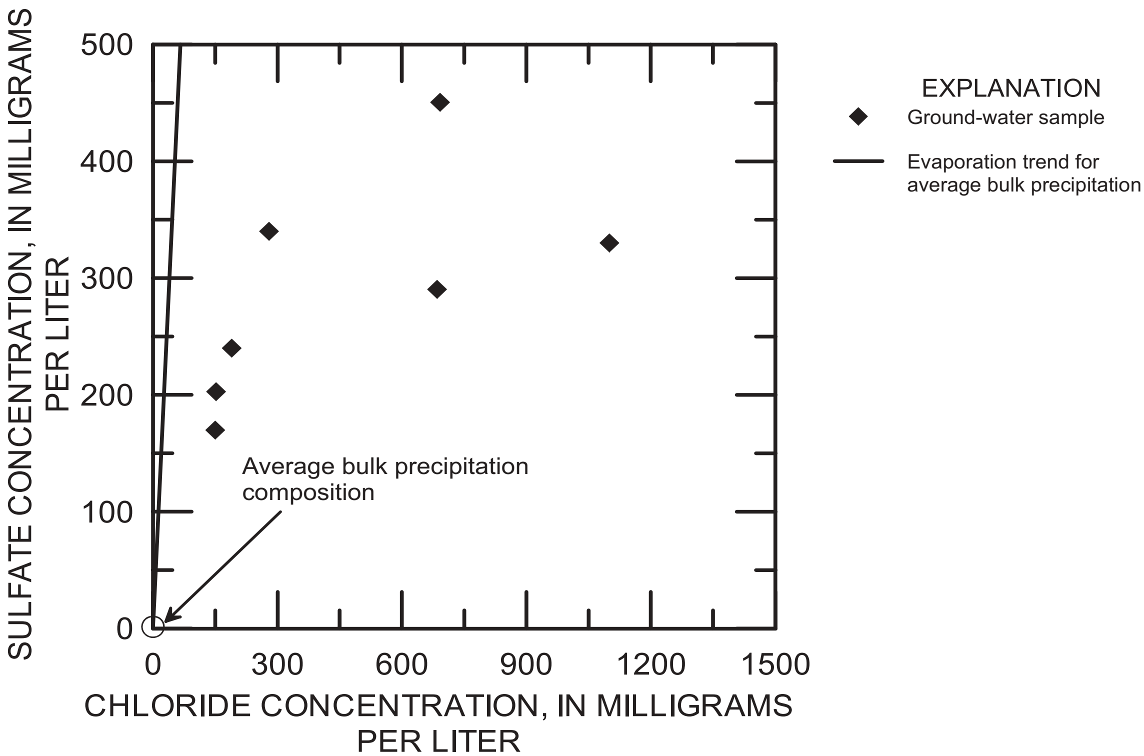



**Figure 96.** Relation of sulfate to chloride concentrations in ground water of the Discharge zone, Middle Rio Grande Basin, New Mexico, and area precipitation.

## INTERPRETATION OF RADIOCARBON AGE OF DISSOLVED INORGANIC CARBON IN GROUND WATER

Radiocarbon dating of DIC in ground water is based on the radioactive decay of $^{14}C$ (half-life 5,730 years). $^{14}C$ is of cosmogenic origin, being produced in the upper atmosphere by the interaction of cosmic rays with atmospheric $^{14}N$. The cosmogenic $^{14}C$ is rapidly oxidized to $^{14}CO_2$ and mixes into the lower atmophere, where it is absorbed by plants during photosynthesis and becomes incorporated into the biologic and hydrologic cycles. Past variations in the solar wind and the geomagnetic fields of the Sun and Earth have caused variations in the flux of cosmic rays reaching the Earth, resulting in variations in the atmospheric concentration of $^{14}CO_2$ (Kalin, 1999). The modern, pre-nuclear detonation atmospheric activity of $^{14}C$ is, by convention, 100 pmC, corresponding to 13.56 disintegrations per minute per gram of carbon in the year A.D. 1950 (Stuiver and Pollach, 1977).

$^{14}C$ is added to ground water during recharge by interaction of infiltrating water with soil $CO_2$ from plant root respiration and microbial degradation of soil organic matter (see for example, Kalin, 1999). Following recharge, the DIC becomes isolated from the modern $^{14}C$ plant-soil gas-air reservoir and decays with time. There are many physical and chemical processes that can affect the $^{14}C$ activity of DIC in ground water beyond that of radioactive decay in the aquifer system that must be considered in order to interpret radioarbon ages and their uncertainties. The most important considerations in radiocarbon dating of the MRGB samples can be grouped under four general topics:

(1) determination of the initial $^{14}C$ activity, $A_o$, of DIC in ground-water recharge, at the point where the infiltrating water is isolated from the modern unsaturated zone $^{14}C$ reservoir,

(2) determination of the extent of geochemical reactions within the aquifer system following recharge and their effect on the initial $^{14}C$ activity,

(3) evaluation of the extent to which old water is mixed with young water in samples pumped from wells, and

(4) correction for historical variations in the atmospheric $^{14}C$ activity, through application of the radiocarbon calibration scale.

These four topics are discussed below.

### Initial Carbon-14 Activity in Recharge Water, $A_o$

In the unsaturated zone, the $CO_2$ partial pressure typically is substantially higher than atmospheric (about $10^{-3.5}$) as a result of biological activity. As infiltrating water moves through the unsaturated zone, it tends to equilibrate with the gas in the unsaturated zone. During infiltration, $CO_2$ in the infiltrating water is augmented by soil-zone $CO_2$. The dissolved $CO_2$ reacts with carbonate and silicate minerals in the recharge area, resulting in increased concentrations of dissolved inorganic carbon (DIC) in the infiltrating water.

The term $A_o$ refers to the initial $^{14}C$ activity of DIC in ground water that occurs following recharge and isolation of the water from the modern $^{14}C$ reservoir of unsaturated-zone $CO_2$. $A_o$ must be known or estimated in order to date the $^{14}C$ of DIC in ground water in hydrologic systems. Many of the waters in recharge areas of the MRGB contain tritium and/or CFCs, which is an indication of the presence of post-1950's water. Water from the post-1950's bomb era has $^{14}C$ activities that are greater than the values that were present historically in the recharge areas, and, if these observed values from recharge areas are used in dating, radiocarbon ages will be biased old.

Several models have been proposed that can be used to estimate $A_o$ values in recharge waters (see for example, Mook, 1972; Wigley and others, 1978; Fontes and Garnier, 1979; Mook, 1980; Fontes, 1990; Plummer and others, 1994; Kalin, 1999). Use of these models requires information about the $^{13}C$ and $^{14}C$ isotopic composition of unsaturated-zone $CO_2$ and carbonate minerals in the recharge area, and the extent to which carbonate minerals react with the infiltrating water. If the pre-1950's recharge water formed in isotopic equilibrium with unsaturated-zone $CO_2$, while reacting with carbonate minerals (for example, calcite, such as occurs in caliche) in the unsaturated zone to chemical and isotopic equilibrium, $A_o$ would be expected to be near 102 pmC, assuming that the $^{14}C$ activity of the unsaturated-zone $CO_2$ was 100 pmC, and the equilibrium fractionation factor for $^{14}C$ between $CO_2$ gas and $HCO_3^-$ is twice the $^{13}C$ equilibrium fractionation factor. In the other extreme, if infiltrating water equilibrates with unsaturated-zone $CO_2$ in the absence of carbonate minerals, and reacts with old, $^{14}C$-free calcite in the saturated zone in isolation from the unsaturated zone $^{14}C$ reservoir, $A_o$ will be near 50 pmC. The first scenario, leading to $A_o$ of 102 pmC, is referred to as "open-system" evolution, and the second scenario, leading to $A_o$ of 50 pmC, represents "closed-system" evolution. There are an unlimited number of intermediate possibilities between the open- and closed-system evolution models, depending on the $^{14}C$ activity of the unsaturated zone carbonate material and the extent to which chemical and isotopic equilibrium are approached during infiltration in the unsaturated zone and in the saturated zone. Unfortunately, there is insufficient chemical and isotopic data to permit accurate modeling of $A_o$ in the MRGB.

In this study, $^{14}C$, $^{3}H$, and CFC data from ground water were used to estimate values of $A_o$ for the waters from the MRGB. $^{14}C$ activities of DIC as a function of CFC-12 and $^{3}H$ activity for all waters from the Northern Mountain Front, Northwestern, West-Central, Eastern Mountain Front, and Central hydrochemical zones, respectively, are compared in figure 97. Water in the Northern Mountain Front, Northwestern, and Eastern Mountain Front zones was probably recharged along mountain fronts that border the basin to the north and east, and water from the West-Central zone may have recharged in high-altitude areas north of the basin. Water from the Central zone originated as seepage from the Rio Grande. Many of the ground-water samples have low $^{14}C$ activities and are likely 10's of thousands of years old, especially those of the West-Central zone (fig. 97). $A_o$ can be inferred, however, as the maximum $^{14}C$ activity in samples with the lowest CFC-12 and/or lowest $^{3}H$ content, as these samples were likely the youngest samples that recharged prior to the bomb era (pre-1952). The maximum $^{14}C$ activity in ground water low in CFC-12 (<20 pg/kg) and low in $^{3}H$ (<0.5 TU) is near 100 pmC, and probably within the range of 95 to 102 pmC (fig. 97), consistent with predominantly open-system evolution. During the past approximately 20 years, the $^{14}C$ activity of atmospheric $CO_2$ has averaged 120 ± 10 pmC in the northern hemisphere (fig. 98). Most of the observed $^{14}C$ activities in samples that contain $^{3}H$ or CFCs are in the range of 95 to 120 pmC, and again consistent with the assumption of open-system evolution (fig. 97). As no samples with $^{14}C$ activities higher than 123 pmC were observed, it is assumed that waters recharged during the mid-1960's and early 1970's (fig. 98) were not sampled in recharge areas, or were mixed and diluted with older water because of well construction when sampled. The $^{14}C$ activity of DIC in two samples of water from the Rio Grande at San Felipe (S304) and Alameda (S300), north of Albuquerque, from June 29, 1996, were 96.1 and 97.1 pmC, respectively. Three other samples from the Rio Grande collected on March 30, 1998 at Albuquerque (sites S300, S301, and S303, table B6) had $^{14}C$ activities of 88.2, 88.9, and 82.9 pmC, respectively. The slightly lower $^{14}C$ activity at S303 (Rio Grande at Rio Bravo) is from an area of discharge from the Albuquerque sewage treatment plant and coincides with an increase in chloride in Rio Grande water that has been attributed to discharge of water from the sewage treatment plant (Phillips and others, 2003). The $^{14}C$ activity of DIC in the source water from the City of Albuquerque production system is typically in the 50-70 pmC range which could account for the somewhat lower $^{14}C$ activity at Rio Bravo. The relatively high $^{14}C$ activity of DIC in the Rio Grande from June 29, 1996 corresponds to a high flow of the river.

In summary, the distribution of $^{14}C$ activities (fig. 97) in both mountain front areas and in recent seepage from the Rio Grande suggests that $A_o$ is likely in the range of 95 to 102 pmC. Throughout this report, a value of $A_o$ equal to 100 pmC is assumed for all waters from the MRGB. The unadjusted radiocarbon ages of this report would be decreased by 400 years if calculated using a value of $A_o$ of 95 pmC instead of 100 pmC, and increased by 150 years if calculated using an $A_o$ value of 102 pmC instead of 100 pmC.

## Geochemical Adjustments to the Radiocarbon Data

Mountain-front recharge (infiltration of precipitation, intermittent stream flow, and subsurface movement of ground water from mountainous areas) is believed to be the primary source of ground water to the Northern Mountain Front, Northwestern, West-Central, Eastern Mountain Front, Southwestern Mountain Front, Abo Arroyo, Tijeras Fault Zone, and Tijeras Arroyo zones. Similar recharge processes likely contribute some water to the aquifer system in the Western Boundary and Northeastern zones, as well. Source rocks in the Jemez Mountain region consist primarily of Cenozoic mafic to silicic volcanic rocks, whereas those in the mountains along the eastern basin margin consist primarily of Precambrian plutonic and metamorphic rocks with some Paleozoic limestone and sandstone (Hawley and Haase, 1992). In the area of Ladron Peak in the southwest, the source rocks consist

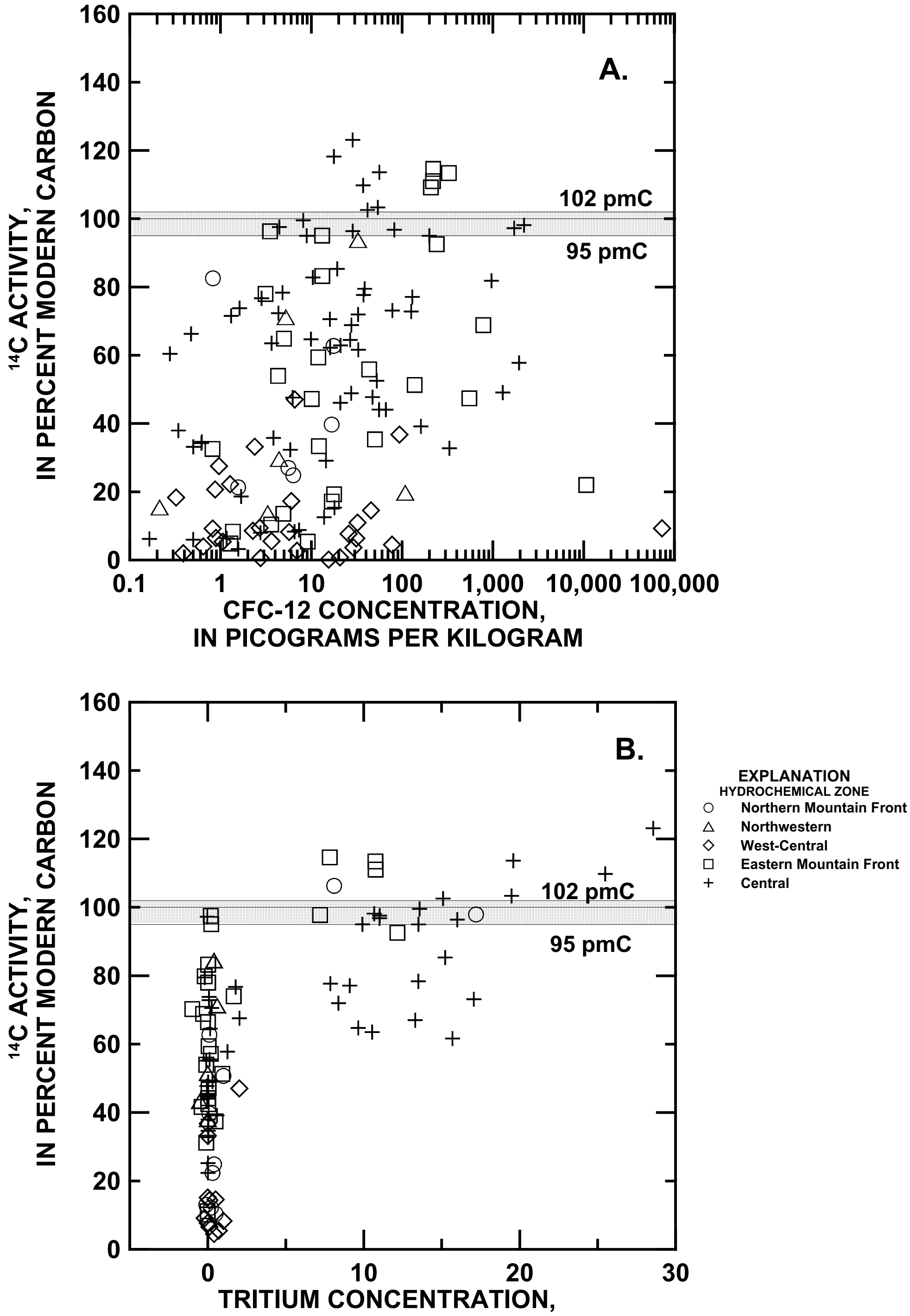



**Figure 97.** $^{14}$C activity in ground water as a function of (A) CFC-12 concentration and (B) tritium concentration, Middle Rio Grande Basin, New Mexico.

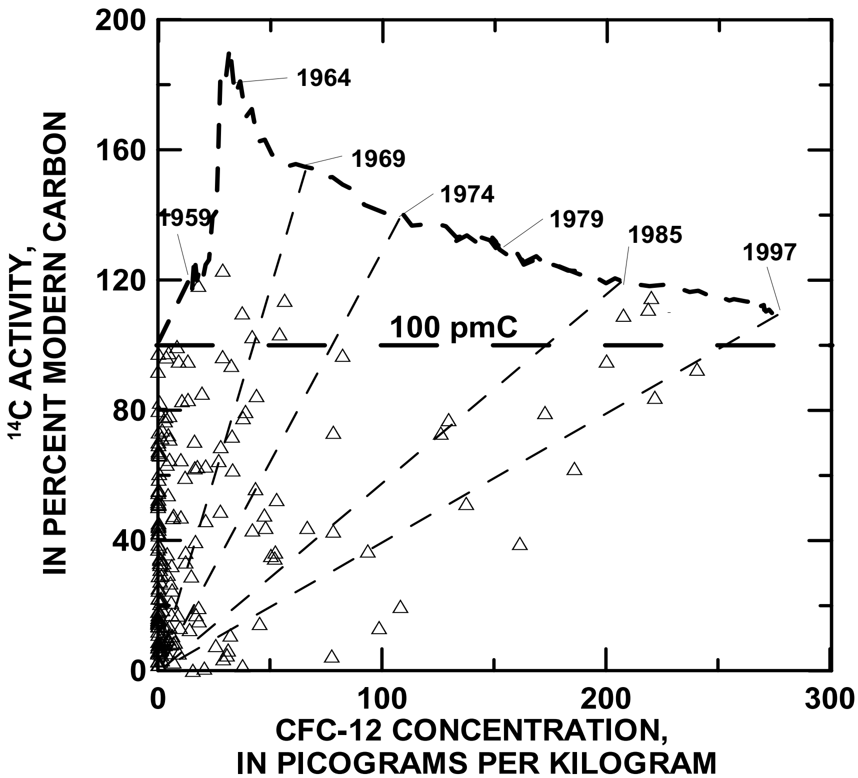



**Figure 98.** $^{14}C$ activities and CFC-12 concentrations measured in ground water from the Middle Rio Grande Basin, New Mexico, in relation to concentrations expected for water in equilibrium with atmospheric values, 1957-97. The dashed lines represent hypothetical mixing of old water with water from 1969, 1974, 1985, and 1997.

primarily of Precambrian granitic and metamorphic rocks and some Paleozoic rocks. In these recharge areas, the expected major processes are evapotranspiration, dissolution of carbonate minerals, and weathering of silicates.

The amount of evapotranspiration resulting as water infiltrates through the soil zone can be estimated by comparing the Cl concentration of ground water in mountain front areas to the Cl concentration assumed for regional bulk precipitation. This method of estimation assumes no other important sources (or sinks) of Cl, which should be a reasonable assumption for most of the mountain front areas of the MRGB, where the source rocks are primarily silicates with essentially no evaporites. Most MRGB and NWIS ground-water samples along the Jemez mountain front tend to have Cl concentrations between about 2.5 and 7.5 mg/L (table 4), as compared to the average concentration of 0.21 mg/L calculated for local bulk precipitation from LTER data collected at Sevilleta National Wildlife Refuge. These values indicate that precipitation was concentrated about 12- to 36-fold during recharge. Along the eastern mountain front, ground-water samples generally have Cl concentrations between about 3.5 and 12.5 mg/L, indicating that precipitation was concentrated about 17- to 60-fold during recharge. The higher Cl concentrations tend to occur from about Abo Arroyo south. Along Ladron Peak, ground-water samples have Cl concentrations of 6.9 and 23 mg/L, indicating concentration by evapotranspiration of about 33- to 110-fold. It is not known whether higher Cl concentrations in the southern part of the basin are the result solely of greater rates of evapotranspiration or are also associated with greater amounts of Paleozoic sedimentary rocks in the recharge areas, which might yield more Cl to recharge water.

Because sediments of the Santa Fe Group aquifer system are derived largely from the surrounding uplands, the mineralogy and chemical processes encountered by water recharging through the streambeds of rivers and arroyos on the basin floor are expected to be similar to those encountered by water recharging near the mountain front. However, the solute concentrations in this water are substantially higher than that of precipitation, and may not encounter unsaturated conditions upon infiltration. Therefore, evaporation during recharge through streambeds may be negligible relative to that occurring in mountain-front areas, and mass transfers associated with water-sediment reactions may be low.

Redox reactions associated with the oxidation of buried organic matter may be important in ground water near rivers, such as in parts of the Central and Rio Puerco zones. Hydrochemical zones that appear to receive substantial recharge through the infiltration of river or arroyo water are the Rio Puerco, Abo Arroyo, Tijeras Arroyo, Northeastern, and Central zones. Surface water in these areas appears to usually be near or at saturation with respect to several silicate and carbonate minerals prior to infiltration. Therefore, the dissolution of large amounts of these minerals upon infiltration is unlikely.

Ground water that flows from adjacent basins into the aquifer system of the MRGB generally has been in extended contact with minerals similar to those present within the MRGB. Thus, little water-rock reaction is likely to take place during inflow into the basin, and mass transfers are likely to be low. The most substantial chemical changes are expected if and when ground-water inflow mixes with local recharge.

If geochemical reactions occur that affect the dissolved inorganic carbon, these reactions usually result in a lowering of the $^{14}C$ activity of DIC, independent of the radioactive decay of $^{14}C$. Applied to the initial $^{14}C$ activity, the carbonate reactions will lower the adjusted value of $A_o$ (termed $A_{nd}$, where “nd” refers to no decay), resulting in adjusted radiocarbon ages that are younger than the unadjusted radiocarbon age. It is, therefore, important to recognize and quantify the effects of any geochemical reactions occurring in the MRGB that can affect the $^{14}C$ activity of DIC.

Possible reactions that can affect the DIC in the MRGB include dissolution of carbonate minerals (primary and secondary calcite, and calcite in caliche), calcite precipitation, carbon isotopic exchange with calcite, and oxidation of organic matter. Cation exchange reactions, in which $Ca^{2+}$ is taken up on clay surfaces in exchange for $Na^{+}$, will lower the calcite saturation state and permit additional dissolution of calcite, if calcite is present locally in the aquifer mineralogy. Anderholm (1985) showed that calcium smectite and mixed-layer, illite-smectite clays, both of which have high ion exchange capacities, are present in the Santa Fe Group aquifer system. Cation exchange may be an important process affecting waters in the West-Central zone, where there are high Na and $HCO_3$ concentrations, low Ca concentrations (in some cases, less than 3 mg/L), and high pH values (exceeding 8.5). Because saturation indices for calcite remain near 0 and the Na/Ca mole ratio generally exceeds 2:1 for ground water throughout the West-Central zone, the continual dissolution of calcite appears to be the most likely source of additional Ca to replace that lost during cation exchange. This process of cation exchange accompanied by additional calcite dissolution probably also occurs to some extent in ground water of other zones, including the Northern Mountain Front, Northwestern, Eastern Mountain Front, and Central zones. The dissolution of calcite accompanying ion exchange dilutes the $^{14}C$ activity of DIC in the ground water, and if not accounted for in age interpretation, the radiocarbon age is biased old. Weathering of primary silicates, such as plagioclase feldspars, releases $Ca^{2+}$ to ground water and raises the pH, both of which can cause calcite to precipitate. Because of isotope fractionation, $^{14}C$ is slightly enriched in calcite precipitates relative to its isotopic abundance in the dissolved phase. Not correcting for this enrichment causes calculated radiocarbon ages to be biased old; however, the effect of silicate weathering and $CaCO_3$ precipitation on radiocarbon ages is generally low compared to dissolution of calcite.

In most cases, changes in the chemical composition of ground water along flow paths in the MRGB appear to be minor. This observation is consistent with the composition of sediments of the Santa Fe Group aquifer system, which consist largely of sands and gravels derived from the weathering of silicate rocks and minerals. These sediments are likely to be unreactive and result in fairly low mass transfers. The primary minerals in the sediments of the Santa Fe Group aquifer system include quartz, plagioclase feldspars, potassium feldspars and clay minerals (Anderholm, 1988; Hawley and Haase, 1992). As discussed above, calcite is, for the most part, very low in abundance in the sediments of the MRGB, and where it occurs, it is usually as calcite cement rather than primary lithic fragments. Most waters are saturated to slightly oversaturated with respect to calcite throughout the basin (appendix C, table C4). It is possible that waters near saturation with calcite could represent a partial equilibrium state in which calcite dissolves or precipitates from ground water that is only slightly undersaturated or slightly oversaturated with respect to calcite, while being driven by co-occurrence of one or more irreversible reactions. Possible irreversible reactions include (1) weathering of plagioclase feldspars that would cause net calcite precipitation, (2) weathering of plagioclase feldspars with cation exchange of $Ca^{2+}$ for $Na^{+}$ on clay minerals that could cause net dissolution of calcite, (3) oxidation of organic matter that would release $CO_2$ and cause dissolution of calcite (if present in the aquifer sediment), and (4) isotope exchange with calcite that would alter the carbon isotopic composition. If it has occurred, oxidation of organic matter is probably indicated only in water in some anaerobic parts of the inner valley of the Rio Grande. With exception of the inner valley Rio Grande waters, most ground water of the MRGB is aerobic indicating low organic carbon content.

Data on the $\delta^{13}C$ of DIC and geochemical mass balance reaction modeling indicate that, although geochemical reactions may be occurring in the MRGB that affect the carbon isotopic composition of the DIC, they are, for the most part, minor and have a small effect on the unadjusted radiocarbon age.

#### Implications for Geochemical Reactions from Carbon-13 Data

Within an individual hydrochemical zone, $\delta^{13}C$ values generally vary by only a few per mil (fig. 39), except in zones affected by mountain-front recharge and where mixing is important. In particular, within the Northwestern, West-Central, Abo Arroyo, Tijeras Arroyo, Northeastern, and Discharge zones, the 10$^{th}$ and 90$^{th}$ percentiles of $\delta^{13}C$ values differ by only 2.5 per mil or less. In the Central zone, this difference is 2.7 per mil. In the Southwestern Mountain Front zone, only one $\delta^{13}C$ value is available, and variability cannot be evaluated. In the Tijeras Fault Zone, Western Boundary, and Rio Puerco zones, where local recharge is believed to be mixing with older, more mineralized waters, $\delta^{13}C$ values can vary up to almost 9 per mil.

For hydrochemical zones that receive recharge primarily from mountain-front processes (the Northern Mountain Front, Northwestern, West-Central, and Eastern Mountain Front zones), $\delta^{13}C$ values immediately along the mountain front usually are substantially lower (more negative, typically -12 per mil) than those $\delta^{13}C$ values further downgradient (typically -7 to -8 per mil). Within a relatively short distance of the mountain front (perhaps 2 to 3 miles), $\delta^{13}C$ values increase and remain fairly constant throughout the rest of the zone. The shift in $\delta^{13}C$ values along the basin margin is discussed further in the section "Historical Variations in Carbon-13 Isotopic Composition of Dissolved Inorganic Carbon".

Although variability in $\delta^{13}C$ values downgradient of the mountain front typically is small in the hydrochemical zones that receive recharge from mountain-front processes, mixing with upwelling mineralized water may result in heavy $\delta^{13}C$ values in some localized areas. No data are available specifically for deep, mineralized water, but the $\delta^{13}C$ values of this water are likely to be elevated because of longer contact times with carbonate minerals in the aquifer system. Mixing with this water in parts of the Northern Mountain Front zone may explain the elevated $\delta^{13}C$ values (greater than -7 per mil) that tend to occur in water from wells with higher Cl concentrations.

In the Central zone, the most depleted $\delta^{13}C$ values (values more negative than about -10 per mil) are in the shallowest wells (total depth less than about 200 feet below land surface), and particularly in the inner valley of the Rio Grande. Therefore, these lighter values appear to be present primarily where oxidation of organic matter is likely to occur. In most other parts of the Central zone, $\delta^{13}C$ values tend to vary over a narrow range of about -8 to -10 per mil, indicating that carbonate reactions probably are not extensive.

In the Western Boundary, Rio Puerco, and Tijeras Fault Zone zones, variations in $\delta^{13}C$ probably reflect mixing between old, mineralized waters and local recharge rather than the occurrence of extensive carbonate reactions. A water sample from Arroyo Salado Spring, just outside the western boundary of the MRGB (Site S009, fig. 11a), indicates that the $\delta^{13}C$ value of DIC in brine leaking into the basin from Paleozoic rocks to the west is about 2 per mil. This enriched value probably is the result of long contact time and isotope exchange with limestone present in rocks outside the basin margins. As discussed earlier, ground water in the Western Boundary zone appears to have progressively higher fractions of local recharge with distance from the western boundary. The pattern of increasingly light $\delta^{13}C$ values with distance from the western boundary is consistent with this pattern of mixing between waters of differing source. Local recharge water, similar to that near the mountain fronts, is likely to have a $\delta^{13}C$ content of about -10 per mil. Mixing of this water and water with a $\delta^{13}C$ value similar to that of Arroyo Salado Spring (site S009) can account for the lighter values (as light as -6.9 per mil) found in ground water of the Western Boundary zone. Similarly, some ground water in the Rio Puerco zone is believed to contain fractions of Western Boundary-zone ground water. The $\delta^{13}C$ content of water in the Rio Puerco also is enriched in $\delta^{13}C$ relative to mountain-front recharge (only one measurement of $\delta^{13}C$ of DIC in Rio Puerco water was obtained, giving a value of -0.11 per mil), but is more depleted in $\delta^{13}C$ than ground-water inflow along the western margin of the basin. Apparently, the $\delta^{13}C$ content of ground water in the Rio Puerco zone can vary substantially, depending on the fractions of water from the differing parts of the watershed present in the area. Finally, ground water of the Tijeras Fault Zone zone is believed to be a mixture of local mountain-front recharge with mineralized water leaking upward along the major faults of the area. A sample from Coyote Spring, a mineralized spring near the basin margin (Site S041, fig. 11b), indicates that mineralized water in the area can have $\delta^{13}C$ values as heavy as -0.6 per mil, probably as a result of extended contact with Pennsylvanian limestone. $\delta^{13}C$ values in ground water of the zone are progressively lighter with distance downgradient, probably as the result of greater fractions of mountain-front recharge water with $\delta^{13}C$ contents near -12 per mil.

Variations in $\delta^{13}C$ of DIC in the Northern Mountain Front, Northwestern, West Central, Western Boundary, Rio Puerco, Eastern Mountain Front and Central zones as a function of the $^{14}C$ activity are shown in figure 99. Samples with $^{14}C$ activity greater than 95 pmC, designated Modern on figure 99, tend to have somewhat lower values of $\delta^{13}C$ than older waters in the basin. In the samples with $^{14}C$ activities less than 95 pmC, there appears to be a trend to somewhat enriched $^{13}C$ values with lower $^{14}C$ activity in the overall data set, but the apparent trend results mostly from differences in $\delta^{13}C$ of different hydrochemical zones and the fact that a large number of samples from the West-Central zone have low $^{14}C$ activity and are

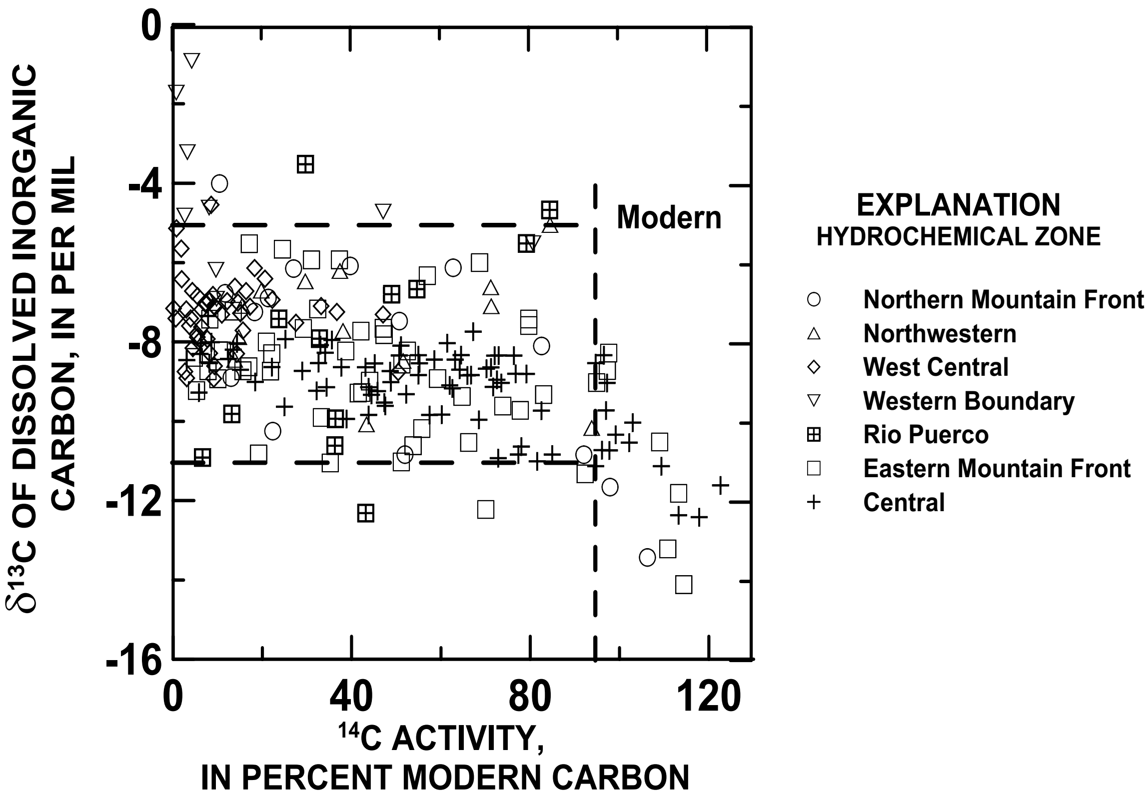



**Figure 99.** Variations in $\delta^{13}C$ of dissolved inorganic carbon (DIC) as a function of $^{14}C$ activity of the DIC in the Middle Rio Grande Basin, New Mexico. The horizontal lines bracket $\delta^{13}C$ values of DIC resulting from equilibrium with soil gases with $\delta^{13}C$ values of -14 to -20 per mil. The vertical line separates modern (post-1950's) samples from older waters.

slightly more enriched in $^{13}C$ than waters from the Central zone. Although there do not appear to be appreciable trends in $\delta^{13}C$ of DIC within individual hydrochemical zones, there are small differences in $\delta^{13}C$ between some hydrochemical zones (fig. 99) that may represent differences in $\delta^{13}C$ of source waters recharged to the zone. The differences in $\delta^{13}C$ of source waters result, in part, from differences in the isotopic composition of carbonate minerals in recharge areas and the relative abundances of $C_3$ and $C_4$ plants in recharge areas. Aspects of the apparent historical abundances of $C_3$ and $C_4$ plants in recharge areas of the MRGB are discussed in the section "Historical Variations in Carbon-13 Isotopic Composition of Dissolved Inorganic Carbon".

The upper and lower horizontal lines on figure 99 correspond to the upper and lower limits of $\delta^{13}C$ of $HCO_3^-$ that would be present in recharge waters, if they evolved under open-system conditions in isotopic equilibrium with soil gas $CO_2$ with $\delta^{13}C$ values of -14 to -20 per mil, similar to the range of $\delta^{13}C$ of soil gases measured along the eastern mountain front (fig. 40). The relatively few samples outside of these lines are samples with $\delta^{13}C$ values more positive than -5.0 per mil from the Western Boundary, Rio Puerco and Tijeras Fault Zone zones that have likely had appreciable contact with Permian limestones and may have mixed with saline waters enriched in $\delta^{13}C$, and two samples (Rio Puerco and Eastern Mountain Front zones) with $\delta^{13}C$ values more negative than -11 per mil. Although the $\delta^{13}C$ data do not eliminate the possibility of geochemical reactions occurring among carbonate phases in the MRGB, they are consistent with the conclusion that little reaction occurs among carbonates in large parts of the basin.

### Geochemical Mass Transfer Models

Another means of testing the geochemical data for chemical reactions is to construct geochemical mass-balance models between hypothetical recharge waters and ground-water compositions occurring within the basin. Although it is not possible to identify all the reactions in the basin, some reactions can be eliminated based on thermodynamic and isotopic constraints (Plummer and others, 1983; Parkhurst and Plummer, 1993). By also including $^{13}C$ and $^{14}C$ data in the reaction modeling, sensitivity of the radiocarbon ages to possible reactions can be evaluated. Waters from the Discharge zone were excluded in geochemical modeling because they represent mixtures of waters and mass transfers from multiple zones that have evolved chemically from virtually all source waters in the basin.

#### *NETPATH*

The geochemical mass balance code, NETPATH (Plummer and others 1994), was used to construct mass-balance models for the origin of waters in the basin and to investigate the sensitivity of the unadjusted radiocarbon ages to effects of possible geochemical reactions. NETPATH uses equations of chemical mass balance, electron balance, and isotope mass balance to define all possible net geochemical reactions between the analyzed initial and final water compositions along a flow path. Because pairs of samples generally cannot be identified along a specific flow path in the MRGB, representative initial water compositions were defined for each hydrochemical zone. The geochemical reactions were constrained among reasonable reactant and product minerals and gases for the system, and to be consistent with the observed mineralogy, chemical, and isotopic data of the aquifer system. Each geochemical reaction model was also solved as an isotope-evolution problem (Wigley and others 1978; Wigley and others, 1979), accounting for various isotopic sources and isotope fractionation along the reaction path to predict the isotopic composition at the end point in the reaction, including adjustment of the initial $^{14}C$ activity for geochemical reactions.

#### Formulation of Geochemical Models

Each ground-water sample in the MRGB was assumed to have evolved from a primary initial water composition that was subsequently altered to varying degrees by

(1) evapotranspiration/dilution processes,
(2) mixing with surface water(s),
(3) mixing with saline upward leakage water(s),
(4) mixing with ground-water inflow from adjacent basins, and
(5) water/rock reaction

#### Source Waters

The choice of initial waters (primary water; table 10) and other source waters varied with each hydrochemical zone. The compositions of the initial waters

**Table 10.** Summary of unadjusted radiocarbon age, source waters and mixing fractions, geochemical mineral-water mass transfer reactions, evaporation factor, adjusted radiocarbon age, and calendar age in one representative geochemical model for each ground-water sample collected for the Middle Rio Grande Basin study.

[no., number; na, not applicable; NMF, Northern Mountain Front; Saline 1, NM041; RP, Discharge-weighted average National Water Information System (NWIS) Rio Puerco; RGA, discharge-weighted average NWIS Rio Grande at Albuquerque; JRW, Discharge-weighted average NWIS Jemez River; MWGW, Mid-West Ground-Water Inflow; SWGW, Southwest Ground-Water Inflow; SWMF, Southwestern Mountain Front, NWIS; EMF, Eastern Mountain Front, median; ABO, median Abo Arroyo; Saline 2, Coyote Spring, NM029; TIJ, Discharge-weighted average NWIS Tijeras Arroyo; NEGW, Northeast Ground-Water Inflow; LUC, Lucero-24, Los Alamos National Laboratory, Representative of southwest arroyo water; GAL, Galisteo Creek above Galisteo Reservoir, used as arroyo source in hydrochemical zone 11; ASSP, Arroyo Salado Spring; 1 σ, one standard deviation; pmC, percent modern carbon; ka, thousands of years; Compositions of end-member waters are given in table 4]

| | | | | | | | Source waters and percent in mixture | | | | | | Mass transfer, millimoles per kilogram water | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site no. | Sample no. | Site name | $^{14}C$ activity (pmC) | $^{14}C$ ± 1 σ (pmC) | Conventional, unadjusted $^{14}C$ age, Libby half-life (ka) | No. of mass balance models found | Primary water | Percent primary water | Secondary water | Percent secondary water | Additional secondary water | Percent additional secondary water | Calcite | Plagioclase feldspar | $CO_2$ | Kaolinite | $SiO_2$ | Ca-Na cation exchange | Gypsum | $CH_2O$ | Evaporation factor | [1] Calculated $\delta^{13}C$ (per mil) | Observed $\delta^{13}C$ (per mil) | Initial $^{14}C$ activity adjusted for geochemical reactions (pmC) | Adjusted $^{14}C$ Age Libby half-life (ka) | Maximum adjusted $^{14}C$ Age Libby half-life (ka) | Minimum adjusted $^{14}C$ Age Libby half-life (ka) | Difference unadjusted $^{14}C$ age minus adjusted age, Libby half-life (ka) | Unadjusted $^{14}C$ calendar years (ka) | Adjusted $^{14}C$ calendar years (ka) | Difference unadjusted calendar years minus adjusted calendar years (ka) |
| | | **Zone 1: Northern Mountain Front** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| S027 | NM486 | CEPO 02 | 21.3 | 0.22 | 12.4 | 4 | NMF | 100.00 | na | na | na | na | -0.37 | 0.33 | 0.00 | -0.22 | -0.33 | -0.14 | 0.00 | 0.00 | 1.15 | -12.21 | - 6.89 | 99.96 | 12.4 | 12.4 | 12.4 | 0.0 | 14.6 | 14.6 | 0.0 |
| S034 | NM027 | Private Production Well #04 | 51.9 | 0.59 | 5.3 | 4 | NMF | 100.00 | na | na | na | na | -0.32 | 0.31 | 0.00 | -0.21 | -0.17 | -0.10 | 0.00 | 0.00 | 0.99 | -12.15 | -10.84 | 99.97 | 5.3 | 5.2 | 5.2 | 0.0 | 5.8 | 5.8 | 0.0 |
| S035 | NM487 | Windmill #37 | 97.9 | 0.69 | 0.2 | 5 | NMF | 100.00 | na | na | na | na | -0.10 | 1.12 | 2.93 | -0.77 | 0.00 | -0.33 | 0.33 | 0.00 | 0.39 | -12.04 | -11.66 | 99.99 | 0.2 | 0.2 | - 1.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S036 | NM026 | Private Production Well #03 | 82.6 | 0.90 | 1.5 | 4 | NMF | 100.00 | na | na | na | na | 0.50 | 0.00 | 0.72 | 0.00 | -0.35 | 0.11 | 0.00 | 0.00 | 0.93 | -10.27 | - 8.10 | 85.60 | 0.3 | 1.6 | 0.3 | 1.2 | 1.6 | 0.2 | 1.4 |
| S065 | NM055 | Domestic Well #05 | 27.0 | 0.25 | 10.5 | 1 | NMF | 92.33 | Saline 1 | 7.67 | na | na | -0.41 | 0.00 | 0.00 | 0.00 | -0.09 | -1.24 | -0.13 | 0.00 | 0.90 | -11.69 | - 6.18 | 88.69 | 9.6 | 9.5 | 9.5 | 1.0 | 12.2 | 11.0 | 1.2 |
| S187 | NM131 | Rio Rancho 12 | 24.8 | 0.23 | 11.2 | 5 | NMF | 92.86 | Saline 1 | 7.14 | na | na | -0.22 | 0.39 | 0.00 | -0.27 | -0.72 | 0.00 | 0.35 | 0.00 | 0.82 | -11.65 | - 9.60 | 89.45 | 10.3 | 10.5 | 10.2 | 0.9 | 13.1 | 11.9 | 1.1 |
| S189 | NM133 | Rio Rancho 15 | 18.3 | 0.19 | 13.7 | 4 | NMF | 97.08 | Saline 1 | 2.92 | na | na | 0.51 | 0.00 | 0.70 | 0.00 | -0.37 | 1.23 | 0.81 | 0.00 | 1.00 | -10.10 | - 6.93 | 82.34 | 12.1 | 13.5 | 12.1 | 1.6 | 16.1 | 14.2 | 1.9 |
| S206 | NM510 | Windmill #38 | 13.0 | 0.15 | 16.4 | 3 | NMF | 99.88 | Saline 1 | 0.12 | na | na | 0.43 | 0.00 | 0.58 | 0.00 | 0.14 | 0.86 | 0.25 | 0.00 | 1.00 | -10.39 | - 8.90 | 86.57 | 15.2 | 16.4 | 15.3 | 1.2 | 19.4 | 18.1 | 1.4 |
| S216 | NM143 | Windmill #09 | 39.7 | 0.49 | 7.4 | 4 | NMF | 99.75 | Saline 1 | 0.25 | na | na | -0.23 | 0.04 | 0.00 | -0.02 | 0.00 | -0.12 | 0.35 | 0.00 | 1.07 | -12.09 | - 6.08 | 99.59 | 7.4 | 7.4 | 7.4 | 0.0 | 8.4 | 8.4 | 0.0 |
| S221 | NM530 | Windmill #45 | 12.2 | 0.19 | 16.9 | 2 | NMF | 99.64 | Saline 1 | 0.36 | na | na | 1.09 | 0.00 | 2.49 | 0.00 | 0.39 | 0.38 | 0.15 | 0.00 | 1.00 | - 9.74 | - 5.83 | 80.99 | 15.2 | 15.3 | 15.3 | 1.7 | 20.0 | 18.1 | 2.0 |
| S222 | NM514 | Windmill #39 | 10.4 | 0.16 | 18.2 | 2 | NMF | 98.85 | Saline 1 | 1.15 | na | na | 1.36 | 0.00 | 4.85 | 0.00 | -0.28 | 0.79 | 0.70 | 0.00 | 1.00 | -10.05 | - 4.31 | 83.50 | 16.7 | 16.7 | 16.7 | 1.4 | 21.5 | 19.8 | 1.6 |
| S254 | NM168 | Private Production Well #12 | 92.0 | 0.81 | 0.7 | 4 | NMF | 100.00 | na | na | na | na | -0.12 | 0.05 | 0.33 | -0.03 | 0.30 | 0.00 | -0.04 | 0.00 | 0.72 | -12.09 | -10.82 | 99.98 | 0.7 | 0.7 | 0.7 | 0.0 | 0.6 | 0.6 | 0.0 |
| S277 | NM525 | Windmill #40 | 50.7 | 0.38 | 5.5 | 3 | NMF | 100.00 | na | na | na | na | -1.10 | 0.92 | 0.00 | -0.63 | -1.82 | -0.49 | -0.05 | 0.00 | 3.21 | -13.00 | - 7.47 | 99.80 | 5.4 | 5.5 | 5.4 | 0.0 | 6.1 | 6.1 | 0.0 |
| S279 | NM527 | Windmill #42 | 106.3 | 0.75 | - 0.5 | 5 | NMF | 100.00 | na | na | na | na | 0.85 | 0.00 | 2.40 | 0.00 | 0.78 | 0.00 | 0.06 | 0.00 | 0.54 | -10.14 | -13.43 | 84.52 | - 1.8 | - 0.5 | - 1.8 | 1.4 | - 0.8 | - 2.4 | 1.7 |
| S281 | NM528 | Windmill #43 | 22.3 | 0.22 | 12.0 | 4 | NMF | 100.00 | na | na | na | na | -0.39 | 0.82 | 0.58 | -0.57 | -1.50 | 0.00 | -0.06 | 0.00 | 1.12 | -12.13 | -10.25 | 99.97 | 12.0 | 12.1 | 11.5 | 0.0 | 14.1 | 14.1 | 0.0 |
| | | **Zone 2: Northwestern** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| S103 | NM497 | Lincoln D | 13.8 | 0.20 | 15.9 | 5 | NMF | 99.89 | Saline 1 | 0.11 | na | na | 0.34 | 0.01 | 0.00 | -0.01 | 0.00 | 0.84 | 0.27 | 0.00 | 1.06 | -10.39 | - 8.44 | 86.51 | 14.7 | 15.9 | 14.7 | 1.2 | 18.9 | 17.5 | 1.4 |
| S104 | NM498 | Lincoln M | 15.5 | 0.19 | 15.0 | 3 | NMF | 99.98 | Saline 1 | 0.02 | na | na | 0.08 | 0.38 | 0.00 | -0.26 | 0.00 | 0.60 | 0.20 | 0.00 | 0.87 | -11.58 | - 7.08 | 96.44 | 14.7 | 15.0 | 14.7 | 0.3 | 17.8 | 17.4 | 0.3 |
| S105 | NM499 | Lincoln S | 29.6 | 0.35 | 9.8 | 6 | NMF | 99.98 | Saline 1 | 0.02 | na | na | -0.01 | 0.24 | 0.00 | -0.17 | 0.00 | 0.08 | 0.05 | 0.00 | 0.93 | -12.00 | - 6.46 | 99.96 | 9.8 | 9.8 | 8.7 | 0.0 | 11.3 | 11.3 | 0.0 |
| S191 | NM326 | Rio Rancho 4 | 19.8 | 0.17 | 13.0 | 3 | NMF | 99.77 | Saline 1 | 0.23 | na | na | 0.14 | 0.00 | 0.22 | 0.00 | 0.04 | 0.85 | 0.46 | 0.00 | 1.00 | -11.35 | - 6.70 | 94.38 | 12.6 | 13.1 | 12.6 | 0.5 | 15.3 | 14.8 | 0.6 |
| S192 | NM128 | Rio Rancho 8 | 14.7 | 0.16 | 15.4 | 5 | NMF | 99.81 | Saline 1 | 0.19 | na | na | 0.00 | 0.00 | -0.14 | 0.00 | -0.54 | 0.83 | 0.54 | 0.00 | 1.00 | -11.48 | - 7.62 | 99.59 | 15.4 | 15.4 | 15.4 | 0.0 | 18.2 | 18.2 | 0.0 |
| S276 | NM179 | Windmill #12 | 38.1 | 0.38 | 7.8 | 4 | NMF | 99.96 | Saline 1 | 0.04 | na | na | 0.16 | 0.50 | 0.00 | -0.35 | -0.96 | -0.06 | 0.00 | 0.00 | 0.74 | -11.20 | - 7.25 | 93.32 | 7.2 | 7.8 | 6.6 | 0.6 | 8.8 | 8.1 | 0.7 |
| S278 | NM526 | Windmill #41 | 71.3 | 0.50 | 2.7 | 4 | NMF | 99.80 | Saline 1 | 0.20 | na | na | 0.08 | 0.00 | 0.00 | 0.00 | -0.60 | 0.39 | 0.31 | 0.00 | 1.36 | -11.57 | - 7.09 | 96.20 | 2.4 | 2.7 | 2.4 | 0.3 | 2.9 | 2.6 | 0.4 |
| S280 | NM180 | Windmill #13 | 84.5 | 0.92 | 1.4 | 4 | NMF | 99.97 | Saline 1 | 0.03 | na | na | 0.33 | 0.20 | 0.00 | -0.14 | -0.69 | 0.00 | 0.18 | 0.00 | 0.91 | -10.47 | - 5.04 | 87.25 | 0.3 | 1.4 | - 0.6 | 1.1 | 1.4 | 0.1 | 1.3 |
| S286 | NM184 | Private Production Well #13 | 71.2 | 0.62 | 2.7 | 4 | NMF | 100.00 | na | na | na | na | -0.58 | 2.52 | 2.68 | -1.74 | -3.28 | 0.00 | 0.27 | 0.00 | 0.62 | -12.13 | - 6.61 | 99.97 | 2.7 | 2.7 | 0.2 | 0.0 | 2.9 | 2.9 | 0.0 |
| S287 | NM185 | Private Production Well #14 | 37.4 | 0.37 | 7.9 | 4 | NMF | 99.97 | Saline 1 | 0.03 | na | na | -0.72 | 0.73 | 0.00 | -0.50 | -1.55 | 0.00 | 0.06 | 0.00 | 2.03 | -12.41 | - 6.20 | 99.87 | 7.9 | 7.9 | 7.3 | 0.0 | 9.0 | 9.0 | 0.0 |
| | | **Zone 3: West Central** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| S003 | NM481 | 98th St. D | 0.1 | 0.10 | 53.4 | 4 | NMF | 92.48 | Saline 1 | 7.52 | na | na | 1.96 | 0.00 | 1.73 | 0.00 | -0.41 | 5.00 | 2.16 | 0.00 | 1.00 | - 7.90 | - 7.15 | 63.15 | 49.7 | 53.3 | 49.8 | 3.7 | 40.9 | 48.1 | - 7.2 |
| S004 | NM482 | 98th St. MD | 3.7 | 0.12 | 26.5 | 3 | NMF | 99.84 | Saline 1 | 0.16 | na | na | 0.44 | 0.00 | 0.00 | 0.00 | -0.66 | 1.60 | 0.45 | 0.00 | 1.52 | -10.00 | - 7.51 | 83.19 | 25.0 | 26.5 | 23.9 | 1.5 | 29.5 | 28.2 | 1.3 |
| S005 | NM483 | 98th St. MS | 0.8 | 0.11 | 38.9 | 4 | NMF | 100.00 | na | na | na | na | 1.99 | 0.00 | 1.92 | 0.00 | -0.58 | 3.52 | 0.95 | 0.00 | 0.91 | - 8.11 | - 4.95 | 67.61 | 35.8 | 38.9 | 35.8 | 3.1 | 41.0 | 37.7 | 3.3 |
| S006 | NM484 | 98th St. S | 6.4 | 0.15 | 22.1 | 3 | NMF | 99.78 | Saline 1 | 0.22 | na | na | 1.01 | 0.00 | 0.00 | 0.00 | -0.23 | 2.15 | 0.66 | 0.00 | 0.85 | - 8.27 | - 7.62 | 68.75 | 19.1 | 22.2 | 19.1 | 3.0 | 25.5 | 22.5 | 3.1 |
| S008 | NM003 | Private Production Well #01 | 5.5 | 0.10 | 23.3 | 4 | NMF | 99.77 | Saline 1 | 0.23 | na | na | 0.00 | 0.22 | 0.00 | -0.15 | -0.61 | 1.36 | 0.88 | 0.00 | 0.97 | -11.98 | - 7.76 | 99.65 | 23.3 | 23.3 | 22.8 | 0.0 | 26.7 | 26.7 | 0.0 |
| S010 | NM255 | Private Production Well #16 | 9.3 | 0.28 | 19.1 | 4 | NMF | 99.83 | Saline 1 | 0.17 | na | na | -0.05 | 0.00 | -0.28 | 0.00 | -0.67 | 1.54 | 1.04 | 0.00 | 1.00 | -10.64 | - 8.60 | 99.96 | 19.1 | 19.1 | 19.1 | 0.0 | 22.4 | 22.4 | 0.0 |
| S018 | NM260 | Domestic Well #21 | 11.0 | 0.13 | 17.8 | 3 | NMF | 99.55 | Saline 1 | 0.45 | na | na | 0.20 | 0.00 | 0.49 | 0.00 | 0.07 | 1.81 | 1.35 | 0.00 | 1.00 | -11.07 | - 7.30 | 92.52 | 17.1 | 17.7 | 17.2 | 0.6 | 21.0 | 20.3 | 0.7 |
| S019 | NM007 | Belen 4 | 14.6 | 0.17 | 15.5 | 3 | NMF | 99.14 | Saline 1 | 0.86 | na | na | -0.19 | 0.00 | 0.93 | 0.00 | -0.29 | 1.46 | 1.84 | 0.00 | 1.00 | -12.03 | - 7.18 | 99.07 | 15.4 | 15.5 | 15.5 | 0.1 | 18.3 | 18.3 | 0.1 |
| S020 | NM008 | Belen 5 | 16.4 | 0.17 | 14.5 | 3 | NMF | 99.41 | Saline 1 | 0.59 | na | na | -0.10 | 0.00 | 0.74 | 0.00 | -0.18 | 1.52 | 1.61 | 0.00 | 1.00 | -12.00 | - 6.65 | 99.32 | 14.5 | 14.5 | 14.5 | 0.1 | 17.2 | 17.1 | 0.1 |
| S029 | NM015 | Cerro Colorado Landfill PW | 7.4 | 0.12 | 21.0 | 3 | NMF | 99.01 | Saline 2 | 0.99 | na | na | -0.11 | 0.00 | 0.00 | 0.00 | -0.51 | 1.91 | 1.91 | 0.00 | 1.18 | -11.17 | - 7.22 | 88.69 | 20.0 | 20.7 | 20.0 | 1.0 | 24.4 | 23.4 | 1.0 |
| S037 | NM264 | College 2 | 5.4 | 0.09 | 23.5 | 3 | NMF | 99.90 | Saline 1 | 0.10 | na | na | 0.77 | 0.00 | 0.00 | 0.00 | -0.34 | 1.94 | 0.55 | 0.00 | 0.94 | 8.67 | - 7.80 | 74.25 | 21.1 | 23.5 | 21.1 | 2.4 | 26.8 | 24.5 | 2.3 |
| S066 | NM056 | Gonzales 1 | 47.0 | 0.40 | 6.1 | 3 | NMF | 99.73 | Saline 1 | 0.27 | na | na | 0.08 | 0.00 | 0.20 | 0.00 | 0.01 | 1.13 | 0.67 | 0.00 | 1.00 | -11.59 | - 7.30 | 96.37 | 5.8 | 6.0 | 5.7 | 0.3 | 6.8 | 6.4 | 0.3 |
| S086 | NM492 | Isleta D | 2.7 | 0.19 | 29.0 | 5 | NMF | 99.17 | Saline 1 | 0.83 | na | na | 0.00 | 0.50 | 0.00 | -0.34 | -1.06 | 2.04 | 1.20 | 0.00 | 0.87 | -11.94 | - 8.74 | 98.74 | 28.9 | 29.0 | 28.2 | 0.1 | 31.6 | 31.5 | 0.1 |
| S101 | NM294 | Leavitt 1 | 17.3 | 0.14 | 14.1 | 4 | NMF | 99.66 | Saline 1 | 0.34 | na | na | 0.60 | 0.00 | 0.00 | 0.00 | -0.32 | 1.73 | 0.58 | 0.00 | 0.99 | - 9.21 | - 7.10 | 78.54 | 12.2 | 14.1 | 12.1 | 1.9 | 16.7 | 14.3 | 2.4 |
| S108 | NM076 | Los Lunas 3 | 27.6 | 0.24 | 10.4 | 3 | NMF | 99.73 | Saline 1 | 0.27 | na | na | 0.37 | 0.00 | 0.40 | 0.00 | 0.07 | 1.44 | 0.59 | 0.00 | 1.00 | -10.53 | - 7.52 | 87.52 | 9.3 | 10.3 | 9.3 | 1.1 | 12.0 | 10.7 | 1.3 |

**Table 10.** Summary of unadjusted radiocarbon age, source waters and mixing fractions, geochemical mineral-water mass transfer reactions, evaporation factor, adjusted radiocarbon age, and calendar age in one representative geochemical model for each ground-water sample collected for the Middle Rio Grande Basin study -- Continued

| | | | | | | | Source waters and percent in mixture | | | | | | Mass transfer, millimoles per kilogram water | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site no. | Sample no. | Site name | $^{14}C$ activity (pmC) | $^{14}C$ ± 1 σ (pmC) | Conventional, unadjusted $^{14}C$ age, Libby half-life (ka) | No. of mass balance models found | Primary water | Percent primary water | Secondary water | Percent secondary water | Additional secondary water | Percent additional secondary water | Calcite | Plagioclase feldspar | $CO_2$ | Kaolinite | $SiO_2$ | Ca-Na cation exchange | Gypsum | $CH_2O$ | Evaporation factor | [1] Calculated $\delta^{13}C$ (per mil) | Observed $\delta^{13}C$ (per mil) | Initial $^{14}C$ activity adjusted for geochemical reactions (pmC) | Adjusted $^{14}C$ Age Libby half-life (ka) | Maximum adjusted $^{14}C$ Age Libby half-life (ka) | Minimum adjusted $^{14}C$ Age Libby half-life (ka) | Difference unadjusted $^{14}C$ age minus adjusted age, Libby half-life (ka) | Unadjusted $^{14}C$ calendar years (ka) | Adjusted $^{14}C$ calendar years (ka) | Difference unadjusted calendar years minus adjusted calendar years (ka) |
| S109 | NM077 | Los Lunas 4 | 50.5 | 0.42 | 5.5 | 4 | NMF | 99.66 | Saline 1 | 0.34 | na | na | 0.29 | 0.00 | 0.42 | 0.00 | 0.11 | 1.19 | 0.44 | 0.00 | 1.00 | -10.81 | - 8.65 | 89.86 | 4.6 | 5.4 | 4.7 | 0.9 | 6.1 | 5.1 | 1.0 |
| S145 | NM308 | NM Utilities 1 | 13.9 | 0.16 | 15.8 | 4 | NMF | 99.83 | Saline 1 | 0.17 | na | na | -0.18 | 0.08 | 0.00 | -0.05 | 0.00 | 0.24 | 0.21 | 0.00 | 1.11 | -11.99 | - 6.60 | 99.72 | 15.8 | 15.8 | 15.8 | 0.0 | 18.8 | 18.8 | 0.0 |
| S147 | NM310 | NM Utilities 3 | 15.7 | 0.17 | 14.9 | 5 | NMF | 99.82 | Saline 1 | 0.18 | na | na | 0.10 | 0.09 | 0.00 | -0.06 | 0.00 | 1.00 | 0.46 | 0.00 | 1.15 | -11.40 | - 7.70 | 95.64 | 14.5 | 14.8 | 14.1 | 0.4 | 17.6 | 17.2 | 0.4 |
| S148 | NM311 | NM Utilities 4 | 7.4 | 0.09 | 21.0 | 3 | NMF | 99.92 | Saline 1 | 0.08 | na | na | 0.14 | 0.00 | 0.10 | 0.00 | 0.06 | 0.75 | 0.40 | 0.00 | 1.00 | -10.98 | - 7.00 | 94.21 | 20.5 | 21.0 | 20.5 | 0.5 | 24.4 | 23.9 | 0.5 |
| S166 | NM509 | Rabbit Hill | 8.6 | 0.13 | 19.7 | 4 | NMF | 100.00 | na | na | na | na | 0.20 | 0.00 | 0.17 | 0.00 | -0.74 | 0.79 | 0.17 | 0.00 | 3.05 | -11.07 | - 4.53 | 92.21 | 19.1 | 19.7 | 19.1 | 0.6 | 23.1 | 22.4 | 0.7 |
| S167 | NM107 | Domestic Well #12 | 5.9 | 0.11 | 22.8 | 3 | NMF | 99.89 | Saline 1 | 0.11 | na | na | 0.03 | 0.00 | 0.00 | 0.00 | -0.37 | 1.80 | 1.28 | 0.00 | 1.05 | -11.84 | - 7.89 | 98.58 | 22.7 | 22.8 | 22.6 | 0.1 | 26.2 | 26.1 | 0.1 |
| S172 | NM322 | Rio Bravo 5 D | 3.1 | 0.08 | 27.9 | 3 | NMF | 95.99 | Saline 1 | 4.01 | na | na | -0.15 | 0.00 | 0.00 | 0.00 | -0.33 | 2.80 | 2.53 | 0.00 | 0.55 | -11.44 | - 8.90 | 93.97 | 27.4 | 27.8 | 27.4 | 0.5 | 30.6 | 30.2 | 0.4 |
| S174 | NM109 | Rio Bravo 1 D | 15.1 | 0.19 | 15.2 | 5 | NMF | 98.88 | Saline 1 | 1.12 | na | na | 0.09 | 0.00 | -0.38 | 0.00 | -0.36 | 2.09 | 1.56 | 0.00 | 1.00 | - 9.97 | - 7.27 | 94.43 | 14.7 | 15.2 | 14.7 | 0.5 | 18.0 | 17.4 | 0.5 |
| S175 | NM110 | Rio Bravo 1 M | 33.2 | 0.28 | 8.9 | 5 | NMF | 98.90 | Saline 1 | 1.10 | na | na | 0.00 | 0.29 | 0.00 | -0.20 | -0.52 | 2.17 | 1.70 | 0.00 | 0.84 | -11.92 | - 7.09 | 98.33 | 8.7 | 8.8 | 8.7 | 0.1 | 10.2 | 10.0 | 0.2 |
| S186 | NM130 | Rio Rancho 10 | 12.2 | 0.23 | 16.9 | 4 | NMF | 99.61 | Saline 1 | 0.39 | na | na | 0.16 | 0.00 | 0.00 | 0.00 | -0.57 | 0.97 | 0.49 | 0.00 | 1.54 | -11.19 | - 7.03 | 92.90 | 16.3 | 16.9 | 16.3 | 0.6 | 20.0 | 19.3 | 0.7 |
| S188 | NM132 | Rio Rancho 13 | 3.0 | 0.09 | 28.2 | 4 | NMF | 99.99 | Saline 1 | 0.01 | na | na | 0.00 | 0.41 | 0.00 | -0.28 | -1.03 | 1.45 | 0.64 | 0.00 | 0.99 | -12.00 | - 7.10 | 99.98 | 28.2 | 28.2 | 27.2 | 0.0 | 30.9 | 30.9 | 0.0 |
| S193 | NM129 | Rio Rancho 9 | 7.7 | 0.12 | 20.6 | 4 | NMF | 99.94 | Saline 1 | 0.06 | na | na | 0.24 | 0.00 | -0.29 | 0.00 | -0.53 | 1.21 | 0.35 | 0.00 | 1.00 | - 9.81 | - 7.81 | 89.65 | 19.7 | 20.6 | 19.7 | 0.9 | 24.0 | 23.1 | 0.9 |
| S196 | NM135 | Windmill #05 | 36.8 | 0.34 | 8.0 | 4 | NMF | 99.67 | Saline 1 | 0.33 | na | na | 0.04 | 0.00 | 0.00 | 0.00 | -0.26 | 1.33 | 0.77 | 0.00 | 1.10 | -11.78 | - 7.38 | 97.82 | 7.9 | 8.0 | 7.6 | 0.2 | 9.2 | 8.9 | 0.2 |
| S200 | NM139 | Private Production Well #08 | 9.2 | 0.18 | 19.1 | 3 | NMF | 99.44 | Saline 1 | 0.56 | na | na | -0.15 | 0.00 | 0.38 | 0.00 | -0.30 | 1.88 | 1.77 | 0.00 | 1.00 | -12.02 | - 7.08 | 99.26 | 19.1 | 19.1 | 19.1 | 0.1 | 22.5 | 22.4 | 0.1 |
| S217 | NM144 | Santa Ana Boundary D | 6.5 | 0.14 | 22.0 | 4 | NMF | 100.00 | na | na | na | na | 1.79 | 0.00 | 1.59 | 0.00 | -0.46 | 2.87 | 0.54 | 0.00 | 0.63 | - 8.18 | - 7.18 | 68.18 | 18.9 | 22.0 | 19.0 | 3.1 | 25.4 | 22.3 | 3.1 |
| S218 | NM145 | Santa Ana Boundary M | 8.2 | 0.12 | 20.1 | 5 | NMF | 100.00 | na | na | na | na | 3.73 | 0.00 | 4.01 | 0.00 | 0.14 | 4.72 | 0.70 | 0.00 | 0.37 | - 7.51 | - 6.81 | 62.60 | 16.3 | 20.0 | 16.3 | 3.8 | 23.5 | 19.3 | 4.2 |
| S219 | NM146 | Santa Ana Boundary S | 5.5 | 0.15 | 23.2 | 4 | NMF | 75.00 | JRW | 25.00 | na | na | 0.86 | 0.00 | 0.00 | 0.00 | -0.37 | 1.41 | 0.06 | 0.00 | 1.00 | - 7.95 | - 6.64 | 77.04 | 21.2 | 23.2 | 21.2 | 2.1 | 26.6 | 24.6 | 2.0 |
| S230 | NM516 | Sierra Vista D | 1.9 | 0.11 | 31.9 | 4 | NMF | 98.61 | Saline 1 | 1.39 | na | na | 0.59 | 0.00 | 0.00 | 0.00 | -0.57 | 2.94 | 1.73 | 0.00 | 1.00 | - 9.44 | - 5.53 | 77.66 | 29.9 | 31.9 | 29.8 | 2.0 | 34.0 | 32.3 | 1.7 |
| S236 | NM155 | SAF (Soil Amendment Facility) | 4.5 | 0.13 | 24.9 | 4 | NMF | 99.83 | Saline 1 | 0.17 | na | na | -0.02 | 0.00 | -0.28 | 0.00 | -0.59 | 2.40 | 2.03 | 0.00 | 1.00 | -11.00 | - 8.01 | 99.94 | 24.9 | 24.9 | 24.9 | 0.0 | 28.1 | 28.1 | 0.0 |
| S241 | NM519 | SWAB Test Hole 1 D | 6.6 | 0.16 | 21.9 | 4 | NMF | 98.01 | Saline 1 | 1.99 | na | na | 0.07 | 0.00 | 0.00 | 0.00 | -0.44 | 1.78 | 1.33 | 0.00 | 1.76 | -11.52 | - 6.87 | 94.19 | 21.4 | 21.8 | 21.4 | 0.5 | 25.3 | 24.8 | 0.5 |
| S242 | NM520 | SWAB Test Hole 1 S | 9.1 | 0.14 | 19.2 | 4 | NMF | 99.54 | Saline 1 | 0.46 | na | na | 0.00 | 0.36 | 0.00 | -0.24 | -1.04 | 1.68 | 0.95 | 0.00 | 1.11 | -11.97 | - 8.92 | 99.29 | 19.2 | 19.2 | 17.6 | 0.1 | 22.6 | 22.5 | 0.1 |
| S243 | NM521 | SWAB Test Hole 2 D | 14.4 | 0.16 | 15.6 | 3 | NMF | 99.89 | Saline 1 | 0.11 | na | na | 0.43 | 0.00 | 0.00 | 0.00 | -0.53 | 0.98 | 0.27 | 0.00 | 0.84 | -10.04 | - 8.28 | 83.60 | 14.2 | 15.6 | 14.2 | 1.4 | 18.5 | 16.7 | 1.7 |
| S263 | NM346 | Volcano Cliff 1 | 9.5 | 0.13 | 19.0 | 4 | NMF | 99.88 | Saline 1 | 0.12 | na | na | -0.05 | 0.03 | 0.00 | -0.02 | 0.00 | 0.55 | 0.32 | 0.00 | 1.12 | -11.78 | - 7.10 | 99.81 | 18.9 | 18.9 | 18.7 | 0.0 | 22.3 | 22.3 | 0.0 |
| S266 | NM347 | West Bluff Nest 1 Well 1 | 2.0 | 0.07 | 31.4 | 5 | NMF | 97.96 | Saline 1 | 2.04 | na | na | 0.00 | 0.23 | 0.00 | -0.16 | -0.81 | 2.43 | 1.73 | 0.00 | 0.91 | -11.86 | - 6.40 | 96.91 | 31.2 | 31.4 | 30.9 | 0.2 | 33.6 | 33.4 | 0.2 |
| S272 | NM353 | West Mesa 3 | 9.0 | 0.11 | 19.3 | 2 | NMF | 99.86 | Saline 1 | 0.14 | na | na | 0.47 | 0.00 | 0.00 | 0.00 | -0.41 | 1.44 | 0.35 | 0.00 | 1.10 | - 9.74 | - 6.80 | 82.45 | 17.8 | 19.3 | 17.5 | 1.5 | 22.7 | 21.0 | 1.7 |
| S283 | NM181 | Zia Ball Park D | 18.3 | 0.23 | 13.6 | 1 | NMF | 99.91 | Saline 1 | 0.09 | na | na | 1.28 | 0.00 | 0.92 | 0.00 | -0.48 | 2.34 | 0.54 | 0.00 | 1.00 | - 8.54 | - 6.12 | 71.09 | 10.9 | 10.9 | 10.9 | 2.7 | 16.1 | 12.7 | 3.4 |
| S284 | NM182 | Zia Ball Park M | 20.7 | 0.24 | 12.7 | 2 | NMF | 99.89 | Saline 1 | 0.11 | na | na | 1.28 | 0.00 | 0.79 | 0.00 | -0.49 | 2.31 | 0.49 | 0.00 | 1.00 | - 8.42 | - 6.39 | 70.12 | 9.8 | 11.1 | 9.8 | 2.8 | 14.9 | 11.3 | 3.6 |
| S285 | NM183 | Zia Ball Park S | 22.2 | 0.29 | 12.1 | 4 | NMF | 98.17 | Saline 1 | 1.83 | na | na | -1.13 | 1.05 | 0.00 | -0.72 | -2.07 | 0.00 | 0.33 | 0.00 | 4.06 | -12.36 | - 6.93 | 97.14 | 11.8 | 11.8 | 9.4 | 0.2 | 14.2 | 13.9 | 0.3 |
| S288 | NM186 | Zia BMT D | 8.3 | 0.17 | 20.0 | 2 | NMF | 100.00 | Saline 1 | na | na | na | 0.26 | 0.00 | 0.00 | 0.00 | -0.72 | 1.40 | 0.54 | 0.00 | 2.02 | -10.76 | - 8.27 | 89.64 | 19.1 | 19.2 | 19.2 | 0.9 | 23.4 | 22.5 | 0.9 |
| | | **Zone 4: Western Boundary** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| S031 | NM263 | Windmill #18 | 8.1 | 0.10 | 20.1 | 3 | LUC | 84.25 | ASSP | 15.75 | na | na | -2.74 | 0.44 | 0.00 | -0.30 | 0.00 | 5.50 | 6.59 | 0.00 | 0.40 | - 3.02 | - 4.60 | 73.36 | 17.7 | 18.9 | 17.6 | 2.5 | 23.6 | 20.9 | 2.7 |
| S039 | NM266 | Windmill #20 | 0.8 | 0.06 | 38.9 | 5 | LUC | 93.73 | ASSP | 6.27 | na | na | 1.27 | 0.50 | 0.00 | -0.35 | 0.00 | 9.10 | 3.95 | 0.00 | 1.17 | - 3.54 | - 1.70 | 80.16 | 37.1 | 38.6 | 36.7 | 1.8 | 41.0 | 39.1 | 1.9 |
| S059 | NM278 | Windmill #21 | 9.8 | 0.10 | 18.7 | 2 | LUC | 83.96 | ASSP | 16.04 | na | na | -9.20 | 0.00 | 0.00 | 0.00 | 0.53 | -9.94 | 6.08 | 0.00 | 0.59 | - 4.31 | - 6.90 | 72.59 | 16.1 | 16.2 | 16.1 | 2.6 | 22.0 | 19.1 | 2.9 |
| S074 | NM285 | Windmill #23 | 4.2 | 0.10 | 25.4 | 4 | LUC | 91.43 | ASSP | 8.57 | na | na | -1.48 | 0.02 | -1.58 | -0.02 | 0.00 | 1.09 | 0.00 | 0.00 | 1.18 | - 2.77 | - 0.90 | 84.59 | 24.1 | 24.1 | 23.6 | 1.3 | 28.5 | 27.3 | 1.2 |
| S169 | NM320 | Rest Area | 80.7 | 0.74 | 1.7 | 2 | LUC | 89.06 | ASSP | 10.95 | na | na | -6.90 | 0.00 | 0.00 | 0.00 | 0.59 | -0.77 | 7.94 | 0.00 | 0.51 | - 4.04 | - 5.50 | 80.42 | 0.0 | 0.0 | 0.0 | 1.8 | 1.8 | - 0.2 | 2.0 |
| S201 | NM329 | Windmill #26 | 2.7 | 0.10 | 29.1 | 1 | LUC | 99.99 | ASSP | 0.01 | na | na | -6.28 | 0.00 | 0.00 | 0.00 | 0.36 | 4.83 | 18.98 | 0.00 | 0.47 | - 5.77 | - 4.80 | 99.76 | 29.1 | 29.0 | 29.0 | 0.0 | 31.6 | 31.6 | 0.0 |
| S252 | NM167 | Windmill #10 | 9.7 | 0.24 | 18.7 | 3 | LUC | 97.56 | ASSP | 2.44 | na | na | -1.52 | 0.00 | 0.00 | 0.00 | 0.49 | 9.23 | 8.34 | 0.00 | 0.39 | - 4.74 | - 6.17 | 95.23 | 18.4 | 18.7 | 18.4 | 0.4 | 22.1 | 21.7 | 0.4 |
| S260 | NM345 | Windmill #33 | 3.3 | 0.10 | 27.4 | 3 | LUC | 89.61 | ASSP | 10.39 | na | na | -0.45 | 0.00 | 0.00 | 0.00 | 0.33 | 8.27 | 6.23 | 0.00 | 0.58 | - 3.36 | - 3.20 | 81.49 | 25.8 | 25.8 | 25.8 | 1.6 | 30.2 | 28.9 | 1.4 |
| | | **Zone 5: Rio Puerco** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| S032 | NM262 | Windmill #17 | 29.8 | 0.21 | 9.7 | 6 | RP | 90.80 | SWGW | 9.20 | na | na | 0.49 | 0.00 | 0.03 | 0.00 | 0.36 | 0.02 | 0.00 | 0.00 | 0.81 | - 1.99 | - 3.50 | 28.50 | - 0.3 | 1.5 | - 0.3 | 10.1 | 11.3 | - 0.6 | 11.8 |
| S069 | NM058 | Domestic Well #06 | 36.5 | 0.35 | 8.1 | 4 | RP | 94.79 | MWGW | 5.21 | na | na | -1.11 | 0.00 | 1.31 | 0.00 | 0.53 | -3.54 | 0.00 | 0.00 | 0.58 | - 4.51 | - 9.31 | 60.15 | 4.0 | 4.4 | 4.0 | 4.1 | 9.2 | 4.4 | 4.8 |
| S073 | NM062 | Windmill #03 | 49.1 | 0.42 | 5.7 | 4 | RP | 84.50 | MWGW | 15.51 | na | na | -4.35 | 0.00 | 1.93 | 0.00 | 0.18 | -8.27 | 0.00 | 0.00 | 0.96 | - 6.64 | - 6.99 | 51.40 | 0.4 | 0.5 | 0.4 | 5.3 | 6.4 | 0.3 | 6.1 |
| S082 | NM409 | Windmill #36 | 43.3 | 0.40 | 6.7 | 3 | RP | 100.00 | na | na | na | na | -2.27 | 0.00 | 1.58 | 0.00 | 0.38 | -0.98 | 7.17 | 0.00 | 0.85 | - 6.07 | -12.30 | 80.07 | 4.9 | 5.1 | 5.0 | 1.8 | 7.6 | 5.5 | 2.1 |
| S085 | NM408 | Windmill #35 | 13.2 | 0.12 | 16.3 | 4 | RP | 100.00 | na | na | na | na | -2.64 | 0.75 | 3.55 | -0.51 | 0.00 | 1.98 | 5.46 | 0.00 | 0.44 | - 9.82 | - 9.80 | 96.79 | 16.0 | 15.9 | 15.0 | 0.3 | 19.3 | 19.0 | 0.3 |
| S111 | NM079 | Domestic Well #10 | 54.7 | 0.46 | 4.8 | 4 | RP | 93.80 | MWGW | 6.21 | na | na | -2.52 | 0.00 | 0.42 | 0.00 | 0.38 | -4.77 | 0.00 | 0.00 | 0.81 | - 3.88 | - 6.76 | 50.21 | - 0.7 | - 0.2 | - 0.7 | 5.5 | 5.4 | - 1.0 | 6.3 |
| S185 | NM324 | Domestic Well #31 | 36.3 | 0.37 | 8.1 | 5 | RP | 98.78 | MWGW | 1.22 | na | na | 0.39 | 0.07 | 2.24 | -0.05 | 0.00 | -1.06 | 0.00 | 0.00 | 1.50 | - 4.36 | -10.60 | 70.51 | 5.3 | 6.0 | 5.3 | 2.8 | 9.3 | 5.9 | 3.4 |
| S198 | NM137 | Windmill #07 | 84.5 | 0.71 | 1.4 | 3 | RP | 92.37 | MWGW | 7.63 | na | na | -2.09 | 0.00 | 0.34 | 0.00 | -0.03 | -2.27 | 0.00 | 0.00 | 2.37 | - 3.60 | - 4.65 | 45.15 | - 5.0 | - 1.7 | - 5.1 | 6.4 | 1.4 | - 7.3 | 8.7 |

**Table 10.** Summary of unadjusted radiocarbon age, source waters and mixing fractions, geochemical mineral-water mass transfer reactions, evaporation factor, adjusted radiocarbon age, and calendar age in one representative geochemical model for each ground-water sample collected for the Middle Rio Grande Basin study -- Continued

| | | | | | | | Source waters and percent in mixture | | | | | | Mass transfer, millimoles per kilogram water | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site no. | Sample no. | Site name | $^{14}C$ activity (pMC) | $^{14}C$ ± 1 σ (pMC) | Conventional, unadjusted $^{14}C$ age, Libby half-life (ka) | No. of mass balance models found | Primary water | Percent primary water | Secondary water | Percent secondary water | Additional secondary water | Percent additional secondary water | Calcite | Plagioclase feldspar | $CO_2$ | Kaolinite | $SiO_2$ | Ca-Na cation exchange | Gypsum | $CH_2O$ | Evaporation factor | [1] Calculated $\delta^{13}C$ (per mil) | Observed $\delta^{13}C$ (per mil) | Initial $^{14}C$ activity adjusted for geochemical reactions (pmC) | Adjusted $^{14}C$ Age Libby half-life (ka) | Maximum adjusted $^{14}C$ Age Libby half-life (ka) | Minimum adjusted $^{14}C$ Age Libby half-life (ka) | Difference unadjusted $^{14}C$ age minus adjusted age, Libby half-life (ka) | Unadjusted $^{14}C$ calendar years (ka) | Adjusted $^{14}C$ calendar years (ka) | Difference unadjusted calendar years minus adjusted calendar years (ka) |
| S237 | NM341 | Windmill #30 | 23.8 | 0.29 | 11.5 | 3 | RP | 77.56 | SWGW | 22.44 | na | na | -5.62 | 0.90 | 1.55 | -0.62 | 0.00 | -12.87 | 0.00 | 0.00 | 0.29 | - 5.06 | - 7.40 | 30.96 | 2.1 | 2.1 | 0.6 | 9.4 | 13.5 | 2.3 | 11.2 |
| S238 | NM342 | Windmill #31 | 32.9 | 0.35 | 8.9 | 4 | RP | 92.90 | MWGW | 7.10 | na | na | -2.54 | 0.13 | 1.36 | -0.09 | 0.00 | -4.53 | 0.00 | 0.00 | 1.47 | - 5.36 | - 7.90 | 58.49 | 4.6 | 4.7 | 4.5 | 4.3 | 10.3 | 5.1 | 5.2 |
| | | **Zone 6: Southwestern Mountain Front** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| S022 | NM009 | Windmill #02 | 40.0 | 0.41 | 7.4 | 4 | SWMF | 100.00 | na | na | na | na | -0.91 | 0.00 | -1.81 | 0.00 | -0.41 | 0.00 | 0.04 | 0.00 | 1.92 | - 6.63 | - 5.76 | 101.09 | 7.4 | 7.5 | 7.3 | - 0.1 | 8.3 | 8.4 | - 0.1 |
| | | **Zone 7: Abo Arroyo** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| S021 | NM261 | Stock Well #01 | 83.9 | 0.70 | 1.4 | 2 | EMF | 47.70 | ABO | 52.30 | na | na | -0.97 | 0.00 | 0.00 | 0.00 | -0.12 | -0.04 | 0.08 | 0.00 | 1.20 | - 9.58 | - 5.40 | 92.87 | 0.8 | 0.9 | 0.9 | 0.6 | 1.4 | 0.8 | 0.7 |
| S024 | NM011 | Domestic Well #02 | 17.1 | 0.18 | 14.2 | 5 | EMF | 59.36 | ABO | 40.64 | na | na | -0.05 | 0.06 | 0.00 | -0.04 | 0.00 | -0.17 | -1.33 | 0.00 | 0.83 | - 9.94 | - 6.94 | 94.47 | 13.7 | 13.7 | 13.7 | 0.5 | 16.8 | 16.2 | 0.6 |
| S090 | NM064 | Domestic Well #08 | 13.0 | 0.17 | 16.4 | 5 | EMF | 58.26 | ABO | 41.74 | na | na | -0.54 | 0.13 | 0.00 | -0.09 | 0.00 | 0.05 | -0.49 | 0.00 | 0.76 | -10.07 | - 6.49 | 94.29 | 15.9 | 15.9 | 15.9 | 0.5 | 19.4 | 18.9 | 0.5 |
| S093 | NM067 | Domestic Well #09 | 31.1 | 0.28 | 9.4 | 7 | EMF | 95.41 | ABO | 4.59 | na | na | -0.77 | 0.27 | -1.11 | -0.18 | 0.00 | 0.33 | 0.00 | 0.00 | 1.00 | - 8.85 | - 8.54 | 99.94 | 9.4 | 8.8 | 9.4 | 0.0 | 10.8 | 10.8 | 0.0 |
| | | **Zone 8: Eastern Mountain Front** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| S007 | NM002 | Domestic Well #01 | 113.4 | 0.96 | - 1.0 | 3 | EMF | 100.00 | na | na | na | na | 0.07 | 0.00 | 0.84 | 0.00 | 0.00 | -0.05 | 0.11 | 0.00 | 1.01 | -11.81 | -11.84 | 98.46 | - 1.1 | - 1.0 | - 1.2 | 0.1 | - 1.4 | - 1.5 | 0.2 |
| S013 | NM256 | Windmill #14 | 74.0 | 0.55 | 2.4 | 3 | EMF | 99.49 | Saline 1 | 0.51 | na | na | -0.61 | 0.00 | 0.00 | 0.00 | -0.36 | 0.27 | 0.14 | 0.00 | 0.23 | -10.38 | - 9.60 | 99.54 | 2.4 | 2.3 | 2.3 | 0.0 | 2.6 | 2.5 | 0.0 |
| S014 | NM257 | Private Production Well #17 | 79.8 | 0.66 | 1.8 | 4 | EMF | 99.94 | Saline 1 | 0.06 | na | na | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | -0.13 | 0.32 | 0.00 | 0.94 | -11.91 | - 7.40 | 99.96 | 1.8 | 1.8 | 1.8 | 0.0 | 1.9 | 1.9 | 0.0 |
| S015 | NM006 | Windmill #01 | 97.7 | 0.87 | 0.2 | 6 | EMF | 99.89 | Saline 1 | 0.11 | na | na | -0.38 | 0.34 | 0.00 | -0.23 | -0.34 | 0.00 | 0.11 | 0.00 | 0.65 | -12.10 | - 8.26 | 99.90 | 0.2 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| S030 | NM016 | Charles 4 | 51.4 | 0.43 | 5.3 | 7 | EMF | 98.33 | Saline 1 | 1.67 | na | na | -0.10 | 0.19 | 0.00 | -0.13 | 0.08 | 0.00 | 0.05 | 0.00 | 0.69 | -11.96 | - 8.54 | 98.83 | 5.3 | 5.3 | 5.0 | 0.1 | 5.9 | 5.8 | 0.1 |
| S042 | NM031 | Domestic Well #03 | 21.0 | 0.20 | 12.5 | 4 | EMF | 100.00 | na | na | na | na | -3.48 | 0.00 | 1.63 | 0.00 | 0.27 | 0.01 | 2.61 | 0.00 | 1.05 | -13.01 | - 7.95 | 99.80 | 12.5 | 12.5 | 12.5 | 0.0 | 14.7 | 14.7 | 0.0 |
| S055 | NM042 | Elena Gallegos | 109.2 | 0.91 | - 0.7 | 4 | EMF | 100.00 | na | na | na | na | 0.32 | 0.01 | 0.92 | -0.01 | -0.04 | 0.00 | 0.10 | 0.00 | 1.09 | -11.23 | -10.50 | 93.57 | - 1.2 | - 0.7 | - 1.3 | 0.5 | - 1.0 | - 1.7 | 0.7 |
| S056 | NM043 | Embudito Spring | 114.6 | 1.06 | - 1.1 | 3 | EMF | 100.00 | na | na | na | na | 0.08 | 0.00 | 1.43 | 0.00 | -0.05 | -0.05 | 0.32 | 0.00 | 1.61 | -11.82 | -14.10 | 98.48 | - 1.2 | - 1.1 | - 1.3 | 0.1 | - 1.5 | - 1.6 | 0.2 |
| S071 | NM060 | Domestic Well #07 | 97.5 | 0.80 | 0.2 | 3 | EMF | 100.00 | na | na | na | na | 0.00 | 0.42 | 0.45 | -0.29 | -0.52 | -0.19 | -0.10 | 0.00 | 0.94 | -12.00 | - 8.75 | 100.00 | 0.2 | 0.2 | - 0.4 | 0.0 | 0.1 | 0.1 | 0.0 |
| S083 | NM407 | Windmill #34 | 17.2 | 0.32 | 14.2 | 5 | EMF | 99.23 | Saline 1 | 0.77 | na | na | -0.40 | 0.15 | 0.00 | -0.11 | 0.00 | 0.07 | 0.20 | 0.00 | 1.04 | -12.10 | - 5.50 | 99.44 | 14.1 | 14.1 | 14.1 | 0.0 | 16.7 | 16.7 | 0.1 |
| S095 | NM068 | Kirtland 1 | 59.4 | 0.51 | 4.2 | 5 | EMF | 99.83 | Saline 1 | 0.17 | na | na | -0.33 | 0.12 | 0.00 | -0.08 | 0.00 | 0.13 | 0.32 | 0.00 | 0.85 | -12.10 | - 8.89 | 99.86 | 4.2 | 4.2 | 4.2 | 0.0 | 4.6 | 4.6 | 0.0 |
| S106 | NM295 | Domestic Well #23 | 11.2 | 0.11 | 17.6 | 7 | EMF | 99.13 | Saline 1 | 0.87 | na | na | -0.73 | 0.71 | 0.00 | -0.49 | 0.00 | 0.58 | 0.27 | 0.00 | 0.84 | -12.08 | - 8.20 | 99.35 | 17.6 | 17.6 | 17.3 | 0.0 | 20.8 | 20.8 | 0.1 |
| S110 | NM078 | Love 1 | 47.2 | 0.39 | 6.0 | 7 | EMF | 99.86 | Saline 1 | 0.14 | na | na | -0.28 | 0.21 | -0.49 | -0.15 | 0.00 | 0.36 | 0.00 | 0.00 | 0.77 | -11.06 | - 7.63 | 100.09 | 6.0 | 6.0 | 6.0 | 0.0 | 6.7 | 6.8 | 0.0 |
| S113 | NM080 | Domestic Well #11 | 8.3 | 0.14 | 20.0 | 4 | EMF | 99.91 | Saline 1 | 0.09 | na | na | -0.07 | 0.00 | 0.00 | 0.00 | 0.40 | 1.06 | 0.33 | 0.00 | 0.55 | -12.02 | - 7.43 | 99.93 | 20.0 | 19.9 | 19.9 | 0.0 | 23.4 | 23.4 | 0.0 |
| S114 | NM500 | Matheson D | 35.4 | 0.29 | 8.4 | 6 | EMF | 99.97 | Saline 1 | 0.03 | na | na | -0.09 | 0.28 | 0.00 | -0.19 | 0.00 | 0.53 | -0.01 | 0.00 | 0.66 | -12.04 | -11.03 | 99.97 | 8.4 | 8.4 | 8.4 | 0.0 | 9.5 | 9.5 | 0.0 |
| S115 | NM501 | Matheson M | 55.9 | 0.41 | 4.7 | 3 | EMF | 99.97 | Saline 1 | 0.03 | na | na | 0.16 | 0.14 | 0.00 | -0.10 | 0.00 | 1.00 | -0.06 | 0.00 | 0.77 | -11.51 | -10.16 | 95.88 | 4.3 | 4.7 | 4.4 | 0.3 | 5.2 | 4.8 | 0.4 |
| S116 | NM502 | Matheson S | 64.9 | 0.52 | 3.5 | 1 | EMF | 99.92 | Saline 1 | 0.08 | na | na | 0.00 | 0.98 | 1.51 | -0.68 | -0.90 | 0.12 | 0.00 | 0.00 | 0.56 | -12.00 | - 9.35 | 99.96 | 3.5 | 3.5 | 3.5 | 0.0 | 3.8 | 3.8 | 0.0 |
| S117 | NM298 | Domestic Well #25 | 95.1 | 0.67 | 0.4 | 5 | EMF | 100.00 | Saline 1 | 0.00 | na | na | 0.00 | 0.00 | -0.03 | 0.00 | -0.02 | -0.02 | -0.03 | 0.00 | 0.98 | -11.82 | - 9.00 | 100.01 | 0.4 | 0.4 | 0.2 | 0.0 | 0.3 | 0.3 | 0.0 |
| S118 | NM299 | Windmill #24 | 37.4 | 0.38 | 7.9 | 5 | EMF | 98.70 | Saline 1 | 1.30 | na | na | -0.53 | 0.09 | 0.00 | -0.06 | 0.00 | 0.14 | 0.36 | 0.00 | 0.80 | -11.80 | - 5.90 | 99.05 | 7.8 | 7.8 | 7.8 | 0.1 | 9.0 | 8.9 | 0.1 |
| S119 | NM300 | Domestic Well #26 | 47.4 | 0.34 | 6.0 | 3 | EMF | 99.87 | Saline 1 | 0.13 | na | na | -0.87 | 0.56 | 0.00 | -0.39 | -0.91 | 0.00 | 0.13 | 0.00 | 2.09 | -12.33 | - 7.80 | 99.83 | 6.0 | 6.0 | 6.0 | 0.0 | 6.7 | 6.7 | 0.0 |
| S122 | NM505 | Mesa Del Sol S | 33.4 | 0.27 | 8.8 | 6 | EMF | 99.48 | Saline 1 | 0.52 | na | na | -0.87 | 0.56 | 0.00 | -0.39 | 0.00 | 0.01 | -0.05 | 0.00 | 0.94 | -12.40 | - 9.88 | 99.55 | 8.8 | 8.7 | 8.7 | 0.0 | 10.1 | 10.1 | 0.0 |
| S140 | NM306 | MRN 1 | 42.2 | 0.30 | 6.9 | 5 | EMF | 99.70 | Saline 1 | 0.30 | na | na | -0.54 | 0.05 | 0.00 | -0.04 | 0.00 | 0.00 | 0.35 | 0.00 | 1.08 | -12.18 | - 7.70 | 99.74 | 6.9 | 6.9 | 6.9 | 0.0 | 7.8 | 7.8 | 0.0 |
| S141 | NM095 | National Utility 7 | 68.8 | 0.60 | 3.0 | 5 | EMF | 100.00 | na | na | na | na | -0.12 | 1.17 | 1.02 | -0.81 | -1.30 | 0.00 | -0.08 | 0.00 | 0.51 | -12.02 | - 5.97 | 100.00 | 3.0 | 3.0 | 1.7 | 0.0 | 3.2 | 3.2 | 0.0 |
| S149 | NM312 | Nor Este D | 8.0 | 0.11 | 20.3 | 5 | EMF | 90.99 | Saline 1 | 9.01 | na | na | -0.87 | 0.37 | 0.00 | -0.25 | 0.00 | 0.49 | 0.49 | 0.00 | 0.65 | -11.51 | - 8.70 | 93.58 | 19.8 | 20.0 | 19.7 | 0.5 | 23.7 | 23.2 | 0.5 |
| S150 | NM313 | Nor Este M | 17.1 | 0.19 | 14.2 | 5 | EMF | 89.47 | Saline 1 | 10.53 | na | na | -1.17 | 0.57 | 0.00 | -0.39 | 0.00 | -0.61 | 0.09 | 0.00 | 0.65 | -11.79 | - 8.60 | 92.49 | 13.6 | 13.7 | 13.4 | 0.6 | 16.8 | 16.0 | 0.8 |
| S162 | NM317 | Stock Well #03 | 52.7 | 0.48 | 5.2 | 7 | EMF | 99.83 | Saline 1 | 0.17 | na | na | -0.77 | 0.87 | 0.00 | -0.60 | -0.78 | 0.00 | -0.08 | 0.00 | 0.56 | -12.03 | - 8.20 | 99.82 | 5.1 | 5.2 | 5.2 | 0.0 | 5.7 | 5.7 | 0.0 |
| S163 | NM318 | PL 2 | 38.8 | 0.36 | 7.6 | 5 | EMF | 99.77 | Saline 1 | 0.23 | na | na | -0.39 | 0.10 | 0.00 | -0.07 | 0.00 | 0.13 | 0.33 | 0.00 | 0.87 | -11.98 | - 8.20 | 99.81 | 7.6 | 7.6 | 7.6 | 0.0 | 8.6 | 8.6 | 0.0 |
| S164 | NM106 | Ponderosa 1 | 42.5 | 0.36 | 6.9 | 6 | EMF | 96.51 | Saline 1 | 3.49 | na | na | -0.27 | 0.24 | -0.42 | -0.17 | 0.00 | -0.35 | 0.00 | 0.00 | 0.84 | -11.09 | - 9.25 | 97.71 | 6.7 | 6.7 | 6.6 | 0.2 | 7.8 | 7.5 | 0.2 |
| S165 | NM328 | Windmill #25 | 10.2 | 0.16 | 18.4 | 6 | EMF | 99.55 | Saline 1 | 0.45 | na | na | -0.16 | 0.24 | 0.00 | -0.17 | 0.00 | 1.63 | 0.51 | 0.00 | 0.65 | -11.09 | - 8.90 | 99.67 | 18.4 | 18.4 | 18.1 | 0.0 | 21.7 | 21.6 | 0.0 |
| S168 | NM319 | Domestic Well #30 | 5.4 | 0.11 | 23.4 | 5 | EMF | 99.79 | Saline 1 | 0.21 | na | na | -1.80 | 1.59 | 0.00 | -1.10 | -1.99 | 0.00 | 0.10 | 0.00 | 0.71 | -12.47 | - 9.20 | 99.70 | 23.4 | 2.1 | 2.1 | 0.0 | 26.8 | 26.7 | 0.0 |
| S170 | NM108 | Ridgecrest 3 | 70.3 | 0.72 | 2.8 | 7 | EMF | 98.72 | Saline 1 | 1.28 | na | na | -0.32 | 0.33 | 0.02 | -0.23 | 0.00 | -0.13 | 0.00 | 0.00 | 0.64 | -12.05 | -12.20 | 99.09 | 2.8 | 2.7 | 2.6 | 0.1 | 3.1 | 3.0 | 0.1 |
| S195 | NM134 | Domestic Well #13 | 22.2 | 0.21 | 12.1 | 6 | EMF | 99.54 | Saline 1 | 0.46 | na | na | -1.01 | 0.38 | -0.59 | -0.26 | 0.00 | -0.15 | 0.00 | 0.00 | 0.96 | -10.81 | - 8.24 | 99.92 | 12.1 | 12.1 | 12.1 | 0.0 | 14.2 | 14.2 | 0.0 |
| S199 | NM138 | Windmill #08 | 57.2 | 0.49 | 4.5 | 4 | EMF | 99.33 | Saline 1 | 0.67 | na | na | -0.25 | 0.02 | 0.00 | -0.01 | 0.00 | -0.10 | 0.54 | 0.00 | 0.96 | -12.05 | - 6.30 | 99.52 | 4.5 | 4.5 | 4.5 | 0.0 | 5.0 | 4.9 | 0.0 |
| S209 | NM336 | Domestic Well #33 | 15.8 | 0.16 | 14.8 | 6 | EMF | 98.63 | Saline 1 | 1.37 | na | na | -0.42 | 0.00 | 0.00 | 0.00 | 0.67 | 0.55 | 0.46 | 0.00 | 0.64 | -11.61 | - 8.70 | 99.01 | 14.7 | 14.8 | 14.7 | 0.1 | 17.5 | 17.5 | 0.1 |
| S212 | NM141 | Sandia Peak 1 | 78.0 | 0.65 | 2.0 | 1 | EMF | 99.83 | Saline 1 | 0.17 | na | na | 0.00 | 2.23 | 3.43 | -1.54 | -2.10 | -0.33 | 0.00 | 0.00 | 0.45 | -12.00 | - 9.73 | 99.94 | 2.0 | 2.0 | 2.0 | 0.0 | 2.1 | 2.1 | 0.0 |
| S213 | NM142 | Sandia Peak 3 | 83.2 | 0.69 | 1.5 | 7 | EMF | 99.96 | Saline 1 | 0.04 | na | na | -0.01 | 0.05 | 0.09 | -0.03 | 0.00 | 0.04 | 0.00 | 0.00 | 0.98 | -11.83 | - 9.30 | 100.00 | 1.5 | 1.5 | 1.4 | 0.0 | 1.5 | 1.5 | 0.0 |
| S224 | NM148 | Domestic Well #14 | 79.9 | 0.68 | 1.8 | 5 | EMF | 100.00 | na | na | na | na | 1.23 | 0.00 | 1.81 | 0.00 | 0.69 | 0.24 | 0.27 | 0.00 | 0.55 | - 9.84 | - 7.56 | 81.96 | 0.2 | 1.8 | 0.2 | 1.6 | 1.9 | 0.1 | 1.8 |

**Table 10.** Summary of unadjusted radiocarbon age, source waters and mixing fractions, geochemical mineral-water mass transfer reactions, evaporation factor, adjusted radiocarbon age, and calendar age in one representative geochemical model for each ground-water sample collected for the Middle Rio Grande Basin study -- Continued

| Site no. | Sample no. | Site name | $^{14}C$ activity (pmC) | $^{14}C$ ± 1 σ (pmC) | Conventional, unadjusted $^{14}C$ age, Libby half-life (ka) | No. of mass balance models found | Source waters and percent in mixture: Primary water | Percent primary water | Secondary water | Percent secondary water | Additional secondary water | Percent additional secondary water | Mass transfer, millimoles per kilogram water: Calcite | Plagioclase feldspar | $CO_2$ | Kaolinite | $SiO_2$ | Ca-Na cation exchange | Gypsum | $CH_2O$ | Evaporation factor | [1] Calculated $\delta^{13}C$ (per mil) | Observed $\delta^{13}C$ (per mil) | Initial $^{14}C$ activity adjusted for geochemical reactions (pmC) | Adjusted $^{14}C$ Age Libby half-life (ka) | Maximum adjusted $^{14}C$ Age Libby half-life (ka) | Minimum adjusted $^{14}C$ Age Libby half-life (ka) | Difference unadjusted $^{14}C$ age minus adjusted age, Libby half-life (ka) | Unadjusted $^{14}C$ calendar years (ka) | Adjusted $^{14}C$ calendar years (ka) | Difference unadjusted calendar years minus adjusted calendar years (ka) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S229 | NM515 | SH03 UNM | 96.3 | 0.75 | 0.3 | 5 | EMF | 100.00 | na | na | na | na | 0.49 | 0.04 | 1.50 | -0.03 | -0.02 | 0.00 | 0.09 | 0.00 | 0.79 | -10.98 | - 9.42 | 91.52 | - 0.4 | 0.3 | - 0.5 | 0.7 | 0.2 | - 0.7 | 0.8 |
| S233 | NM153 | Domestic Well #16 | 32.6 | 0.30 | 9.0 | 7 | EMF | 99.63 | Saline 1 | 0.37 | na | na | -0.62 | 0.62 | 0.00 | -0.43 | -0.50 | 0.00 | -0.03 | 0.00 | 1.45 | -12.29 | - 7.14 | 99.68 | 9.0 | 8.7 | 8.9 | 0.0 | 10.4 | 10.3 | 0.0 |
| S239 | NM156 | Domestic Well #17 | 22.0 | 0.26 | 12.2 | 4 | EMF | 100.00 | na | na | na | na | 0.01 | 0.00 | 0.66 | 0.00 | -0.01 | 0.24 | -0.01 | 0.00 | 1.18 | -11.98 | - 8.92 | 99.85 | 12.2 | 12.2 | 12.2 | 0.0 | 14.3 | 14.3 | 0.0 |
| S240 | NM157 | Domestic Well #18 | 66.4 | 0.58 | 3.3 | 4 | EMF | 99.99 | Saline 1 | 0.01 | na | na | -0.21 | 0.44 | 0.00 | -0.31 | -0.33 | 0.00 | -0.13 | 0.00 | 0.78 | -12.07 | -10.51 | 99.98 | 3.3 | 3.3 | 3.1 | 0.0 | 3.6 | 3.6 | 0.0 |
| S246 | NM343 | Windmill #32 | 31.2 | 0.32 | 9.4 | 6 | EMF | 99.60 | Saline 1 | 0.40 | na | na | -0.25 | 0.28 | 0.00 | -0.19 | 0.00 | 0.52 | 0.91 | 0.00 | 0.59 | -11.82 | - 5.90 | 99.70 | 9.3 | 9.4 | 9.2 | 0.0 | 10.8 | 10.8 | 0.0 |
| S247 | NM161 | Domestic Well #19 | 4.9 | 0.14 | 24.3 | 6 | EMF | 99.81 | Saline 1 | 0.19 | na | na | 0.40 | 0.19 | 0.00 | -0.13 | 0.00 | 2.05 | 0.22 | 0.00 | 0.68 | -10.86 | - 8.50 | 90.40 | 23.5 | 2.4 | 2.3 | 0.8 | 27.5 | 26.8 | 0.7 |
| S248 | NM162 | Thomas 6 | 44.2 | 0.37 | 6.6 | 6 | EMF | 96.91 | Saline 1 | 3.09 | na | na | -0.33 | 0.27 | -0.11 | -0.19 | 0.00 | -0.44 | 0.00 | 0.00 | 0.79 | -11.75 | - 8.95 | 97.86 | 6.4 | 6.4 | 6.2 | 0.2 | 7.4 | 7.2 | 0.2 |
| S255 | NM523 | Tramway East | 54.0 | 0.39 | 5.0 | 5 | EMF | 99.94 | Saline 1 | 0.06 | na | na | -0.27 | 1.06 | 0.00 | -0.73 | -1.13 | 0.00 | -0.10 | 0.00 | 0.77 | -12.09 | -10.41 | 99.94 | 5.0 | 5.0 | 2.5 | 0.0 | 5.5 | 5.5 | 0.0 |
| S264 | NM174 | Walker 1 | 41.6 | 0.34 | 7.0 | 6 | EMF | 95.88 | Saline 1 | 4.12 | na | na | -0.20 | 0.40 | -0.01 | -0.27 | 0.00 | -0.55 | 0.00 | 0.00 | 0.58 | -11.88 | - 9.26 | 97.11 | 6.8 | 6.8 | 6.8 | 0.2 | 7.9 | 7.7 | 0.3 |
| S274 | NM177 | Domestic Well #20 | 24.7 | 0.24 | 11.2 | 6 | EMF | 99.56 | Saline 1 | 0.44 | na | na | -0.83 | 0.14 | -0.61 | -0.09 | 0.00 | -0.09 | 0.00 | 0.00 | 1.36 | -10.76 | - 5.80 | 99.94 | 11.2 | 11.3 | 11.2 | 0.0 | 13.1 | 13.1 | 0.0 |
| | | **Zone 9: Tijeras Fault Zone** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| S072 | NM061 | Hubbell Spring | 42.8 | 0.37 | 6.8 | 3 | EMF | 100.00 | na | na | na | na | -1.37 | 0.00 | -1.68 | 0.00 | -0.30 | -0.12 | 0.08 | 0.00 | 5.49 | - 5.53 | - 6.40 | 101.31 | 6.9 | 6.9 | 6.8 | - 0.1 | 7.7 | 7.8 | - 0.1 |
| S197 | NM136 | Windmill #06 | 4.8 | 0.13 | 24.5 | 2 | EMF | 96.26 | Saline 2 | 3.74 | na | na | -3.62 | 3.53 | 0.00 | -2.43 | -4.69 | 0.00 | 0.68 | 0.00 | 3.25 | - 9.96 | - 8.22 | 74.14 | 22.1 | 22.1 | 12.8 | 2.4 | 27.7 | 25.5 | 2.2 |
| S227 | NM151 | SFR 3D | 9.7 | 0.14 | 18.8 | 1 | EMF | 84.22 | Saline 2 | 15.77 | na | na | 0.00 | 0.00 | 1.14 | 0.00 | -0.03 | -0.24 | 0.17 | 0.00 | 1.44 | - 4.96 | - 0.98 | 45.99 | 12.5 | 12.5 | 12.5 | 6.2 | 22.1 | 14.7 | 7.4 |
| S228 | NM152 | SFR 3S | 13.2 | 0.15 | 16.2 | 3 | EMF | 61.19 | Saline 2 | 38.81 | na | na | 0.00 | 0.00 | -2.00 | 0.00 | 0.42 | -0.40 | 0.79 | 0.00 | 0.60 | - 1.35 | - 0.95 | 18.39 | 2.6 | 2.6 | 2.6 | 13.6 | 19.2 | 2.8 | 16.4 |
| | | **Zone 10: Tijeras Arroyo** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| S001 | NM001 | 4Hills-1 | 94.0 | 0.67 | 0.5 | 4 | EMF | 2.85 | TIJ | 91.60 | Saline | 5.55 | -1.36 | 0.03 | 0.00 | -0.02 | 0.00 | -0.28 | 1.89 | 0.00 | 1.00 | - 5.34 | - 8.40 | 58.53 | - 3.8 | - 3.8 | - 3.8 | 4.3 | 0.4 | - 5.2 | 5.6 |
| S002 | NM250 | Private Production Well #15 | 82.7 | 0.69 | 1.5 | 2 | EMF | 31.43 | TIJ | 64.70 | Saline | 3.87 | -0.87 | 0.00 | 0.00 | 0.00 | 0.00 | -0.41 | 0.49 | 0.00 | 1.00 | - 6.72 | - 6.80 | 67.71 | - 1.6 | - 1.6 | - 1.6 | 3.1 | 1.6 | - 2.1 | 3.7 |
| S058 | NM277 | Eubank 1 | 62.0 | 0.52 | 3.8 | 4 | EMF | 92.33 | TIJ | 7.67 | na | na | -1.11 | 0.79 | 0.00 | -0.54 | -0.98 | -0.11 | 0.50 | 0.00 | 1.00 | -11.90 | - 6.20 | 98.87 | 3.7 | 3.8 | 3.7 | 0.1 | 4.2 | 4.1 | 0.1 |
| S096 | NM069 | Kirtland 11 | 46.0 | 0.42 | 6.2 | 5 | EMF | 86.12 | TIJ | 13.88 | na | na | -0.21 | 0.00 | 0.00 | 0.00 | 0.08 | 0.21 | 0.43 | 0.00 | 1.01 | -11.38 | - 7.90 | 98.11 | 6.1 | 6.1 | 6.1 | 0.2 | 7.0 | 6.8 | 0.2 |
| S107 | NM075 | Lomas 1 | 72.8 | 0.62 | 2.6 | 6 | EMF | 62.85 | TIJ | 37.15 | na | na | -0.65 | 0.00 | 0.00 | 0.00 | 0.03 | 0.06 | 0.34 | 0.00 | 1.03 | -10.42 | - 6.20 | 94.98 | 2.1 | 2.5 | 2.1 | 0.4 | 2.7 | 2.3 | 0.5 |
| | | **Zone 11: Northeastern** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| S016 | NM258 | Windmill #15 | 28.5 | 0.24 | 10.1 | 4 | EMF | 50.29 | NEGW | 47.73 | Saline | 1.98 | 0.00 | 0.22 | 0.00 | -0.15 | 0.08 | 3.54 | 2.42 | 0.00 | 1.00 | - 7.13 | - 5.30 | 41.70 | 3.1 | 4.6 | 2.4 | 7.0 | 11.7 | 3.3 | 8.4 |
| S017 | NM259 | Windmill #16 | 18.1 | 0.15 | 13.7 | 4 | EMF | 66.05 | NEGW | 33.95 | na | na | -2.22 | 2.17 | 0.00 | -1.50 | -2.79 | 0.00 | 0.42 | 0.00 | 1.19 | - 8.96 | - 7.40 | 56.79 | 9.2 | 9.2 | 9.2 | 4.5 | 16.2 | 10.6 | 5.6 |
| S053 | NM276 | Private Production Well #18 | 76.5 | 0.65 | 2.1 | 4 | EMF | 98.88 | NEGW | 1.11 | na | na | -2.54 | 1.43 | 0.00 | -0.99 | -1.89 | 0.00 | 1.95 | 0.00 | 2.48 | -13.98 | - 5.60 | 97.89 | 2.0 | 1.9 | - 2.7 | 0.2 | 2.3 | 2.1 | 0.2 |
| S144 | NM097 | Private Production Well #06 | 29.2 | 0.37 | 9.9 | 5 | EMF | 59.33 | NEGW | 40.67 | na | na | -1.73 | 0.17 | 0.00 | -0.11 | 0.00 | 0.52 | 2.87 | 0.00 | 1.49 | - 8.59 | - 6.80 | 49.77 | 4.3 | 8.2 | 3.5 | 5.6 | 11.4 | 4.7 | 6.7 |
| S204 | NM332 | Windmill #28 | 19.6 | 0.27 | 13.1 | 5 | EMF | 94.68 | NEGW | 5.21 | Saline | 0.11 | -0.34 | 0.00 | 0.00 | 0.00 | 0.06 | 0.15 | 0.73 | 0.00 | 1.00 | -11.29 | - 6.40 | 92.30 | 12.5 | 12.5 | 11.1 | 0.6 | 15.5 | 14.7 | 0.8 |
| S207 | NM334 | Private Production Well #22 | 69.3 | 0.49 | 2.9 | 3 | EMF | 14.18 | GAL | 85.82 | na | na | -0.54 | 0.19 | 0.08 | -0.13 | 0.00 | -1.01 | 2.57 | 0.00 | 1.00 | - 6.96 | - 6.10 | 99.94 | 2.9 | 3.0 | 3.0 | 0.0 | 3.2 | 3.2 | 0.0 |
| S223 | NM338 | Windmill #29 | 19.5 | 0.26 | 13.1 | 3 | EMF | 80.41 | GAL | 19.59 | na | na | -1.21 | 0.00 | -1.45 | 0.00 | -0.17 | -0.24 | 0.00 | 0.00 | 2.38 | - 6.13 | - 6.70 | 100.90 | 13.2 | 13.2 | 13.2 | - 0.1 | 15.5 | 15.6 | - 0.1 |
| | | **Zone 12: Central** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| S011 | NM004 | Atris-1 | 96.8 | 0.80 | 0.3 | 6 | RGA | 99.92 | Saline 1 | 0.08 | na | na | -0.02 | 0.12 | 0.18 | 0.18 | 0.00 | -0.02 | 0.00 | 0.32 | 1.09 | - 9.16 | - 8.34 | 99.91 | 0.3 | 0.3 | 0.2 | 0.0 | 0.1 | 0.1 | 0.0 |
| S012 | NM005 | Atrisco 3 | 64.7 | 0.53 | 3.5 | 5 | RGA | 100.00 | na | na | na | na | -0.08 | 0.00 | -0.48 | 0.00 | 0.31 | 0.30 | -0.07 | 0.25 | 1.58 | - 7.04 | - 8.31 | 100.42 | 3.5 | 3.5 | 3.5 | 0.0 | 3.8 | 3.8 | 0.0 |
| S025 | NM012 | Burton 2 | 47.7 | 0.40 | 5.9 | 6 | RGA | 99.33 | Saline 1 | 0.67 | na | na | -0.37 | 0.34 | 0.00 | -0.24 | 0.00 | -0.39 | -0.30 | 0.18 | 1.25 | - 8.84 | - 9.08 | 99.14 | 5.9 | 5.8 | 5.8 | 0.1 | 6.6 | 6.6 | 0.1 |
| S026 | NM013 | Burton 5 | 44.7 | 0.37 | 6.5 | 7 | RGA | 99.26 | Saline 1 | 0.74 | na | na | -0.32 | 0.39 | 0.00 | -0.27 | 0.00 | -0.40 | -0.36 | 0.24 | 1.16 | - 9.13 | - 9.35 | 99.09 | 6.4 | 6.4 | 5.6 | 0.1 | 7.3 | 7.2 | 0.1 |
| S033 | NM025 | Private Production Well #02 | 96.4 | 1.15 | 0.3 | 3 | RGA | 100.00 | na | na | na | na | -0.76 | 0.95 | 0.00 | -0.65 | -1.29 | -0.51 | -0.18 | 0.24 | 3.65 | - 9.79 | -10.56 | 99.88 | 0.3 | 0.4 | 0.3 | 0.0 | 0.2 | 0.2 | 0.0 |
| S040 | NM028 | Coronado 1 | 32.8 | 0.27 | 9.0 | 8 | RGA | 97.70 | Saline 1 | 2.30 | na | na | 0.04 | 0.04 | 0.00 | -0.03 | 0.57 | 0.00 | -0.24 | 0.22 | 1.08 | - 8.61 | - 8.50 | 95.44 | 8.6 | 8.7 | 8.1 | 0.4 | 10.3 | 9.8 | 0.5 |
| S043 | NM488 | Del Sol D | 6.2 | 0.14 | 22.3 | 8 | RGA | 98.89 | Saline 1 | 1.11 | na | na | -0.19 | 0.51 | 0.00 | -0.35 | 0.00 | 0.25 | -0.30 | 0.24 | 1.31 | - 9.00 | - 8.27 | 98.66 | 22.2 | 22.3 | 21.7 | 0.1 | 25.7 | 25.6 | 0.1 |
| S043 | NM267 | Del Sol D | 6.4 | 0.09 | 22.1 | 7 | RGA | 98.92 | Saline 1 | 1.08 | na | na | -0.36 | 0.45 | 0.00 | -0.31 | 0.00 | 0.11 | -0.29 | 0.25 | 1.40 | - 9.13 | - 8.00 | 98.68 | 22.0 | 22.0 | 21.6 | 0.1 | 25.5 | 25.4 | 0.1 |
| S044 | NM489 | Del Sol M | 13.7 | 0.16 | 16.0 | 7 | RGA | 98.50 | Saline 1 | 1.50 | na | na | 0.21 | 0.00 | 0.00 | 0.00 | 0.46 | -0.11 | -0.27 | 0.23 | 1.18 | - 8.07 | - 8.33 | 89.71 | 15.1 | 15.8 | 14.3 | 0.9 | 19.0 | 17.9 | 1.0 |
| S044 | NM268 | Del Sol M | 14.5 | 0.16 | 15.5 | 6 | RGA | 98.61 | Saline 1 | 1.39 | na | na | 0.00 | 0.08 | 0.00 | -0.06 | 0.34 | -0.24 | -0.25 | 0.27 | 1.25 | - 8.74 | - 8.00 | 98.35 | 15.4 | 15.4 | 15.1 | 0.1 | 18.4 | 18.2 | 0.2 |
| S045 | NM490 | Del Sol S | 62.2 | 0.48 | 3.8 | 6 | RGA | 96.54 | Saline 1 | 3.46 | na | na | -0.62 | 0.20 | 0.00 | -0.14 | 0.00 | -1.19 | 0.33 | 0.15 | 1.12 | - 9.01 | - 9.06 | 95.71 | 3.5 | 3.7 | 3.4 | 0.4 | 4.2 | 3.8 | 0.4 |
| S046 | NM032 | Duranes 1 | 73.1 | 0.60 | 2.5 | 6 | RGA | 99.92 | Saline 1 | 0.08 | na | na | -0.35 | 0.30 | 0.00 | -0.20 | 0.00 | 0.13 | 0.09 | 0.25 | 1.74 | - 9.24 | -10.86 | 99.86 | 2.5 | 2.5 | 0.9 | 0.0 | 2.7 | 2.7 | 0.0 |
| S047 | NM270 | Duranes 7 | 72.0 | 0.64 | 2.6 | 5 | RGA | 100.00 | na | na | na | na | 0.13 | 0.00 | 0.03 | 0.00 | 0.64 | 0.35 | 0.02 | 0.34 | 1.11 | - 8.22 | - 9.10 | 94.47 | 2.2 | 2.7 | 2.2 | 0.5 | 2.8 | 2.3 | 0.5 |
| S060 | NM279 | Garfield D | 12.6 | 0.16 | 16.7 | 5 | RGA | 100.00 | na | na | na | na | 0.16 | 0.49 | 0.63 | -0.34 | 0.00 | 0.95 | 0.08 | 0.28 | 0.93 | - 9.02 | - 8.40 | 94.81 | 16.2 | 16.7 | 15.2 | 0.4 | 19.7 | 19.2 | 0.5 |
| S061 | NM280 | Garfield M | 22.3 | 0.19 | 12.0 | 5 | RGA | 100.00 | na | na | na | na | 0.43 | 0.00 | 0.50 | 0.00 | 1.15 | 0.66 | -0.09 | 0.28 | 0.87 | - 8.11 | - 8.60 | 86.30 | 10.9 | 12.1 | 10.9 | 1.2 | 14.1 | 12.7 | 1.5 |
| S062 | NM491 | Garfield S | 81.8 | 0.68 | 1.6 | 5 | RGA | 100.00 | na | na | na | na | 0.13 | 0.05 | 1.26 | -0.03 | -0.04 | 0.00 | 0.54 | 0.25 | 1.90 | - 9.67 | -10.70 | 96.26 | 1.3 | 1.7 | 1.3 | 0.3 | 1.7 | 1.3 | 0.3 |
| S064 | NM283 | Domestic Well #22 | 82.8 | 0.69 | 1.5 | 4 | RGA | 99.98 | Saline 1 | 0.02 | na | na | -0.35 | 0.20 | 0.00 | -0.14 | 0.00 | -0.24 | -0.02 | 0.30 | 1.57 | - 9.13 | - 9.70 | 99.92 | 1.5 | 1.5 | 1.5 | 0.0 | 1.6 | 1.6 | 0.0 |

**Table 10.** Summary of unadjusted radiocarbon age, source waters and mixing fractions, geochemical mineral-water mass transfer reactions, evaporation factor, adjusted radiocarbon age, and calendar age in one representative geochemical model for each ground-water sample collected for the Middle Rio Grande Basin study -- Continued

| | | | | | | | Source waters and percent in mixture | | | | | | Mass transfer, millimoles per kilogram water | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site no. | Sample no. | Site name | $^{14}C$ activity (pmC) | $^{14}C$ ± 1 σ (pmC) | Conventional, unadjusted $^{14}C$ age, Libby half-life (ka) | No. of mass balance models found | Primary water | Percent primary water | Secondary water | Percent secondary water | Additional secondary water | Percent additional secondary water | Calcite | Plagioclase feldspar | $CO_2$ | Kaolinite | $SiO_2$ | Ca-Na cation exchange | Gypsum | $CH_2O$ | Evaporation factor | [1] Calculated $\delta^{13}C$ (per mil) | Observed $\delta^{13}C$ (per mil) | Initial $^{14}C$ activity adjusted for geochemical reactions (pmC) | Adjusted $^{14}C$ Age Libby half-life (ka) | Maximum adjusted $^{14}C$ Age Libby half-life (ka) | Minimum adjusted $^{14}C$ Age Libby half-life (ka) | Difference unadjusted $^{14}C$ age minus adjusted age, Libby half-life (ka) | Unadjusted $^{14}C$ calendar years (ka) | Adjusted $^{14}C$ calendar years (ka) | Difference unadjusted calendar years minus adjusted calendar years (ka) |
| S068 | NM057 | Griegos 3 | 67.0 | 0.55 | 3.2 | 4 | RGA | 99.96 | Saline 1 | 0.04 | na | na | -0.36 | 0.52 | 0.75 | -0.36 | 0.00 | 0.04 | 0.00 | 0.25 | 1.20 | -10.21 | - 8.81 | 99.89 | 3.2 | 3.2 | 2.8 | 0.0 | 3.5 | 3.5 | 0.0 |
| S075 | NM286 | Hunter Ridge Nest 1 Well 1 | 25.3 | 0.22 | 11.0 | 3 | RGA | 99.98 | Saline 1 | 0.02 | na | na | 0.33 | 0.00 | 0.00 | 0.00 | 0.57 | 0.81 | -0.02 | 0.31 | 1.17 | - 7.61 | - 7.90 | 87.29 | 9.9 | 11.0 | 9.9 | 1.1 | 12.9 | 11.5 | 1.4 |
| S076 | NM287 | Hunter Ridge Nest 1 Well 2 | 60.4 | 0.54 | 4.0 | 5 | RGA | 100.00 | na | na | na | na | 0.52 | 0.00 | 0.80 | 0.00 | 1.02 | 0.02 | -0.07 | 0.26 | 0.79 | - 8.26 | - 9.80 | 85.26 | 2.8 | 4.0 | 2.8 | 1.3 | 4.4 | 3.0 | 1.5 |
| S078 | NM289 | Hunter Ridge Nest 2 Well 1 | 73.8 | 0.62 | 2.4 | 5 | RGA | 100.00 | na | na | na | na | -0.15 | 0.48 | 0.67 | -0.33 | -0.08 | 0.00 | 0.30 | 0.31 | 0.98 | - 9.63 | - 9.00 | 99.99 | 2.4 | 2.4 | 2.0 | 0.0 | 2.6 | 2.6 | 0.0 |
| S081 | NM292 | Private Production Well #19 | 55.2 | 0.46 | 4.8 | 5 | RGA | 99.98 | Saline 1 | 0.02 | na | na | 0.00 | 0.21 | 0.00 | -0.14 | 0.33 | -0.03 | -0.23 | 0.26 | 1.24 | - 8.85 | - 8.80 | 99.98 | 4.8 | 4.8 | 4.8 | 0.0 | 5.3 | 5.3 | 0.0 |
| S084 | NM063 | Windmill #04 | 79.5 | 0.66 | 1.8 | 8 | RGA | 99.94 | Saline 1 | 0.06 | na | na | -0.21 | 0.27 | 0.00 | -0.19 | 0.00 | 0.09 | -0.26 | 0.19 | 1.69 | - 8.81 | - 8.77 | 99.90 | 1.8 | 1.8 | 1.1 | 0.0 | 1.9 | 1.9 | 0.0 |
| S087 | NM493 | Isleta MD | 35.8 | 0.33 | 8.3 | 4 | RGA | 99.95 | Saline 1 | 0.05 | na | na | 0.64 | 0.00 | 0.00 | 0.00 | 0.57 | 1.14 | -0.18 | 0.25 | 1.13 | - 6.91 | - 7.92 | 77.43 | 6.2 | 6.8 | 6.2 | 2.1 | 9.4 | 7.0 | 2.5 |
| S088 | NM494 | Isleta MS | 72.3 | 0.51 | 2.6 | 4 | RGA | 99.93 | Saline 1 | 0.01 | na | na | 0.18 | 0.00 | 0.00 | 0.00 | 0.37 | 0.03 | -0.27 | 0.25 | 0.94 | - 8.24 | - 8.37 | 92.29 | 2.0 | 2.6 | 0.8 | 0.6 | 2.8 | 2.1 | 0.7 |
| S089 | NM495 | Isleta S | 118.2 | 0.83 | - 1.3 | 3 | RGA | 100.00 | na | na | na | na | -0.03 | 0.00 | -0.34 | 0.00 | -0.13 | -0.13 | -0.21 | 0.25 | 3.67 | - 7.80 | -12.49 | 100.25 | - 1.3 | - 1.4 | - 1.4 | 0.0 | - 1.8 | - 1.8 | 0.0 |
| S097 | NM070 | Kirtland 14 | 48.9 | 0.41 | 5.8 | 7 | RGA | 99.43 | Saline 1 | 0.57 | na | na | -0.23 | 0.36 | 0.00 | -0.25 | 0.00 | -0.37 | -0.36 | 0.23 | 1.10 | - 9.01 | - 8.74 | 99.30 | 5.7 | 5.7 | 4.6 | 0.1 | 6.4 | 6.4 | 0.1 |
| S102 | NM074 | Leyendecker 1 | 72.8 | 0.68 | 2.5 | 7 | RGA | 99.90 | Saline 1 | 0.10 | na | na | 0.24 | 0.24 | 0.00 | -0.17 | 0.00 | -0.16 | -0.25 | 0.22 | 0.93 | - 7.89 | - 8.92 | 89.89 | 1.7 | 2.5 | - 0.2 | 0.9 | 2.7 | 1.8 | 1.0 |
| S120 | NM503 | Mesa Del Sol D | 6.0 | 0.19 | 22.6 | 8 | RGA | 99.44 | Saline 1 | 0.56 | na | na | 0.29 | 0.49 | 0.00 | -0.34 | 0.00 | 1.46 | 0.13 | 0.25 | 0.91 | - 7.87 | - 9.24 | 87.74 | 21.6 | 22.6 | 19.4 | 1.0 | 26.0 | 25.0 | 1.0 |
| S121 | NM504 | Mesa Del Sol M | 3.2 | 0.20 | 27.5 | 8 | RGA | 98.93 | Saline 1 | 1.07 | na | na | 0.38 | 0.27 | 0.00 | -0.19 | 0.00 | 1.05 | -0.28 | 0.25 | 0.96 | - 7.60 | - 8.58 | 84.31 | 26.2 | 27.5 | 24.1 | 1.4 | 30.4 | 29.2 | 1.2 |
| S121 | NM302 | Mesa Del Sol M | 8.3 | 0.09 | 20.0 | 7 | RGA | 98.91 | Saline 1 | 1.09 | na | na | 0.41 | 0.27 | 0.00 | -0.19 | 0.00 | 1.10 | -0.23 | 0.61 | 0.95 | - 6.79 | - 8.50 | 85.36 | 18.7 | 19.9 | 17.8 | 1.3 | 23.4 | 22.0 | 1.3 |
| S124 | NM082 | Montaño 2 D | 103.3 | 0.85 | - 0.3 | 4 | RGA | 100.00 | na | na | na | na | -0.30 | 0.00 | -0.27 | 0.00 | 0.18 | -0.29 | -0.23 | 0.25 | 2.07 | - 8.12 | -10.03 | 100.21 | - 0.2 | 0.5 | - 0.3 | 0.0 | - 0.5 | - 0.5 | 0.0 |
| S125 | NM083 | Montaño 2 M | 109.8 | 0.94 | - 0.7 | 4 | RGA | 100.00 | na | na | na | na | -0.31 | 0.08 | 0.03 | -0.06 | 0.00 | -0.31 | -0.15 | 0.25 | 2.35 | - 9.23 | -11.12 | 99.97 | - 0.8 | - 0.8 | - 0.8 | 0.0 | - 1.1 | - 1.1 | 0.0 |
| S127 | NM085 | Montaño 4 D | 95.0 | 0.82 | 0.4 | 4 | RGA | 100.00 | na | na | na | na | -0.32 | 0.00 | -0.51 | 0.00 | 0.14 | -0.29 | -0.29 | 0.25 | 2.09 | - 7.00 | -11.07 | 100.46 | 0.4 | 0.5 | 0.4 | 0.0 | 0.3 | 0.3 | 0.0 |
| S128 | NM086 | Montaño 4 M | 113.6 | 0.97 | - 1.0 | 5 | RGA | 100.00 | na | na | na | na | 0.50 | 0.16 | 1.25 | -0.11 | 0.00 | 0.09 | 0.51 | 0.25 | 1.61 | - 8.76 | -12.34 | 87.24 | - 2.1 | - 1.1 | - 2.1 | 1.1 | - 1.4 | - 2.8 | 1.4 |
| S130 | NM088 | Montaño 5 D | 97.6 | 0.95 | 0.2 | 5 | RGA | 100.00 | na | na | na | na | 0.01 | 0.00 | 0.32 | 0.00 | 0.57 | 0.04 | 0.02 | 0.25 | 1.13 | - 9.26 | - 9.00 | 99.42 | 0.2 | 0.2 | 0.2 | 0.0 | 0.1 | 0.0 | 0.1 |
| S131 | NM089 | Montaño 5 M | 95.0 | 0.81 | 0.4 | 5 | RGA | 100.00 | na | na | na | na | 0.27 | 0.00 | 0.50 | 0.00 | 0.03 | 0.01 | 0.05 | 0.25 | 0.90 | - 8.61 | - 8.51 | 90.72 | - 0.4 | 0.4 | - 0.4 | 0.8 | 0.3 | - 0.6 | 0.9 |
| S133 | NM091 | Montaño 6 D | 25.2 | 0.23 | 11.1 | 6 | RGA | 100.00 | na | na | na | na | -0.22 | 0.52 | 0.33 | -0.36 | 0.00 | 0.08 | -0.05 | 0.25 | 1.09 | - 9.48 | - 9.57 | 99.98 | 11.1 | 11.1 | 10.6 | 0.0 | 12.9 | 12.9 | 0.0 |
| S134 | NM092 | Montaño 6 MD | 38.0 | 0.31 | 7.8 | 6 | RGA | 100.00 | na | na | na | na | -0.07 | 0.25 | -0.21 | -0.17 | 0.91 | 0.00 | -0.11 | 0.25 | 0.95 | - 8.17 | - 8.62 | 100.17 | 7.8 | 7.8 | 7.4 | 0.0 | 8.8 | 8.9 | 0.0 |
| S135 | NM093 | Montaño 6 MS | 67.5 | 0.56 | 3.2 | 4 | RGA | 100.00 | na | na | na | na | -0.51 | 0.39 | -0.44 | -0.27 | 0.00 | -0.34 | -0.23 | 0.25 | 1.40 | - 7.31 | - 7.69 | 100.41 | 3.2 | 3.2 | 3.1 | 0.0 | 3.4 | 3.5 | 0.0 |
| S137 | NM506 | Montesa M | 18.6 | 0.21 | 13.5 | 3 | RGA | 99.36 | Saline 1 | 0.64 | na | na | -0.03 | 0.00 | 0.00 | 0.00 | 0.84 | -0.13 | -0.31 | 0.25 | 1.04 | - 8.94 | - 8.97 | 99.23 | 13.4 | 13.4 | 13.4 | 0.1 | 15.9 | 15.9 | 0.1 |
| S138 | NM507 | Montesa S | 52.5 | 0.37 | 5.2 | 8 | RGA | 99.90 | Saline 1 | 0.10 | na | na | 0.18 | 0.00 | 0.00 | 0.00 | 0.49 | 0.04 | -0.29 | 0.20 | 1.02 | - 8.00 | - 9.28 | 92.11 | 4.5 | 5.2 | 4.0 | 0.7 | 5.7 | 5.0 | 0.8 |
| S139 | NM305 | Domestic Well #27 | 43.4 | 0.31 | 6.7 | 5 | RGA | 100.00 | na | na | na | na | 0.27 | 0.00 | 0.47 | 0.00 | 1.02 | 0.11 | -0.11 | 0.29 | 0.96 | - 8.30 | - 8.60 | 90.88 | 5.9 | 6.7 | 5.9 | 0.8 | 7.6 | 6.6 | 0.9 |
| S142 | NM307 | Domestic Well #28 | 73.3 | 0.55 | 2.5 | 4 | RGA | 99.83 | Saline 1 | 0.18 | na | na | -0.53 | 0.23 | -0.43 | -0.16 | 0.00 | -0.37 | 0.00 | 0.26 | 1.80 | - 7.45 | - 8.30 | 100.12 | 2.5 | 2.6 | 2.5 | 0.0 | 2.7 | 2.7 | 0.0 |
| S146 | NM309 | NM Utilities 2 | 50.9 | 0.47 | 5.4 | 6 | RGA | 100.00 | na | na | na | na | 0.00 | 0.00 | -0.31 | 0.00 | 0.51 | 0.09 | -0.30 | 0.24 | 1.47 | - 7.78 | - 8.30 | 100.05 | 5.4 | 5.5 | 5.4 | 0.0 | 6.0 | 6.0 | 0.0 |
| S151 | NM508 | Nor Este 3 | 47.6 | 0.35 | 6.0 | 6 | RGA | 100.00 | na | na | na | na | 0.01 | 0.23 | -0.13 | -0.16 | 0.00 | 0.41 | -0.26 | 0.69 | 1.38 | - 8.36 | - 9.49 | 99.43 | 5.9 | 5.9 | 5.3 | 0.0 | 6.7 | 6.6 | 0.1 |
| S153 | NM315 | Open Space | 55.2 | 0.51 | 4.8 | 5 | RGA | 100.00 | na | na | na | na | 0.38 | 0.15 | 0.27 | -0.11 | 0.31 | 0.00 | -0.16 | 0.25 | 0.74 | - 8.01 | - 8.30 | 86.45 | 3.6 | 4.8 | 3.3 | 1.2 | 5.3 | 3.9 | 1.3 |
| S155 | NM316 | Domestic Well #29 | 55.5 | 0.51 | 4.7 | 4 | RGA | 100.00 | na | na | na | na | -0.33 | 0.03 | -0.57 | -0.02 | 0.00 | -0.28 | -0.32 | 0.26 | 1.75 | - 6.82 | - 8.50 | 100.48 | 4.8 | 4.8 | 4.7 | 0.0 | 5.2 | 5.3 | 0.0 |
| S156 | NM100 | Paseo 2D | 76.7 | 0.68 | 2.1 | 4 | RGA | 100.00 | na | na | na | na | -0.36 | 0.01 | -0.71 | -0.01 | 0.00 | -0.30 | -0.25 | 0.25 | 1.75 | - 5.72 | - 8.27 | 100.75 | 2.2 | 2.2 | 2.1 | - 0.1 | 2.3 | 2.3 | - 0.1 |
| S157 | NM101 | Paseo 2MD | 102.6 | 0.84 | - 0.2 | 4 | RGA | 100.00 | na | na | na | na | -0.09 | 0.00 | -0.21 | 0.00 | 0.00 | -0.20 | 0.01 | 0.25 | 1.46 | - 8.20 | -10.46 | 100.17 | - 0.2 | - 0.2 | - 0.2 | 0.0 | - 0.4 | - 0.4 | 0.0 |
| S160 | NM104 | Paseo 3D | 64.5 | 0.53 | 3.5 | 4 | RGA | 100.00 | na | na | na | na | 0.26 | -0.08 | 0.99 | 0.00 | 0.52 | -0.08 | -0.25 | 0.24 | 0.79 | - 9.13 | - 8.66 | 92.48 | 2.9 | 3.5 | 2.9 | 0.6 | 3.8 | 3.1 | 0.7 |
| S161 | NM105 | Paseo 3M | 98.1 | 0.70 | 0.2 | 3 | RGA | 100.00 | na | na | na | na | 0.13 | 0.00 | 0.49 | 0.00 | -0.04 | -0.17 | -0.13 | 0.25 | 2.76 | - 9.03 | -10.70 | 95.20 | - 0.2 | 0.2 | - 0.3 | 0.4 | 0.0 | - 0.5 | 0.5 |
| S171 | NM321 | Ridgecrest 4 | 46.1 | 0.43 | 6.2 | 7 | RGA | 98.85 | Saline 1 | 1.15 | na | na | 0.00 | 0.14 | 0.00 | -0.10 | 0.06 | -0.38 | -0.31 | 0.23 | 1.03 | - 8.61 | - 9.20 | 98.61 | 6.1 | 6.1 | 4.3 | 0.1 | 7.0 | 6.8 | 0.1 |
| S173 | NM323 | Rio Bravo 5 M | 97.3 | 1.11 | 0.2 | 4 | RGA | 99.92 | Saline 1 | 0.08 | na | na | 0.36 | 0.00 | 0.00 | 0.00 | 0.80 | 0.93 | 0.08 | 0.33 | 1.05 | - 7.52 | - 9.70 | 86.20 | - 1.0 | 0.2 | - 1.0 | 1.2 | 0.1 | - 1.3 | 1.4 |
| S177 | NM112 | Rio Bravo 2 D | 61.6 | 0.51 | 3.9 | 6 | RGA | 99.93 | Saline 1 | 0.07 | na | na | 0.01 | 0.00 | 0.00 | 0.00 | 0.78 | 0.39 | 0.00 | 0.25 | 1.21 | - 8.87 | - 7.96 | 99.30 | 3.8 | 3.9 | 0.9 | 0.1 | 4.3 | 4.2 | 0.1 |
| S178 | NM113 | Rio Bravo 2 M | 78.4 | 0.64 | 2.0 | 4 | RGA | 99.28 | Saline 1 | 0.72 | na | na | -0.17 | 0.00 | 0.00 | 0.00 | 0.58 | -0.04 | 0.10 | 0.25 | 1.54 | - 9.04 | -10.56 | 99.12 | 1.9 | 1.9 | 1.8 | 0.1 | 2.1 | 2.0 | 0.1 |
| S179 | NM114 | Rio Bravo 2 S | 99.5 | 0.85 | 0.0 | 7 | RGA | 99.91 | Saline 1 | 0.09 | na | na | -0.18 | 0.17 | 0.00 | -0.12 | 0.00 | -0.02 | -0.06 | 0.25 | 1.94 | - 9.08 | -10.31 | 99.88 | 0.0 | 0.0 | - 1.4 | 0.0 | - 0.1 | - 0.1 | 0.0 |
| S180 | NM115 | Rio Bravo 4 D | 34.6 | 0.29 | 8.5 | 7 | RGA | 99.47 | Saline 1 | 0.53 | na | na | 0.01 | 0.00 | 0.00 | 0.00 | 0.69 | -0.34 | -0.31 | 0.25 | 1.01 | - 8.88 | - 9.05 | 98.95 | 8.4 | 8.5 | 8.0 | 0.1 | 9.7 | 9.6 | 0.1 |
| S181 | NM116 | Rio Bravo 4 M | 77.7 | 0.75 | 2.0 | 5 | RGA | 97.42 | Saline 1 | 2.58 | na | na | -0.55 | 0.00 | 0.00 | 0.00 | 0.46 | -0.96 | 0.42 | 0.24 | 1.31 | - 9.48 | -10.84 | 96.91 | 1.8 | 1.9 | 1.7 | 0.3 | 2.1 | 1.9 | 0.3 |
| S183 | NM126 | Rio Grande Utility 5 | 33.2 | 0.30 | 8.9 | 8 | RGA | 99.47 | Saline 1 | 0.53 | na | na | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.66 | -0.09 | 0.23 | 1.25 | - 8.81 | - 8.12 | 99.08 | 8.8 | 8.8 | 6.0 | 0.1 | 10.2 | 10.1 | 0.1 |
| S184 | NM127 | Rio Grande Utility 6 | 51.3 | 0.46 | 5.4 | 4 | RGA | 100.00 | na | na | na | na | 0.15 | 0.00 | 0.45 | 0.00 | 0.81 | -0.04 | -0.22 | 0.25 | 0.87 | - 8.95 | - 8.30 | 94.77 | 4.9 | 5.3 | 5.0 | 0.4 | 6.0 | 5.4 | 0.5 |
| S190 | NM325 | Rio Rancho 2 | 71.6 | 0.66 | 2.7 | 6 | RGA | 99.05 | Saline 1 | 0.95 | na | na | -0.11 | 0.34 | 0.04 | -0.23 | 0.00 | -0.51 | 0.00 | 0.34 | 1.12 | - 8.53 | - 8.60 | 98.91 | 2.6 | 2.6 | 1.7 | 0.1 | 2.9 | 2.8 | 0.1 |
| S203 | NM331 | Private Production Well #20 | 77.1 | 0.54 | 2.1 | 4 | RGA | 99.98 | Saline 1 | 0.02 | na | na | 0.72 | 0.00 | 0.00 | 0.00 | 0.03 | -0.05 | 0.16 | 0.31 | 1.35 | - 6.46 | - 8.76 | 75.67 | - 0.1 | 0.0 | - 0.1 | 2.2 | 2.2 | - 0.3 | 2.6 |
| S205 | NM333 | Private Production Well #21 | 58.8 | 0.41 | 4.3 | 5 | RGA | 100.00 | na | na | na | na | 0.91 | 0.00 | 2.03 | 0.00 | 2.02 | 0.07 | 0.20 | 0.31 | 0.48 | - 8.49 | - 8.40 | 82.53 | 2.7 | 4.3 | 2.7 | 1.5 | 4.7 | 2.9 | 1.8 |

**Table 10.** Summary of unadjusted radiocarbon age, source waters and mixing fractions, geochemical mineral-water mass transfer reactions, evaporation factor, adjusted radiocarbon age, and calendar age in one representative geochemical model for each ground-water sample collected for the Middle Rio Grande Basin study -- Continued

| Site no. | Sample no. | Site name | $^{14}C$ activity (pmC) | $^{14}C$ ± 1 σ (pmC) | Conventional, unadjusted $^{14}C$ age, Libby half-life (ka) | No. of mass balance models found | Source waters and percent in mixture: Primary water | Percent primary water | Secondary water | Percent secondary water | Additional secondary water | Percent additional secondary water | Mass transfer, millimoles per kilogram water: Calcite | Plagioclase feldspar | $CO_2$ | Kaolinite | $SiO_2$ | Ca-Na cation exchange | Gypsum | $CH_2O$ | Evaporation factor | [1] Calculated $\delta^{13}C$ (per mil) | Observed $\delta^{13}C$ (per mil) | Initial $^{14}C$ activity adjusted for geochemical reactions (pmC) | Adjusted $^{14}C$ Age Libby half-life (ka) | Maximum adjusted $^{14}C$ Age Libby half-life (ka) | Minimum adjusted $^{14}C$ Age Libby half-life (ka) | Difference unadjusted $^{14}C$ age minus adjusted age, Libby half-life (ka) | Unadjusted $^{14}C$ calendar years (ka) | Adjusted $^{14}C$ calendar years (ka) | Difference unadjusted calendar years minus adjusted calendar years (ka) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S208 | NM140 | San Jose 2 | 29.1 | 0.25 | 9.9 | 8 | RGA | 99.33 | Saline 1 | 0.67 | na | na | 0.00 | 0.03 | 0.00 | -0.02 | 0.90 | 0.18 | -0.02 | 0.23 | 1.01 | - 8.82 | - 8.65 | 99.19 | 9.9 | 9.9 | 7.0 | 0.1 | 11.5 | 11.4 | 0.1 |
| S210 | NM511 | Sandia D | 15.3 | 0.16 | 15.1 | 8 | RGA | 98.69 | Saline 1 | 1.31 | na | na | 0.00 | 0.19 | 0.00 | -0.13 | 0.08 | 0.41 | -0.22 | 0.22 | 1.47 | - 8.78 | - 8.66 | 98.42 | 14.9 | 15.0 | 13.2 | 0.1 | 17.8 | 17.7 | 0.1 |
| S214 | NM513 | Sandia S | 62.9 | 0.48 | 3.7 | 7 | RGA | 97.34 | Saline 1 | 2.66 | na | na | 0.09 | 0.00 | 0.00 | 0.00 | 0.20 | -0.47 | -0.02 | 0.24 | 1.28 | - 8.52 | - 9.31 | 93.16 | 3.2 | 3.5 | 1.6 | 0.6 | 4.1 | 3.4 | 0.6 |
| S220 | NM147 | Santa Barbara 1 | 49.1 | 0.46 | 5.7 | 6 | RGA | 99.90 | Saline 1 | 0.10 | na | na | 0.00 | 0.10 | 0.00 | -0.07 | 0.32 | -0.08 | -0.17 | 0.24 | 0.99 | - 8.88 | - 8.97 | 99.88 | 5.7 | 5.7 | 5.3 | 0.0 | 6.4 | 6.4 | 0.0 |
| S231 | NM517 | Sierra Vista M | 34.2 | 0.28 | 8.6 | 5 | RGA | 100.00 | na | na | na | na | 0.92 | 0.00 | 0.16 | 0.00 | 1.08 | 1.60 | -0.02 | 0.25 | 0.88 | - 6.55 | - 8.24 | 71.80 | 5.9 | 8.7 | 5.9 | 2.7 | 9.9 | 6.6 | 3.2 |
| S232 | NM518 | Sierra Vista S | 68.9 | 0.49 | 3.0 | 7 | RGA | 99.69 | Saline 1 | 0.31 | na | na | 0.21 | 0.44 | 1.05 | -0.31 | 0.00 | 0.58 | 0.00 | 0.22 | 1.04 | - 8.88 | - 9.92 | 93.51 | 2.5 | 3.0 | 1.8 | 0.5 | 3.2 | 2.6 | 0.6 |
| S234 | NM339 | Sister Cities D | 8.0 | 0.11 | 20.3 | 5 | RGA | 98.47 | Saline 1 | 1.53 | na | na | 0.22 | 0.00 | 0.59 | 0.00 | 0.92 | 0.37 | -0.09 | 0.25 | 1.00 | - 8.73 | - 7.30 | 91.32 | 19.5 | 20.2 | 19.6 | 0.7 | 23.7 | 22.9 | 0.8 |
| S235 | NM340 | Sister Cities M | 66.3 | 0.46 | 3.3 | 5 | RGA | 100.00 | na | na | na | na | 0.26 | 0.27 | 0.57 | -0.19 | 0.00 | -0.08 | -0.30 | 0.32 | 0.77 | - 8.62 | - 8.80 | 91.65 | 2.6 | 3.3 | 2.0 | 0.7 | 3.6 | 2.8 | 0.8 |
| S244 | NM158 | SWAB 3 - 760 | 44.1 | 0.51 | 6.6 | 5 | RGA | 100.00 | na | na | na | na | -0.08 | 0.07 | -0.63 | -0.05 | 0.00 | 0.06 | -0.50 | 0.25 | 1.27 | - 6.20 | - 9.81 | 100.61 | 6.6 | 6.6 | 6.6 | - 0.1 | 7.4 | 7.5 | - 0.1 |
| S245 | NM159 | SWAB 3 - 980 | 44.1 | 0.37 | 6.6 | 4 | RGA | 100.00 | na | na | na | na | -0.47 | 0.66 | 0.00 | -0.45 | -0.46 | -0.26 | -0.54 | 0.25 | 0.99 | - 9.23 | - 9.06 | 99.97 | 6.6 | 6.6 | 6.6 | 0.0 | 7.4 | 7.4 | 0.0 |
| S253 | NM522 | Tome D | 8.8 | 0.14 | 19.5 | 8 | RGA | 98.89 | Saline 1 | 1.11 | na | na | 0.22 | 0.00 | 0.00 | 0.00 | 0.56 | 0.51 | -0.22 | 0.25 | 1.11 | - 8.08 | - 8.00 | 89.54 | 18.6 | 19.4 | 17.9 | 0.9 | 22.9 | 22.0 | 0.9 |
| S257 | NM344 | Domestic Well #34 | 85.3 | 0.63 | 1.3 | 6 | RGA | 99.76 | Saline 1 | 0.24 | na | na | 0.04 | 0.09 | 0.00 | -0.07 | 0.00 | -0.07 | -0.14 | 0.30 | 2.05 | - 8.64 | -10.80 | 97.96 | 1.1 | 1.3 | 0.7 | 0.2 | 1.3 | 1.1 | 0.2 |
| S259 | NM171 | VGP-1 | 123.1 | 1.02 | - 1.7 | 3 | RGA | 100.00 | na | na | na | na | 0.29 | 0.00 | 0.24 | 0.00 | -0.02 | 0.00 | 0.16 | 0.25 | 2.28 | - 8.26 | -11.58 | 89.47 | - 2.6 | - 1.7 | - 2.5 | 0.9 | - 2.2 | - 3.4 | 1.2 |
| S261 | NM172 | Volandia 2 | 70.6 | 0.60 | 2.8 | 5 | RGA | 100.00 | na | na | na | na | -0.39 | 0.74 | 0.00 | -0.51 | -0.73 | -0.40 | -0.29 | 0.23 | 1.13 | - 9.16 | - 8.63 | 99.96 | 2.8 | 2.8 | 2.3 | 0.0 | 3.0 | 3.0 | 0.0 |
| S262 | NM173 | Volandia 5 | 57.8 | 0.49 | 4.4 | 7 | RGA | 99.73 | Saline 1 | 0.27 | na | na | -0.13 | 0.20 | 0.00 | -0.14 | 0.00 | -0.25 | 0.09 | 0.24 | 1.00 | - 8.97 | - 9.80 | 99.66 | 4.4 | 4.4 | 2.8 | 0.0 | 4.8 | 4.8 | 0.0 |
| S265 | NM175 | Webster 1 | 45.5 | 0.39 | 6.3 | 8 | RGA | 98.86 | Saline 1 | 1.14 | na | na | 0.11 | 0.00 | 0.00 | 0.00 | 0.52 | 0.07 | -0.28 | 0.22 | 1.14 | - 8.35 | - 8.50 | 94.04 | 5.8 | 6.2 | 5.2 | 0.5 | 7.1 | 6.5 | 0.6 |
| S267 | NM348 | West Bluff Nest 1 Well 2 | 32.3 | 0.25 | 9.1 | 2 | RGA | 99.91 | Saline 1 | 0.09 | na | na | -0.12 | 0.68 | 0.70 | -0.47 | 0.00 | 0.41 | 0.00 | 0.46 | 0.98 | - 9.39 | - 9.20 | 99.91 | 9.1 | 9.0 | 8.4 | 0.0 | 10.4 | 10.4 | 0.0 |
| S269 | NM350 | West Bluff Nest 2 Well 1 | 63.5 | 0.45 | 3.6 | 6 | RGA | 99.96 | Saline 1 | 0.04 | na | na | -0.49 | 0.49 | 0.00 | -0.34 | -0.17 | 0.00 | 0.09 | 0.30 | 1.38 | - 9.25 | - 8.40 | 99.88 | 3.6 | 3.6 | 3.6 | 0.0 | 4.0 | 4.0 | 0.0 |
| S275 | NM178 | Yale 1 | 39.2 | 0.35 | 7.5 | 4 | RGA | 100.00 | na | na | na | na | -1.38 | 1.42 | 0.00 | -0.98 | -1.69 | -0.72 | -0.42 | 0.23 | 2.71 | -10.63 | - 9.90 | 99.79 | 7.5 | 7.6 | 7.5 | 0.0 | 8.5 | 8.5 | 0.0 |
| | | **No Zone: Exotic Water** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| S023 | NM010 | Burn Site Well | 49.6 | 0.41 | 5.6 | 3 | EMF | 97.76 | Saline 1 | 2.24 | na | na | 0.00 | 0.00 | 1.46 | 0.00 | -0.14 | -0.41 | 1.25 | 0.00 | 1.05 | -11.93 | - 7.70 | 98.88 | 5.6 | 5.6 | 5.5 | 0.1 | 6.3 | 6.2 | 0.1 |
| S057 | NM044 | Embudo Spring | 111.0 | 1.13 | - 0.8 | 3 | EMF | 100.00 | na | na | na | na | 0.18 | 0.00 | 2.20 | 0.00 | -0.08 | -0.03 | 0.47 | 0.00 | 1.25 | -11.65 | -13.20 | 97.12 | - 1.1 | - 0.9 | - 1.1 | 0.2 | - 1.2 | - 1.5 | 0.3 |
| S063 | NM282 | Windmill #22 | 46.4 | 0.50 | 6.2 | 2 | EMF | 100.00 | na | na | na | na | -1.41 | 0.00 | -1.99 | 0.00 | -0.37 | -0.25 | -0.05 | 0.00 | 13.27 | - 3.22 | - 5.60 | 101.70 | 6.3 | 6.3 | 6.1 | - 0.1 | 6.9 | 7.1 | - 0.2 |
| S067 | NM284 | Granite Hill | 34.5 | 0.29 | 8.5 | 3 | EMF | 90.88 | TIJ | 9.12 | na | na | -0.96 | 0.37 | 0.00 | -0.26 | -0.59 | 0.00 | 0.53 | 0.00 | 1.73 | -11.92 | - 7.90 | 98.68 | 8.4 | 8.3 | 8.4 | 0.1 | 9.8 | 9.7 | 0.1 |
| S070 | NM059 | HERTF | 40.6 | 0.38 | 7.2 | 2 | EMF | 97.75 | Saline 1 | 2.25 | na | na | 0.00 | 0.00 | 0.41 | 0.00 | 0.06 | -0.50 | 0.55 | 0.00 | 0.94 | -11.92 | - 7.50 | 98.58 | 7.1 | 7.1 | 7.1 | 0.1 | 8.2 | 8.1 | 0.1 |
| S091 | NM496 | Private Production Well #23 | 93.8 | 0.66 | 0.5 | 4 | JRW | 98.99 | Saline 1 | 1.01 | na | na | 1.29 | 0.00 | 2.80 | 0.00 | 0.52 | 0.33 | -0.42 | 0.00 | 1.00 | - 6.40 | -10.16 | 78.75 | - 1.4 | - 1.0 | - 2.2 | 1.9 | 0.4 | - 1.9 | 2.3 |
| S094 | NM293 | Stock Well #02 | 79.3 | 0.61 | 1.9 | 4 | Precip. | 100.00 | na | na | na | na | 0.70 | 0.11 | 1.37 | -0.07 | 0.00 | 1.16 | 0.42 | 0.00 | 3.28 | - 7.50 | - 5.50 | 66.28 | - 1.4 | 1.8 | - 2.0 | 3.3 | 2.0 | - 1.9 | 3.9 |
| S112 | NM297 | Domestic Well #24 | 13.6 | 0.12 | 16.0 | 2 | EMF | 97.78 | Saline 1 | 2.22 | na | na | -1.52 | 0.06 | 0.00 | -0.04 | 0.00 | -0.21 | 1.30 | 0.00 | 1.53 | -13.34 | - 7.20 | 98.07 | 15.9 | 15.9 | 15.9 | 0.2 | 19.0 | 18.8 | 0.2 |
| S152 | NM098 | Private Production Well #07 | 62.7 | 0.55 | 3.7 | 4 | JRW | 94.56 | Saline 1 | 5.44 | na | na | -0.07 | 0.13 | 2.34 | -0.09 | 0.00 | -2.12 | 0.17 | 0.00 | 1.00 | - 7.82 | - 6.11 | 99.99 | 3.7 | 3.8 | 3.7 | 0.0 | 4.1 | 4.1 | 0.0 |
| S202 | NM330 | Windmill #27 | 47.2 | 0.35 | 6.0 | 3 | LUC | 99.86 | ASSP | 0.14 | na | na | -8.48 | 0.00 | 0.00 | 0.00 | 0.10 | -0.99 | 7.80 | 0.00 | 0.72 | - 6.21 | - 4.70 | 99.42 | 6.0 | 6.0 | 6.0 | 0.0 | 6.8 | 6.7 | 0.1 |
| S211 | NM512 | Sandia M | 10.4 | 0.14 | 18.2 | 7 | EMF | 93.95 | Saline 1 | 6.05 | na | na | -0.59 | 0.69 | 0.00 | -0.48 | 0.00 | 0.73 | 0.10 | 0.00 | 0.81 | -11.96 | - 8.20 | 95.72 | 17.8 | 18.0 | 17.2 | 0.3 | 21.4 | 21.0 | 0.4 |
| S250 | NM165 | Private Production Well #10 | 51.3 | 0.43 | 5.4 | 4 | EMF | 99.86 | Saline 1 | 0.14 | na | na | -0.51 | 0.19 | 0.00 | -0.13 | -0.25 | 0.00 | 0.21 | 0.00 | 1.21 | -12.21 | -11.00 | 99.86 | 5.4 | 5.3 | 5.3 | 0.0 | 6.0 | 5.9 | 0.0 |
| S256 | NM169 | Tunnel Spring | 92.6 | 0.77 | 0.6 | 4 | EMF | 100.00 | na | na | na | na | 5.64 | 0.10 | 7.18 | -0.16 | 0.00 | -0.16 | 0.26 | 0.00 | 0.35 | - 7.92 | -11.30 | 65.99 | - 2.7 | 0.6 | - 2.7 | 3.3 | 0.5 | - 3.6 | 4.2 |
| S258 | NM524 | Vallecito Springs | 43.4 | 0.33 | 6.7 | 2 | NMF | 99.94 | Saline 1 | 0.06 | na | na | 0.68 | 0.00 | 2.24 | 0.00 | -0.70 | 0.48 | 0.22 | 0.00 | 1.00 | -10.41 | -10.07 | 86.71 | 5.6 | 5.5 | 5.5 | 1.1 | 7.6 | 6.2 | 1.4 |
| S273 | NM176 | Windmill #11 | 36.5 | 0.34 | 8.1 | 4 | SWMF | 100.00 | na | na | na | na | -1.02 | 0.14 | -0.61 | -0.10 | -0.54 | 0.00 | 0.04 | 0.00 | 2.45 | -10.77 | - 3.99 | 100.25 | 8.1 | 8.2 | 8.1 | 0.0 | 9.2 | 9.3 | 0.0 |
| S282 | NM529 | Windmill #44 | 51.6 | 0.38 | 5.3 | 1 | JRW | 62.41 | Saline 1 | 37.59 | na | na | -2.14 | 0.00 | 2.99 | 0.00 | 0.22 | -9.08 | 6.98 | 0.00 | 1.00 | -10.19 | - 8.47 | 81.67 | 3.7 | 3.7 | 3.7 | 1.6 | 5.9 | 4.0 | 1.9 |

[1] NETPATH models were constructed assuming an initial $\delta^{13}C$ of -12 per mil, similar to that found in modern recharge waters.

and other end-member source-water compositions used in the geochemical models are given in table 4. In many cases, the chemical compositions of the source waters represent averages of sample compositions from the NWIS surface-water database, or in the cases of ASSP, Saline Water 1 and Saline Water 2, the compositions are those of individual samples collected as a part of this investigation (see table 4).

#### Phases

Phases considered in the geochemical models as possible reactants and products included calcite, plagioclase feldspar ($AN_{38}$), carbon dioxide gas, kaolinite, silica, gypsum, Ca/Na exchange, and, in areas undergoing redox reactions, organic carbon (designated $CH_2O$ for carbon of oxidation state zero). The choices of phases considered are only representative of groups of phases that can occur in the MRGB.

The models also included the possibility of evapotranspiration or dilution. Evapotranspiration or dilution factors are computed in NETPATH as a special case of mixing, in which an initial water, which can mix with various natural sources (such as surface waters) mixes with an additional initial water (pure water; addition or removal). Both evaporation and dilution factors are computed in NETPATH as positive numbers ($\geq 1$). If dilution occurs, NETPATH divides the initial concentrations by the evaporation factor, resulting in a decrease in concentration. In evaporation, all initial concentrations are increased (multiplied) by the evaporation factor in NETPATH. See Plummer and others (1994) for further details on how evaporation is calculated in NETPATH. The dilution factor is the inverse of the evaporation factor in table 10, i.e., values of the evaporation factor <1.

#### Carbon Isotopic Composition of Sources

The initial $^{14}C$ activity of source waters was assumed to be 100 pmC for DIC in precipitation and mountain-front recharge (as discussed above), and was assumed to be the measured value for surface waters and samples ASSP, Saline Water 1 and Saline Water 2 (see table 4). The $^{14}C$ activity of DIC in ground-water inflow was assumed to be low (2 pmC). Only one measurement of $^{14}C$ activity of DIC in water from the Rio Puerco was available (64 pmC). Additional calculations were made in which the $^{14}C$ activity of DIC in Rio Puerco water was assumed to be 100 pmC. This value was used to represent possible conditions during times of high flow/runoff.

Values of $\delta^{13}C$ of DIC in source waters were assigned using logic similar to that used to assign $^{14}C$ activities. Consequently, $\delta^{13}C$ of DIC in mountain-front waters was set to a value of -12 per mil, which is that observed in ground water in areas where mountain-front recharge occurs. From several lines of evidence (see discussion in the section "Historical Variations in Carbon-13 Isotopic Composition of Dissolved Inorganic Carbon"), there may have been a higher abundance of $C_4$ plants in recharge areas of the MRGB in the past than today, resulting in $\delta^{13}C$ values of recharge waters more positive than that observed today ($\delta^{13}C$ of recharge near -8 per mil, historically). However, in all the geochemical models constructed, a $\delta^{13}C$ value of -12 per mil was used (see table 4) that is consistent with modern observations. Because the stable carbon isotopes were not used to constrain the geochemical reactions, the calculated mass transfers do not depend on the assumed initial value of $\delta^{13}C$ of DIC in recharge waters. However, the difference between the calculated $\delta^{13}C$ of DIC and the assumed initial value of -12 per mil gives an indication of the relative extent of carbonate reactions in the aquifer system. If the geochemical reactions can be shown to have little effect on the $\delta^{13}C$ of DIC in the aquifer, this indicates that the initial $\delta^{13}C$ of DIC recharged to the aquifer system was near the value observed in ground water. Consequently, it may be possible to use the observed $\delta^{13}C$ values to infer paleoclimatic conditions and possible historical variations in $C_3$ and $C_4$ plant abundance in recharge areas of the MRGB.

#### Model Results

Results of the geochemical modeling exercise for each ground-water sample are summarized in table 10. The results are grouped by hydrochemical zones and include, for each water analysis, the measured $^{14}C$ activity of DIC and unadjusted radiocarbon age (Libby half-life), the number of models found by NETPATH, and results from one "representative" model for each water. The representative model includes the primary initial water and the percent of the primary initial water (100 percent if mixing is not included), names and percentages of other source waters in mixtures, mass transfers of calcite, plagioclase feldspar, carbon dioxide, kaolinite, silica, cation exchange, gypsum, and organic matter, the value of the evaporation factor (>1.0

for evaporation, <1.0 for dilution), the calculated and observed $\delta^{13}C$, the initial $^{14}C$ activity after adjustment for the calculated geochemical reaction ($A_{nd}$), the adjusted radiocarbon age (Libby half-life), and the maximum and minimum adjusted radiocarbon ages found for all the models by NETPATH. For samples in the Rio Puerco zone (zone 5), table 10 includes calculations in which the $^{14}C$ activity of DIC in Rio Puerco water was assumed to be 64 pmC. Additional calculations (not shown in table 10) were made for the zone 5 waters in which the $^{14}C$ activity of DIC in Rio Puerco water was assumed to be 100 pmC, yielding adjusted ages about 2 ka older than those calculated at 64 pmC.

#### Evapotranspiration

The initial waters used in the NETPATH models (table 4) were averaged and/or representative recharge waters observed along the basin margins and/or representative surface waters. Consequently, all evapotranspiration/dilution factors were calculated relative to these starting waters, rather than with respect to the composition of precipitation. The geochemical mass transfer calculations indicate net evaporation (evapotranspiration) throughout most of the MRGB, except in the Western Boundary and Eastern Mountain Front zones, where overall dilution (modeled with pure water) is indicated. Several hydrochemical processes would lead to a calculation of "dilution" in the NETPATH models. During periods of wetter climate, mountain-front recharge waters may have contained less dissolved Cl, as well as other ions, than in the initial waters of table 4. Thus, NETPATH would calculate a dilution factor to produce more dilute observed samples. Occassionally, dilution was also noted in other waters with mountain-front recharge sources, though, in general, the effect throughout the hydrochemical zone was of evaporation. Dilution was also commonly found in the Western Boundary zone. Waters in the Western Boundary zone were modeled primarily as mixtures of arroyo recharge (using source water LUC, table 4) along the basin margin with inflow of saline ground water, which was assumed to have composition of the water sampled at Arroyo Salado Spring (sample ASSP, table 4). The calculated dilution factor for the Western Boundary zone may reflect uncertainty in source-water composition, although the possibilities of dilution from local infiltration of meteoric water or of historical variations in the salinity of Rio Puerco water also cannot be excluded. Water in the Rio Puerco, Abo Arroyo, and Central zones is dominated by infiltration of surface water. There may be historical variations in surface-water composition beyond the discharge-weighted average compositions given in table 4. For example, it is possible that the composition of the Rio Grande was more dilute at times in the past than today. Net evaporation for most ground waters with surface-water sources was calculated in NETPATH, probably because the concentrating effect of evapotranspiration in river valleys exceeds historical variations in surface-water composition. In the Rio Puerco zone, the calculated evaporation factor varies widely among individual water samples (0.3 (dilution) to 3.3 (evaporation)), which may indicate, in part, historical variations in the salinity of Rio Puerco water.

#### Mixing Fractions of Source Waters

The possibility that many of the waters of the MRGB are mixtures of 2 or more source waters was considered. Potential for upward leakage of saline water was considered throughout the basin. There are only limited data available on the composition of saline water in the MRGB. However, some wells and springs located near faults contain high fractions of saline water. Two analyses of saline water collected as a part of this investigation were included in the modeling. One sample, designated "Saline Water 1" is predominantly a NaCl-type water from a domestic well (S054, NM041) (table 4). "Saline Water 1" was considered to be representative of upward leakage of NaCl-type saline waters throughout most of the basin. A second saline water, designated "Saline Water 2", is a Na-Ca-$HCO_3$-Cl-type water that discharges from Coyote Spring (S041, NM029) associated with the Tijeras Fault Zone in the Monzano Mountains. This water type is thought to be representative of saline sources locally in Tijeras Arroyo and in the Tijeras Fault Zone area. Although the composition of saline waters probably varies in different parts of the basin, the consistent use of "Saline Water 1" through most parts of the basin provides a relative scale for comparison on a regional basis. The mathematical solution to the evaporation factor, mixing fraction(s), and mass transfer was based in NETPATH on the solution to the entire set of mass-balance equations and constraints, and, because there were no constraints that were independent of the solution compositions, could not be based on a single constraint such as Cl.

Ranges and averages of the percent contribution from the primary and secondary water in each sample are summarized by hydrochemical zone in table 11. The geochemical models indicate that most samples in the Northern Mountain Front, Northwestern, West Central, Southwestern Mountain Front, and Eastern Mountain Front zones contain typically more than 90-percent mountain-front source water that has mixed with generally low fractions of saline upward leakage water. The fractions of "Saline Water 1" were lowest in the Northwestern and Southwestern Mountain Front zones, and averaged 1.5, 0.7, and 1.0 percent in the Northern Mountain Front, West Central, and Eastern Mountain Front zones, respectively.

The geochemical models indicate that water samples from the Western Boundary and Rio Puerco zones contain, on average, 7.8 and 7.4 percent, respectively, of ground-water inflow from sources along the western margin of the basin. Water samples in the Rio Puerco zone contain an average of approximately 93 percent Rio Puerco water. Water samples from the Abo Arroyo zone were predominantly of Eastern Mountain Front origin mixed with an average of 28 percent Abo Arroyo water. Water from the Central zone was almost entirely of Rio Grande origin, averaging 99.6 percent water of Rio Grande origin (range 96.5-100 percent), which was mixed with "Saline Water 1". Waters from the Tijeras Fault Zone and Tijeras Arroyo were found to be complex mixtures of Eastern Mountain Front water with varying fractions of Tijeras Arroyo water and "Saline Waters 1 and 2". Water in the Northeastern zone is apparently complex mixtures of Eastern Mountain Front water, Northeast Ground-Water Inflow, surface water from Galisteo Creek, and "Saline Water 1" (table 11).

### Mineral Mass Transfer

The average values of mineral mass transfer, in millimoles per kilogram of water (mmol/kg water), for each hydrochemical zone and the average calculated evaporation factor are summarized in table 12. The calculated average mass transfers are generally quite low, yet there is probably some significance to the differences in values between hydrochemical zones. The NETPATH models indicate that, on average, there is net precipitation of low amounts of calcite through most of the MRGB. The exception is the West-Central zone, where low calculated amounts of calcite dissolve in association with low increases in Ca/Na cation exchange. The calculated net calcite mass transfer is near zero in other parts of the basin (Northern Mountain Front, Northwestern, and Central zones). The calculations indicate that low amounts of plagioclase feldspar weathering occur throughout the MRGB. Small masses of kaolinite, and probably other clay minerals, were calculated to form throughout the basin as primary aluminosilicate minerals such as plagioclase feldspars dissolve.

**Table 11.** Summary of predominant ground-water sources by hydrochemical zone for the Middle Rio Grande Basin, New Mexico

[no, number; na, not applicable; NMF, Northern Mountain Front; Saline 1, NM041; RP, discharge-weighted average National Water Information System (NWIS) Rio Puerco; RGA, discharge-weighted average NWIS Rio Grande at Albuquerque; MWGW, Mid-West Ground-Water Inflow; SWGW, Southwest Ground-Water Inflow; SWMF, Southwestern Mountain Front, NWIS; EMF, Eastern Mountain Front, median; ABO, median Abo Arroyo; Saline 2, Coyote Spring, NM029; TIJ, discharge-weighted average NWIS Tijeras Arroyo; NEGW, Northeast Ground-Water Inflow; GAL, Galesteo Creek above Galisteo Reservoir, used as arroyo source in hydrochemical zone 11; ASSP, Arroyo Salado Spring; LUC, Lucero-24, Los Alamos National Laboratory, Representative of southwest arroyo water]

| Zone no. | Hydrochemical zone | Primary water | Percent range of primary water | Average percent of primary water | Secondary water | Percent range of secondary water | Average percent of secondary water | Additional secondary water | Percent range of additional secondary water | Average percent of additional secondary water |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Northern Mountain Front | NMF | 92.3 - 100 | 98.5 | Saline 1 | 0 - 7.3 | 1.5 | na | na | na |
| 2 | Northwestern | NMF | 97.1 - 100 | 99.9 | Saline 1 | 0 - 2.9 | 0.1 | na | na | na |
| 3 | West Central | NMF | 92.5 - 100 | 99.3 | Saline 1 | 0 - 7.5 | 0.7 | na | na | na |
| 4 | Western Boundary | LUC | 84.0 - 100 | 92.2 | ASSP | 0 - 16.0 | 7.8 | na | na | na |
| 5 | Rio Puerco | RP | 77.6 - 100 | 92.6 | MWGS or SWGW | 0 - 22.4 | 7.4 | na | na | na |
| 6 | Southwestern Mountain Front | SWMF | 100 | 100.0 | Saline 1 | 0 | 0.0 | na | na | na |
| 7 | Abo Arroyo | EMF | 47.7 - 100 | 72.1 | ABO | 0 - 52.3 | 27.9 | na | na | na |
| 8 | Eastern Mountain Front | EMF | 89.5 - 100 | 99.0 | Saline 1 | 0 - 10.5 | 1.0 | na | na | na |
| 9 | Tijeras Fault Zone | EMF | 61.2 - 100 | 89.5 | Saline 1,2 | 0 - 38.8 | 10.5 | na | na | na |
| 10 | Tijeras Arroyo | EMF | 2.9 - 92.3 | 61.6 | TIJ | 9.1 - 91.6 | 37.4 | Saline 2 | 0 - 6.6 | 1.6 |
| 11 | Northeastern | EMF | 14.2 - 98.9 | 66.3 | NEGW, GAL | 1.1 - 85.8 | 33.4 | Saline 1 | 0 - 2.0 | 0.3 |
| 12 | Central | RGA | 96.5 - 100 | 99.6 | Saline 1 | 0 - 3.5 | 0.4 | na | na | na |

**Table 12.** Summary of average mineral mass transfers and evaporation factor by hydrochemical zone for ground water from the Middle Rio Grande Basin, New Mexico

[no., number; mmols per kg water, millimoles per kilogram of water; $CH_2O$, organic carbon; evaporation factor greater than 1 for evaporation, less than 1 for dilution; mineral mass transfer negative for precipitation (outgassing), positive for dissolution; nd, not detected.]

| | | Average mass transfer (mmols per kg water) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Zone no. | Hydrochemical zone | Calcite | Plag-ioclase | $CO_2$ | Kaol-inite | $SiO_2$ | Ca-Na Ex-change | Gypsum | $CH_2O$ | Evap-oration Factor |
| 1 | Northern Mountain Front | 0.1 | 0.3 | 1.1 | - 0.2 | - 0.2 | - 0.2 | 0.1 | nd | 1.1 |
| 2 | Northwestern | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.3 | nd | 1.1 |
| 3 | West Central | 0.4 | 0.1 | 0.3 | - 0.1 | - 0.4 | 1.8 | 0.9 | nd | 1.1 |
| 4 | Western Boundary | - 4.0 | 0.1 | - 0.2 | - 0.1 | 0.3 | 2.9 | 7.3 | nd | 0.7 |
| 5 | Rio Puerco | - 2.0 | 0.2 | 1.4 | - 0.1 | 0.2 | - 3.2 | 1.2 | nd | 1.2 |
| 6 | Southwestern Mountain Front | - 1.0 | 0.1 | - 1.2 | - 0.1 | - 0.5 | 0.0 | 0.0 | nd | 2.2 |
| 7 | Abo Arroyo | - 0.7 | 0.1 | - 0.6 | - 0.1 | - 0.1 | 0.0 | - 0.4 | nd | 3.4 |
| 8 | Eastern Mountain Front | - 0.3 | 0.3 | 0.4 | - 0.2 | - 0.2 | 0.1 | 0.2 | nd | 0.9 |
| 9 | Tijeras Fault Zone | - 0.8 | 0.6 | - 0.1 | - 0.4 | - 0.8 | - 0.3 | 0.6 | nd | 2.1 |
| 10 | Tijeras Arroyo | - 0.9 | 0.2 | 0.0 | - 0.1 | - 0.2 | - 0.1 | 0.7 | nd | 1.1 |
| 11 | Northeastern | - 1.2 | 0.6 | - 0.2 | - 0.4 | - 0.7 | 0.4 | 1.6 | nd | 1.5 |
| 12 | Central | 0.0 | 0.2 | 0.1 | - 0.1 | 0.2 | 0.1 | - 0.1 | 0.3 | 1.3 |

Additional sources of carbon included $CO_2$ gas and organic matter ($CH_2O$). The $CO_2$ mass transfer is expected to be low, as most ground-water systems are closed to gas exchange after recharge. Although the calculated $CO_2$ mass transfers are not zero, they are low and reflect, in part, uncertainties in the DIC content of paleorecharge waters, as well as small analytical errors that are ultimately compensated for in NETPATH in the calculated masses of neutral phases like $CO_2$ and $CH_2O$. Cation exchange (release of Na and uptake of Ca) appears to occur in the North-western, West Central, Western Boundary, and Northeastern zones, and as uptake of Na and release of Ca in the Rio Puerco zone. Gypsum occurrence is low or zero throughout most of the MRGB sediment, except in parts of the Western Boundary, Rio Puerco, and Northeastern zones, where the calculated mass of gypsum dissolution is higher than in other hydro-chemical zones. The small differences in gypsum mass transfer outside of the Western Boundary and Rio Puerco zones probably reflect, at least in part, uncer-tainty in the calcium sulfate content of source waters to the MRGB. Redox reactions were considered only in the Central zone, where anoxic conditions are present in the inner valley of the Rio Grande. On average, a net oxidation of organic matter of 0.28 mmols/kg was calculated for waters in the inner valley of the Rio Grande. Inclusion of iron sulfide and ferric hydroxide phases in the models with redox and iron constraints indicated, in most models, oxidation of pyrite, as indicated in the sulfur-34 data of figure 36.

#### Adjusted and Unadjusted Radiocarbon Ages

In most cases, the adjusted radiocarbon age is nearly identical to the unadjusted radiocarbon age, indicating that geochemical reactions do not appre-ciably affect the calculated ages (table 10). The magnitude of the geochemical adjustments can be judged by the magnitude of the differences in unadjusted and adjusted ages. For zones 1-12, respec-tively, the average differences in unadjusted and adjusted radiocarbon ages (both ages calculated using the Libby half-life) are 0.5, 1.2, 1.0, 1.2, 4.9, -0.1, 0.2, 0.1, 3.7, 1.3, 2.5, and 0.3 ka, respectively. The largest differences between unadjusted and adjusted radio-carbon ages are for some waters from the Rio Puerco, Tijeras Fault Zone, and Northeastern zones, and result from mixing with high fractions of old ground water with low $^{14}C$ activity. The geochemical modeling found mixtures containing as much as 22 percent of Southwest Ground-Water Inflow ($^{14}C$ activity assumed to be 2 pmC) in the Rio Puerco zone. In the Tijeras Fault Zone zone, the sample from SFR-3S (S228) contained nearly 39 percent of Saline 2 water ($^{14}C$ activity assumed to be 5 pmC), and in the Northeastern zone, 3 of the 7 waters contained 34 – 48 percent of Northeastern Ground-Water Inflow ($^{14}C$ activity assumed to be 2 pmC). Most of the samples from the Northern Mountain Front, Northwestern, West-Central, Western Boundary, Southwestern Mountain Front, Abo Arroyo, Eastern Mountain Front, Tijeras Arroyo, and Central zones have adjusted ages nearly identical to the unadjusted age because the geochemical mass transfers are small and the samples contain low fractions of old ground-water inflow or old saline sources.

#### Sensitivity of the Radiocarbon Age to Reaction Uncertainty

Sensitivity calculations, in which compositions of clays, feldspars, and ion exchangers were varied within reasonable limits, did not appreciably alter adjusted $^{14}C$ ages. Other calculations were made to test the possibility of isotopic exchange of calcite with the ground water DIC. If calcite/limestone fragments in the sediment of the MRGB recrystallize, they can exchange their $^{13}C$ and $^{14}C$ isotopic composition with that of the DIC in ground water. Because most carbonate minerals in the sediment are enriched in $^{13}C$ and depleted in $^{14}C$ relative to the isotopic composition of $HCO_3$ in recharge waters, isotopic exchange would, in effect, increase the $\delta^{13}C$ of $HCO_3^-$ and lower the adjusted $^{14}C$ activity, resulting in adjusted radiocarbon ages that are younger than those calculated in samples unaffected by carbon isotope exchange. In many cases, particularly with waters near mountain-front recharge areas, whereas inclusion of isotopic exchange could improve the agreement in calculated and observed $\delta^{13}C$, the resulting adjusted radiocarbon age was impossibly young (negative age) in samples that from other hydrologic considerations are likely to be several to perhaps ten thousand years in age. Because most samples appear to have a net flux of calcite precipitation, further isotopic exchange with surfaces of secondary calcites would probably not appreciably alter the $^{13}C$ and $^{14}C$ isotopic composition of the DIC in ground water.

Other calculations in which the compositions of cation exchangers and clay minerals were varied had little effect on the adjusted radiocarbon age. There are three reasons why the adjusted radiocarbon ages are insensitive to uncertainty in composition of reactant and product minerals-- (1) silicate weathering reactions, which have little or no effect on the $^{14}C$ activity of the DIC, predominate, (2) mineral mass transfers that do occur and do affect the DIC reservoir are low, and (3) calcite tends to form (precipitate) during weathering of plagioclase feldspar over large parts of the basin, which does not appreciably affect the $^{14}C$ activity of DIC. Calcite precipitation has little effect on the $^{14}C$ activity because the fractionation factor between $HCO_3$ and calcite is small and the mass of calcite precipitated is small relative to the mass of $HCO_3$ in ground water. Similarly, calcite cementation has little effect on the $\delta^{13}C$ of DIC in ground water.

As a means of evaluating the sensitivity of adjusted radiocarbon ages to model uncertainty, the range of the adjusted ages calculated among the total number of models in NETPATH for an individual water sample is given in table 10. Also given is the difference between the unadjusted radiocarbon age (Libby half-life) and the representative adjusted radiocarbon age from NETPATH (converted to the Libby half-life).

The evaluation using NETPATH is not exhaustive, but shows again that the extent of geochemical reactions affecting the chemical and isotopic composition of waters in the MRGB is probably small and has generally negligible effect on the initial $^{14}C$ activity, $A_o$. Although the reaction modeling is non-unique, any other reactions that might affect the waters of the MRGB are also thought not to appreciably affect the initial $^{14}C$ activity. Therefore, the unadjusted radiocarbon age was adopted in the present investigation.

#### Regional Variations in Unadjusted Radiocarbon Age

The unadjusted radiocarbon age of water in the upper approximately 500 feet of the Santa Fe Group aquifer system throughout the MRGB is shown in figure 100. The youngest water (0-2 ka) occurs along the mountain-front basin margins (eastern edge of the Eastern Mountain Front zone, the northeast, northwest, and southwest margins of the basin), and along parts of the Rio Grande, Rio Puerco, and Jemez River. Water with DIC unadjusted radiocarbon age of 0-10 ka extends along nearly the entire reach of the Rio Grande, the Rio Puerco, Galisteo Creek, Tijeras Arroyo, and Abo Arroyo, associated with recent surface-water infiltration. The oldest water generally is in the West-Central zone, the Western Boundary zone, and parts of the Eastern Mountain Front zone, as well as throughout the Discharge zone (fig. 100).

The median unadjusted radiocarbon age of DIC in ground water from 275 analyses throughout the MRGB, excluding samples contaminated with post-bomb $^{14}C$, is 8.1 ka, with a range of approximately 0 to more than 50 ka. In the mountain-front hydrochemical zones, the median unadjusted radiocarbon ages, for the

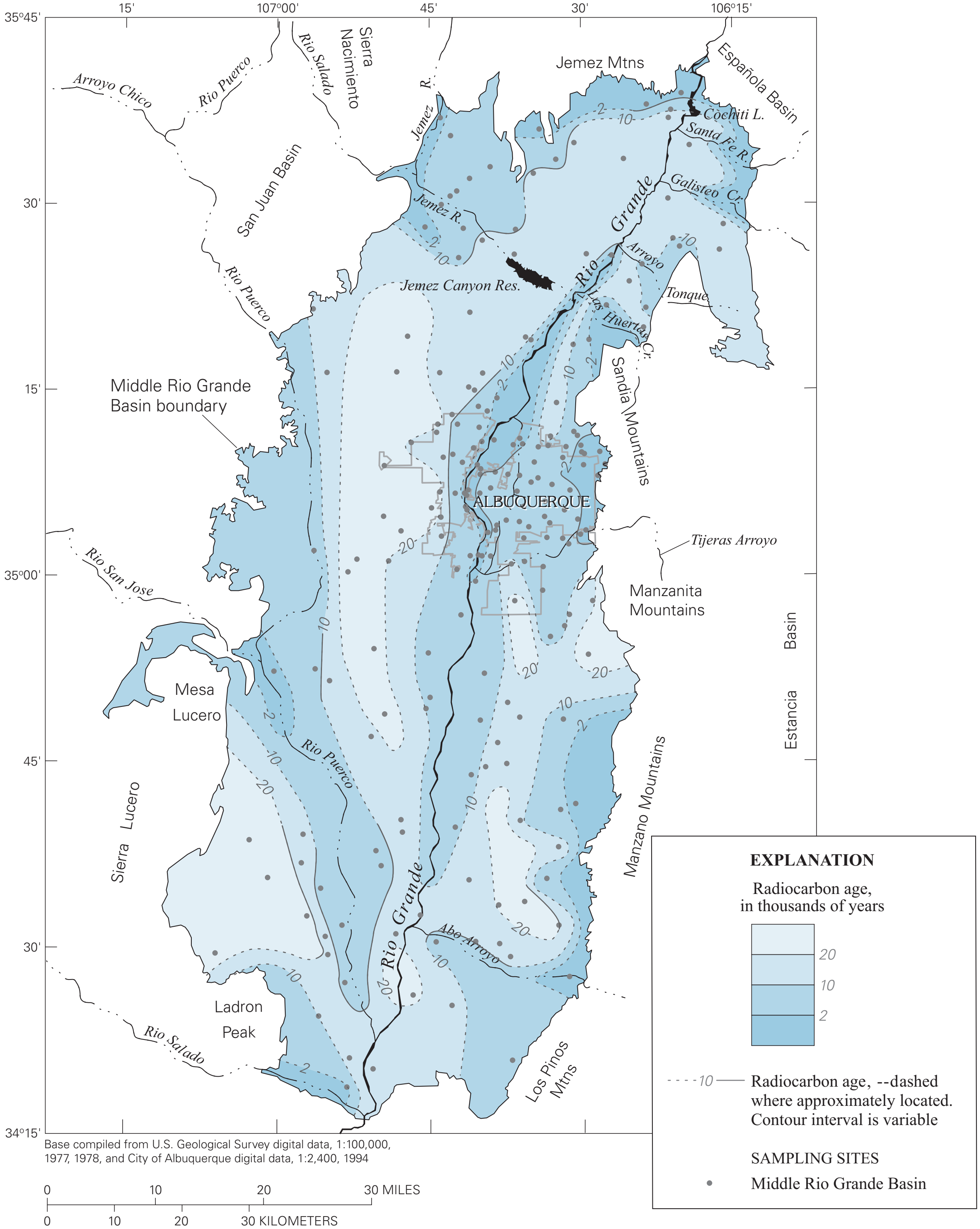



**Figure 100.** Unadjusted radiocarbon age of DIC in ground water for the Middle Rio Grande Basin, New Mexico.

Northern Mountain Front, Northwestern, Southwestern, and Eastern Mountain Front zones, are 8.8, 8.8, 7.7, and 5.2 ka, respectively. Water in the West-Central, Western Boundary, and Discharge zones has median unadjusted radiocarbon ages of 19.5, 20.4, and 17.9 ka, respectively. The median age of water in the Discharge zone is younger than water in the West-Central and Western Boundary zones because of mixing with relatively younger water from other adjacent zones. Ground water dominated by river/arroyo sources has median unadjusted radiocarbon ages of 8.1, 4.6, and 3.2 ka for the Rio Puerco, Central, and Tijeras Arroyo zones, respectively. The median unadjusted radiocarbon ages of DIC in water from the Abo Arroyo, Tijeras Fault Zone, and Northeastern zones are 9.4, 16.2, and 10.0 ka, respectively.

Variations in radiocarbon age and stable isotopic composition of water are shown as a function of depth along three east-west cross sections in the vicinity of Albuquerque in relation to hydrochemical zone boundaries in figures 101-103. The locations of the cross sections are shown on figure 70. Details of the hydrogeology and stable isotopic composition of water are given in figures 71-73. Three ranges of radiocarbon age are shown on figures 101-103: <5 ka, 5-20 ka, and >20 ka. Relatively younger water of Eastern Mountain Front and Rio Grande origin overlies the relatively older water of the West-Central zone in the vicinity of Albuquerque (figs. 101-103).

Evidently, the width of the Central zone (Rio Grande origin) is greatest at the water table and decreases with depth. Several monitoring well nests are of sufficient depth to extend through the Central zone into the West-Central zone, west of the Rio Grande (figs. 101-103), and into the Eastern Mountain Front zone, east of the Rio Grande (fig.101). The maximum depth of the Central zone exceeds 1,500 feet. Radiocarbon ages of the Central zone waters range from modern to greater than 20 ka beneath Albuquerque. There is a steep lateral gradient in radiocarbon age in the upper 500 feet of the aquifer system separating waters of the Central and West-Central zones, particularly along the Menaul and Los Padillas sections (figs. 102-103). The boundary between the Eastern Mountain Front and Central zones slopes to the west along the Paseo Del Norte section (fig. 101), but may be nearly vertical further to the south of Paseo Del Norte (figs. 102-103). Along the Los Padillas section (fig. 103), water of Eastern Mountain Front origin lies above Central zone water near the water table (S122).

## Mixing of Waters in the Well Bore

All ground water pumped from wells is a mixture, because the well has a finite open interval over which the water is withdrawn. However, for wells with narrow open intervals (for example, less than 50 feet in the MRGB), changes in chemical and isotopic composition can be small over the depth of the open interval. Consequently, mixing may not normally be noticed in ground-water discharge from wells with narrow open intervals, unless the open interval is near or at the water table, where $^{14}C$ activity gradients or gradients in anthropogenic consitituents like CFCs or $^{3}H$ with depth can be large. Mixing of water in wells results in a mixed $^{14}C$ activity of DIC in the well discharge; the most extreme case being mixing of relatively old (at least pre-1950's) ground water with young, post-1950's water that has elevated $^{14}C$ activity, resulting in $^{14}C$ activities that can be appreciably higher than those of the old (unmixed) fraction.

Evidence for well-bore mixing in the MRGB is seen in the comparison of $^{14}C$ activities with the CFC-12 and/or $^{3}H$ data. Some samples have low $^{14}C$ activities that indicate unadjusted radiocarbon ages of more than 1,000 years, yet contain detectible concentrations of CFC-12 (>0.5 pg/kg) and/or $^{3}H$ (>0.3 TU) that indicate samples containing at least a fraction of post-1950's water (fig. 98). The upper line of figure 98 shows $^{14}C$ activities of $CO_2$ from measurements made at Schauinsland, Germany (1977-97) (Levin and Kromer, 1997), and Vermunt, Austria (1959-83) (Levin and others, 1994), which are considered representative of northern-hemisphere $^{14}C$ atmospheric activities. During the mid-1960's, the $^{14}C$ activity in the atmosphere nearly doubled (from 100 pmC, pre-bomb, to nearly 200 pmC in 1964) as a result of atmospheric testing of thermo-nuclear devices. The atmospheric $^{14}C$ activity is plotted in figure 98 as a function of the CFC-12 concentration, in pg/kg, that would be in ground water recharged in equilibrium with air at 6,500 feet altitude and 10$^{o}$C. The numbers on the curve give the corresponding date of recharge. The dashed lines show hypothetical mixing lines of young and old water. Samples that plot below the heavy dashed atmospheric curve and contain more than approximately 5 pg/kg of CFC-12 (fig. 98), a concentration that is 10 times above

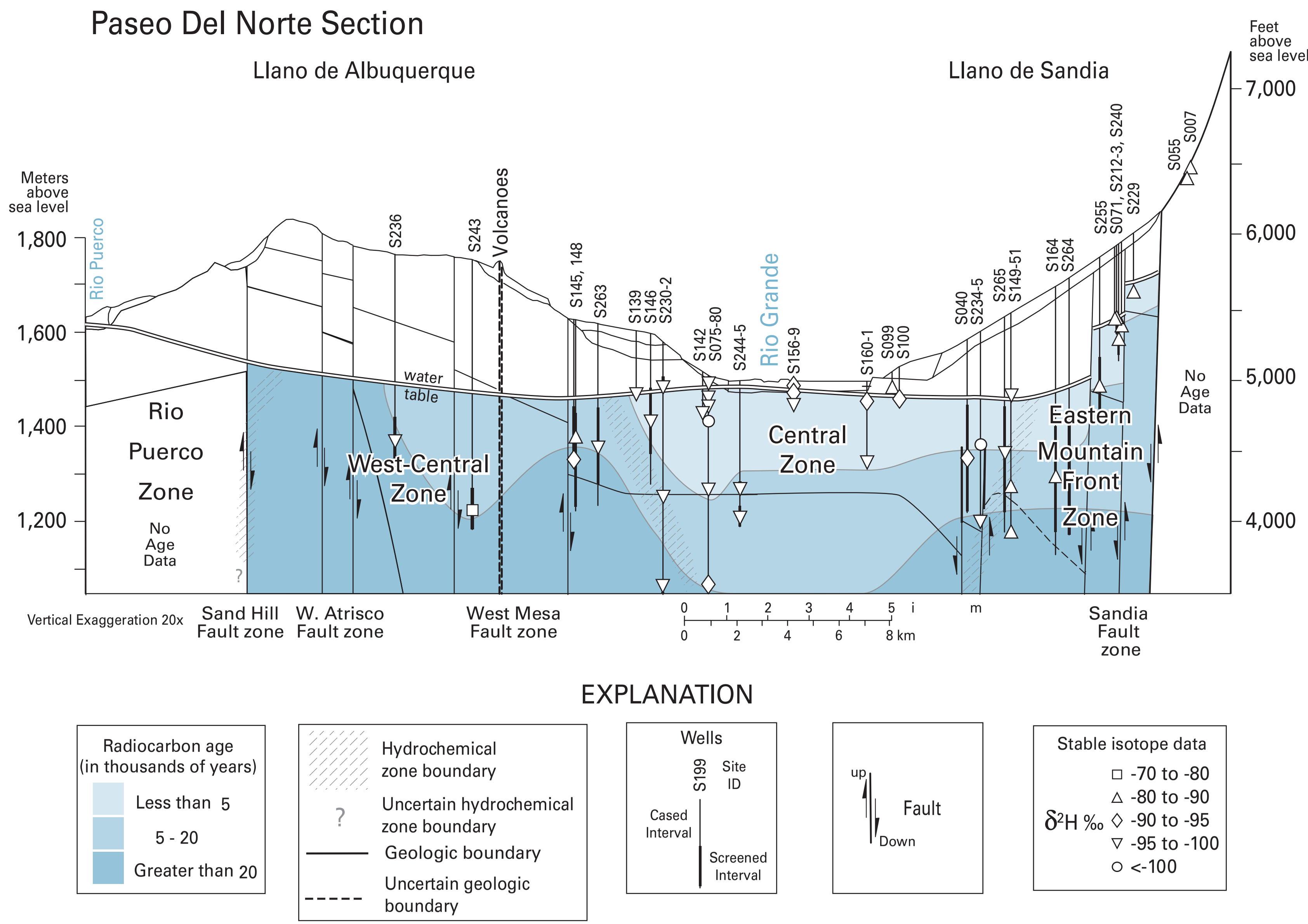



**Figure 101.** Schematic hydrochemical cross section of the Middle Rio Grande Basin, New Mexico, aligned with Paseo del Norte Boulevard, Albuquerque, showing ranges of $\delta^2H$ and radiocarbon age for ground water in relation to position of hydrochemical zone boundaries. The cross section is located on figure 70. See figure 71 for details of the hydrogeology.

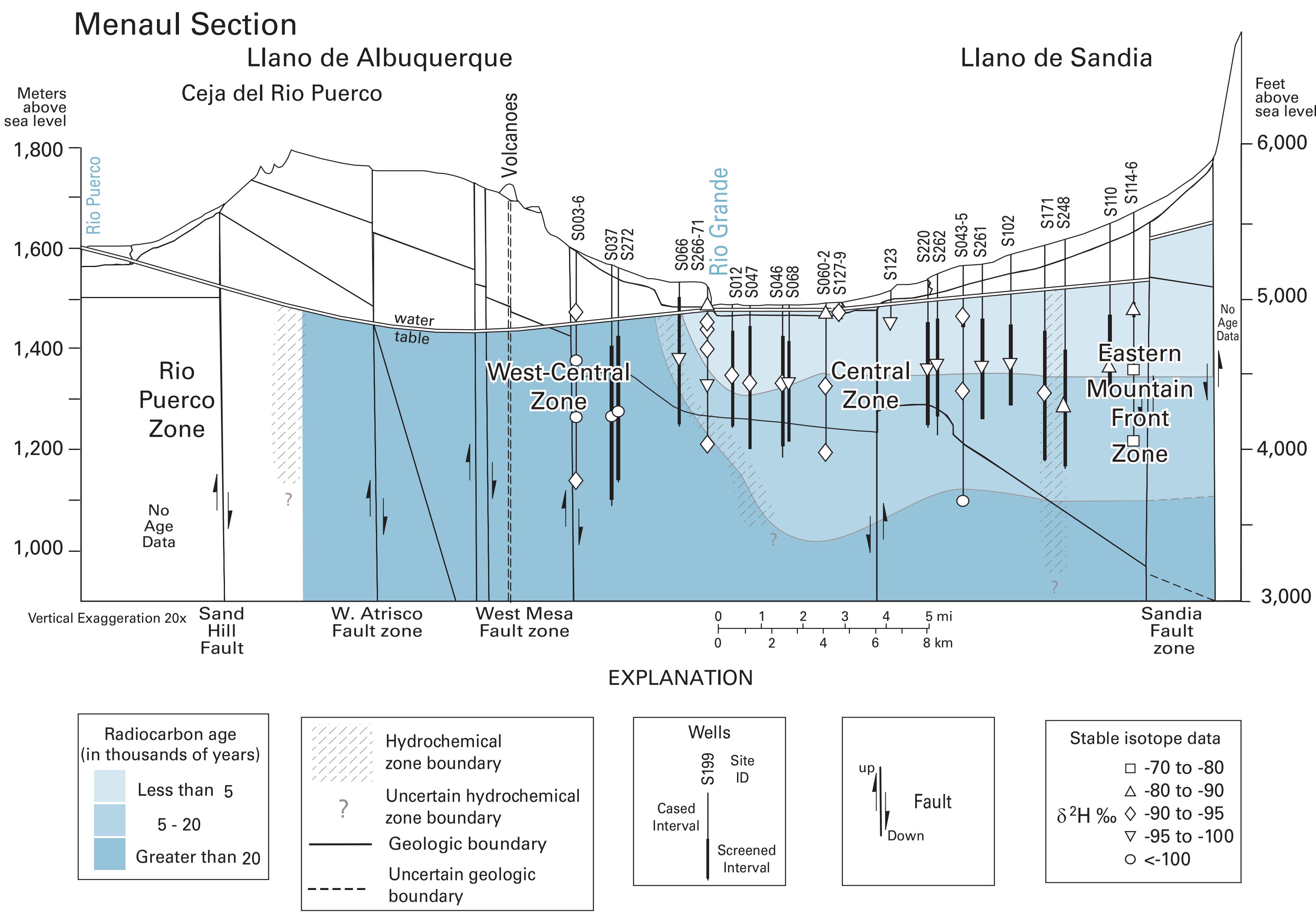



**Figure 102.** Schematic hydrochemical cross section of the Middle Rio Grande Basin, New Mexico, aligned with Menaul Boulevard showing ranges of $\delta^2$H and radiocarbon age for ground water in relation to position of hydrochemical zone boundaries. The cross section is located on figure 70. See figure 72 for details of the hydrogeology.

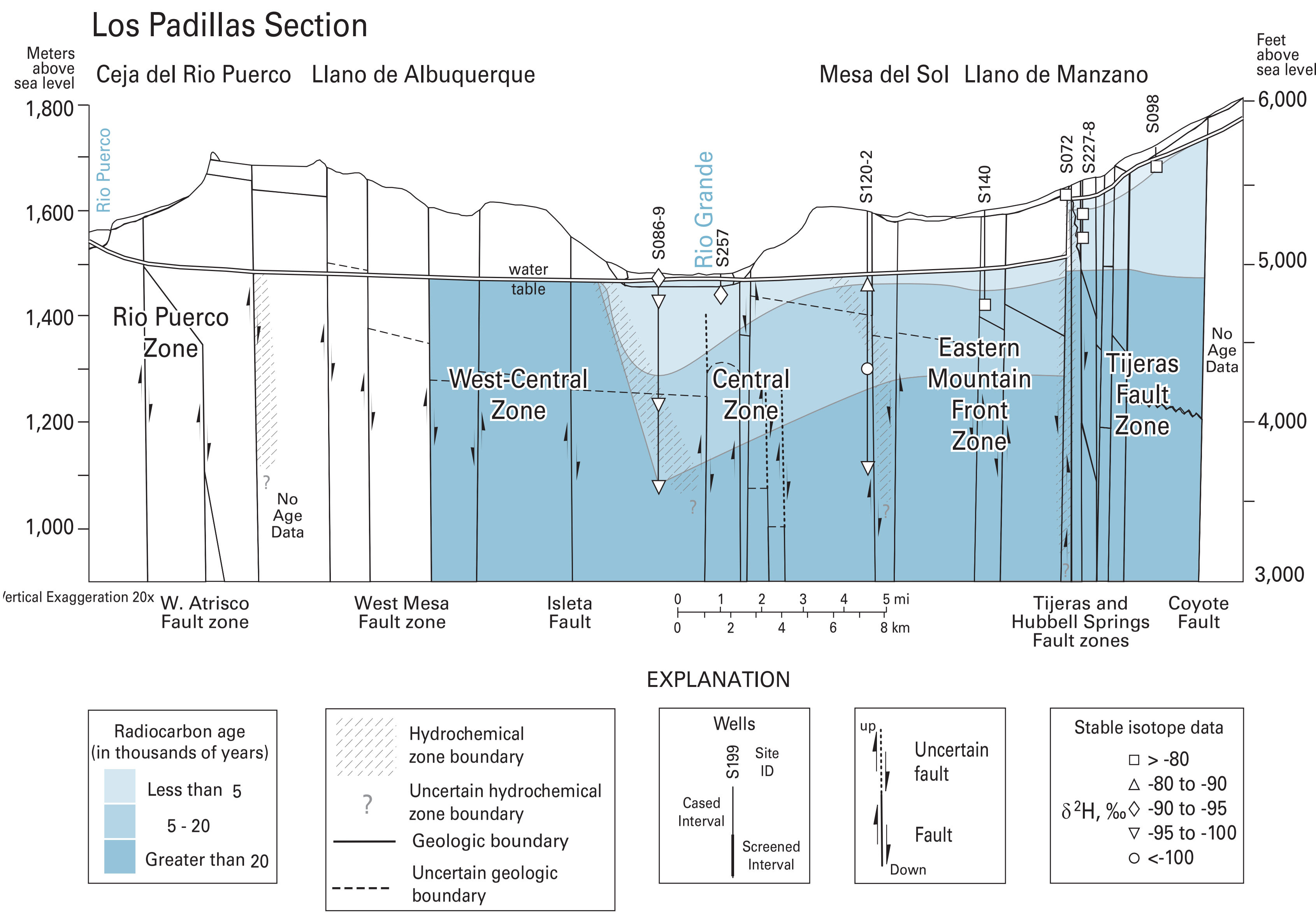



**Figure 103.** Schematic hydrochemical cross section of the Los Padillas vicinity showing ranges of $\delta^2H$ and radiocarbon age for ground water in relation to position of hydrochemical zone boundaries. The cross-section line is shown on figure 70. See figure 73 for details of the hydrogeology.

the analytical detection limit of 0.5 pg/kg, are likely mixtures that contain a fraction of post-1950 water.

Eleven of the ground-water samples have $^{14}C$ activities of more than 100 pmC and, based on the $^{14}C$ activity alone, are post-1950 in age or contain fractions of post-1950 recharge. All of the 11 samples with $^{14}C$ activities that are more than 100 pmC also contain elevated tritium concentrations (7.8-28.6 TU) and/or elevated concentrations of CFC-12 (18-327 picograms per kg (pg/kg) of CFC-12) (table 13).

Water recharged prior to 1950 in the MRGB would contain less than approximately 3 pg/kg of CFC-12 and less than about 0.2 TU. Of the 263 $^{14}C$ measurements of DIC in ground-water samples from the MRGB (table 13), CFC-12 was analyzed in 216 of the samples, and $^{3}H$ was determined in 148 samples. Tritium was determined in 46 of the 47 samples that could not be analyzed for CFC-12 (mostly windmills where there was the possibility of air contamination prior to sampling). Both $^{3}H$ and CFC-12 were measured in 102 of the samples with $^{14}C$ measurements (table 13). Of the 216 samples with CFC-12 analyses, 101 contained $\leq 3$ pg/kg of CFC-12, and 81 of the 148 samples with $^{3}H$ determined contained $\leq 0.2$ TU. A total of 162 samples contained $\leq 3$ pg/kg of CFC-12 and/or $\leq 0.2$ TU of tritium. Although still mixtures, these 162 samples (62 percent of the samples with $^{14}C$ measurements) do not contain an appreciable fraction of post-1950's water. However, 115 of the 216 samples with CFC-12 analyses contain a fraction of post-1950 water. Of the 47 samples in which CFCs could not be measured reliably, 19 samples had $^{3}H$ concentrations greater than 0.2 TU and also likely contained a fraction of post-1950's water. Thus, based on CFC-12 and/or $^{3}H$ data, 51 percent of the ground-water samples with $^{14}C$ measurements likely contain at least a small fraction of post-1950's water.

In the MRGB, ground-water mixtures pumped from wells that are open to large intervals of the aquifer system (> 200 feet) can be mixtures of water from large ranges in age. In some cases, pumping can lower the water table around the well screen, permitting water withdrawals from near the water table. Ground-water mixtures are common in discharge from municipal production wells that can be open to more than 800 feet of aquifer system and can discharge hundreds of gallons per minute. The mixing is not always evident in major-element chemical composition or even stable isotope composition, if the aquifer system is fairly uniform in chemical and/or isotopic composition with depth. $^{14}C$ and other environmental tracers with concentrations that vary with ground-water age can be affected by mixing processes, particularly if there are steep age gradients with respect to depth.

The uncertainty in $^{14}C$ activity of DIC in water discharging from wells was estimated using the $^{14}C$ data from the piezometer nests (table 7) that permitted estimation of the local depth gradient in $^{14}C$ activity, and using well-construction information defining the length of the open interval of the well. To a first approximation, it was assumed that the flow of ground water into the open interval of the well was constant with depth. Although this approximation may be valid for some Albuquerque production wells, Thorn (2000) presents detailed flowmeter logs from six Albuquerque production wells that show considerable variation in the amount of flow contributed by different lithologies across large screened intervals. In some cases, for example, well Love 6, it would be more reasonable to assume that the well discharge is derived from only the upper half of the screened interval. In other wells, for example at Gonzales 2, Gonzales 3, and Ponderosa 3, the assumption that flow is derived evenly across the open interval is well justified (Thorn, 2000). All radiocarbon ages determined for this study were based on the measured (unadjusted) $^{14}C$ activity, but, in estimating the age uncertainty, the uncertainty in the measurement was allowed to vary, in many cases, to an extent considerably higher than the reported analytical uncertainty (table 10).

Samples containing < 5 pg/kg of CFC-12 and/or <0.5 TU of $^{3}H$ from piezometer nests or wells with narrow sampling intervals (generally < 50 feet of open interval) that did not intercept the water table were considered the most reliable of all the $^{14}C$ samples, and were assigned error bounds equal to the reported analytical uncertainty (table 13). Samples containing < 5 pg/kg of CFC-12 and/or $^{3}H$ of <0.5 TU that were from wells with large open intervals (> 50 feet), including municipal production wells, usually had uncertainties in $^{14}C$ activity greater than those samples from narrow sampling intervals. For these samples, estimates of the $^{14}C$ activity gradient nearest the well (table 7) were used in conjunction with the length of the open interval to estimate the uncertainty in $^{14}C$ activity.

Ground-water samples containing more than 5 pg/kg of CFC-12 and/or more than 0.5 TU of $^{3}H$ from piezometers with screens that do not intercept the water table likely contain drilling fluid. For these samples,

**Table 13.** Estimation of uncertainties in $^{14}C$ activities for ground water from the Middle Rio Grande Basin, New Mexico

[bls, below land surface; no., number; nd, not determined; na, not applicable; MW, monitoring well; DW, domestic well; PW, production well; SP, spring; WM, windmill; SW, stock well; TU, tritium unit; pg/kg, picogram per kilogram; P, sample as powder of precipitated barium carbonate; S, water sample collected in septum bottle; pmC, percent modern carbon; O, old, datable on the $^{14}C$ timescale; M, modern, $^{14}C$ age probably less than 200 years or post-bomb; yrs, years]

| Site no. | Sample no. | Site name | Well type | Altitude (feet) | Depth (feet bls) | Feet of water above top of screen | Water level, (feet bls) | Depth to top of screen (feet bls) | Depth to bottom of screen (feet bls) | Screen length (feet) | Type of pump | Tritium (TU) | CFC-12 concen-tration (pg/kg) | $\delta^{13}C$ (per mil) | Sample as $BaCO_3$ powder, P, or dis-solved, S | Meas-ured $^{14}C$ activity (pmC) | $^{14}C$ ±1σ (pmC) | Conv., un-adjusted $^{14}C$ age Libby halflife (yrs) | Old, O or Modern, M | Esti-mated "+" uncer-tainty (pmC) | Esti-mated "-" uncer-tainty (pmC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Zone 1: Northern Mountain Front** | | | | | | | | | | | | | | | | | | | |
| S027 | NM486 | CEPO 02 | MW | 5,335 | 320 | 149 | 121 | 270 | 315 | 45 | Grundfos | nd | 2 | -6.9 | S | 21.3 | 0.2 | 12,415 | O | 0.2 | 0.2 |
| S034 | NM027 | Private Production Well #04 | PW | 5,298 | 250 | nd | 190 | nd | nd | nd | Unknown | nd | 0 | -10.8 | P | 51.9 | 0.6 | 5,264 | O | 5. | 5. |
| S035 | NM487 | Windmill #37 | WM | 5,533 | 290 | nd | 150 | nd | nd | nd | Windmill | 17.2 | nd | -11.7 | S | 97.9 | 0.7 | 170 | M | nd | nd |
| S036 | NM026 | Private Production Well #03 | PW | 5,362 | 300 | 90 | 160 | 250 | 300 | 50 | Unknown | nd | 1 | -8.1 | P | 82.6 | 0.9 | 1,540 | O | 0.9 | 10. |
| S065 | NM055 | Domestic Well #05 | DW | 5,172 | 330 | 160 | 160 | 320 | 330 | 10 | Submersible | nd | 6 | -6.2 | P | 27.0 | 0.3 | 10,518 | O | 0.3 | 1. |
| S187 | NM131 | Rio Rancho 12 | PW | 5,240 | 1,487 | 574 | 226 | 800 | 1,435 | 635 | Turbine | 0.4 | 6 | -9.6 | S | 24.8 | 0.2 | 11,188 | O | 15. | 15. |
| S206 | NM510 | Windmill #38 | WM | 5,542 | 535 | nd | 461 | nd | nd | nd | Windmill | - 0.1 | nd | -8.9 | S | 13.0 | 0.2 | 16,395 | O | 0.2 | 2. |
| S216 | NM143 | Windmill #09 | WM | 5,725 | 637 | nd | 585 | nd | nd | nd | Windmill | 0.1 | 17 | -6.1 | P | 39.7 | 0.5 | 7,421 | O | 0.5 | 10. |
| S221 | NM530 | Windmill #45 | WM | 5,632 | 555 | nd | nd | nd | nd | nd | Windmill | 0.2 | nd | -5.8 | S | 12.2 | 0.2 | 16,926 | O | 0.5 | 3. |
| S222 | NM514 | Windmill #39 | WM | 6,107 | 260 | nd | nd | nd | nd | nd | Windmill | 0.5 | nd | -4.3 | S | 10.4 | 0.2 | 18,181 | O | 0.2 | 2. |
| S254 | NM168 | Private Production Well #12 | PW | 5,525 | 690 | 91 | 265 | 356 | 690 | 334 | Turbine | nd | 0 | -10.8 | P | 92.0 | 0.8 | 667 | O | 8. | 8. |
| S277 | NM525 | Windmill #40 | WM | 5,946 | 100 | nd | 37 | nd | nd | nd | Windmill | 1.0 | nd | -7.5 | S | 50.7 | 0.4 | 5,456 | O | 1. | 5. |
| S279 | NM527 | Windmill #42 | WM | 6,275 | 56 | nd | 13 | nd | nd | nd | Windmill | 8.1 | nd | -13.4 | S | 106. | 0.8 | -489 | M | nd | nd |
| S281 | NM528 | Windmill #43 | WM | 6,281 | 1,109 | nd | 991 | nd | nd | nd | Windmill | 0.3 | nd | -10.3 | S | 22.3 | 0.2 | 12,043 | O | 1. | 5. |
| | | **Zone 2: Northwestern** | | | | | | | | | | | | | | | | | | | |
| S103 | NM497 | Lincoln D | MW | 5,450 | 1,260 | 705 | 496 | 1,200 | 1,240 | 40 | Bennett | nd | 3 | -8.4 | S | 13.8 | 0.2 | 15,909 | O | 0.2 | 2. |
| S104 | NM498 | Lincoln M | MW | 5,450 | 835 | 316 | 494 | 810 | 830 | 20 | Bennett | nd | 0 | -7.1 | S | 15.5 | 0.2 | 14,997 | O | 0.2 | 2. |
| S105 | NM499 | Lincoln S | MW | 5,450 | 595 | 5 | 486 | 490 | 590 | 100 | Bennett | 0.0 | 4 | -6.5 | S | 29.6 | 0.4 | 9,768 | O | 3. | 3. |
| S191 | NM326 | Rio Rancho 4 | PW | 5,415 | 990 | 274 | 396 | 670 | 990 | 320 | Turbine | nd | 108 | -6.7 | S | 19.8 | 0.2 | 13,021 | O | 3. | 6. |
| S192 | NM128 | Rio Rancho 8 | PW | 5,827 | 1,618 | 102 | 880 | 982 | 1,599 | 617 | Turbine | nd | 0 | -7.6 | P | 14.7 | 0.2 | 15,385 | O | 10. | 10. |
| S189 | NM133 | Rio Rancho 15 | PW | 5,794 | 1,310 | 45 | 775 | 820 | 1,290 | 470 | Turbine | nd | 0 | -6.9 | P | 18.3 | 0.2 | 13,655 | O | 5. | 5. |
| S276 | NM179 | Windmill #12 | WM | 5,970 | 727 | 48 | 667 | 715 | 725 | 10 | Windmill | 0.0 | nd | -7.3 | P | 38.1 | 0.4 | 7,756 | O | 0.4 | 5. |
| S278 | NM526 | Windmill #41 | WM | 5,618 | 448 | nd | 373 | nd | nd | nd | Windmill | 0.6 | nd | -7.1 | S | 71.3 | 0.5 | 2,718 | O | 1. | 10. |
| S280 | NM180 | Windmill #13 | WM | 5,554 | 240 | 9 | 116 | 125 | 135 | 10 | Windmill | 0.4 | nd | -5.0 | P | 84.5 | 0.9 | 1,356 | O | 0.9 | 5. |
| S286 | NM184 | Private Production Well #13 | PW | 5,615 | 572 | 150 | 242 | 392 | 552 | 160 | Submersible | nd | 5 | -6.6 | P | 71.2 | 0.6 | 2,729 | O | 0.6 | 6. |
| S287 | NM185 | Private Production Well #14 | PW | 5,525 | 320 | 110 | 150 | 260 | 320 | 60 | Submersible | nd | 0 | -6.2 | P | 37.4 | 0.4 | 7,903 | O | 0.4 | 4. |
| | | **Zone 3: West Central** | | | | | | | | | | | | | | | | | | | |
| S003 | NM251 | 98th St. D | MW | 5,320 | 1,544 | 1,113 | 421 | 1,534 | 1,539 | 5 | Bennett | nd | 3 | -7.4 | S | 0.62 | 0.1 | 40,833 | O | 0.1 | 0.5 |
| S003 | NM481 | 98th St. D | MW | 5,320 | 1,544 | 1,113 | 421 | 1,534 | 1,539 | 5 | Bennett | nd | 16 | -7.2 | S | 0.13 | 0.1 | 53,382 | O | 0.1 | 0.1 |
| S004 | NM252 | 98th St. MD | MW | 5,320 | 1,112 | 679 | 423 | 1,102 | 1,107 | 5 | Bennett | nd | 1 | -7.4 | S | 3.98 | 0.1 | 25,897 | O | 0.1 | 1. |
| S004 | NM482 | 98th St. MD | MW | 5,320 | 1,112 | 679 | 423 | 1,102 | 1,107 | 5 | Bennett | nd | 29 | -7.5 | S | 3.69 | 0.1 | 26,505 | O | 0.1 | 1. |
| S005 | NM483 | 98th St. MS | MW | 5,320 | 749 | 323 | 416 | 739 | 744 | 5 | Bennett | nd | 21 | -5.0 | S | 0.79 | 0.1 | 38,887 | O | 0.1 | 0.2 |
| S006 | NM484 | 98th St. S | MW | 5,320 | 438 | -3 | 391 | 388 | 433 | 45 | Bennett | 0.1 | 31 | -7.6 | S | 6.37 | 0.2 | 22,119 | O | 0.2 | 2. |
| S008 | NM003 | Private Production Well #01 | PW | 5,725 | 1,292 | 244 | 834 | 1,078 | 1,272 | 194 | Unknown | 0.7 | 0 | -7.8 | P | 5.47 | 0.1 | 23,343 | O | 1. | 1. |
| S010 | NM255 | Private Production Well #16 | PW | 5,688 | 1,300 | 461 | 781 | 1,242 | 1,294 | 52 | Submersible | nd | 72,872 | -8.6 | S | 9.31 | 0.3 | 19,071 | O | 0.3 | 5. |
| S018 | NM260 | Domestic Well #21 | DW | 5,320 | 660 | 165 | 475 | 640 | 660 | 20 | Submersible | nd | 32 | -7.3 | S | 11.0 | 0.1 | 17,753 | O | 0.1 | 10. |
| S019 | NM007 | Belen 4 | PW | 4,920 | 504 | 0 | 150 | 150 | 504 | 354 | Submersible | 0.5 | 45 | -7.2 | P | 14.6 | 0.2 | 15,484 | O | 2. | 5. |
| S020 | NM008 | Belen 5 | PW | 4,930 | 600 | 291 | 144 | 435 | 600 | 165 | Submersible | nd | 0 | -6.7 | P | 16.4 | 0.2 | 14,537 | O | 2. | 2. |

**Table 13.** Estimation of uncertainties in $^{14}C$ activities for ground water from the Middle Rio Grande Basin, New Mexico -- Continued

| Site no. | Sample no. | Site name | Well type | Altitude (feet) | Depth (feet bls) | Feet of water above top of screen | Water level, (feet bls) | Depth to top of screen (feet bls) | Depth to bottom of screen (feet bls) | Screen length (feet) | Type of pump | Tritium (TU) | CFC-12 concentration (pg/kg) | $\delta^{13}C$ (per mil) | Sample as $BaCO_3$ powder, P, or dissolved, S | Measured $^{14}C$ activity (pmC) | $^{14}C$ ±1σ (pmC) | Conv., unadjusted $^{14}C$ age Libby halflife (yrs) | Old, O or Modern, M | Estimated "+" uncertainty (pmC) | Estimated "-" uncertainty (pmC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S029 | NM015 | Cerro Colorado Landfill PW | PW | 5,830 | 1,661 | 457 | 898 | 1,355 | 1,655 | 300 | Unknown | nd | 0 | -7.2 | P | 7.35 | 0.1 | 20,970 | O | 2. | 2. |
| S037 | NM264 | College 2 | PW | 5,226 | 1,605 | 221 | 329 | 550 | 1,564 | 1,014 | Turbine | nd | 1 | -7.8 | S | 5.39 | 0.1 | 23,461 | O | 2. | 2. |
| S066 | NM056 | Gonzales 1 | PW | 5,111 | 970 | 183 | 167 | 350 | 950 | 600 | Turbine | 2.7 | 7 | -7.3 | P | 47.0 | 0.4 | 6,058 | O | 24. | 24. |
| S086 | NM492 | Isleta D | MW | 4,900 | 1,340 | 1,312 | 18 | 1,330 | 1,335 | 5 | Bennett | nd | 7 | -8.7 | S | 2.71 | 0.2 | 28,985 | O | 0.2 | 2. |
| S101 | NM294 | Leavitt 1 | PW | 5,076 | 1,140 | 95 | 193 | 288 | 1,128 | 840 | Turbine | nd | 6 | -7.1 | S | 17.3 | 0.1 | 14,103 | O | 2. | 4. |
| S108 | NM076 | Los Lunas 3 | PW | 4,965 | 605 | 150 | 182 | 332 | 562 | 230 | Submersible | nd | 1 | -7.5 | P | 27.6 | 0.2 | 10,356 | O | 5. | 5. |
| S109 | NM077 | Los Lunas 4 | PW | 4,981 | 610 | 149 | 129 | 278 | 582 | 304 | Submersible | nd | 0 | -8.7 | P | 50.5 | 0.4 | 5,496 | O | 10. | 10. |
| S145 | NM308 | NM Utilities 1 | PW | 5,390 | 1,050 | 115 | 533 | 648 | 1,050 | 402 | Turbine | nd | 0 | -6.6 | S | 13.9 | 0.2 | 15,845 | O | 4. | 4. |
| S147 | NM310 | NM Utilities 3 | PW | 5,460 | 1,364 | 161 | 489 | 650 | 1,351 | 701 | Turbine | nd | 0 | -7.7 | S | 15.7 | 0.2 | 14,878 | O | 7. | 7. |
| S148 | NM311 | NM Utilities 4 | PW | 5,455 | 1,357 | 153 | 539 | 692 | 1,339 | 647 | Turbine | nd | 0 | -7.0 | S | 7.36 | 0.1 | 20,959 | O | 6. | 6. |
| S166 | NM509 | Rabbit Hill | MW | 5,655 | 608 | 251 | 102 | 353 | 603 | 250 | Grundfos | nd | 2 | -4.5 | S | 8.59 | 0.1 | 19,717 | O | 0.1 | 4. |
| S167 | NM107 | Domestic Well #12 | DW | 5,358 | 985 | 435 | 530 | 965 | 980 | 15 | Submersible | nd | 0 | -7.9 | P | 5.85 | 0.1 | 22,803 | O | 0.1 | 0.1 |
| S172 | NM322 | Rio Bravo 5 D | MW | 4,931 | 149 | 128 | 11 | 139 | 144 | 5 | Grundfos | nd | 0 | -8.9 | S | 3.11 | 0.1 | 27,879 | O | 0.1 | 1. |
| S174 | NM109 | Rio Bravo 1 D | MW | 4,931 | 149 | nd | 11 | 139 | 144 | 5 | Bennett | 0.0 | 0 | -7.3 | P | 15.1 | 0.2 | 15,181 | O | 0.2 | 0.2 |
| S175 | NM110 | Rio Bravo 1 M | MW | 4,931 | 104 | nd | 11 | 94 | 99 | 5 | Bennett | 0.0 | 2 | -7.1 | P | 33.2 | 0.3 | 8,855 | O | 0.3 | 0.3 |
| S186 | NM130 | Rio Rancho 10 | PW | 5,504 | 1,470 | 269 | 556 | 825 | 1,450 | 625 | Turbine | nd | 0 | -7.0 | P | 12.2 | 0.2 | 16,912 | O | 9. | 9. |
| S188 | NM132 | Rio Rancho 13 | PW | 6,055 | 1,920 | 242 | 1,101 | 1,343 | 1,721 | 378 | Turbine | nd | 0 | -7.1 | P | 3.00 | 0.1 | 28,168 | O | 2. | 2. |
| S193 | NM129 | Rio Rancho 9 | PW | 6,054 | 1,540 | 38 | 1,082 | 1,120 | 1,520 | 400 | Turbine | 0.0 | 26 | -7.8 | P | 7.72 | 0.1 | 20,575 | O | 5. | 5. |
| S196 | NM135 | Windmill #05 | WM | 5,470 | 620 | nd | 599 | nd | nd | nd | Windmill | 0.0 | 94 | -7.4 | P | 36.8 | 0.3 | 8,037 | O | 0.3 | 30. |
| S200 | NM139 | Private Production Well #08 | PW | 4,840 | 249 | 132 | 92 | 224 | 249 | 25 | Submersible | nd | 1 | -7.1 | P | 9.23 | 0.2 | 19,140 | O | 0.2 | 0.2 |
| S217 | NM144 | Santa Ana Boundary D | MW | 5,322 | 750 | 724 | 6 | 730 | 750 | 20 | Bennett | nd | 1 | -7.2 | P | 6.47 | 0.1 | 21,994 | O | 0.1 | 1. |
| S218 | NM145 | Santa Ana Boundary M | MW | 5,322 | 492 | 456 | 16 | 472 | 492 | 20 | Bennett | nd | 6 | -6.8 | P | 8.24 | 0.1 | 20,052 | O | 0.1 | 3. |
| S219 | NM146 | Santa Ana Boundary S | MW | 5,322 | 210 | 159 | 31 | 190 | 210 | 20 | Bennett | nd | 4 | -6.6 | P | 5.54 | 0.2 | 23,241 | O | 0.2 | 1. |
| S230 | NM516 | Sierra Vista D | MW | 5,110 | 1,644 | 1,455 | 179 | 1,634 | 1,639 | 5 | Bennett | nd | 0 | -5.5 | S | 1.89 | 0.1 | 31,879 | O | 0.1 | 0.5 |
| S236 | NM155 | SAF (Soil Amendment Facility) | PW | 5,866 | 1,463 | 194 | 922 | 1,116 | 1,429 | 313 | Turbine | 0.4 | 77 | -8.0 | P | 4.50 | 0.1 | 24,911 | O | 2. | 2. |
| S241 | NM519 | SWAB Test Hole 1 D | MW | 5,796 | 1,179 | 254 | 885 | 1,139 | 1,179 | 40 | Swab | 0.1 | nd | -6.9 | S | 6.57 | 0.2 | 21,871 | O | 0.5 | 0.5 |
| S242 | NM520 | SWAB Test Hole 1 S | MW | 5,796 | 1,121 | 93 | 887 | 980 | 1,121 | 141 | Swab | - 0.2 | nd | -8.9 | S | 9.12 | 0.1 | 19,236 | O | 2. | 2. |
| S243 | NM521 | SWAB Test Hole 2 D [1] | MW | 5,730 | 1,805 | 728 | 797 | 1,525 | 1,795 | 270 | Swab | 0.1 | nd | -8.3 | S | 14.4 | 0.2 | 15,595 | O | 0.2 | 2. |
| S263 | NM346 | Volcano Cliff 1 | PW | 5,335 | 1,200 | 70 | 458 | 528 | 1,056 | 528 | Turbine | nd | 3 | -7.1 | S | 9.45 | 0.1 | 18,951 | O | 0.1 | 3. |
| S266 | NM347 | West Bluff Nest 1 Well 1 | MW | 5,100 | 1,095 | 912 | 173 | 1,085 | 1,090 | 5 | Grundfos | nd | 0 | -6.4 | S | 2.00 | 0.1 | 31,425 | O | 0.1 | 0.1 |
| S272 | NM353 | West Mesa 3 | PW | 5,145 | 1,365 | 166 | 239 | 405 | 1,353 | 948 | Turbine | nd | 0 | -6.8 | S | 9.00 | 0.1 | 19,343 | O | 2. | 2. |
| S283 | NM181 | Zia Ball Park D | MW | 5,397 | 770 | 736 | 14 | 750 | 770 | 20 | Bennett | nd | 0 | -6.1 | P | 18.3 | 0.2 | 13,625 | O | 0.2 | 1. |
| S284 | NM182 | Zia Ball Park M | MW | 5,397 | 506 | 471 | 15 | 486 | 506 | 20 | Bennett | nd | 1 | -6.4 | P | 20.7 | 0.2 | 12,660 | O | 0.3 | 1. |
| S285 | NM183 | Zia Ball Park S | MW | 5,397 | 300 | 261 | 19 | 280 | 300 | 20 | Bennett | nd | 1 | -6.9 | P | 22.2 | 0.3 | 12,079 | O | 0.3 | 1. |
| S288 | NM186 | Zia BMT D | MW | 5,740 | 800 | nd | nd | 750 | 800 | 50 | Bennett | 1.0 | nd | -8.3 | P | 8.29 | 0.2 | 20,003 | O | 0.2 | 1. |
| | | **Zone 4: Western Boundary** | | | | | | | | | | | | | | | | | | | |
| S031 | NM263 | Windmill #18 | WM | 4,850 | 143 | nd | 112 | nd | nd | nd | Windmill | - 0.7 | nd | -4.6 | S | 8.14 | 0.1 | 20,150 | O | 0.1 | 3. |
| S039 | NM266 | Windmill #20 | WM | 5,249 | 439 | nd | nd | nd | nd | nd | Pump Jack | - 0.1 | nd | -1.7 | S | 0.79 | 0.1 | 38,887 | O | 0.1 | 0.5 |
| S059 | NM278 | Windmill #21 | WM | 5,190 | 395 | 41 | 349 | 390 | 395 | 5 | Pump Jack | 0.1 | 14 | -6.9 | S | 9.80 | 0.1 | 18,659 | O | 0.1 | 1. |
| S074 | NM285 | Windmill #23 | WM | 5,434 | 620 | nd | 545 | nd | nd | nd | Pump Jack | 0.1 | nd | -0.9 | S | 4.24 | 0.1 | 25,389 | O | 0.1 | 1. |
| S169 | NM320 | Rest Area | PW | 4,905 | 212 | 9 | 164 | 173 | 212 | 39 | Submersible | 15.6 | nd | -5.5 | S | 80.7 | 0.7 | 1,720 | O | 0.7 | 10. |
| S201 | NM329 | Windmill #26 | WM | 5,654 | 630 | nd | nd | nd | nd | nd | Windmill | 0.0 | nd | -4.8 | S | 2.68 | 0.1 | 29,074 | O | 0.1 | 1. |

**Table 13.** Estimation of uncertainties in $^{14}C$ activities for ground water from the Middle Rio Grande Basin, New Mexico -- Continued

| Site no. | Sample no. | Site name | Well type | Altitude (feet) | Depth (feet bls) | Feet of water above top of screen | Water level, (feet bls) | Depth to top of screen (feet bls) | Depth to bottom of screen (feet bls) | Screen length (feet) | Type of pump | Tritium (TU) | CFC-12 concen-tration (pg/kg) | $\delta^{13}C$ (per mil) | Sample as $BaCO_3$ powder, P, or dis-solved, S | Meas-ured $^{14}C$ activity (pmC) | $^{14}C$ $\pm 1\sigma$ (pmC) | Conv., un-adjusted $^{14}C$ age Libby halflife (yrs) | Old, O or Modern, M | Esti-mated "+" uncer-tainty (pmC) | Esti-mated "-" uncer-tainty (pmC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S252 | NM167 | Windmill #10 | WM | 5,188 | 428 | 18 | 371 | 388 | 428 | 40 | Pump Jack | 0.5 | nd | -6.2 | P | 9.69 | 0.2 | 18,749 | O | 0.2 | 3. |
| S260 | NM345 | Windmill #33 | WM | 5,004 | 281 | 62 | 207 | 269 | 279 | 10 | Windmill | 0.5 | nd | -3.2 | S | 3.29 | 0.1 | 27,427 | O | 0.1 | 1. |
| | | **Zone 5: Rio Puerco** | | | | | | | | | | | | | | | | | | | |
| S032 | NM262 | Windmill #17 | WM | 4,771 | 61 | nd | 34 | nd | nd | nd | Windmill | 0.3 | nd | -3.5 | S | 29.8 | 0.2 | 9,736 | O | 0.2 | 10. |
| S069 | NM058 | Domestic Well #06 | DW | 5,191 | 590 | 205 | 385 | 590 | 590 | nd | Submersible | 0.2 | 52 | -9.3 | P | 36.5 | 0.4 | 8,107 | O | 0.4 | 5. |
| S073 | NM062 | Windmill #03 | WM | 5,035 | 268 | nd | 225 | nd | nd | nd | Windmill | - 0.2 | nd | -7.0 | P | 49.1 | 0.4 | 5,720 | O | 0.4 | 5. |
| S082 | NM409 | Windmill #36 | WM | 5,570 | 720 | nd | 599 | nd | nd | nd | Windmill | 0.1 | 42 | -12.3 | S | 43.3 | 0.4 | 6,733 | O | 2. | 10. |
| S085 | NM408 | Windmill #35 | WM | 5,423 | 700 | nd | 580 | nd | nd | nd | Windmill | 0.2 | 99 | -9.8 | S | 13.2 | 0.1 | 16,254 | O | 1. | 4. |
| S111 | NM079 | Domestic Well #10 | DW | 5,169 | 657 | 237 | 400 | 637 | 657 | 20 | Submersible | nd | 0 | -6.8 | P | 54.7 | 0.5 | 4,842 | O | 0.5 | 1. |
| S185 | NM324 | Domestic Well #31 | DW | 5,280 | 150 | nd | 75 | nd | nd | nd | Submersible | nd | 12 | -10.6 | S | 36.3 | 0.4 | 8,134 | O | 0.4 | 10. |
| S198 | NM137 | Windmill #07 | WM | 5,125 | 212 | nd | 134 | nd | nd | nd | Windmill | 7.3 | 44 | -4.7 | P | 84.5 | 0.7 | 1,354 | O | 0.7 | 30. |
| S237 | NM341 | Windmill #30 | WM | 5,010 | 440 | nd | nd | nd | nd | nd | Windmill | 0.0 | nd | -7.4 | S | 23.8 | 0.3 | 11,538 | O | 0.3 | 5. |
| S238 | NM342 | Windmill #31 | WM | 4,849 | 90 | nd | 52 | nd | nd | nd | Windmill | - 0.3 | nd | -7.9 | S | 32.9 | 0.4 | 8,935 | O | 0.4 | 5. |
| | | **Zone 6: Southwestern Mountain Front** | | | | | | | | | | | | | | | | | | | |
| S022 | NM009 | Windmill #02 | WM | 5080 | 316 | nd | nd | nd | nd | nd | Windmill | 0.0 | nd | -5.8 | P | 40.0 | 0.4 | 7,356 | O | 0.4 | 5. |
| | | **Zone 7: Abo Arroyo** | | | | | | | | | | | | | | | | | | | |
| S021 | NM261 | Stock Well #01 | SW | 5,373 | 192 | nd | 171 | nd | nd | nd | Submersible | 11.8 | 221 | -5.4 | S | 83.9 | 0.7 | 1,407 | M | nd | nd |
| S024 | NM011 | Domestic Well #02 | DW | 5,181 | 400 | nd | nd | nd | nd | nd | Submersible | 0.0 | 2 | -6.9 | P | 17.1 | 0.2 | 14,201 | O | 0.4 | 3. |
| S090 | NM064 | Domestic Well #08 | DW | 5,032 | 360 | 40 | 280 | 320 | 360 | 40 | Submersible | nd | 3 | -6.5 | P | 13.0 | 0.2 | 16,395 | O | 0.2 | 2. |
| S093 | NM067 | Domestic Well #09 | DW | 4,910 | 350 | 190 | 150 | 340 | 350 | 10 | Submersible | nd | 1 | -8.5 | P | 31.1 | 0.3 | 9,382 | O | 0.3 | 2. |
| | | **Zone 8: Eastern Mountain Front** | | | | | | | | | | | | | | | | | | | |
| S007 | NM002 | Domestic Well #01 | DW | 6,490 | 55 | nd | 30 | nd | nd | nd | Submersible | 10.6 | 327 | -11.8 | P | 113. | 1.0 | -1,010 | M | nd | nd |
| S013 | NM256 | Windmill #14 | WM | 5,450 | 270 | 40 | 220 | 260 | 270 | 10 | Windmill | 1.7 | nd | -9.6 | S | 74.0 | 0.6 | 2,421 | O | 0.6 | 15. |
| S014 | NM257 | Private Production Well #17 | PW | 5,320 | 360 | 70 | 240 | 310 | 360 | 50 | Submersible | - 0.2 | nd | -7.4 | S | 79.8 | 0.7 | 1,810 | O | 4. | 20. |
| S015 | NM006 | Windmill #01 | WM | 5,634 | 42 | nd | 13 | nd | nd | nd | Windmill | 7.2 | nd | -8.3 | P | 97.7 | 0.9 | 184 | M | nd | nd |
| S030 | NM016 | Charles 4 | PW | 5,324 | 1,055 | 70 | 386 | 456 | 1,032 | 576 | Turbine | 0.0 | 0 | -8.5 | P | 51.4 | 0.4 | 5,348 | O | 14. | 14. |
| S042 | NM031 | Domestic Well #03 | DW | 5,067 | 480 | 110 | 350 | 460 | 480 | 20 | Submersible | nd | 0 | -8.0 | P | 21.0 | 0.2 | 12,537 | O | 0.2 | 0.2 |
| S055 | NM042 | Elena Gallegos | PW | 6,455 | 95 | -8 | 28 | 20 | 95 | 75 | Submersible | nd | 207 | -10.5 | S | 109. | 0.9 | -705 | M | nd | nd |
| S056 | NM043 | Embudito Spring | SP | 6,440 | na | na | na | na | na | na | Peristaltic | 7.8 | 220 | -14.1 | S | 115. | 1.1 | -1,095 | M | nd | nd |
| S071 | NM060 | Domestic Well #07 | DW | 5,988 | 600 | 178 | 392 | 570 | 590 | 20 | Submersible | 0.2 | 0 | -8.8 | P | 97.5 | 0.8 | 205 | M | nd | nd |
| S083 | NM407 | Windmill #34 | WM | 5,142 | 440 | nd | 313 | nd | nd | nd | Windmill | - 0.2 | 17 | -5.5 | S | 17.2 | 0.3 | 14,159 | O | 1. | 5. |
| S095 | NM068 | Kirtland 1 | PW | 5,383 | 1,199 | 123 | 427 | 550 | 800 | 250 | Submersible | 0.1 | 12 | -8.9 | P | 59.4 | 0.5 | 4,187 | O | 6. | 6. |
| S106 | NM295 | Domestic Well #23 | DW | 4,781 | 160 | 142 | 8 | 150 | 160 | 10 | Submersible | 0.0 | 0 | -8.2 | S | 11.2 | 0.1 | 17,615 | O | 1. | 1. |
| S110 | NM078 | Love 1 | PW | 5,462 | 1,170 | 7 | 589 | 596 | 1,096 | 500 | Turbine | 0.1 | 10 | -7.6 | P | 47.2 | 0.4 | 6,029 | O | 13. | 13. |
| S113 | NM080 | Domestic Well #11 | DW | 5,055 | 352 | 97 | 240 | 337 | 352 | 15 | Submersible | nd | 1 | -7.4 | P | 8.33 | 0.1 | 19,964 | O | 0.1 | 1. |
| S114 | NM500 | Matheson D | MW | 5,575 | 1,520 | 733 | 727 | 1,460 | 1,500 | 40 | Bennett | nd | 50 | -11.0 | S | 35.4 | 0.3 | 8,353 | O | 0.3 | 4. |
| S115 | NM501 | Matheson M | MW | 5,575 | 1,045 | 300 | 720 | 1,020 | 1,040 | 20 | Bennett | nd | 43 | -10.2 | S | 55.9 | 0.4 | 4,676 | O | 2. | 2. |
| S116 | NM502 | Matheson S | MW | 5,575 | 705 | 17 | 583 | 600 | 700 | 100 | Bennett | 0.0 | 5 | -9.4 | S | 64.9 | 0.5 | 3,475 | O | 3. | 3. |
| S117 | NM298 | Domestic Well #25 | DW | 5,985 | 447 | 66 | 373 | 439 | 445 | 6 | Submersible | 0.2 | 13 | -9.0 | S | 95.1 | 0.7 | 406 | M | nd | nd |
| S118 | NM299 | Windmill #24 | WM | 5,512 | 196 | nd | 115 | nd | nd | nd | Windmill | 0.5 | nd | -5.9 | S | 37.4 | 0.4 | 7,898 | O | 5. | 5. |
| S119 | NM300 | Domestic Well #26 | DW | 5,760 | 150 | nd | 70 | nd | nd | nd | Submersible | nd | 551 | -7.8 | S | 47.4 | 0.3 | 6,000 | O | 2. | 10. |

**Table 13.** Estimation of uncertainties in $^{14}C$ activities for ground water from the Middle Rio Grande Basin, New Mexico -- Continued

| Site no. | Sample no. | Site name | Well type | Altitude (feet) | Depth (feet bls) | Feet of water above top of screen | Water level, (feet bls) | Depth to top of screen (feet bls) | Depth to bottom of screen (feet bls) | Screen length (feet) | Type of pump | Tritium (TU) | CFC-12 concen-tration (pg/kg) | $\delta^{13}C$ (per mil) | Sample as $BaCO_3$ powder, P, or dis-solved, S | Meas-ured $^{14}C$ activity (pmC) | $^{14}C$ ±1σ (pmC) | Conv., un-adjusted $^{14}C$ age Libby halflife (yrs) | Old, O or Modern, M | Esti-mated "+" uncer-tainty (pmC) | Esti-mated "-" uncer-tainty (pmC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S122 | NM304 | Mesa Del Sol S | MW | 5,326 | 525 | 13 | 407 | 420 | 520 | 100 | Bennett | nd | 18 | -10.8 | S | 19.3 | 0.2 | 13,227 | O | 15. | 0.2 |
| S122 | NM505 | Mesa Del Sol S | MW | 5,326 | 525 | 13 | 407 | 420 | 520 | 100 | Bennett | 0.0 | 12 | -9.9 | S | 33.4 | 0.3 | 8,819 | O | 0.3 | 3. |
| S140 | NM306 | MRN 1 | MW | 5,304 | 607 | 130 | 417 | 547 | 587 | 40 | Bennett | nd | 0 | -7.7 | S | 42.2 | 0.3 | 6,925 | O | 0.3 | 5. |
| S141 | NM095 | National Utility 7 | PW | 5,510 | 150 | nd | 80 | nd | nd | nd | Submersible | - 0.3 | 785 | -6.0 | P | 68.8 | 0.6 | 3,001 | O | 5. | 10. |
| S149 | NM312 | Nor Este D | MW | 5,460 | 1,525 | 977 | 538 | 1,515 | 1,520 | 5 | Bennett | nd | 0 | -8.7 | S | 7.96 | 0.1 | 20,329 | O | 0.1 | 1. |
| S150 | NM313 | Nor Este M | MW | 5,460 | 1,193 | 643 | 540 | 1,183 | 1,188 | 5 | Bennett | nd | 0 | -8.6 | S | 17.1 | 0.2 | 14,177 | O | 0.2 | 2. |
| S162 | NM317 | Stock Well #03 | SW | 5,320 | 460 | nd | nd | nd | nd | nd | Submersible | nd | 0 | -8.2 | S | 52.7 | 0.5 | 5,152 | O | 0.5 | 5. |
| S163 | NM318 | PL 2 | MW | 5,330 | 617 | 126 | 451 | 577 | 597 | 20 | Bennett | nd | 0 | -8.2 | S | 38.8 | 0.4 | 7,599 | O | 0.4 | 2. |
| S164 | NM106 | Ponderosa 1 | PW | 5,647 | 1,800 | 210 | 754 | 964 | 1,693 | 729 | Turbine | 0.0 | 0 | -9.3 | P | 42.5 | 0.4 | 6,883 | O | 20. | 20. |
| S165 | NM328 | Windmill #25 | WM | 5,440 | 420 | nd | 335 | nd | nd | nd | Windmill | 0.0 | nd | -8.9 | S | 10.2 | 0.2 | 18,377 | O | 0.2 | 2. |
| S168 | NM319 | Domestic Well #30 | DW | 5,137 | 400 | 100 | 290 | 390 | 400 | 10 | Submersible | nd | 9 | -9.2 | S | 5.41 | 0.1 | 23,431 | O | 0.1 | 1. |
| S170 | NM108 | Ridgecrest 3 | PW | 5,385 | 1,475 | 148 | 472 | 620 | 1,436 | 816 | Turbine | 0.0 | 0 | -12.2 | P | 70.3 | 0.7 | 2,837 | O | 20. | 20. |
| S195 | NM134 | Domestic Well #13 | DW | 5,176 | 600 | 260 | 320 | 580 | 600 | 20 | Submersible | nd | 0 | -8.2 | P | 22.2 | 0.2 | 12,076 | O | 0.2 | 0.2 |
| S199 | NM138 | Windmill #08 | WM | 5,350 | 44 | nd | 23 | nd | nd | nd | Windmill | 0.2 | nd | -6.3 | P | 57.2 | 0.5 | 4,494 | O | 0.5 | 20. |
| S209 | NM336 | Domestic Well #33 | DW | 4,970 | 480 | 140 | 320 | 460 | 480 | 20 | Submersible | nd | 0 | -8.7 | S | 15.8 | 0.2 | 14,817 | O | 0.2 | 0.2 |
| S212 | NM141 | Sandia Peak 1 | PW | 5,978 | 800 | 199 | 361 | 560 | 760 | 200 | Turbine | 0.0 | 3 | -9.7 | P | 78.0 | 0.7 | 1,998 | O | 4. | 4. |
| S213 | NM142 | Sandia Peak 3 | PW | 5,978 | 603 | 23 | 360 | 383 | 583 | 200 | Turbine | 0.0 | 13 | -9.3 | P | 83.2 | 0.7 | 1,475 | O | 5. | 5. |
| S224 | NM148 | Domestic Well #14 | DW | 5,462 | 580 | 236 | 324 | 560 | 580 | 20 | Submersible | nd | 0 | -7.6 | P | 79.9 | 0.7 | 1,802 | O | 0.7 | 0.7 |
| S229 | NM515 | SH03 UNM | MW | 6,060 | 495 | -25 | 445 | 420 | 490 | 70 | Bennett | 8.3 | 4 | -9.4 | S | 96.3 | 0.8 | 302 | M | nd | nd |
| S233 | NM153 | Domestic Well #16 | DW | 5,338 | 400 | 150 | 225 | 375 | 395 | 20 | Submersible | nd | 1 | -7.1 | P | 32.6 | 0.3 | 9,011 | O | 0.3 | 0.3 |
| S239 | NM156 | Domestic Well #17 | DW | 6,080 | 300 | 35 | 225 | 260 | 300 | 40 | Submersible | nd | 10,691 | -8.9 | P | 22.0 | 0.3 | 12,163 | O | 0.3 | 10. |
| S240 | NM157 | Domestic Well #18 | DW | 5,943 | 550 | 110 | 400 | 510 | 530 | 20 | Submersible | 0.0 | 0 | -10.5 | P | 66.4 | 0.6 | 3,287 | O | 0.6 | 0.6 |
| S246 | NM343 | Windmill #32 | WM | 5,160 | 380 | nd | nd | nd | nd | nd | Windmill | - 0.1 | nd | -5.9 | S | 31.2 | 0.3 | 9,364 | O | 0.3 | 5. |
| S247 | NM161 | Domestic Well #19 | DW | 5,380 | 640 | 208 | 390 | 598 | 638 | 40 | Submersible | nd | 1 | -8.5 | P | 4.86 | 0.1 | 24,293 | O | 0.2 | 0.2 |
| S248 | NM162 | Thomas 6 | PW | 5,408 | 1,536 | 224 | 536 | 760 | 1,520 | 760 | Turbine | 0.0 | 0 | -9.0 | P | 44.2 | 0.4 | 6,557 | O | 12. | 12. |
| S255 | NM523 | Tramway East | PW | 5,880 | 1,100 | 224 | 474 | 698 | 1,098 | 400 | Turbine | - 0.1 | 4 | -10.4 | S | 54.0 | 0.4 | 4,954 | O | 10. | 10. |
| S264 | NM174 | Walker 1 | PW | 5,699 | 1,723 | 189 | 802 | 991 | 1,711 | 720 | Turbine | - 0.4 | 0 | -9.3 | P | 41.6 | 0.3 | 7,038 | O | 14. | 14. |
| S274 | NM177 | Domestic Well #20 | DW | 5,050 | 368 | 128 | 220 | 348 | 368 | 20 | Submersible | nd | 0 | -5.8 | P | 24.7 | 0.2 | 11,246 | O | 0.2 | 0.2 |
| | | **Zone 9: Tijeras Fault Zone** | | | | | | | | | | | | | | | | | | | |
| S041 | NM030 | Coyote Spring (NM029) | SP | 5,840 | na | na | na | na | na | na | Bennett | 0.3 | 92 | -0.6 | S | 4.83 | 0.1 | 24,342 | O | 0.1 | 2. |
| S072 | NM061 | Hubbell Spring | SP | 5,437 | na | na | na | na | na | na | Peristaltic | nd | 78 | -6.4 | P | 42.8 | 0.4 | 6,817 | O | 0.4 | 26. |
| S197 | NM136 | Windmill #06 | WM | 5,725 | 295 | nd | 204 | nd | nd | nd | Windmill | 0.2 | 31 | -8.2 | P | 4.76 | 0.1 | 24,460 | O | 0.1 | 2. |
| S227 | NM151 | SFR 3D | MW | 5,494 | 362 | 149 | 163 | 312 | 352 | 40 | Bennett | nd | 4 | -1.0 | P | 9.67 | 0.1 | 18,766 | O | 30. | 3. |
| S228 | NM152 | SFR 3S | MW | 5,494 | 222 | 19 | 164 | 182 | 212 | 30 | Bennett | nd | 10 | -1.0 | P | 13.2 | 0.2 | 16,242 | O | 30. | 3. |
| | | **Zone 10: Tijeras Arroyo** | | | | | | | | | | | | | | | | | | | |
| S001 | NM001 | 4Hills-1 | MW | 5,669 | 70 | -32 | 57 | 25 | 65 | 40 | Bennett | 4.0 | 364 | -8.4 | P | 94.0 | 0.7 | 501 | M | nd | nd |
| S002 | NM250 | Private Production Well #15 | PW | 5,647 | 1,200 | 34 | 616 | 650 | 1,180 | 530 | Turbine | nd | 785 | -6.8 | S | 82.7 | 0.7 | 1,526 | O | 20. | 20. |
| S058 | NM277 | Eubank 1 | MW | 5,457 | 615 | -16 | 566 | 550 | 610 | 60 | Bennett | 1.7 | 185 | -6.2 | S | 62.0 | 0.5 | 3,835 | O | 0.5 | 20. |
| S096 | NM069 | Kirtland 11 | PW | 5,466 | 1,327 | 125 | 545 | 670 | 1,327 | 657 | Unknown | 0.0 | 0 | -7.9 | P | 46.0 | 0.4 | 6,241 | O | 15. | 15. |
| S107 | NM075 | Lomas 1 | PW | 5,595 | 1,300 | -31 | 731 | 700 | 1,300 | 600 | Turbine | nd | 0 | -6.2 | S | 72.8 | 0.6 | 2,552 | O | 15. | 15. |
| | | **Zone 11: Northeastern** | | | | | | | | | | | | | | | | | | | |

**Table 13.** Estimation of uncertainties in $^{14}C$ activities for ground water from the Middle Rio Grande Basin, New Mexico -- Continued

| Site no. | Sample no. | Site name | Well type | Altitude (feet) | Depth (feet bls) | Feet of water above top of screen | Water level, (feet bls) | Depth to top of screen (feet bls) | Depth to bottom of screen (feet bls) | Screen length (feet) | Type of pump | Tritium (TU) | CFC-12 concen-tration (pg/kg) | $\delta^{13}C$ (per mil) | Sample as $BaCO_3$ powder, P, or dis-solved, S | Meas-ured $^{14}C$ activity (pmC) | $^{14}C$ ±1σ (pmC) | Conv., un-adjusted $^{14}C$ age Libby halflife (yrs) | Old, O or Modern, M | Esti-mated "+" uncer-tainty (pmC) | Esti-mated "-" uncer-tainty (pmC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S016 | NM258 | Windmill #15 | WM | 5520 | 55 | nd | 25 | nd | nd | nd | Windmill | 0.0 | nd | -5.3 | S | 28.5 | 0.2 | 10,078 | O | 0.2 | 5. |
| S017 | NM259 | Windmill #16 | WM | 5780 | 300 | nd | 240 | nd | nd | nd | Windmill | - 0.2 | nd | -7.4 | S | 18.1 | 0.2 | 13,726 | O | 0.2 | 5. |
| S053 | NM276 | Private Production Well #18 | PW | 5382 | nd | nd | nd | nd | nd | nd | Submersible | 13.7 | nd | -5.6 | S | 76.5 | 0.7 | 2,150 | O | 2. | 30. |
| S144 | NM097 | Private Production Well #06 | PW | 5496 | 800 | 173 | 347 | 520 | 760 | 240 | Submersible | nd | 1 | -6.8 | P | 29.2 | 0.4 | 9,886 | O | 5. | 5. |
| S204 | NM332 | Windmill #28 | WM | 5320 | 175 | nd | 115 | nd | nd | nd | Windmill | - 0.3 | nd | -6.4 | S | 19.6 | 0.3 | 13,107 | O | 0.3 | 5. |
| S207 | NM334 | Private Production Well #22 | PW | 5260 | 286 | 138 | 130 | 268 | 286 | 18 | Submersible | nd | 0 | -6.1 | S | 69.3 | 0.5 | 2,941 | O | 0.5 | 5. |
| S223 | NM338 | Windmill #29 | WM | 5594 | 292 | nd | nd | nd | nd | nd | Windmill | 0.1 | nd | -6.7 | S | 19.5 | 0.3 | 13,115 | O | 0.3 | 5. |
| | | **Zone 12: Central** | | | | | | | | | | | | | | | | | | | |
| S011 | NM004 | Atris-1 | MW | 4,960 | 31 | 13 | 13 | 26 | 31 | 5 | Bennett | 11.0 | 82 | -8.3 | P | 96.8 | 0.8 | 264 | M | nd | nd |
| S012 | NM005 | Atrisco 3 | PW | 4,950 | 813 | 167 | 13 | 180 | 804 | 624 | Turbine | 9.7 | 10 | -8.3 | P | 64.7 | 0.5 | 3,496 | O | 27. | 27. |
| S025 | NM012 | Burton 2 | PW | 5,284 | 857 | 7 | 418 | 425 | 845 | 420 | Turbine | 0.1 | 47 | -9.1 | P | 47.7 | 0.4 | 5,941 | O | 10. | 10. |
| S026 | NM013 | Burton 5 | PW | 5,275 | 1,170 | 135 | 415 | 550 | 1,150 | 600 | Turbine | 0.0 | 0 | -9.4 | P | 44.7 | 0.4 | 6,475 | O | 14. | 14. |
| S033 | NM025 | Private Production Well #02 | PW | 4,974 | 182 | 21 | 121 | 142 | 172 | 30 | Submersible | 16.0 | 29 | -10.6 | P | 96.4 | 1.2 | 297 | M | nd | nd |
| S040 | NM028 | Coronado 1 | PW | 5,288 | 1,186 | 95 | 384 | 479 | 1,184 | 705 | Turbine | 0.0 | 332 | -8.5 | S | 32.8 | 0.3 | 8,962 | O | 14. | 14. |
| S043 | NM267 | Del Sol D | MW | 5,210 | 1,567 | 1,220 | 337 | 1,557 | 1,562 | 5 | Bennett | nd | 1 | -8.0 | S | 6.37 | 0.1 | 22,119 | O | 0.1 | 1. |
| S043 | NM488 | Del Sol D | MW | 5,210 | 1,567 | 1,220 | 337 | 1,557 | 1,562 | 5 | Bennett | nd | 0 | -8.3 | S | 6.20 | 0.1 | 22,337 | O | 0.1 | 0.5 |
| S044 | NM268 | Del Sol M | MW | 5,210 | 842 | 486 | 346 | 832 | 837 | 5 | Bennett | nd | 0 | -8.0 | S | 14.5 | 0.2 | 15,523 | O | 0.2 | 0.5 |
| S044 | NM489 | Del Sol M | MW | 5,210 | 842 | 486 | 346 | 832 | 837 | 5 | Bennett | nd | 0 | -8.3 | S | 13.7 | 0.2 | 15,997 | O | 0.2 | 2. |
| S045 | NM490 | Del Sol S | MW | 5,210 | 425 | -34 | 349 | 315 | 415 | 100 | Bennett | 0.2 | 16 | -9.1 | S | 62.2 | 0.5 | 3,813 | O | 3. | 5. |
| S046 | NM032 | Duranes 1 | PW | 4,960 | 1,000 | 170 | 34 | 204 | 924 | 720 | Turbine | 10.6 | 78 | -10.9 | P | 73.1 | 0.6 | 2,516 | O | 25. | 25. |
| S047 | NM270 | Duranes 7 | PW | 4,954 | 950 | 140 | 4 | 144 | 950 | 806 | Turbine | 7.6 | 33 | -9.1 | S | 72.0 | 0.6 | 2,644 | O | 30. | 30. |
| S060 | NM279 | Garfield D | MW | 4,964 | 1,020 | 946 | 49 | 995 | 1,010 | 15 | Grundfos | nd | 0 | -8.4 | S | 12.6 | 0.2 | 16,672 | O | 0.2 | 0.2 |
| S061 | NM280 | Garfield M | MW | 4,964 | 582 | 504 | 48 | 552 | 572 | 20 | Grundfos | 0.0 | 0 | -8.6 | S | 22.3 | 0.2 | 12,047 | O | 0.2 | 0.2 |
| S062 | NM491 | Garfield S | MW | 4,964 | 93 | -1 | 44 | 43 | 83 | 40 | Grundfos | 9.2 | 964 | -10.7 | S | 81.8 | 0.7 | 1,610 | M | nd | nd |
| S064 | NM283 | Domestic Well #22 | DW | 5,230 | 315 | 79 | 222 | 300 | 315 | 15 | Submersible | nd | 10 | -9.7 | S | 82.8 | 0.7 | 1,516 | O | 0.7 | 3. |
| S068 | NM057 | Griegos 3 | PW | 4,968 | 916 | 240 | 20 | 260 | 916 | 656 | Turbine | 13.3 | 0 | -8.8 | P | 67.0 | 0.6 | 3,217 | O | 30. | 30. |
| S075 | NM286 | Hunter Ridge Nest 1 Well 1 | MW | 5,110 | 1,518 | 1,345 | 163 | 1,508 | 1,513 | 5 | Grundfos | nd | 0 | -7.9 | S | 25.3 | 0.2 | 11,034 | O | 0.2 | 2. |
| S076 | NM287 | Hunter Ridge Nest 1 Well 2 | MW | 5,110 | 855 | 686 | 159 | 845 | 850 | 5 | Grundfos | nd | 0 | -9.8 | S | 60.4 | 0.5 | 4,046 | O | 0.5 | 2. |
| S078 | NM289 | Hunter Ridge Nest 2 Well 1 | MW | 5,110 | 359 | 198 | 151 | 349 | 354 | 5 | Grundfos | 0.1 | 2 | -9.0 | S | 73.8 | 0.6 | 2,440 | O | 0.6 | 2. |
| S081 | NM292 | Private Production Well #19 | PW | 5,227 | 2,020 | 461 | 269 | 730 | 2,000 | 1,270 | Turbine | nd | 0 | -8.8 | S | 55.2 | 0.5 | 4,769 | O | 32. | 32. |
| S084 | NM063 | Windmill #04 | WM | 5,016 | 167 | -3 | 150 | 147 | 167 | 20 | Windmill | - 0.2 | 39 | -8.8 | P | 79.5 | 0.7 | 1,847 | O | 0.7 | 50. |
| S087 | NM493 | Isleta MD | MW | 4,900 | 815 | 798 | 7 | 805 | 810 | 5 | Bennett | nd | 4 | -7.9 | S | 35.8 | 0.3 | 8,261 | O | 0.3 | 3. |
| S088 | NM494 | Isleta MS | MW | 4,900 | 185 | 169 | 6 | 175 | 180 | 5 | Bennett | nd | 4 | -8.4 | S | 72.3 | 0.5 | 2,603 | O | 0.5 | 5. |
| S089 | NM495 | Isleta S | MW | 4,900 | 50 | 4 | 6 | 10 | 40 | 30 | Bennett | 19.9 | 18 | -12.5 | S | 118. | 0.8 | -1,345 | M | nd | nd |
| S097 | NM070 | Kirtland 14 | PW | 5,322 | 1,000 | 20 | 360 | 380 | 1,000 | 620 | Submersible | 0.0 | 28 | -8.7 | P | 48.9 | 0.4 | 5,753 | O | 14. | 14. |
| S102 | NM074 | Leyendecker 1 | PW | 5,285 | 1,000 | 55 | 413 | 468 | 996 | 528 | Turbine | 0.1 | 126 | -8.9 | P | 72.8 | 0.7 | 2,546 | O | 20. | 20. |
| S120 | NM503 | Mesa Del Sol D | MW | 5,326 | 1,630 | 1,179 | 401 | 1,580 | 1,620 | 40 | Bennett | nd | 1 | -9.2 | S | 5.99 | 0.2 | 22,613 | O | 0.2 | 5. |
| S121 | NM302 | Mesa Del Sol M | MW | 5,326 | 1,015 | 578 | 412 | 990 | 1,010 | 20 | Bennett | nd | 7 | -8.5 | S | 8.32 | 0.1 | 19,974 | O | 0.1 | 5. |
| S121 | NM504 | Mesa Del Sol M | MW | 5,326 | 1,015 | 578 | 412 | 990 | 1,010 | 20 | Bennett | nd | 2 | -8.6 | S | 3.24 | 0.2 | 27,550 | O | 0.2 | 2. |
| S124 | NM082 | Montano 2 D | MW | 4,970 | 147 | 117 | 21 | 138 | 143 | 5 | Bennett | 19.5 | 54 | -10.0 | P | 103. | 0.9 | -263 | M | nd | nd |
| S125 | NM083 | Montano 2 M | MW | 4,970 | 99 | 73 | 17 | 90 | 95 | 5 | Bennett | 25.5 | 37 | -11.1 | P | 110. | 0.9 | -748 | M | nd | nd |
| S127 | NM085 | Montano 4 D | MW | 4,975 | 132 | 78 | 45 | 123 | 128 | 5 | Bennett | 13.5 | 9 | -11.1 | P | 95.0 | 0.8 | 412 | M | nd | nd |

**Table 13.** Estimation of uncertainties in $^{14}C$ activities for ground water from the Middle Rio Grande Basin, New Mexico -- Continued

| Site no. | Sample no. | Site name | Well type | Altitude (feet) | Depth (feet bls) | Feet of water above top of screen | Water level, (feet bls) | Depth to top of screen (feet bls) | Depth to bottom of screen (feet bls) | Screen length (feet) | Type of pump | Tritium (TU) | CFC-12 concentration (pg/kg) | $\delta^{13}C$ (per mil) | Sample as $BaCO_3$ powder, P, or dissolved, S | Measured $^{14}C$ activity (pmC) | $^{14}C$ ±1σ (pmC) | Conv., unadjusted $^{14}C$ age Libby halflife (yrs) | Old, O or Modern, M | Estimated "+" uncertainty (pmC) | Estimated "-" uncertainty (pmC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S128 | NM086 | Montano 4 M | MW | 4,974 | 94 | 42 | 43 | 85 | 90 | 5 | Bennett | 19.6 | 56 | -12.3 | P | 114. | 1.0 | -1,026 | M | nd | nd |
| S130 | NM088 | Montano 5 D | MW | 4,977 | 150 | 125 | 10 | 135 | 145 | 10 | Bennett | 11.0 | 4 | -9.0 | P | 97.6 | 1.0 | 197 | M | nd | nd |
| S131 | NM089 | Montano 5 M | MW | 4,977 | 75 | 53 | 7 | 60 | 70 | 10 | Bennett | 9.9 | 200 | -8.5 | P | 95.0 | 0.8 | 411 | M | nd | nd |
| S133 | NM091 | Montano 6 D | MW | 4,970 | 983 | 941 | 31 | 972 | 978 | 6 | Bennett | 0.0 | 0 | -9.6 | P | 25.2 | 0.2 | 11,075 | O | 0.2 | 0.2 |
| S134 | NM092 | Montano 6 MD | MW | 4,970 | 836 | 796 | 30 | 826 | 831 | 5 | Bennett | 0.0 | 0 | -8.6 | P | 38.0 | 0.3 | 7,783 | O | 0.3 | 5. |
| S135 | NM093 | Montano 6 MS | MW | 4,970 | 568 | 530 | 28 | 558 | 563 | 5 | Bennett | 2.0 | 0 | -7.7 | P | 67.5 | 0.6 | 3,153 | O | 0.6 | 10. |
| S137 | NM506 | Montesa M | MW | 5,100 | 708 | 482 | 216 | 698 | 703 | 5 | Bennett | nd | 2 | -9.0 | S | 18.6 | 0.2 | 13,499 | O | 0.2 | 5. |
| S138 | NM507 | Montesa S | MW | 5,100 | 330 | 49 | 211 | 260 | 320 | 60 | Bennett | 0.0 | 53 | -9.3 | S | 52.5 | 0.4 | 5,175 | O | 2. | 5. |
| S139 | NM305 | Domestic Well #27 | DW | 5,197 | 326 | nd | 264 | nd | nd | nd | Submersible | nd | 0 | -8.6 | S | 43.4 | 0.3 | 6,711 | O | 0.3 | 5. |
| S142 | NM307 | Domestic Well #28 | DW | 5,064 | 275 | 156 | 103 | 259 | 274 | 15 | Submersible | nd | 0 | -8.3 | S | 73.3 | 0.6 | 2,498 | O | 0.6 | 0.6 |
| S146 | NM309 | NM Utilities 2 | PW | 5,280 | 1,000 | 48 | 302 | 350 | 800 | 450 | Turbine | nd | 0 | -8.3 | S | 50.9 | 0.5 | 5,418 | O | 12. | 12. |
| S151 | NM508 | Nor Este S | MW | 5,460 | 608 | -3 | 541 | 538 | 598 | 60 | Bennett | 0.0 | 6 | -9.5 | S | 47.6 | 0.4 | 5,960 | O | 0.4 | 2. |
| S153 | NM315 | Open Space | PW | 5,145 | 462 | 43 | 262 | 305 | 410 | 105 | Turbine | - 0.1 | nd | -8.3 | S | 55.2 | 0.5 | 4,781 | O | 0.5 | 15. |
| S155 | NM316 | Domestic Well #29 | DW | 4,895 | 210 | 145 | 55 | 200 | 210 | 10 | Submersible | 0.1 | 0 | -8.5 | S | 55.5 | 0.5 | 4,731 | O | 0.5 | 5. |
| S156 | NM100 | Paseo 2D | MW | 4,989 | 150 | 119 | 16 | 135 | 145 | 10 | Bennett | 1.8 | 3 | -8.3 | P | 76.7 | 0.7 | 2,132 | O | 0.7 | 10. |
| S157 | NM101 | Paseo 2MD | MW | 4,989 | 95 | 68 | 12 | 80 | 90 | 10 | Bennett | 15.1 | 42 | -10.5 | P | 103. | 0.8 | -204 | M | nd | nd |
| S160 | NM104 | Paseo 3D | MW | 5,006 | 544 | 469 | 70 | 539 | 544 | 5 | Bennett | 0.2 | 27 | -8.7 | P | 64.5 | 0.5 | 3,521 | O | 0.5 | 4. |
| S161 | NM105 | Paseo 3M | MW | 5,006 | 144 | 86 | 53 | 139 | 144 | 5 | Bennett | 10.7 | 2,205 | -10.7 | S | 98.1 | 0.7 | 152 | M | nd | nd |
| S171 | NM321 | Ridgecrest 4 | PW | 5,344 | 1,424 | 141 | 431 | 572 | 1,412 | 840 | Turbine | nd | 21 | -9.2 | S | 46.1 | 0.4 | 6,224 | O | 17. | 17. |
| S173 | NM323 | Rio Bravo 5 M | MW | 4,931 | 104 | 83 | 11 | 94 | 99 | 5 | Grundfos | 13.1 | 1,713 | -9.7 | S | 97.3 | 1.1 | 224 | M | nd | nd |
| S177 | NM112 | Rio Bravo 2 D | MW | 4,929 | 154 | nd | 12 | 144 | 149 | 5 | Bennett | 15.7 | 33 | -8.0 | P | 61.6 | 0.5 | 3,888 | O | 0.5 | 20. |
| S178 | NM113 | Rio Bravo 2 M | MW | 4,929 | 91 | nd | 11 | 81 | 86 | 5 | Bennett | 13.5 | 5 | -10.6 | P | 78.4 | 0.6 | 1,959 | O | 0.6 | 20. |
| S179 | NM114 | Rio Bravo 2 S | MW | 4,929 | 49 | nd | 11 | 39 | 44 | 5 | Bennett | 13.6 | 8 | -10.3 | P | 99.5 | 0.9 | 39 | M | nd | nd |
| S180 | NM115 | Rio Bravo 4 D | MW | 4,933 | 149 | nd | 23 | 139 | 144 | 5 | Bennett | 0.0 | 1 | -9.1 | P | 34.6 | 0.3 | 8,516 | O | 0.3 | 0.3 |
| S181 | NM116 | Rio Bravo 4 M | MW | 4,933 | 124 | nd | 24 | 114 | 119 | 5 | Bennett | 7.9 | 38 | -10.8 | P | 77.7 | 0.8 | 2,028 | O | 0.8 | 10. |
| S183 | NM126 | Rio Grande Utility 5 | PW | 4,958 | 670 | 132 | 158 | 290 | 660 | 370 | Unknown | nd | 1 | -8.1 | P | 33.2 | 0.3 | 8,862 | O | 10. | 10. |
| S184 | NM127 | Rio Grande Utility 6 | PW | 5,010 | 602 | 140 | 191 | 330 | 590 | 260 | Unknown | nd | 0 | -8.3 | P | 51.3 | 0.5 | 5,356 | O | 10. | 10. |
| S190 | NM325 | Rio Rancho 2 | PW | 5,266 | 751 | 213 | 295 | 508 | 751 | 243 | Turbine | nd | 1 | -8.6 | S | 71.6 | 0.7 | 2,689 | O | 6. | 6. |
| S203 | NM331 | Private Production Well #20 | PW | 5,050 | 110 | 42 | 23 | 65 | 100 | 35 | Submersible | 9.1 | 129 | -8.8 | S | 77.1 | 0.5 | 2,090 | O | 0.5 | 20. |
| S205 | NM333 | Private Production Well #21 | PW | 5,050 | 557 | 502 | 15 | 517 | 547 | 30 | Submersible | nd | 0 | -8.4 | S | 58.8 | 0.4 | 4,260 | O | 0.4 | 2. |
| S208 | NM140 | San Jose 2 | PW | 4,992 | 1,000 | 168 | 96 | 264 | 996 | 732 | Turbine | 3.1 | 15 | -8.7 | P | 29.1 | 0.3 | 9,916 | O | 20. | 20. |
| S210 | NM511 | Sandia D | MW | 5,440 | 1,305 | 809 | 486 | 1,295 | 1,300 | 5 | Bennett | nd | 18 | -8.7 | S | 15.3 | 0.2 | 15,065 | O | 0.2 | 5. |
| S214 | NM513 | Sandia S | MW | 5,440 | 535 | 6 | 479 | 485 | 525 | 40 | Bennett | 0.1 | 21 | -9.3 | S | 62.9 | 0.5 | 3,726 | O | 2. | 2. |
| S220 | NM147 | Santa Barbara 1 | PW | 5,139 | 1,000 | 55 | 257 | 312 | 984 | 672 | Turbine | 0.3 | 1,285 | -9.0 | P | 49.1 | 0.5 | 5,719 | O | 15. | 15. |
| S231 | NM517 | Sierra Vista M | MW | 5,110 | 928 | 765 | 153 | 918 | 923 | 5 | Bennett | nd | 1 | -8.2 | S | 34.2 | 0.3 | 8,609 | O | 0.3 | 3. |
| S232 | NM518 | Sierra Vista S | MW | 5,110 | 210 | -9 | 149 | 140 | 200 | 60 | Bennett | 0.0 | 28 | -9.9 | S | 68.9 | 0.5 | 2,998 | O | 0.5 | 5. |
| S234 | NM339 | Sister Cities D | MW | 5,340 | 1,308 | 950 | 348 | 1,298 | 1,303 | 5 | Bennett | nd | 3 | -7.3 | S | 8.03 | 0.1 | 20,259 | O | 0.1 | 1. |
| S235 | NM340 | Sister Cities M | MW | 5,340 | 799 | 441 | 348 | 789 | 794 | 5 | Bennett | nd | 0 | -8.8 | S | 66.3 | 0.5 | 3,306 | O | 0.5 | 1. |
| S244 | NM158 | SWAB 3 - 760 | MW | 4,995 | 840 | 668 | 42 | 710 | 790 | 80 | Bennett | 0.0 | 66 | -9.8 | P | 44.1 | 0.5 | 6,584 | O | 0.5 | 20. |
| S245 | NM159 | SWAB 3 - 980 | MW | 4,995 | 1,055 | 826 | 44 | 870 | 1,050 | 180 | Bennett | 0.0 | 56 | -9.1 | P | 44.1 | 0.4 | 6,580 | O | 0.4 | 15. |
| S253 | NM522 | Tome D | MW | 5,020 | 1,200 | 989 | 196 | 1,185 | 1,195 | 10 | Grundfos | nd | 7 | -8.0 | S | 8.80 | 0.1 | 19,523 | O | 0.1 | 3. |
| S257 | NM344 | Domestic Well #34 | DW | 4,920 | 109 | nd | 12 | nd | nd | nd | Submersible | 16.3 | 19 | -10.8 | S | 85.3 | 0.6 | 1,277 | O | 0.6 | 30. |
| S259 | NM171 | VGP-1 | MW | 4,923 | 64 | 51 | 8 | 59 | 64 | 5 | Bennett | 28.6 | 29 | -11.6 | P | 123. | 1.0 | -1,669 | M | nd | nd |

**Table 13.** Estimation of uncertainties in $^{14}C$ activities for ground water from the Middle Rio Grande Basin, New Mexico -- Continued

| Site no. | Sample no. | Site name | Well type | Altitude (feet) | Depth (feet bls) | Feet of water above top of screen | Water level, (feet bls) | Depth to top of screen (feet bls) | Depth to bottom of screen (feet bls) | Screen length (feet) | Type of pump | Tritium (TU) | CFC-12 concen-tration (pg/kg) | $\delta^{13}C$ (per mil) | Sample as $BaCO_3$ powder, P, or dis-solved, S | Meas-ured $^{14}C$ activity (pmC) | $^{14}C$ ±1σ (pmC) | Conv., un-adjusted $^{14}C$ age Libby halflife (yrs) | Old, O or Modern, M | Esti-mated "+" uncer-tainty (pmC) | Esti-mated "-" uncer-tainty (pmC) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S261 | NM172 | Volandia 2 | PW | 5,208 | 1,016 | 28 | 332 | 360 | 852 | 492 | Turbine | 0.3 | 16 | -8.6 | P | 70.6 | 0.6 | 2,800 | O | 12. | 12. |
| S262 | NM173 | Volandia 5 | PW | 5,112 | 1,020 | 38 | 222 | 260 | 900 | 640 | Turbine | 1.3 | 1,942 | -9.8 | S | 57.8 | 0.5 | 4,406 | O | 16. | 16. |
| S265 | NM175 | Webster 1 | PW | 5,436 | 1,484 | 90 | 530 | 620 | 1,345 | 725 | Turbine | - 0.1 | 0 | -8.5 | P | 45.5 | 0.4 | 6,333 | O | 15. | 15. |
| S267 | NM348 | West Bluff Nest 1 Well 2 | MW | 5,100 | 689 | 517 | 162 | 679 | 684 | 5 | Grundfos | nd | 6 | -9.2 | S | 32.3 | 0.3 | 9,071 | O | 0.3 | 0.3 |
| S269 | NM350 | West Bluff Nest 2 Well 1 | MW | 5,100 | 328 | 163 | 155 | 318 | 323 | 5 | Grundfos | 11.5 | 4 | -8.4 | S | 63.5 | 0.5 | 3,647 | O | 0.5 | 30. |
| S275 | NM178 | Yale 1 | PW | 5,159 | 1,000 | 69 | 267 | 336 | 960 | 624 | Turbine | 0.6 | 161 | -9.9 | S | 39.2 | 0.4 | 7,531 | O | 18. | 18. |
| | | **Zone 13: Discharge** | | | | | | | | | | | | | | | | | | | |
| S143 | NM096 | Private Production Well #05 | PW | 4,755 | 258 | 218 | 20 | 238 | 258 | 20 | Unknown | nd | 1 | -7.3 | P | 7.46 | 0.1 | 20,850 | O | 1. | 1. |
| S194 | NM327 | Domestic Well #32 | DW | 4,730 | 130 | 100 | 20 | 120 | 130 | 10 | Submersible | 1.2 | 6 | -7.0 | S | 10.8 | 0.1 | 17,863 | O | 0.1 | 5. |
| S226 | NM150 | Domestic Well #15 | DW | 4,860 | 223 | 73 | 137 | 210 | 220 | 10 | Submersible | nd | 2 | -5.3 | P | 11.6 | 0.2 | 17,290 | O | 0.2 | 1. |
| | | **No Zone: Exotic Water** | | | | | | | | | | | | | | | | | | | |
| S009 | NM485 | Arroyo Salado Spring | SP | 5,744 | na | na | na | na | na | na | None | 2.6 | nd | 1.8 | S | 7.64 | 0.2 | 20,659 | O | 0.2 | 7. |
| S023 | NM010 | Burn Site Well | PW | 6,369 | 341 | 163 | 68 | 231 | 341 | 110 | Unknown | 0.7 | 68,206 | -7.7 | S | 49.6 | 0.4 | 5,639 | O | 5. | 20. |
| S028 | NM014 | Cerro Colorado Landfill MW | MW | 5,488 | 746 | -15 | 570 | 555 | 616 | 61 | Submersible | nd | 37 | 2.0 | S | 1.59 | 0.1 | 33,268 | O | nd | nd |
| S038 | NM265 | Windmill #19 | WM | 5,720 | 100 | nd | nd | nd | nd | nd | Windmill | - 0.1 | nd | -10.9 | S | 6.68 | 0.1 | 21,738 | O | 0.1 | 2. |
| S054 | NM041 | Domestic Well #04 | DW | 5,065 | 390 | nd | nd | nd | nd | nd | Submersible | nd | 0 | -7.6 | P | 29.3 | 0.3 | 9,867 | O | nd | nd |
| S057 | NM044 | Embudo Spring | SP | 6,600 | na | na | na | na | na | na | Peristaltic | 10.8 | 219 | -13.2 | S | 111. | 1.1 | -840 | M | nd | nd |
| S063 | NM282 | Windmill #22 | WM | 5,980 | 180 | nd | nd | nd | nd | nd | Windmill | 0.2 | nd | -5.6 | S | 46.4 | 0.5 | 6,177 | O | 0.5 | 2. |
| S067 | NM284 | Granite Hill | MW | 5,749 | 89 | nd | 32 | nd | nd | nd | Grundfos | nd | 52 | -7.9 | S | 34.5 | 0.3 | 8,549 | O | 0.3 | 5. |
| S070 | NM059 | HERTF | PW | 6,227 | 500 | 44 | 405 | 449 | 500 | 51 | Unknown | 0.3 | 1,014 | -7.5 | S | 40.6 | 0.4 | 7,239 | O | 20. | 20. |
| S091 | NM496 | Private Production Well #23 | PW | 5,525 | 81 | 14 | 5 | 19 | 81 | 62 | Submersible | 13.0 | 33 | -10.2 | S | 93.8 | 0.7 | 515 | M | nd | nd |
| S094 | NM293 | Stock Well #02 | SW | 5,700 | 120 | nd | 107 | nd | nd | nd | Submersible | nd | 173 | -5.5 | S | 79.3 | 0.6 | 1,866 | O | 20. | 20. |
| S112 | NM297 | Domestic Well #24 | DW | 5,131 | 560 | 80 | 460 | 540 | 560 | 20 | Submersible | nd | 5 | -7.2 | S | 13.6 | 0.1 | 16,038 | O | 2. | 2. |
| S152 | NM098 | Private Production Well #07 | PW | 5,350 | 440 | 59 | 141 | 200 | 380 | 180 | Submersible | 0.1 | 18 | -6.1 | P | 62.7 | 0.6 | 3,745 | O | 5. | 5. |
| S202 | NM330 | Windmill #27 | WM | 5,911 | nd | nd | nd | nd | nd | nd | Windmill | 6.4 | nd | -4.7 | S | 47.2 | 0.4 | 6,036 | O | 0.4 | 25. |
| S211 | NM512 | Sandia M | MW | 5,440 | 1,025 | 529 | 486 | 1,015 | 1,020 | 5 | Bennett | nd | 4 | -8.2 | S | 10.4 | 0.1 | 18,158 | O | 0.2 | 3. |
| S249 | NM164 | Private Production Well #09 | PW | 6,610 | 240 | -146 | 206 | 60 | 240 | 180 | Submersible | 10.6 | 886 | -11.0 | P | 51.3 | 0.4 | 5,360 | M | nd | nd |
| S256 | NM169 | Tunnel Spring | SP | 6,410 | na | na | na | na | na | na | Peristaltic | 12.2 | 240 | -11.3 | S | 92.6 | 0.8 | 622 | M | nd | nd |
| S258 | NM524 | Vallecito Springs | SP | 5,840 | na | na | na | na | na | na | None | - 0.5 | nd | -10.1 | S | 43.4 | 0.3 | 6,713 | O | 5. | 10. |
| S273 | NM176 | Windmill #11 | WM | 5,680 | 280 | nd | nd | nd | nd | nd | Windmill | 0.8 | nd | -4.0 | P | 36.5 | 0.3 | 8,100 | O | 0.3 | 10. |
| S282 | NM529 | Windmill #44 | WM | 5,400 | 147 | nd | 85 | nd | nd | nd | Windmill | 0.0 | nd | -8.5 | S | 51.6 | 0.4 | 5,323 | O | 1. | 5. |

[1] SWAB Test Hole 2 D probably has a broken casing at 1,130 feet below land surface. Measured water level was 803.25 feet. Sample may be from about 327 feet below the water table.

the error bars in $^{14}C$ activity were increased based on estimates of the $^{14}C$ activity of the ground water and of the drilling fluid. The drilling fluid was assumed to have been made with water from the City of Albuquerque distribution system (50 to 70 pmC), and with CFC concentrations approaching that of water in equilibrium with air at the time of drilling. Reference air-water equilibrium CFC concentrations at 5,000 feet altitude for CFC-11, CFC-12, and CFC-113 are, at 10°C, 655, 300 and 85 pg/kg, respectively; at 13°C, 530, 250, 68 pg/kg, and at 20°C, 400, 190, and 50 pg/kg, respectively. Apparently, some of the monitoring-well nests were not developed sufficiently after completion at the intermediate and deep intervals to remove all the water introduced in drilling (see, for example, 98th Street, Tome, Matheson, Sandia, and Isleta, figure 104). CFC-12 was detected in many of the shallow intervals of piezometer nests, but most of these wells have screens of more than 40-100 feet and either intercept the water table or are within 10 feet of the water table.

Ground-water samples containing more than 5 pg/kg of CFC-12 and/or more than 0.5 TU of $^{3}H$ can occur in wells that contain a mixture of water from both old and young sources. Examples of such wells include those that intercept the water table, are completed at shallow depths in the inner valley of the Rio Grande, or are affected by areal infiltration or seepage from rivers and arroyos. Although these samples can contain a fraction of young (post-1950's) water, there is usually not enough information to estimate either the amount of young water in the mixture or the age of the young fraction. In the MRGB, all samples that contained $^{14}C$ activities that were greater than 100 pmC also contained CFC-12 concentrations that were greater than 5 pg/kg and/or $^{3}H$ activities greater than 0.5 TU, and were judged to be predominantly post-bomb water. For these samples, no fraction of old water could be dated; the samples were designated modern (M), and the error bars were left as the reported values of the analytical errors. When the $^{14}C$ activity was less than 100 pmC and the sample contained CFC-12 concentrations that were higher than 5 pg/kg and/or $^{3}H$ activities higher than 0.5 TU, the sample was assumed to be a mixture of post- and pre-bomb water. In estimating error bars that encompassed the age of the old fraction, the upper error bound was assigned the analytical value, but the lower bound was increased based on estimates of local $^{14}C$ activity gradients.

Ground-water samples from domestic wells containing more than 5 pg/kg of CFC-12 and/or more than 0.5 TU of $^{3}H$ may have been contaminated by local anthropogenic sources, such as seepage from septic tanks. In this case, it was assumed that the source of added carbon had a $^{14}C$ activity of 100 pmC. For samples containing less than 50 pg/kg CFC-12, it is likely that the fraction of septic-tank or other young water is small. For this group of samples, the upper error bound for $^{14}C$ activity was the analytical value, but the lower value was increased several pmC.

The $^{14}C$ data along with information on the type of well, well construction, tritium and CFC-12 concentrations, the measured $^{14}C$ activity with reported analytical uncertainty, and the estimated uncertainty in the $^{14}C$ activity taking into account the potential mixing processes discussed above are summarized in table 13. The most reliable $^{14}C$ ages are those from monitoring wells and domestic wells, because of the relatively narrow open intervals (10-20 feet) of these well types, compared to production wells with median open intervals of 400 feet (table 2). Many of the radiocarbon ages from the production wells are of little use because the uncertainty in the $^{14}C$ age can span more than 10,000 years as a result of the large open interval of the well. For example, Private Production well #19 (S081, NM292), with an open interval of 1,270 feet, has an unadjusted radiocarbon age of about 4,800 years that may vary within the age interval of 2,100 to 11,800 years based on the estimated uncertainty (table 13). In contrast, the median $^{14}C$ age for all of the monitoring wells with $^{14}C$ data is 11,600, and the median $^{14}C$ age uncertainty associated with the relatively narrow open intervals is -100 to +1,000 years (table 13).

## Radiocarbon Calibration

As shown above, it was concluded that the unadjusted radiocarbon age accurately represents the radiocarbon age of ground water throughout most of the MRGB. Excluding waters from the Tijeras Fault Zone and Northeastern zones, which have higher average geochemical corrections (3.7 and 2.5 ka, respectively), the average difference between the unadjusted radiocarbon age and the NETPATH-adjusted age is only 0.5 ka (unadjusted radiocarbon age minus NETPATH-adjusted age, Libby half-life) in 231 samples. The close agreement in unadjusted radiocarbon age and NETPATH-adjusted age results from

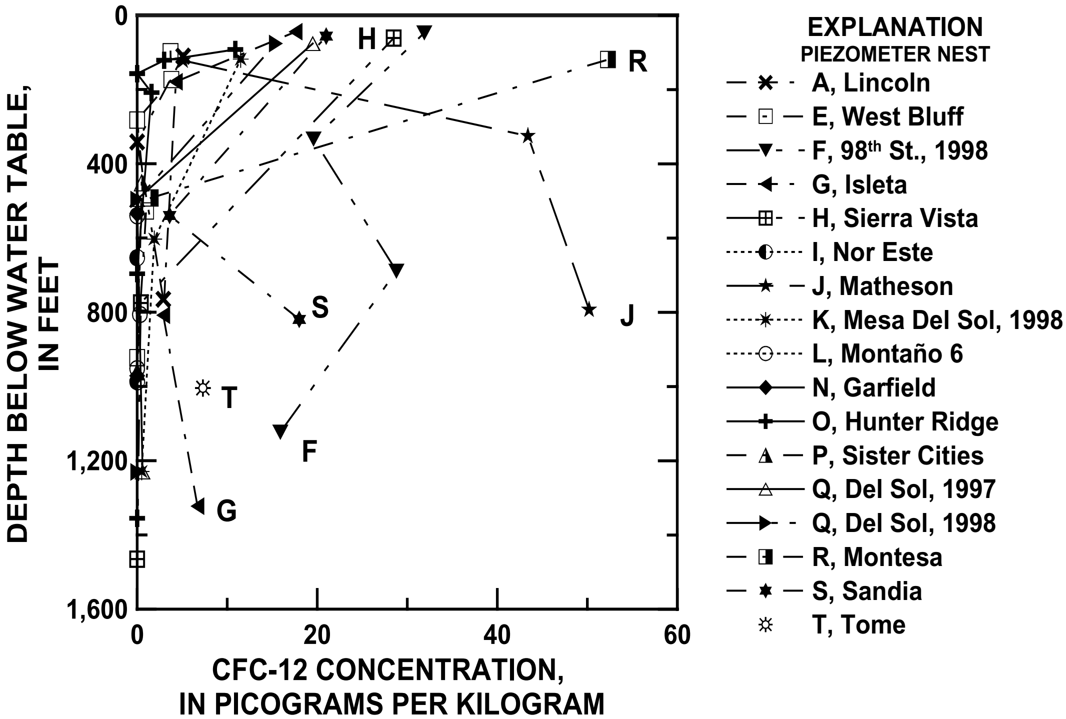



**Figure 104.** Concentration of CFC-12 in ground water from narrow-screened piezometers in the vicinity of Albuquerque, New Mexico as a function of depth below the water table (see figures 58 and 69 for location, and appendix A1 for well construction information).

$A_o$ being near 100 pmC and corrections for geochemical reactions being small throughout most of the aquifer system. Carbon-14 is not often so "well behaved" in all ground-water systems, but in the MRGB, mountain-front infiltration waters apparently evolve under open-system conditions that result in pre-bomb $A_o$ values near 100 pmC. The DIC of Rio Grande water, which recharges most of the central part of the basin, also appears to be near 100 pmC under pre-bomb conditions. Other surface-water sources also have high $^{14}C$ activities. In addition, the $^{14}C$ activity of DIC in most waters appears to be little affected by water/rock reactions in the basin. This result is mostly a consequence of the fact that the Santa Fe Group aquifer system of the MRGB is low in carbonate mineral and organic carbon content; where calcite occurs, it is usually precipitating as secondary cementation rather than dissolving, which has little effect on the $^{14}C$ activity. It has been assumed that these conditions prevailed over the historical span of the waters sampled in the MRGB, as there is little reason to expect that these conditions differed appreciably in the past. The average difference between the unadjusted radiocarbon age and NETPATH-adjusted age is 0.1 ka in the Eastern Mountain Front zone and 0.3 ka in the Central zone, where the most precise age-depth data are available from piezometer nests typically in the vicinity of Albuquerque.

Because the radiocarbon ages in the MRGB seem mostly insensitive to the recharge and reaction processes that usually obscure radiocarbon dating in many carbonate aquifers, it was concluded that the radiocarbon ages in the MRGB may be accurate enough to warrant further conversion to calendar years, taking advantage of recent compilations and extensions of radiocarbon calibration data. The conversion to calendar years is still a small refinement for ground-water systems, but probably provides more accurate estimates of calendar ages and travel times for use in calibration of a ground-water flow model (Sanford and others, 2001; 2004).

Calendar years as a function of radiocarbon years are shown in figure 105 and are based on $^{14}C$ measurements from tree ring, coral and lake varve chronologies (Stuiver and others, 1998; Bard and others, 1998; Kitagawa and van der Plicht, 1998a,

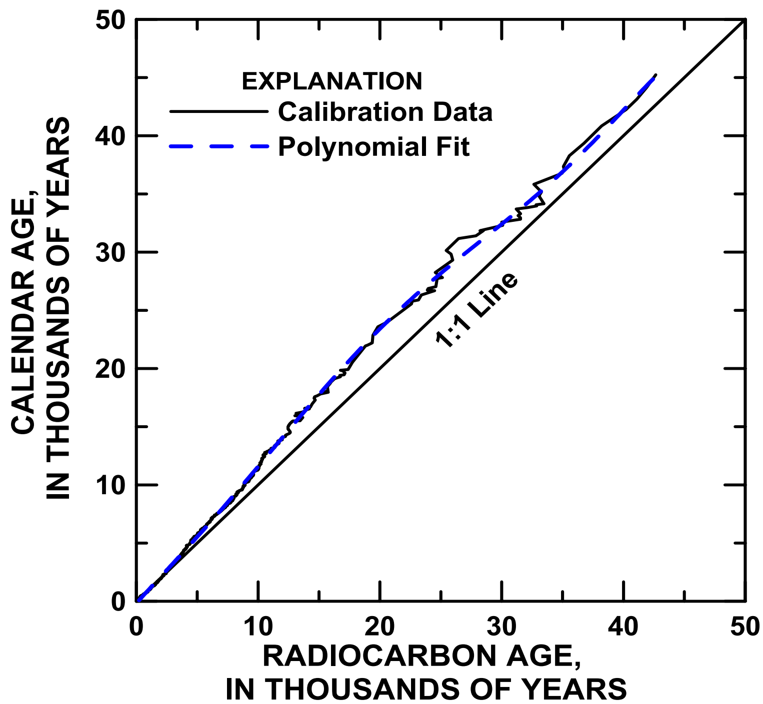



**Figure 105.** Relation between radiocarbon years and calendar years. The blue line is a 6-degree polynomial fit (eqn. 19)

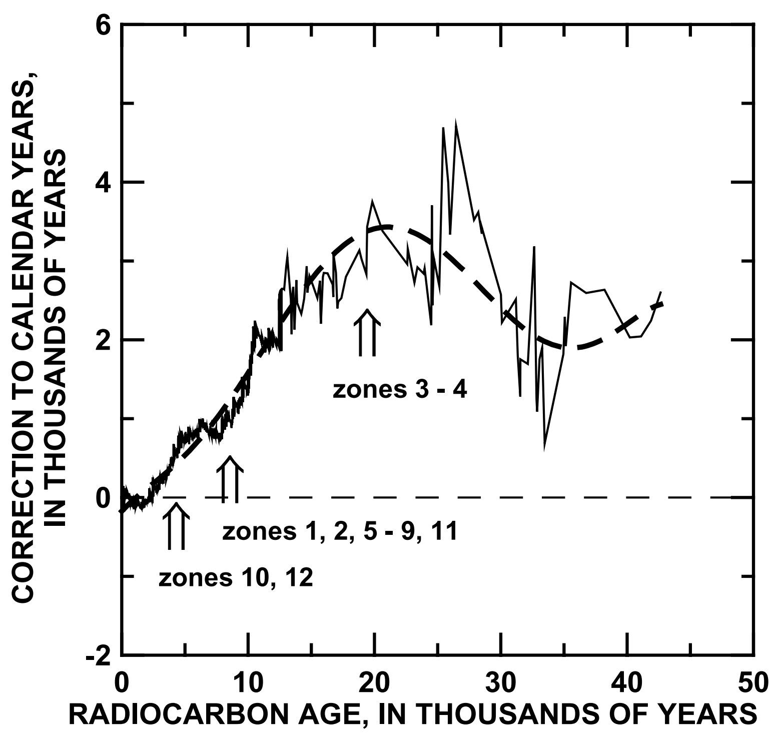



**Figure 106.** Correction to be added to the Conventional Radiocarbon Age to correct to calendar years. For most waters of the Middle Rio Grande Basin, the correction is less than 1,000 years. For waters from the West-Central and Western Boundary hydrochemical zones (zones 3 and 4, respectively), the calendar year ages are, on average, about 3 thousand years greater than the radiocarbon age. See table 8 for names of hydrochemical zones corresponding to specific zone numbers.

1998b, 2000). A polynomial (eqn. 19) was fitted to the data of figure 105 and used to estimate calendar years from the apparent unadjusted radiocarbon age (Libby half-life),

$$\text{Cal. Yrs. B.P.} = -173.94 + 1.1713A - 2.0521\times10^{-5}A^2 + 4.0150\times10^{-9}A^3 - 2.4519\times10^{-13}A^4 + 5.7738\times10^{-18}A^5 - 4.6915\times10^{-23}A^6, \quad (19)$$

where A is the unadjusted radiocarbon age (Libby half-life) in years. Over the range of most of the unadjusted radiocarbon ages of the waters in the MRGB, the calendar year age differs from the unadjusted radiocarbon age by between 0 and about 3 ka. The correction that is added to the apparent unadjusted radiocarbon age to correct to calendar years is given in figure 106. Waters from the Tijeras Arroyo and Central zones (zones 10 and 12) have median unadjusted radiocarbon ages of approximately 5 ka and, for these, the average calendar age is less than 1 ka greater than the unadjusted radiocarbon ages. Water from the Northern Mountain Front, Northwestern, Rio Puerco, Southwestern Monutain Front, Abo Arroyo, Eastern Mountain Front, and Tijeras Fault Zone zones (zones 1, 2, 5-9, and 11) have, on average, calendar year ages that are about 1 ka greater than the apparent unadjusted radiocarbon age. The oldest waters sampled in the MRGB, from the West-Central and Western Boundary zones (zones 3 and 4), have unadjusted calendar year ages that are typically 3 ka older than the unadjusted radiocarbon ages. The unadjusted radiocarbon ages and calendar year ages of DIC for all the MRGB waters are given in table 10. Although the radiocarbon calibration data obtained from tree rings (Stuiver and others, 1998) and $^{230}$Th/$^{234}$U dating or corals (Bard and others, 1998) are relatively precise, greater uncertainties in radiocarbon calibration are associated with data obtained from varves (Kitagawa and van der Plicht, 1998a, 1998b). Recently, additional calibration data have been obtained from a stalagmite in the calendar year age range of 11 to 45 ka that indicate large variations in atmospheric $^{14}$C activity between 33 and 45 ka (Beck and others, 2001; Bard, 2001). Although radiocarbon calibration to about 20 ka now seems well established, extension of the calibration to the dating limits of the radiocarbon method (about 45 ka) is currently under investigation by the radiocarbon scientific community. Most of the radiocarbon ages from the MRGB are in the range of 0 - 20 ka, where calibration data are most reliable. Nevertheless, in keeping with previous work in the hydrochemical sciences, all radiocarbon age information used in this report is based on the (unadjusted) radiocarbon age, rather than calendar years. However, a companion report (Sanford and others, 2004) uses the calendar year ages in calibrating a ground-water flow model.

# INTERPRETATION OF ENVIRONMENTAL AND CLIMATIC INFORMATION FROM RADIOCARBON AGES, STABLE ISOTOPES, AND DISSOLVED GASES

This section describes the use of ground-water ages and stable isotope and dissolved gas compositions in conjunction with depth information to examine (1) variations in radiocarbon age with depth in various parts of the basin, (2) historical variations in the stable isotopic composition of paleowater of Rio Grande and eastern mountain front origin, (3) paleo-recharge temperatures of ground water in the West-Central, Eastern Mountain Front, and Central zones, and (4) historical variations in the abundance ratio of $C_4/C_3$ plants throughout the MRGB. As is the case for many areas where environmental records can be retrieved from ground-water archives, trends in chemical and isotopic data with radiocarbon age can be demonstrated in the MRGB, but their causes cannot be established with certainty.

## Age Gradients

Numerous data are available describing radiocarbon age as a function of depth in various parts of the MRGB. Although water composition and stable isotopic composition are relatively constant to depths of more than 600 feet in parts of the MRGB, there can be appreciable variation in ground-water age with depth. The most reliable age information as a function of depth was obtained from the piezometer nests that are open to relatively narrow intervals (typically 5 to 10 feet) of the aquifer system (fig. 107). The average age gradient, expressed as years per foot of aquifer (yr $ft^{-1}$), was calculated between the upper- and bottom-most interval from the piezometer nests that extend vertically across 200 to more than 1,300 feet of the aquifer system. The average age gradient from this set of piezometer nests is 18 ± 12 yr $ft^{-1}$. The average age between the upper and lowest interval is 12.2 ± 6.1 ka.

The magnitudes of age gradients were observed to differ among piezometer nests based on location and mean age of water. Some of the smallest age gradients (indicative of relatively large thicknesses of water of similar age) were calculated between the upper- and bottom-most intervals of piezometer nests along the eastern mountain front (Eastern Mountain Front zone), such as at nest S114-S116 (7.0 yr $ft^{-1}$ with a mean age of 6.9 ka); along the west side of the Rio Grande north of Albuquerque (Central zone), at nest S075-S078 (7.6 yr $ft^{-1}$, mean age of 6.7 ka); and between nests S004 and S006 (mostly West-Central zone), (6.7 yr $ft^{-1}$, mean age of 24.3 ka). Age gradients in the upper 500 to 800 feet of the Central zone along the west side of the Rio Grande are lower than on the east side of the Rio Grande. However, below 800 feet, age gradients in the Central zone tend to be higher west of the Rio Grande than observed east of the Rio Grande (fig. 107a).

Most age gradients do not extrapolate to zero age at the water table (fig. 107), indicating that ground water in the piezometer nest likely has moved horizontally from the point of recharge, and that following recharge and flow to the present location, little or no additional water has been added to the water table for periods as long as 20 ka (S004, fig. 107b). The piezometer nests from the Eastern Mountain Front zone (fig. 107b) that extrapolate nearest to zero age at the water table (S212 and S114) are located adjacent to the eastern mountain front at Albuquerque.

More detailed age-depth information is found by calculating age gradients between each depth interval for each piezometer nest. Typically, two values are found for each nest, between the deep and medium completions and the medium and shallow completions. Several piezometer nests have four completions, yielding three values of the age gradient at those locations. The resulting age gradients, calculated between each pair of open intervals, vary between about 3 and 60 yr $ft^{-1}$ (fig. 108). Higher age gradients generally are found between the deep and medium completions than between the medium and shallow completions. During the past 16 ka, the piezometer nests indicate a possible maximum age gradient at about 10 ka and minimum between about 12-16 ka. Based on the limited data, the age gradients (in yr $ft^{-1}$) tend to decrease from a maximum at 10 ka to relatively low values during the past few thousand years (fig. 108). Although there is an appearance of temporal variation in age gradients, it can be ambiguious to examine age gradients out of context for the ground-water flow system. Furthermore, flow in recharge areas is not vertical at any of the piezometer nests, and some nests are located near discharge areas. For example, in the period 15 to 25 ka, age gradients vary by a factor of nearly 20 (fig. 108). The age gradients from two piezometers in the youngest (and most

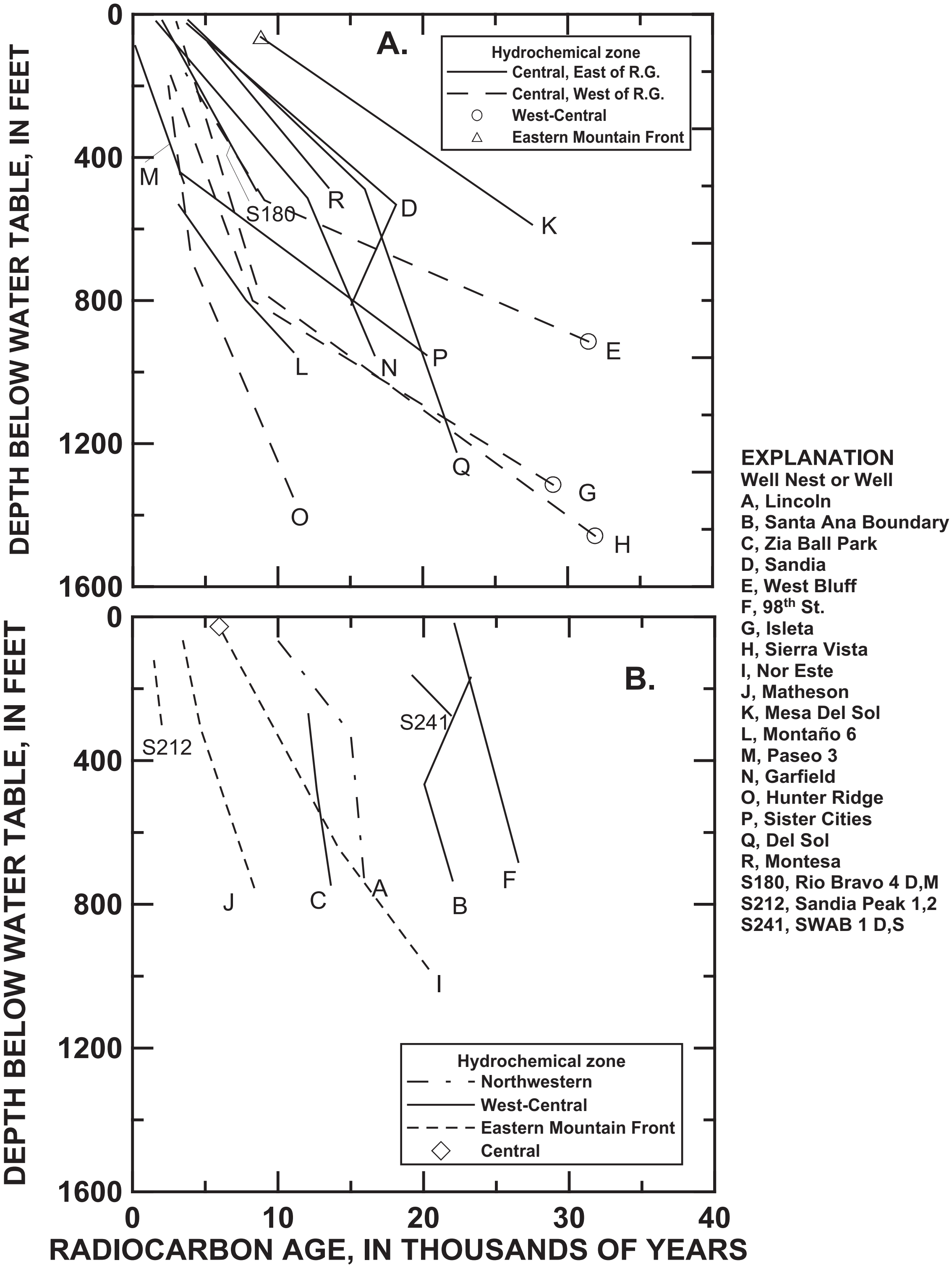



**Figure 107.** Profiles of radiocarbon age as a function of depth from piezometer nests from the Middle Rio Grande Basin. (A) Piezometer nests or wells penetrating waters of the Central hydrochemical zone, either east or west of the Rio Grande. Symbols denote piezometer nests where the deep completion is in the West-Central zone or the shallow completion is in the Eastern Mountain Front zone. (B) Piezometer nests or wells in the Northwestern, West-Central and Eastern Mountain Front zones. Water at the shallow completion of the piezometer nest in the Eastern Mountain Front zone at site S149 is of Rio Grande origin (Central zone). See figures 11a, 11b, 59, and 69 for well locations, and table A1 for well construction information.

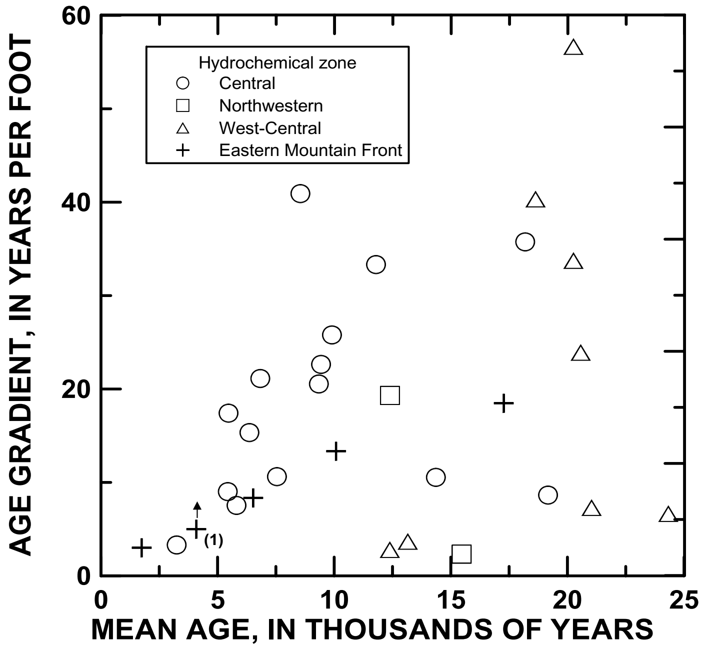



**Figure 108.** Age gradients in years per foot (yr $ft^{-1}$) of aquifer calculated between each pair of open intervals for each piezometer nest and plotted at the mean radiocarbon age of the two intervals. Age gradients vary from about 3 to 60 yr $ft^{-1}$ of aquifer in the upper 1,300 feet of aquifer and are quite variable for waters older than about 10 ka. Relatively low age gradients are found for waters recharged in the past 5 ka. (1) S115-S116 mid-shallow interval. Water-level measurements indicate that water at the shallow depth of piezometer S116 is perched, resulting in likely under-estimation of the age gradient between the mid and shallow depths at this piezometer.

shallow) waters along the eastern mountain front and the Central zone are about 3 yr $ft^{-1}$ (fig. 108). The implied modern recharge rate near the eastern mountain front and Rio Grande from these two piezometers is on the order of 0.1 ft $yr^{-1}$, assuming an average porosity of 0.3, and is within the range of recharge rates reported for other semiarid environments (see for example, Scanlon and others, 2002; Flint and others, 2002; Zhu and others, 2003).

Along the eastern mountain front, there appear to be two different age-depth relations. In the calculations of figure 109, radiocarbon ages for all samples from wells in the Eastern Mountain Front zone (production, domestic, and monitoring wells) were used and age was plotted at the mid-depth of the open interval in feet below the water table. Water from the Eastern Mountain Front zone found north of Albuquerque or south of Tijeras Arroyo has a relatively high age gradient (approximately 150 yr $ft^{-1}$) in relation to waters from the Eastern Mountain Front zone at Albuquerque (approximately 12 yr $ft^{-1}$) (fig. 109). Apparently, over at least the past 10 ka, there has been appreciably more recharge along the eastern mountain front at Albuquerque than either to the north or south of the Albuquerque vicinity. Factors that may contribute to this difference are a greater thickness of ancestrial Rio Grande sands at Albuquerque than elsewhere along the eastern mountain front (Hawley and Haase 1992), the presence of the Hubbell Bench and Tijeras and Hubbell Springs fault zones to the south that place low permeability rocks at shallow depths, and higher precipitation rates along the Sandia Mountains at Albuquerque than along lower altitude portions of the eastern mountain front.

Although an evaluation of the climate history of the southwestern U.S. is beyond the scope of this investigation, two studies (Allen and Anderson, 2000, and Polyak and others, 2001) are of particular significance because they provide direct information on the timing of moisture delivery to the near vicinity of the MRGB.

Allen and Anderson (2000) radiocarbon dated high stands of paleo-Lake Estancia, and interpreted sedimentologic, biologic, and geochemical proxies to identify nine periods of wet climate in the Estancia Basin, central New Mexico, east of the MRGB (fig. 1), between 12 and 24 ka, B.P. The high stands of Lake Estancia record the pluvial of the last glacial period

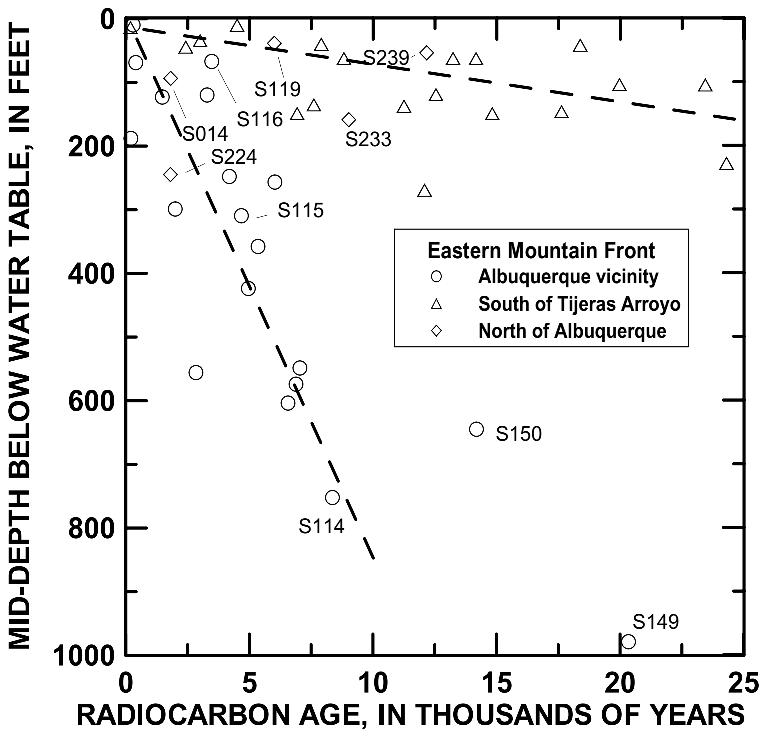



**Figure 109.** Radiocarbon age as a function at the depth below the water table of the mid-point of the open interval for all wells from the Eastern Mountain Front zone. Two age-depth relations are apparent. A relatively thick zone of recharge from the eastern mountain front is seen at Albuquerque, but in areas north of Albuquerque and south of Tijeras Arroyo, there has been relatively less recharge of comparable age to the Eastern Mountain Front zone.

throughout the southwestern U.S. (Benson and others, 1990, 1998, 2004; Oviatt and others, 1992, Phillips and others, 1992; Wilkins and Currey, 1997; Allen and Anderson, 2000, and references therein). Lake Estancia expanded and contracted repeatedly during the last glacial period, with high stands beginning at about 23.3 and 22 ka B.P., and was maintained near its maximum altitude between 20 and 15 ka B.P., referred to as the "Glacial Maximum Highstand" (GMH) by Allen and Anderson (2000). The 15 ka GMH was terminated by an abrupt dry episode that lasted about 1 ka. Two more wet periods (highstands) followed, beginning at about 13.9 and 13.1 ka B.P. The climate during the 13.9 ka highstand was apparently as wet as during the GMH. Lake Estancia desiccated after 12 ka B.P., followed by a brief expansion at about 10 ka B.P. Mid-Holocene deflation of the basin floor began about 7 ka B.P., near the onset of the generally dry and warmer conditions elsewhere in North America during the middle Holocene (8-4 ka B.P.) (for example, Dean and others, 1996). Important dry periods indicated by the Lake Estancia record are 14-15 ka B.P., 12 to 10 ka B.P., and after 10 ka B.P. into the mid-Holocene (Allen and Anderson, 2000). The maximum in age gradients from the piezometers (fig. 108) at about 10 ka B.P. generally is consistent with the expected low amounts of recharge at the beginning of the Holocene.

In another important record of wet periods in New Mexico, Polyak and others (2001) show that two stalagmites from Hidden Cave, Guadalupe Mountains, in extreme southeastern New Mexico, grew between 3,200 and 800 years ago, based on uranium series dating. The stalagmites contained 12 species of mites that are known to live in climates that are wetter and cooler than the present in southeastern New Mexico. The stalagmites contain no record of growth either prior to 3,200 years ago, or after 800 years ago. There is considerable evidence that the mid-Holocene warm period (8-4 ka) was followed by a change to near present-day conditions that began about 4 ka B.P. in the north-central parts of the United States and shifted with time to the southwestern United States (MacKay and Elias, 1992, Thompson and others, 1993; Nordt and others, 1994; Dean, 1997). Evidence from packrat middens suggests that the late Holocene became increasingly arid (Betancourt and others, 2001); however, other studies indicate wetter intervals within the late Holocene (Toomey and others, 1993; Buck and Monger, 1999; Wilkins and Currey, 1999; Polyak and others, 2001). The data of figure 108 suggest generally that recharge rates in the past 2-4 ka B.P. may have been higher than in the period 5-10 ka B.P.

## Historical Variations in Stable Isotopic Composition of Rio Grande and Eastern Mountain Front Recharge

Recharge of water from the Rio Grande to ground water in the Central zone has apparently occurred throughout the past 25 ka. Radiocarbon-dated ground water in the Central zone provides a record of historical variations of the stable isotopic composition of Rio Grande water that recharged the aquifer system. The $\delta^2H$ stable isotopic composition of ground water from the Central zone was apparently at a minimum during the last glacial period, with two values of $\delta^2H$ measured near -105 per mil with radiocarbon ages of 20 and 28 ka B.P. (fig. 110). Values of $\delta^2H$ of water from the Central zone rose to a local maximum of about -94 per mil at about 15 ka B.P., and then fell to a local minimum of -98 to -100 per mil at about 5 ka B.P. During the past 5 ka, water from the Central zone has become more enriched in $^2H$, reaching values of $\delta^2H$ near -90 per mil in modern waters (fig. 110). All measurements from Central zone ground water are included in figure 110. Some samples were from production wells with open intervals of as much as 1,200 feet, which can affect the radiocarbon age because of mixing in the well bore. Samples with negative radiocarbon ages contain fractions of post-bomb water and are the youngest of the data set. These samples normally would plot with samples of zero radiocarbon age on figure 110, but were left with apparent negative ages to separate those samples from water samples that are young but pre-bomb in age. Regardless of their radiocarbon age, their stable isotopic composition is representative of recent (post-bomb) water.

Values of $\delta^2H$ of ground water from the Central zone and Eastern Mountain Front zone having

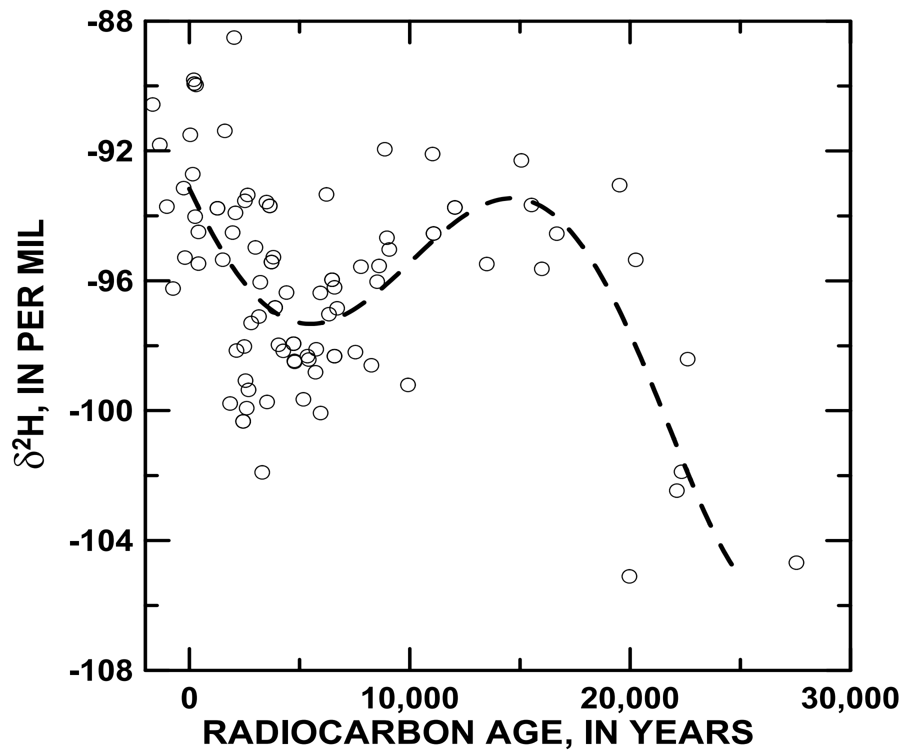



**Figure 110.** $\delta^2H$ isotopic composition of ground water of Rio Grande origin (Central zone) as a function of radiocarbon age, Middle Rio Grande Basin, New Mexico. The dashed line is a 5-degreee polynomial fit to the data points.

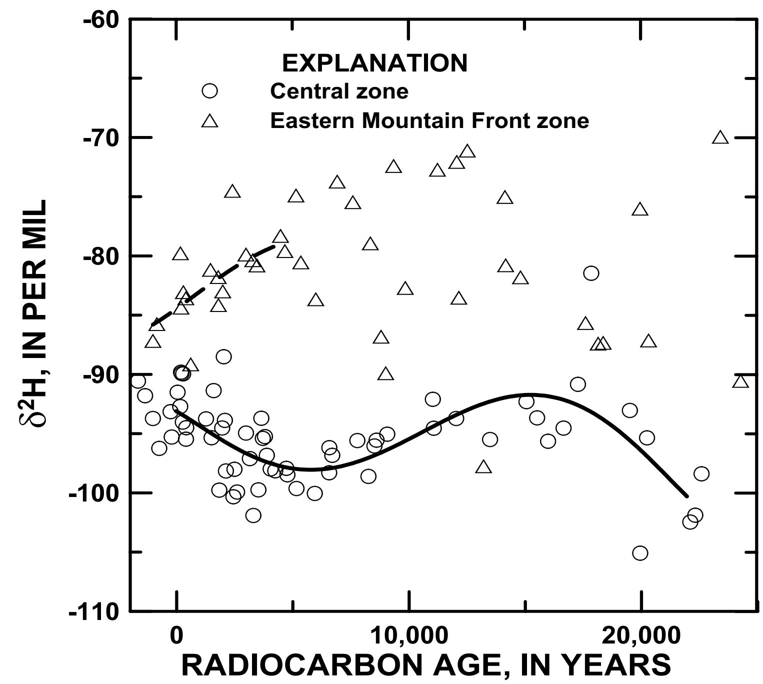



**Figure 111.** Comparison of the $\delta^2H$ isotopic composition of ground water from the Central zone with water recharged along the eastern mountain front as a function of radiocarbon age, Middle Rio Grande Basin, New Mexico. The lines represent 5-degree polynomial fits to the data.

radiocarbon ages from modern to more than 22 ka B.P. are shown in figure 111. Samples from wells with more than 200 feet of open interval were excluded. Apparently, the pattern in historical variations in the stable isotopic composition of water from the Central zone was not sensitive to well-screen length in the present data set, probably because only 20 percent of the samples were from wells with screens greater than 200 feet.

During the past 5,000 years, while $\delta^2H$ of water from the Central zone increased by nearly 6 per mil from a local minimum near –98 per mil, $\delta^2H$ of moisture recharged along the eastern mountain front became more depleted in $^2H$, by about 7 per mil (fig. 111). The changes in $\delta^2H$ of Central-zone water and Eastern Mountain Front-zone water during the past 5 ka, as evidenced in the ground-water samples, are small, but vary in opposite direction as a function of radiocarbon age (fig. 111). Most ground water from the Eastern Mountain Front zone with radiocarbon ages greater than 5 ka B.P., range in $\delta^2H$ isotopic composition from about -90 to -70 per mil with little evidence of temporal variability (fig. 111). Water recharged from the Rio Grande to the Central zone apparently had a local minimum in $\delta^2H$ isotopic composition at approximately 5 ka B.P., had a maximum at about 15 ka B.P., and had an overall minimum at about 22 ka B.P. (fig. 111).

It was shown in the section “Sources of Recharge and Underflow to the Santa Fe Group Aquifer System” that over the past 20 years, the $\delta^2H$ of Rio Grande water has varied with the extent of winter snow pack in southern Colorado and northern New Mexico. Winters with high snowfall in southern Colorado and northern New Mexico are followed by spring runoff in the Rio Grande that is more depleted in $^2H$ than in years of low snowfall. Sulfur isotope and tritium data (discussed earlier) also indicate that Rio Grande water is a mixture of ground-water sources and snowmelt. During the summer and fall, Rio Grande water is enriched in $^2H$ (fig. 23), reaching values of $\delta^2H$, for example, of approximately -85 per mil in August through October of 1998 (table B6). The enriched values are probably representative of base flow from the Rio Grande drainage basin mixed with runoff of lower-altitude precipitation from the summer monsoon season. The summer monsoon season occurs today in the months of July through October in the MRGB.

The depleted stable isotope values for Rio Grande water at about 20-28 ka B.P. probably indicate cooling during the last glacial period and high proportions of snowmelt in the Rio Grande. Recharge temperatures determined from measurements of noble gases in ground water from the Carrizo aquifer (central Texas) and the San Juan Basin (northwestern New Mexico) were 5.2 ± 0.7 and 5.5 ± 0.7°C lower, respectively, during the last glacial maximum (approximately 20,000 radiocarbon years B.P.) than during the Holocene (Stute and others, 1992; Stute and others, 1995). Phillips and others (1986) found depletion of some 25 per mil in $\delta^2H$ of Pleistocene-age water relative to modern waters from the central San Juan Basin, northwestern New Mexico, and an average cooling of 5 to 7°C during the last glacial period. Thompson and others (1999) reconstructed the pattern of annual temperature and annual precipitation in the vicinity of Yucca Mountain, southern Nevada, from studies of packrat middens for four intervals of the late Pleistocene. For the periods of 35-30 ka, 27-23 ka, 20.5-18 ka, and 14-11.5 ka, mean annual temperature was lower than today by about 4, 5, 8, and 5.5°C, respectively, and mean annual precipitation was estimated to be 1.5, 2.2, 2.4, and 2.6 times modern levels of precipitation, respectively. Lake Estancia, to the east of the MRGB, had nine high stands from about 22 ka to 12 ka (Allen and Anderson, 2000); thus, it is reasonable to assume an increased snow pack through much of this period. Yet, the Rio Grande actually became more enriched in $^2H$ during the period from about 22 to 15 ka (fig. 110).

To a first approximation, water in the Rio Grande contains fractions of high altitude (relatively depleted in $^2H$) snowmelt from southern Colorado and northern New Mexico and runoff of precipitation that falls at lower altitude (relatively enriched in $^2H$) within the Rio Grande drainage basin, including runoff from thunderstorms during the summer monsoon season (July-October). During the pluvial from about 22 ka to 12 ka, as recorded at Lake Estancia (Allen and Anderson, 2000), the somewhat enriched stable isotope composition of paleo-Rio Grande water (ground water from the Central zone which reached a maximum in $\delta^2H$ at about 15 ka B.P.) indicates an increased fraction of low-altitude runoff mixed with snowmelt in discharge of the Rio Grande (fig. 111), despite mean annual temperatures that were likely lower than today. During the mid-Holocene warm period (4-8 ka B.P.), the $\delta^2H$ of the Rio Grande was actually more depleted than today, reflecting less low-altitude runoff from the drainage basin, and a higher fraction of snowmelt from the mountains of southern Colorado and northern New Mexico than today.

Two scenarios were considered to explain the historical variability in the $\delta^2H$ isotopic composition of Central zone ground water: 1) variability in amounts of low-altitude precipitation delivered to the basin, and 2) changes in the timing of peak runoff of snowmelt from northern New Mexico and southern Colorado. Both scenarios would vary the proportions of depleted high-altitude snowmelt and low-altitude runoff in Rio Grande discharge.

In the first scenario, dry climatic periods would lead to less runoff of low-altitude precipitation and higher fractions of snowmelt in Rio Grande discharge, resulting in Rio Grande water that is relatively depleted in $^2H$. Periods of relatively enriched $^2H$ isotopic composition of Rio Grande water would result from periods of increased low-altitude precipitation in the basin. Consequently, the stable isotope record from the Central zone would indicate increased low-altitude precipitation in the basin during the last pluvial, from about 22 to12 ka B.P. and during the past approximately 5 ka. (fig. 111). The relatively depleted stable isotopic composition of Central zone water from the mid-Holocene warm period, approximately 4-8 ka B.P., would indicate a period of decreased low-altitude precipitation in the basin.

Even though the discharge of the Rio Grande may have been higher during the pluvial of the last glacial period (12-22 ka B.P.), the fraction of water from low-altitude recharge in the river also apparently increased, causing an increase in the $\delta^2H$ isotopic composition of the river relative to the mid-Holocene, when supposedly less low-altitude runoff occurred. During the past 5 ka, the rise in $\delta^2H$ of Rio Grande water of about 7 per mil may again reflect an increased fraction of low-altitude water relative to the dry period of the mid-Holocene, even though river discharge is probably less today than in the late Pleistocene pluvial.

In the second scenario, it is recognized that the timing of the spring snowmelt in the mountains of southern Colorado and northern New Mexico shifts with changes in seasonal temperature. During the last glacial period, colder temperatures would delay the spring snowmelt and delay the season of peak spring runoff of isotopically depleted snowmelt. A cooling of 5°C during the LGM may have caused periods of peak runoff of snowmelt to overlap, at least in part, with the summer monsoon season, resulting in an increase in the fraction of low-altitude summer precipitation mixed with mountain snowmelt. The resulting isotopic composition of the Rio Grande during peak runoff would be enriched in $^2H$ relative to that of snowmelt. During warm climatic periods, mountain snowmelt would occur in early spring and likely peak prior to the summer monsoon season, as presently, resulting in peak runoff of the Rio Grande that is more depleted in $^2H$ than in cold times when snowmelt is delayed. This scenario implies that recharge to ground water of the Central zone occurs primarily during periods of high Rio Grande discharge.

On the basis of the available data, neither of the two scenarios for explaining the historical variations in the isotopic composition of Central-zone ground water can be eliminated, and it is likely that, to some extent, both processes described in the two scenarios contribute to the isotopic composition of Rio Grande water.

The stable isotopic composition of Eastern Mountain Front-zone water (triangles on fig. 111) is primarily a function of altitude and temperature effects (Dansgaard, 1964). Because of isotope fractionation, precipitation from higher altitude and lower temperature is more depleted than precipitation falling at lower altitude and higher temperature. More depleted precipitation falls in colder than warmer climates. There is a wide variation in $\delta^2H$ of water recharged along the Eastern Mountain Front, particularly for waters older than 5 ka B.P. (fig. 111). However, some of the most depleted waters from the Eastern Mountain Front have radiocarbon ages from the LGM, approximately 20 ka B.P., and these are near -90 per mil in $\delta^2H$. The maximum range in $\delta^2H$ of Eastern Mountain Front zone water varies from about -70 per mil in some samples recharged during the mid-Holocene to about -90 per mil in some samples from the LGM. If the change in $\delta^2H$ of water between the LGM and the mid-Holocene results from temperature effects only, a temperature variation of about $3.9 \pm 0.2^oC$ is indicated based on the temperature dependence of isotope fractionation (van der Straaten and Mook, 1983). In the past 5 ka, the decrease of about 7 per mil in $\delta^2H$ of water recharged along the Eastern Mountain Front, if the result of temperature changes only, indicates average cooling along the eastern basin margin of about $1.4^oC$ (van der Straaten and Mook, 1983). However, further study is needed to determine if other processes, such as change in moisture source or shift in predominant season of recharge, could account for the decrease in $\delta^2H$ along the basin margin during the past 5 ka.

Even though the trends in stable isotope composition of the Rio Grande and eastern mountain front recharge are in opposite directions during the past 5 ka, they both may indicate a consistent climatic scenario—for example, increased low-altitude precipitation accompanied by cooling of about $1.4^oC$ during the past 5 ka along the eastern mountain front. Similar conclusions can be drawn from the $\delta^{18}O$ data. There is no evidence that this climatic trend has changed in the most recent past, but the data are probably not precise enough to resolve climatic changes during the past 1 ka. More reliable indicators of recent climatic change can be found in the stalagmite record of Polyak and others (2001), and the tree-ring record of Grissino-Mayer (1995, 1996). The stalagmite record indicates a cooler, wetter climate during the period 3,200 to 800 years, B.P., which changed to the present warmer and dryer climate about 800 years ago. Grissino-Mayer (1995, 1996) used tree-ring data to reconstruct a record of precipitation at El Malpais National Monument, located about 70 miles west of the MRGB in northwestern New Mexico, spanning the the period 136 B.C. to A.D. 1992. The tree-ring data record alternating periods of above-normal and below-normal rainfall. Periods of above-normal rainfall occurred during A.D. 81-257, 521-660, 1024-1398, and 1791-1992. Below-normal rainfall occurred during the periods A.D. 258-520, 661-1023 and 1399-1790. During the past 200 years, rainfall at El Malpais National Monument exceeded any since A.D. 660, and the period 1978-1992 was the wettest 15-year period of the entire 2,129-year tree ring record. The minimum and maximum averaged annual rainfalls interpreted from short-term (10-year smoothing) tree-ring records were 12.86 and 16.65 inches per year, respectively.

## Paleorecharge Temperatures

Measured concentrations of dissolved $N_2$ and Ar were used to estimate recharge temperatures and quantities of excess air (Herzberg and Mazor, 1979; Heaton, 1981; Heaton and Vogel, 1981; Heaton and others, 1983; Busenberg and others, 1993; Stute and Schlosser, 1999) in MRGB ground-water samples, as summarized in table A5. Recharge temperature is the temperature at the water table during recharge, and excess air refers to quantities of air trapped during recharge that subsequently dissolved under increased hydrostatic pressure during periods when the water table rose above the capillary fringe. Recharge temperature is determined from the measured dissolved gas concentrations using the temperature dependence of the Henry's Law solubilities of atmospheric gases and an assumed altitude (barometric pressure) of recharge. Although the accuracy of the reported recharge temperature is typically ± 0.5°C on laboratory standards (table D9), the altitude of recharge in the MRGB is uncertain for some hydrochemical zones. The highest uncertainties in recharge altitude apply to water from the West-Central zone that could potentially have infiltrated above 11,000 feet above sea level along the highest flanks of the Jemez Mountains, or at approximately 5,000 feet at the water table within parts of the MRGB.

In calculation of recharge temperatures from the dissolved gas data, a most likely recharge altitude was assumed for each hydrochemical zone and was varied by ± 1,500 feet (table A6). Water recharged at 6,500 ± 1,500 feet has an uncertainty in recharge temperature of ± 2°C (table A6). Recharge temperatures were calculated for assumed recharge altitudes of 5,000, 6,500, or 8,000 feet (table A6). As the altitude of the Rio Grande is near 5,000 feet, no water in the basin is recharged at altitudes lower than about 5,000 feet. The average rechare altitudes of waters recharged in the Northwestern, Western Boundary, Rio Puerco, Northeastern, and Central hydrochemical zones were assumed to be 5,000 feet. A recharge altitude of 6,500 feet was assumed for water recharged in the Northern Mountain Front, Eastern Mountain Front, Tijeras Fault Zone, and Tijeras Arroyo hydrochemical zones. Water in the West-Central hydrochemical zone was assumed to have recharged at an average altitude of 8,000 feet. The recharge temperature is underestimated if the recharge altitude is overestimated. Thus, if water within parts of the West-Central zone recharged the MRGB by direct infiltration to the water table near 5,000 feet, the recharge temperatures calculated assuming recharge at 8,000 feet would be underestimated by 4-5°C (table A6). Conversely, if water in the West-Central zone were recharged at altitudes of, for example, 11,000 feet along the Jemez Mountains, the recharge temperature calculated assuming recharge at 8,000 feet would be biased high by about 4-5°C. Although the recharge altitude can be particularly uncertain for recharge in the West-Central zone, recharge altitudes of more than 14,000 feet (the highest altitude along the Jemez Mountains) would be required to lower some of the $N_2$-Ar recharge temperatures to the present mean annual temperature at Albuquerque (13.6°C). The impossibility of explaining some of the very warm recharge temperatures (such as 30°C) observed in parts of the MRGB by assuming high recharge altitudes is further demonstrated considering that, because of altitude, recharge temperatures would be considerably lower than 13.6°C at high altitude, requiring recharge altitudes considerably higher than 14,000 feet. Although the assumption of higher-altitude recharge can help to lower the calculated recharge temperatures for waters from the West-Central zone, additional processes must be affecting the waters in the West-Central zone in order to account for the calculated warm recharge temperatures. In contrast, the recharge altitude is known within approximately 200 feet for water recharged as infiltration from the Rio Grande, and the resulting uncertainty in recharge temperature is probably less than ± 0.3°C.

In reducing waters, denitrification processes can reduce dissolved $NO_3$ to $N_2$ gas. If not recognized and corrected for, denitrification leads to a warm bias in recharge temperature, an overestimate of excess air in ground-water samples, and a low estimate of total $NO_3$ initially recharged in ground water. Several procedures were utilized to refine recharge temperatures, excess air, and amounts of denitrification. For aerobic samples (dissolved oxygen concentrations greater than approximately 0.5 mg/L), it was assumed that denitrification had not occurred, and that the samples were not mixtures of anaerobic and aerobic waters. In this case, the recharge temperature and excess air were calculated directly from the dissolved $N_2$ and Ar data, using the assumed recharge altitude for the particular hydrochemical zone in which the sample was located; the quantity of $N_2$ derived from denitrification was assumed to be zero. For waters with low dissolved oxygen concentrations (dissolved oxygen concentrations less than approximately 0.5 mg/L), such as in some samples from the inner valley of the Rio Grande, there is potential for denitrification. In calculating recharge temperatures of anaerobic waters, average quantities of excess air or average recharge temperatures were assumed, based on results from aerobic samples in the same hydrochemical zone, and then used with the dissolved $N_2$ and Ar data to estimate quantities of denitrification. The results are summarized in tables A5-A6.

Throughout the MRGB, most ground-water temperatures are appreciably warmer than the modern mean annual temperature at Albuquerque (13.6°C) (fig. 30). Median ground-water temperatures vary by hydrochemical zone from 16.1°C (water in the Tijeras Arroyo zone) to 23.8°C (water in the West-Central zone) (table 8). Maximum water temperatures are about 30°C for some water on the West Mesa, west of Albuquerque. Warm ground-water temperatures in the MRGB result from heating under the effect of the local geothermal gradient (Reiter, 2001). The lowest water temperatures are found in shallow water samples at relatively high altitude— for example, discharge from Embudo and Embudito Springs along the eastern mountain front above Albuquerque (altitudes of 6,600 and 6,440 feet, respectively) has water temperatures of 8-9°C.

In arid and semiarid environments, recharge can occur (if at all) as continuous, diffuse infiltration of water, maintaining close contact with the unsaturated zone air, or as transient, focused recharge in response to, for example, floods in arroyos or stream valleys that bypass most water contact with the unsaturated-zone air (Gee and Hillel, 1988). Therefore, water may partially or fully equilibrate with the unsaturated zone air during diffuse-flow recharge (resulting in warm recharge temperatures calculated from the dissolved $N_2$-Ar data), or retain $N_2$ and Ar concentrations acquired at the land surface during focused recharge (resulting in cold recharge temperatures calculated from the dissolved $N_2$-Ar data). Except for direct infiltration from rivers, recharge temperatures calculated from dissolved gas data may be biased warm (depending on the extent of gas exchange during infiltration) because of warming during infiltration in recharge areas to the MRGB. If a paleoclimate signal remains in the calculated recharge temperatures, it will be found primarily in the samples with the lowest recharge temperatures for each hydrochemical zone as a function of time.

The recharge temperatures calculated from the dissolved $N_2$-Ar concentrations for water samples from the West-Central zone and the Eastern Mountain Front zone are plotted against the measured water temperatures in figure 112. The recharge temperatures for waters from the West-Central zone were calculated assuming a recharge altitude of 8,000 feet, and those from the Eastern Mountain Front zone were calculated for recharge at 6,500 feet. A relatively large range in recharge temperature is indicated, from about 3 to 22°C for waters from the West-Central zone and about 8 to 18°C for waters from the Eastern Mountain Front zone. Points plotting nearest the 1:1 line indicate ground water that has calculated recharge temperatures similar to the measured water temperature, such as could be found in recharge that is still near the water table in the area where infiltration occurred. Most samples have water temperatures that are appreciably warmer than the calculated recharge temperature, indicating warming in the aquifer system under effect of the local geothermal gradient, presumably as a result of ground-water circulation to depths below the water table following recharge (see for example, Reiter, 2001).

Assuming an average lapse rate of about -5.5 °C/km (Meyer, 1992), and the mean annual temperature of 13.6°C at Albuquerque (altitude approximately 5,000 feet above sea level), recharge temperatures of about 11.1 and 8.6°C would be anticipated for water recharged at 6,500 and 8,000 feet, respectively, today. A cooling of 5°C in the mean annual temperature at the last glacial maximum (Stute and others, 1992, 1995) could lead to recharge temperatures of 3-4°C for higher altitude recharge along the flanks of the Jemez Mountains (8,000 feet) and recharge temperatures of about 6 and 9°C at altitudes of 6,500 and 5,000 feet during that time. Some waters from the West-Central zone were apparently recharged near 4°C, if the recharge altitude was near 8,000 feet (fig. 112). Examples include waters from sites S193, S288, S166, and S219 that have recharge temperatures of 3.2, 4.5, 5.4, and 5.8°C, and radiocarbon ages of 20.6, 20.0, 19.7, and 23.2 ka B.P., respectively. One other sample from the West-Central zone, S175, (Fig. 112) has a recharge temperature of 4.1°C and radiocarbon age of 8.9 ka. Two horizontal lines (fig. 112) show the modern mean annual temperature estimated for recharge at altitudes of 6,500 and 8,000 feet (11.1 and 8.6°C, respectively). Most of the waters from the West-Central zone have recharge temperatures lower than the mean annual temperature at Albuquerque (13.6°C), and many have recharge temperatures lower than 8.6°C (fig. 112). Recharge temperatures in the West-Central zone waters that are lower than the modern mean annual temperature (8.6°C) indicate recharge that occurred at altitudes higher than 8,000 feet (barometric pressure lower than that at 8,000 feet, and mean annual temperature lower than 8.6°C), or recharge that occurred during the last glacial period, when mean annual temperature would be lower than that observed today. Similarly, waters from the Eastern Mountain Front

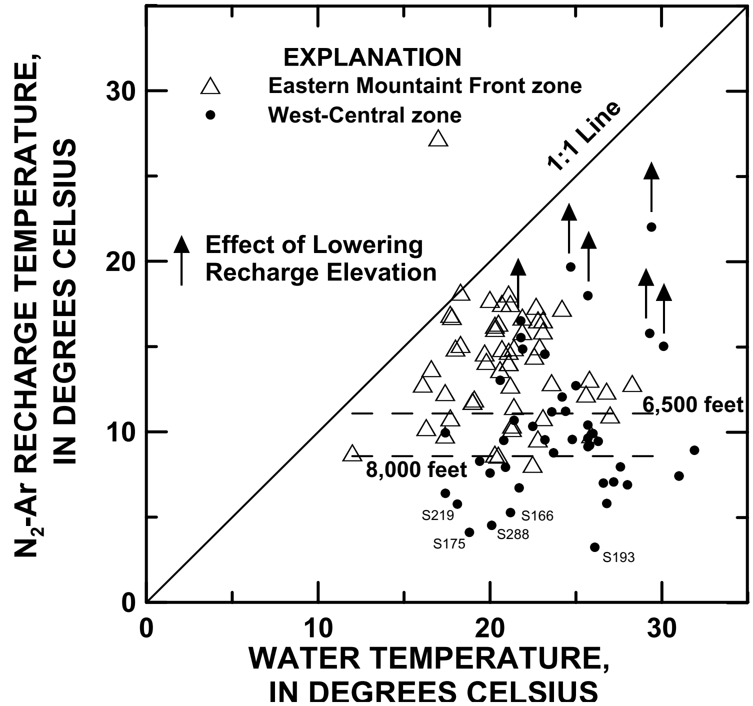



**Figure 112** Comparison of $N_2$-Ar recharge temperature with the measured ground-water temperature for waters from the West-Central and Eastern Mountain Front zones, Middle Rio Grande Basin, New Mexico. The arrows show the effect on the calculated recharge temperature if a lower elevation of recharge is assumed in the calculation. The recharge temperatures were calculated assuming altitudes of 6,500 feet for the Eastern Mountain Front and 8,000 feet above sea level for the West-Central zone waters, respectively. The dashed lines show the estimated modern mean annual temperature for altitudes of 6,500 and 8,000 feet.

zone with recharge temperatures lower than 11.1°C indicate recharge that occurred at altitudes higher than 6,500 feet, where mean annual temperature would be lower than 11.1°C and barometric pressure would be lower than that at 6,500 feet, or recharge during the last glacial period, when mean annual temperature would be lower than that observed today.

Other waters from the West-Central and Eastern Mountain Front zones were recharged at temperatures appreciably warmer than the paleo and modern mean annual temperature (fig. 112). These samples may indicate recharge that has occurred by diffuse infiltration through a relatively thick unsaturated zone (probably greater than 300 feet) where the infiltration water is warmed along a geothermal gradient prior to reaching the water table. Where recharge has occurred through a warm unsaturated zone, such as may be the case for some samples from the West-Central and Eastern Mountain Front zones with recharge temperatures warmer than the mean annual temperature, the recharge altitudes were probably lower than 8,000 feet and 6,500 feet, respectively, because the water table altitude may be below 8,000 feet in recharge areas for the West-Central zone, and below 6,500 feet for the Eastern Mountain Front zone (fig. 9). The arrows on figure 112 indicate that the calculated recharge temperatures for some samples from the West-Central zone would be closer to the 1:1 line if the samples were recharged at an altitude lower than 8,000 feet.

Calculated recharge temperatures in relation to hydrochemical zones for all samples in those hydrochemical zones in which the $N_2$ and Ar dissolved-gas measurements were made are shown in figures 113a,b. Several distinct patterns in recharge temperature are recognized in parts of the MRGB (figs. 113a,b).

$N_2$-Ar recharge temperatures for all West-Central zone waters, calculated assuming a recharge altitude of 8,000 feet, are shown in figure 113a. In the northern part of the basin, waters from the West-Central zone are included in figure 113a that were identified beneath the Northwestern zone. Also shown are waters from the West-Central zone that were

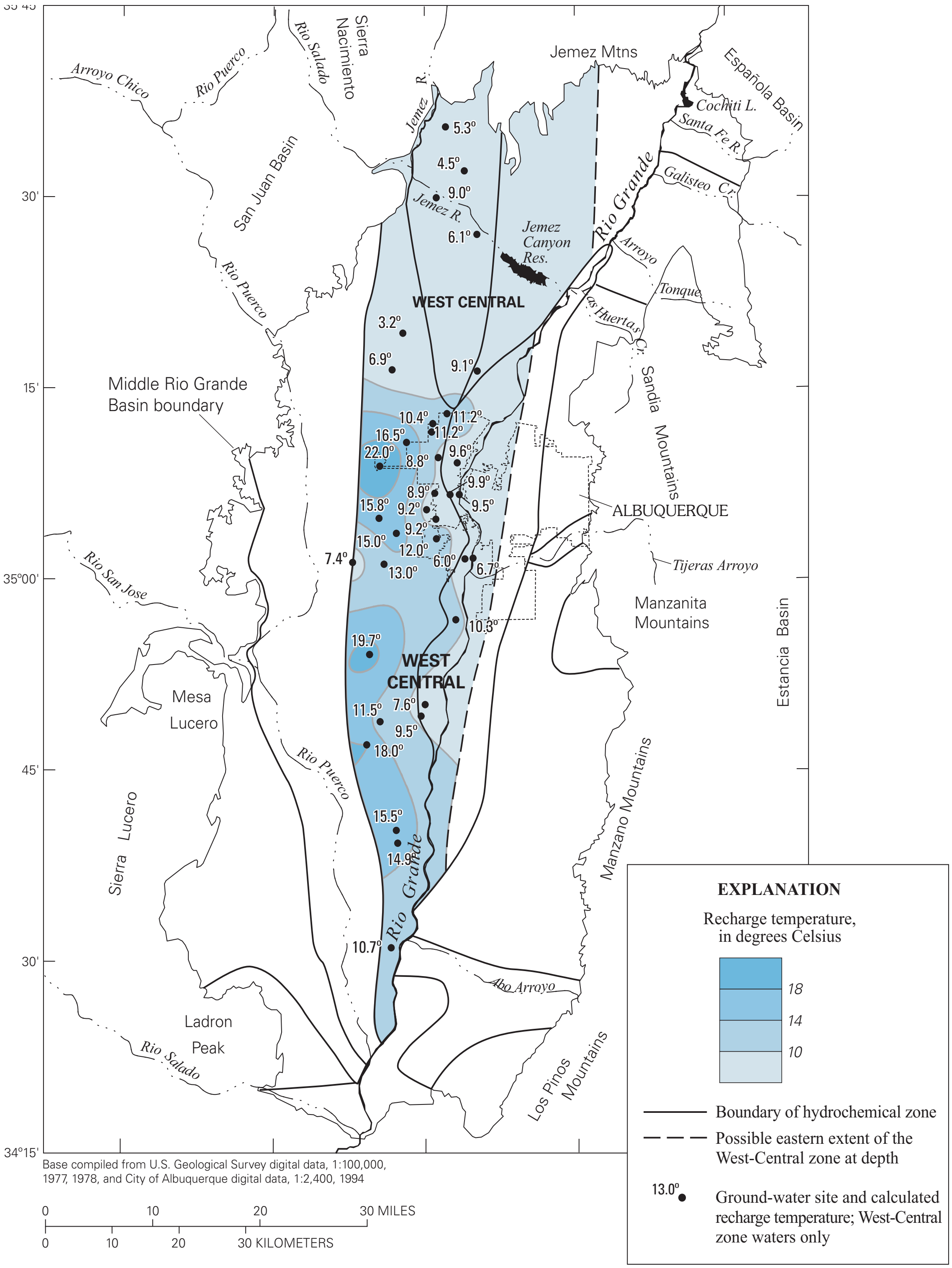



**Figure 113a.** $N_2$-Ar recharge temperatures for all dissolved gas samples from the West-Central zone of the Middle Rio Grande Basin, New Mexico, calculated at an assumed recharge altitude of 8,000 feet. Included are samples in the West-Central zone from beneath the Northwestern zone in the northern part of the basin and beneath the Central zone along the Rio Grande. Site labels indicate the calculated recharge temperatures. Two groups of recharge temperatures are evident. Relatively low recharge temperatures are found for samples from the West-Central zone in the northern third of the basin and along the eastern half of the zone. Relatively warm recharge temperatures occur in the western half of the southern two-thirds of the West-Central zone.

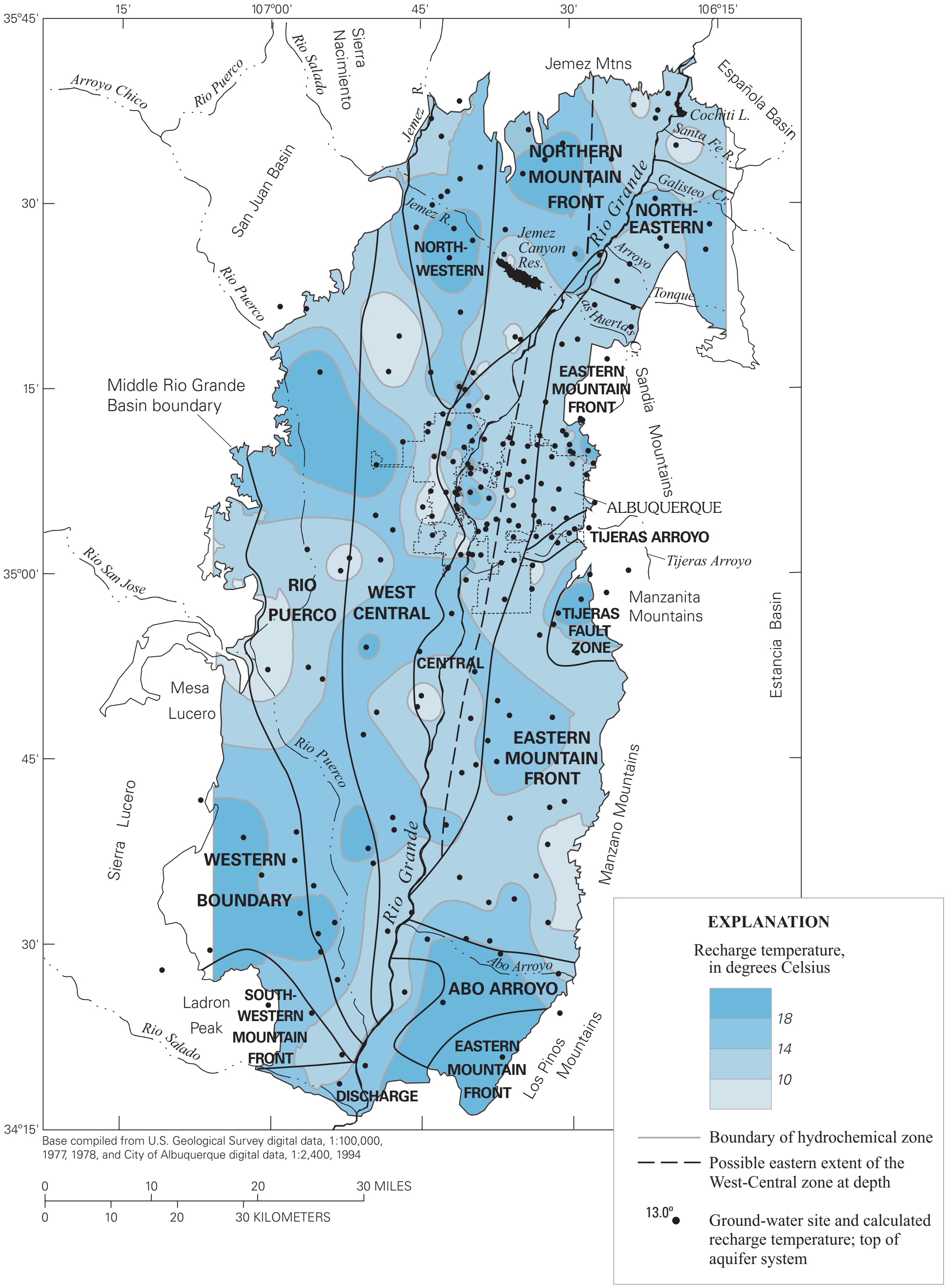



**Figure 113b.** $N_2$-Ar recharge temperatures for all dissolved gas samples from the upper-most hydrochemical zones in the Middle Rio Grande Basin, New Mexico, including the West-Central zone where it is at the water table. Excluded are samples from the West-Central zone beneath the Northwestern and Central zones (fig. 113a). The waters from the Northern Mountain Front and Northwestern zones have warm recharge temperatures in comparison to waters from the West-Central zone at lower depths in the northern third of the basin (fig. 113a). Most samples throughout the MRGB have recharge temperatures warmer than 14°C. See text for recharge altitudes used in the calculations and tables A5 and A6 for summaries of the calculations.

identified beneath Central zone waters (fig. 113a). The labels for the West-Central zone samples give the calculated recharge temperature for each sample. Two general groupings of recharge temperatures are evident for the West-Central zone waters. Along the northern third and eastern half of the basin, West-Central zone waters have recharge temperatures less than 10°C. Across the northern third of the basin, West-Central zone waters have an average recharge temperature of 6.7 ± 2.0°C. Along the western half of the southern two-thirds of the basin, West-Central zone waters have appreciably warmer recharge temperatures than those in the northern third and eastern half of the basin, typically warmer than 10°C and as warm as 22°C (fig. 113a). Whereas the waters from the northern third and eastern half of the West-Central zone have recharge temperatures consistent with the suggested recharge source along the flanks of the Jemez Mountains, most of the waters along the western half of the southern two-thirds of the West-Central zone were warmed appreciably in contact with air and have exchanged gases. These waters of the West-Central zone with warm recharge temperatures apparently have a different mechanism of recharge than those recognized along the northern margin of the basin, yet they retain the otherwise same chemical and isotopic signature of West-Central zone waters (tables 8-9).

The $N_2$-Ar recharge temperatures for all measured samples from zones at the top of the water table across the MRGB are mapped in figure 113b. Waters from the Northern Mountain Front and Northwestern zones have average recharge temperatures of 13.5 ± 4.1 and 18.1 ± 3.0°C, respectively— more than 7°C warmer than waters from the West-Central zone beneath the Northern Mountain Front and Northwestern zones. The waters in the Northern Mountain Front and Northwestern zones are younger than those in the West-Central zone (table 8), and, based on relatively enriched stable isotopic composition, were recharged at lower altitudes than those of the West-Central zone. The dissolved gas recharge temperatures indicate that the waters from the Northern Mountain Front and Northwestern zones were warmed during recharge, such as may have occurred during infiltration through relatively deep unsaturated zones along the northern margin of the basin. Other evidence of warming during recharge is seen in waters in the southeast part of the basin, in recharge in the vicinity of the Tijeras Fault Zone, in eastern mountain front recharge near Albuquerque, and in areas along the western margin of the basin (fig. 113b).

There are also differences in recharge temperatures across the northern mountain front, with relatively low recharge temperatures (7.9 - 12.5°C) in the northeastern part of the Northern Mountain Front zone, and relatively high recharge temperatures (15.7 - 20.3°C) in the northwestern part of the zone (fig. 113b). Presumably, these differences reflect differences in recharge mechanism, with higher proportions of focused recharge through arroyos in the northeast, and greater proportions of diffuse infiltration in the northwestern part of the Northern Mountain Front zone. Depths to the water table are typically larger in the northwestern part of the Northern Mountain Front zone than in the northeast, being as much as 991 feet to the water table in the northwestern part of the Northern Mountain Front zone, and typically 141-226 feet in the northeastern part of the zone. The median ground-water temperature in the Northern Mountain Front zone is 18.9°C (table 8), with a median radiocarbon age of about 7 ka B.P., and median $\delta^2H$ of -77.7 per mil.

All of the samples from the Northwestern hydrochemical zone have relatively warm recharge temperatures (14.1-24.5°C), indicative of predominantly diffuse recharge. Water levels are typically 300-500 feet below land surface in the Northwestern hydrochemical zone. Water from the Northwestern zone can be traced south to the Lincoln Middle School piezometer nest (sites S103-105), where the deep, medium and shallow completions have recharge temperatures of 19.4, 18.3, and 19.4°C, respectively, and span the upper-most 600 feet of the aquifer system, and to the nearby Rio Rancho wells 4 and 8 (sites S191 and S192), where recharge temperatures are 18.6 and 17.7°C, respectively. Further to the south of the Lincoln nest, the waters sampled were of Rio Grande origin and waters of the Northwestern hydrochemical zone were no longer recognized. Most waters from the Northwestern hydrochemical zone have radiocarbon ages of less than about 15 ka (median radiocarbon age of 7.7 ka B.P.), and most have relatively enriched $\delta^2H$ (median $\delta^2H$ of -64.7 per mil). The $\delta^2H$ values of water from both the Northern Mountain Front and Northwestern hydrochemical zones are enriched in $^2H$ relative to Eastern Mountain Front zone water (-81.0 per mil), and indicative of low-altitude recharge to the MRGB. Some of the waters from the Northern

Mountain Front and Northwestern hydrochemical zones have approximately modern radiocarbon ages.

Water from the West-Central zone has recharge temperatures that range from 3.2 to 22.0°C, which is the highest range in recharge temperatures calculated for any hydrochemical zone in the MRGB. In the northern part of the basin, low recharge temperatures (4.5 to 9.9°C) are found in water from the six wells that intercept water from the West-Central hydrochemical zone beneath waters of the Northwestern zone (water from sites S288, S166, S218, S219, S283, S285). Low recharge temperatures (3.2 and 6.9°C) are found at Rio Rancho wells 9 and 13 (S193 and S188, respectively) in the northwestern part of the West-Central zone. Low recharge temperatures (7.6 to 11.2°C) are also found along the eastern-most half of the West-Central zone from an area just northwest of Albuquerque south to vicinity of Belen (fig. 113a). Warm recharge temperatures (14.9 to 22.0°C) can be found in water from the westernmost half of the West-Central zone from the vicinity of site S243 south to Belen. The axis of the ground-water trough (fig. 9) approximately divides waters with warm recharge temperatures on the west side of the West-Central zone from those with cold recharge temperatures on the east side of the West-Central zone. The waters in the West-Central zone with low recharge temperatures can be traced throughout the eastern-most half of the West-Central zone to the northern margin of the basin beneath water of the Northwestern hydrochemical zone (fig. 113a). The waters with warm recharge temperatures occurring in the western-most half of the West-Central zone have exchanged gases with warm unsaturated-zone air during recharge, indicating a different mechanism of recharge than that for waters with cold recharge temperatures in the eastern-most half of the West-Central zone. All of the waters from the West-Central zone typically have old radiocarbon ages (median radiocarbon age of 19.7 ka B.P.) and are depleted in $^2H$ (median $^2H$ of -96.7 per mil) relative to waters of the Northern Mountain Front, Northwestern, and Eastern Mountain Front zones.

Most recharge temperatures of waters from the Eastern Mountain Front zone range from 8.1 to 18.2°C. The lowest temperatures (8-9°C) are about 2°C warmer than that expected for recharge during the last glacial period at altitudes of approximately 6,500 feet, and occur in waters with radiocarbon ages of modern to about 18 ka B.P. Relatively low recharge temperatures (8.1-13.7°C) are calculated for waters along the northeastern part of Albuquerque (fig. 113b), while along the southeastern side of Albuquerque, Eastern Mountain Front zone waters have relatively warm recharge temperatures (15.0 to 17.4°C). The lowest recharge temperatures from the Eastern Mountain Front zone, being near the expected mean annual temperature, probably indicate waters originating primarily as focused recharge through a series of arroyos and canyons that capture runoff from the Sandia Mountains to the east. Relatively warm recharge temperatures in southeastern Albuquerque are apparently recharged by more diffuse infiltration through the warm unsaturated zone; the median water temperature of the Eastern Mountain Front zone is 22.0°C, and the median calculated recharge temperature is 14.3°C.

Where the aquifer system and surface-water sources are in contact, seepage from surface-water sources passes directly into the aquifer system; for those samples, the calculated recharge temperature probably represents the surface-water temperature at the time of recharge. For example, waters from the Tijeras Arroyo zone have a narrow range of recharge temperatures (11.8-12.7°C) that probably represent average water temperatures of discharge from Tijeras Arroyo. Twenty-two, approximately monthly, measurements of the temperature of Tijeras Arroyo water between January 1997 and March 1999 averaged 13.8°C (table B2). Streambed temperatures recorded at 30-minute intervals in 1990 at a depth of approximately 1 foot beneath Tijeras Arroyo ranged from about 3 to 23 °C (Constantz and Thomas, 1996), with an average temperature of 12-13°C. Water from the Central zone (of Rio Grande origin) has $N_2$-Ar recharge temperatures that range from 7.3 to 23.4°C. These recharge temperatures, more than any others in the MRGB, are probably most representative of water temperatures at the time of recharge. The recharge temperatures from the Central zone are examined in more detail below.

Relatively warm recharge temperatures (14.2 to 21.9°C) are calculated for waters in the southwestern part of the basin (Western Boundary and Rio Puerco zones) (fig. 113b) and may indicate diffuse recharge of infiltration from the Rio Puerco and other arroyos in areas where, in the past, they were not in direct contact with the water table. Water levels in the vicinity of the warm recharge temperatures form the Western Boundary and Rio Puerco zones range from 269 to 390 feet below land surface.

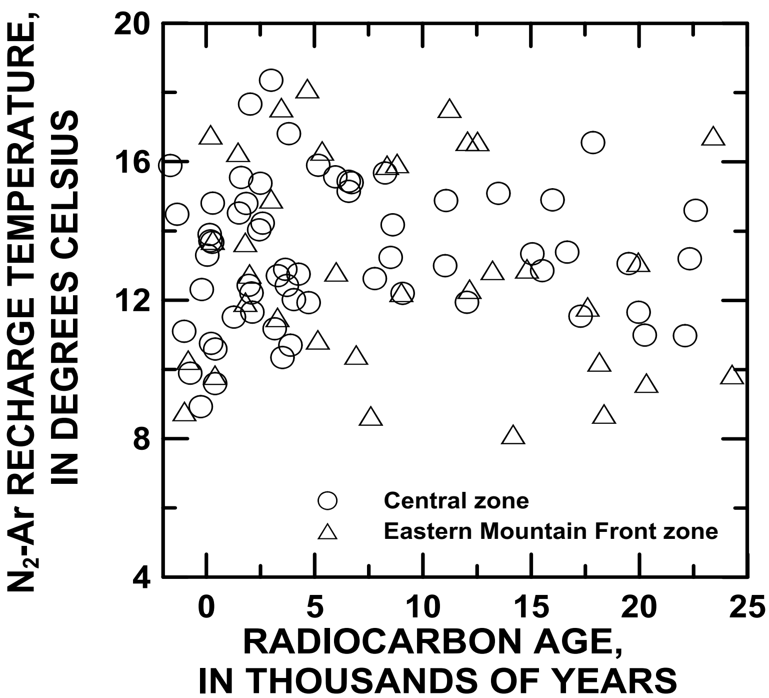



**Figure 114.** $N_2$-Ar recharge temperatures of ground water from the Central Zone and Eastern Mountain Front zone, Middle Rio Grande Basin, New Mexico, as a function of radiocarbon age.

Recharge temperatures for waters from the Eastern Mountain Front zone are compared to recharge temperatures of waters from the Central zone as a function of radiocarbon age in figure 114. As discussed above, an uncertainty of ± 1,500 feet in recharge altitude for waters from the Eastern Mountain Front zone results in uncertainties of ± 2°C in calculated recharge temperature, whereas recharge temperatures for waters of Rio Grande origin are probably reliable within the analytical precision of ± 0.5°C. Yet, the recharge temperatures for waters from the Eastern Mountain Front and the Central zone vary considerably (fig. 114). Recharge temperatures from the eastern mountain front vary from 8.1 to 18.1°C, with the minimum corresponding to the expected modern recharge temperature for recharge at about 8,000 feet. Of the measurements obtained for recharge temperature of waters from the eastern mountain front, the values average 11.4 ± 2.8, 13.9 ± 3.3, 12.9 ± 2.9, and 13.6 ± 3.0°C over the radiocarbon age intervals of 15-27 ka, 11-13 ka, 5-9 ka, and 0-5 ka B.P. Over the same radiocarbon age spans, the average of values of recharge temperature for waters from the Central zone are 12.7 ± 1.4, 13.3 ± 1.5, 14.5 ± 1.4, and 13.0 ± 2.2°C, respectively. The number of samples in each age range differ and the uncertainties represent one standard deviation of the values averaged.

Whereas recharge temperatures of waters recharged through the Eastern Mountain Front can be biased warm because of infiltration through relatively deep unsaturated zones, the waters from the Central zone probably indicate actual Rio Grande water temperatures as the surface water infiltrated the aquifer system. During the period June 1996 through March 1999, 74 monthly measurements of the temperature of Rio Grande water near Albuquerque (table B2) averaged 13.9 ± 7.6°C, which is near the modern mean annual temperature at Albuquerque of 13.6°C and within the range of the $N_2$-Ar recharge temperatures calculated for all of the paleowaters of Rio Grande origin, 12.7 ± 1.4 to 14.5 ± 1.4°C. Presently (2003), Rio Grande water temperatures are maximum in late July (modern values near 25°C) and minimum in early January (modern values near 0°C) (table B2). All values of recharge temperature for Central zone waters range from 8.9 to 18.4°C. Using the modern seasonal temperature variation of the Rio Grande and assuming that the $N_2$-Ar concentrations in Rio Grande water are in equilibrium with the atmosphere at the temperature of the air-water interface, the temperature range of 8.9

to 18.4°C corresponds to recharge occurring in the modern seasonal periods mid-March to early June, and mid-September to late November. Because the fall season usually is a period of low flow in the Rio Grande, it is more likely that the predominant season of ground-water recharge to the Central zone occurred during the spring when river discharge was probably high.

The coolest average recharge temperatures retrieved from paleo Rio Grande water samples were from the period 15-27 ka B.P., and warmest from the period 5-9 ka B.P.; however, because the standard deviations of the two groups overlap, it is only possible to conclude that the average temperature of Rio Grande water recharged to the MRGB has been nearly constant for the past 27 ka, and the average temperature over the four time periods has been within about 1°C of the modern mean annual temperature. A significant implication is that, if the average recharge temperatures of Central zone waters record long-term temporal variations in mean annual temperature near Albuquerque, the cooling of some 5°C, which occurred at higher altitudes along the basin margins during the LGM (Stute and others, 1992, 1995) is not observed in the waters recharged along the lower altitudes of the Rio Grande within the basin.

If Rio Grande water recharges predominantly during peak spring flow, the averaged recharge temperatures represent spring temperatures in the Rio Grande rather than the mean annual temperature, and, thus, cannot be compared to the present mean annual temperature at Albuquerque. Yet, the relative minimum in Rio Grande recharge temperature during the last glacial period is still only about 1°C cooler than modern Rio Grande temperatures. One possibility to explain the apparent lack of paleoclimatic variation in average Rio Grande water temperatures over the past 27 ka is that the timing of peak discharge of the Rio Grande is probably linked to seasonal temperature, coming later during cold periods and earlier when the climate is warmer. As a result, the average water temperatures of the Rio Grande during peak discharge may not have varied appreciably over the past 27 ka, as observed.

If, during the LGM, the mean annual temperature in the southwestern U.S. lowered approximately 5°C relative to the modern mean annual temperature, the observed range of recharge temperatures of paleo Rio Grande waters (8.9-18.4°C), representing the time of peak discharge in the Rio Grande, indicates that the season of peak discharge and peak infiltration of Rio Grande water to the aquifer system shifted approximately 30-60 days later into the summer, resulting in peak Rio Grande runoff from mountain snowmelt in June and July, rather than April and May as is observed today. As a result, the paleo water temperatures of the Rio Grande during peak discharge, as recorded in the dissolved $N_2$ and Ar concentrations in ground-water infiltration from the river, would appear to be nearly constant through time.

Of the two scenarios discussed earlier to explain the historical variations in stable isotopic composition of Central-zone ground water, the $N_2$-Ar recharge temperature data are consistent with the hypothesis of a seasonal shift in the timing of peak river discharge. Thus, during cool climatic periods, peak discharge and runoff of snowmelt would occur later into the summer, when river-water temperatures had warmed to the range currently observed in mid- to late-spring, and possibly overlapping with part of the summer monsoon season. The resulting dischage of the Rio Grande could contain fractions of both snowmelt and precipitation from summer thunderstorms, and, within the range of stable isotopic composition of water observed for the Rio Grande, would be relatively enriched in $^2H$. During warm climates, peak discharge and runoff of snowmelt would occur earlier in the year, such as is observed today, in advance of the summer monsoon season, and Rio Grande discharge would contain a higher fraction of mountain snowmelt, resulting in stable isotopic compositions that are relatively depleted in $^2H$. Although seasonal shift in peak discharge in response to seasonal temperature is consistent with the observed stable isotope and paleo recharge temperature variations, the possibility of historical variations in the amount of precipitation cannot be excluded. Increased delivery of low-altitude precipitation, such as from summer thunderstorms, during the pluvial that followed the LGM could also contribute to elevated $^2H$ content of paleo Rio Grande water that peaked around 15 ka B.P. (fig. 111), and decreased low-altitude precipitaition during the mid-Holocene warm period (4-8 ka B.P.) could have resulted in relatively depleted $^2H$ content of Rio Grande water. Both processes in combination probably affected the $^2H$ content of Rio Grande water, and further study of the strength and timing of the summer monsoon would improve understanding of the relative importance of changes in temperature and contribution of summer precipitation in affecting the stable isotopic composition of Rio Grande water.

Although the average temperature of paleo Rio Grande water has been nearly constant over time, there are small differences in average temperatures that may be important, particularly during the past 5 ka. Since the mid-Holocene warm period (4-8 ka B.P.), there has been a small shift in the average temperature of Rio Grande water recharged to the MRGB, being about 1.5°C cooler today than during the mid-Holocene warm period. A similar extent of cooling was suggested by the stable isotope data from the eastern mountain front waters over the past 5 ka B.P. (fig. 111).

Recharge temperatures of waters from the Eastern Mountain Front zone and the West-Central zone are shown in figure 115. As with the Eastern Mountain Front-zone waters, waters from the West-Central zone show large variations in recharge temperature. Apparently, during the last pluvial period recorded in Lake Estancia, 24 to about 12 ka B.P. (Allen and Anderson, 2000), recharge to the West-Central zone occurred both as focused recharge (and/or possibly through relatively shallow unsaturated zones), resulting in low $N_2$-Ar recharge temperatures, and as diffuse infiltration (through relatively deep unsaturated zones), resulting in warm recharge temperatures. Most samples older than about 24 ka B.P. plot in a narrow and relatively low range of recharge temperatures relative to those of radiocarbon age of about 10 to 24 ka B.P. (fig. 115). This indicates that during the last glacial maximum and during the pluvial period that followed, recharge to the West-Central zone occurred both as diffuse infiltration and as focused recharge, while during periods prior to about 24 ka B.P., recharge to the West-Central zone contained a higher fraction of focused-recharge water. Waters with radiocarbon age younger than about 8 ka were not observed in the West-Central zone.

The labels on the data points of figure 115 give the corresponding value of $\delta^2$H, in per mil, of water in the sample. Most of the samples with the lowest recharge temperatures from the West-Central zone are

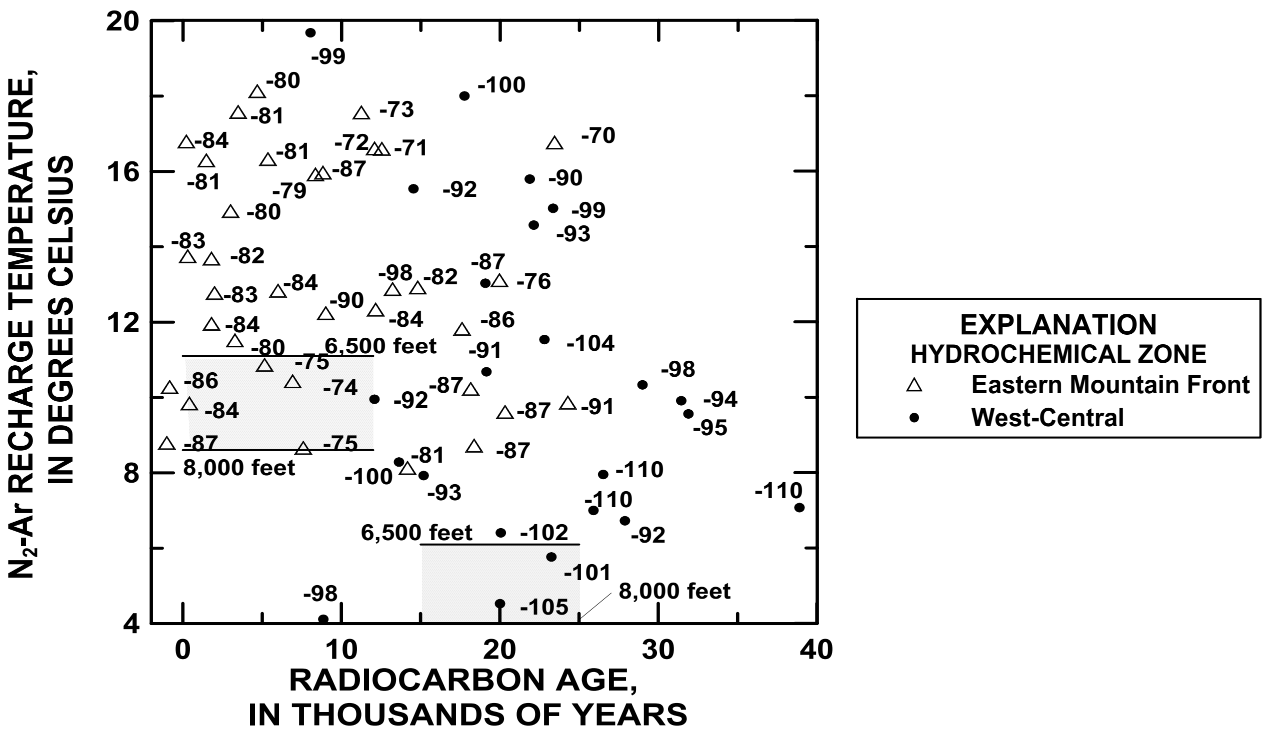



**Figure 115.** Comparison of $N_2$-Ar recharge temperatures for waters from the Eastern Mountain Front and West-Central zones as a function of radiocarbon age. The labels are values of $\delta^2$H in per mil for the water sample. An uncertainty of ± 1,500 feet in recharge altitude results in an uncertainty of ± 2 °C in recharge temperature. The shaded patterns show the modern and Last Glacial Maximum estimated mean annual temperatures for recharge at 6,500 and 8,000 feet. Most samples have recharge temperatures that are warmer than the estimated mean annual temperature.

also depleted in $^2H$, consistent with focused recharge at higher altitude. Most of the samples from the West-Central zone with warm recharge temperatures that were recharged during the last glacial period are enriched in $^2H$ relative to those with low recharge temperatures (fig. 115), consistent with diffuse recharge of precipitation falling at relatively low altitude. Using the relation describing variations in $\delta^2H$ with altitude, $\Delta\delta^2H/\Delta E$ = -2.2 per mil per 100 m altitude (Vuataz and Goff, 1986), the range in $\delta^2H$ values found for waters from the West-Central zone recharged during the last glacial period ($\delta^2H$ = -81 to -110 per mil) represents precipitation that fell over a range in altitude of approximately 1,200 m (3,900 feet). Similarly, the range in $\delta^2H$ values of waters from the West-Central zone that are older than about 24 ka B.P. (-94 to -110 per mil) could represent precipitation that fell over a range in altitude of about 730 m (2,400 feet).

Waters from the Eastern Mountain Front zone vary less in their stable isotope composition than waters from the West-Central zone, presumably because recharge altitude varies less for waters from the Eastern Mountain Front zone than for waters from the West-Central zone. Most of the waters from the Eastern Mountain Front zone have $\delta^2H$ values of about -71 to -87 per mil (fig. 115), which could represent precipitation that fell over a range of approximately 730 m (2,400 feet) in altitude. Both the West-Central and Eastern Mountain Front zones can be recharged as either focused or diffuse infiltration, resulting in a wide range of recharge temperatures recorded in dissolved $N_2$ and Ar concentrations.

## Historical Variations in Carbon-13 Isotopic Composition of Dissolved Inorganic Carbon

It was shown in the sections "Chemical and Isotopic Composition of Ground Water in the Middle Rio Grande Basin" and "Interpretation of Radiocarbon Age of Dissolved Inorganic Carbon in Ground Water" that $\delta^{13}C$ of DIC in ground water from the MRGB varies little as a function of $^{14}C$ activity of the DIC (fig. 99), except in some of the most recent waters located in mountain-front recharge areas, and in some waters from the inner valley of the Rio Grande that have been affected by oxidation of organic carbon. Having interpreted the radiocarbon age of the DIC, temporal variations in $\delta^{13}C$ of the DIC are now examined for waters specifically located along (1) the northern and eastern margins of the basin (Northern Mountain Front, Northwestern, and Eastern Mountain Front zones), (2) the West-Central zone that contains water apparently recharged along the flanks of the Jemez Mountains, and (3) the Central zone of Rio Grande origin. These zones were selected because they are least affected by possible geochemical reactions with carbonate minerals. The mineralogy is predominantly silicate, and where carbonate reactions were detected in geochemical mass-balance models using NETPATH, the reaction was usually precipitation of small amounts calcite cement accompanying dissolution of plagioclase feldspar. Because the fractionation factor between $HCO_3$ and calcite is small and the mass of calcite precipitated is small relative to the mass of $HCO_3$ in ground water, little change in $\delta^{13}C$ of DIC occurs in areas undergoing calcite cementation. The modeled geochemical reactions had almost no effect on the $\delta^{13}C$ of the initial water (table 10). Therefore, it seems reasonable to assume that the values of $\delta^{13}C$ of DIC in ground water in these parts of the MRGB are representative of $\delta^{13}C$ of the source water. The results of this study then indicate that $\delta^{13}C$ of the recharge waters to the MRGB has been remarkably constant for nearly the past 25 ka (fig. 116).

Of the 195 values of $\delta^{13}C$ with radiocarbon ages greater than 200 years shown in figure 116, $\delta^{13}C$ of DIC averages -8.2 ± 1.4 per mil. In the 16 samples from the MRGB with radiocarbon ages less than 200 years (of which 11 samples have $^{14}C$ activities greater than 100 pmC and likely contain a fraction of post-bomb water), $\delta^{13}C$ of DIC averages -11.3 ± 1.5 per mil. Nine of the 16 samples are from the Central zone and could possibly be affected by microbial degradation of organic carbon in the inner valley of the Rio Grande; however, geochemical modeling showed only small amounts of oxidation of organic carbon (table 10). The remaining seven samples include the post-bomb waters from the Northern and Eastern Mountain Front zones, and average -11.9 ± 2.0 per mil. These samples occur in remote areas where it is unlikely that they are affected by anthropogenic organic carbon sources such as seepage from septic tanks. Examples include water from Embudito and Embudo Springs in the Sandia Mountains east of Albuquerque (sites S056 and S057) with $\delta^{13}C$ values of -14.1 and -13.2 per mil, respectively; water from Domestic Well #01 in Bear Canyon northeast of Albuquerque (S007, $\delta^{13}C$ of -11.8 per mil); water from Tunnel Spring along the eastern mountain front north of Albuquerque (S256, $\delta^{13}C$ =

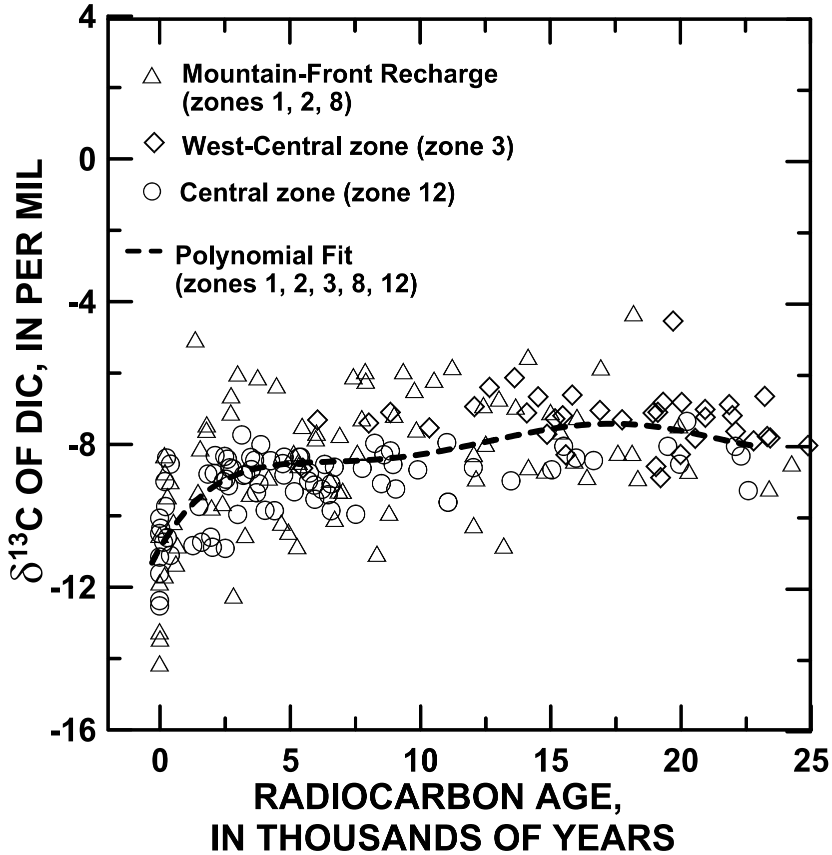



**Figure 116.** $\delta^{13}C$ isotopic composition of dissolved inorganic carbon (DIC) as a function of radiocarbon age for waters from basin margins (hydrochemical zones 1, 2, and 8), the West-Central zone (zone 3), and the Central zone (zone 12), Middle Rio Grande Basin, New Mexico. The dashed line is a 5-degree polynomial fit to the data

-11.3 per mil), and water from Windmill #42 along the northern margin of the basin (S279, $\delta^{13}C$ = -13.4 per mil). Today, and in the recent past ( perhaps as recently as only the past 200 years), $\delta^{13}C$ of DIC in recharge waters along the basin margins may have become depleted in $^{13}C$ by about 3 per mil relative to a value of about -8.2 per mil that prevailed for the previous 25,000 years. No geochemical reactions were found using NETPATH that would account for an increase of 3 per mil in $^{13}C$ between post-bomb and pre-bomb waters along the basin margins.

The recent apparent decrease in the $\delta^{13}C$ isotopic composition of DIC in recharge waters along the basin margin and in water of Rio Grande origin may indicate a fairly recent increase in the abundance of $C_3$ plants relative to $C_4$ plants in MRGB recharge areas. The timing of the onset of the decrease in $\delta^{13}C$ of DIC in recharge waters cannot be resolved precisely from the radiocarbon ages. The polynomial fit to the data of figure 116 suggests that $\delta^{13}C$ of DIC was nearly constant from about 25 ka to about 5 ka, with a decrease by about 1 per mil at 5 ka, followed by an abrupt decrease in $^{13}C$ that occurred apparently within the past 1 ka or less. The CFC-12, tritium, and $^{14}C$ data indicate that most of the shift in $\delta^{13}C$ occurred prior to the mid-1960's along the basin margins (fig.117c), in low-tritium (pre-bomb) waters (fig.117b), and may have begun within the past 200 to 1,000 years (fig.117a).

Measurements of $\delta^{13}C$ of pedogenic carbonates in southern Arizona indicate $C_4$ dominance during the last glacial period, followed by a decrease that has been attributed to a replacement of $C_4$ grasslands during the Holocene by $C_3$/CAM desert shrubs and succulents (Liu and others, 1996). Liu and others (1996) attributed the replacement to climatic factors including an increase in temperature and reduction in summer precipitation at the end of the last glacial period. The

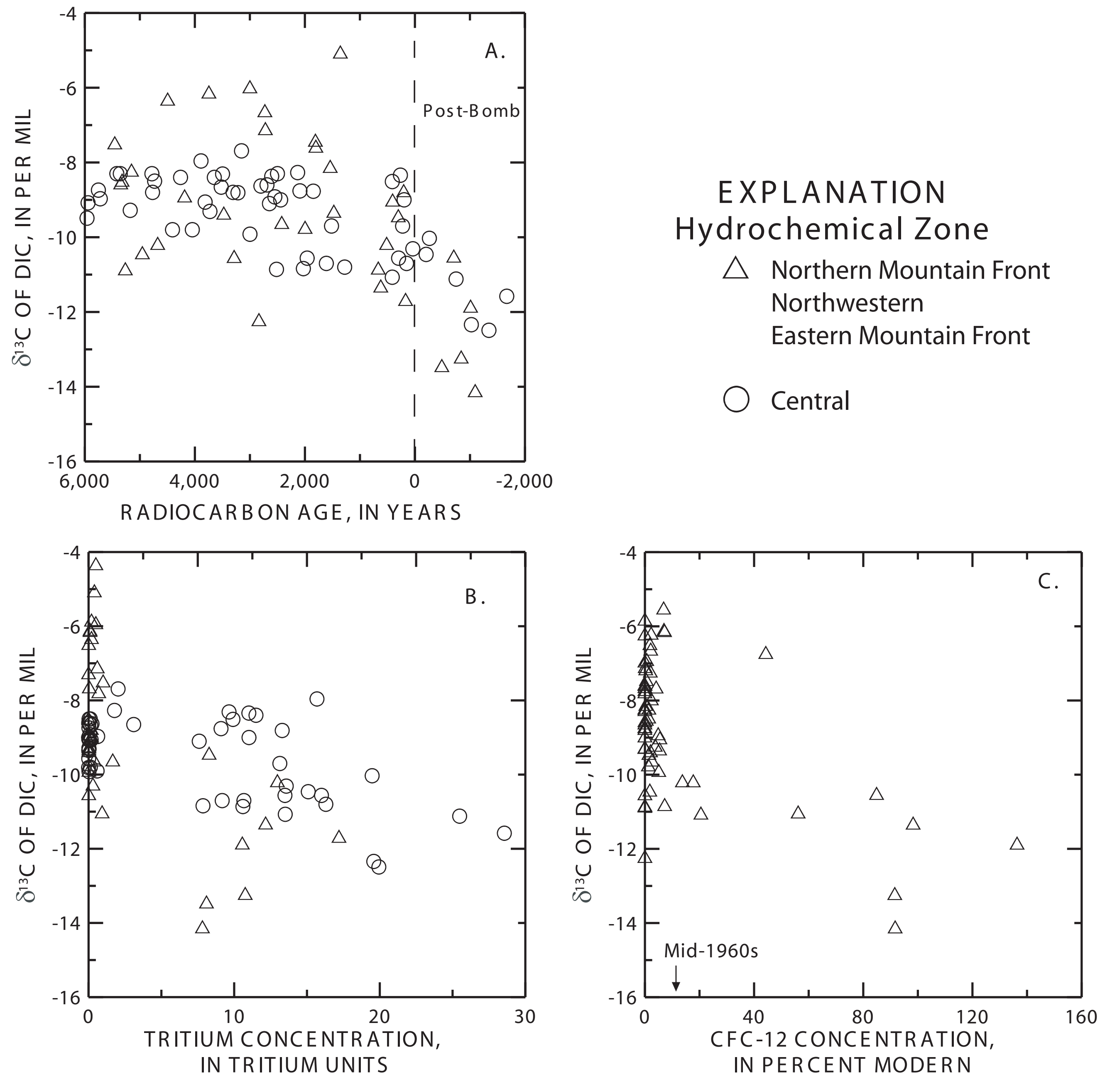



**Figure 117.** Values of $\delta^{13}C$ isotopic composition of dissolved inorganic carbon, DIC, in relatively young (post-bomb) waters of the Northern Mountain Front, Northwestern, Eastern Mountain Front and Central hydrochemical zones, Middle Rio Grande Basin, New Mexico, as a function of (A) radiocarbon age, (B) tritium concentration, and (C) CFC-12 concentration (as percent of modern).

landscape in southern Arizona was apparently dominated by $C_4$ grasslands for most of the past 700 ka (Liu and others, 1996).

The $\delta^{13}C$ values from the MRGB (-8.2 ± 1.4 per mil) are considerably more enriched in $^{13}C$ than those reported by Phillips and others (1989) for waters in the San Juan basin, in northwestern New Mexico (average $\delta^{13}C$ of -14.1 ± 3.4 per mil). From studies of $\delta^{13}C$ of herbivore tooth enamal, Connin and others (1998) found that during the last glacial period there was an increase in $C_4$ plant abundance eastward across the southwestern United States, which may, in part, account for the differences between the $\delta^{13}C$ values of the San Juan basin and MRGB. Using modern correlations between climate and $C_4$ grass abundance, Connin and others (1998) concluded that there was significant summer precipitation in parts of southern Arizona and New Mexico during the last glaciation.

The data presented here indicate that $C_4$ plant dominance prevailed in the MRGB through the last glacial period and through most of the Holocene. The increase in $C_3$ dominance in the MRGB is a relatively recent phenomena, as has been observed in southern New Mexico (Grover and Musick, 1990; Monger and others, 1998), parts of southeastern Arizona (McPherson and others, 1993), and along the Rio Grande Plains of southern Texas, where measurements of $\delta^{13}C$ and $^{14}C$ activity of soil organic carbon indicate that a shift from $C_4$ grassland to $C_3$ woodland occurred as recently as the past 50 to 100 years (Boutton and others, 1998). Apparently, a number of factors including amount and seasonality of precipitation, temperature, soil texture, and atmospheric $P_{CO2}$ can influence the relative abundances of $C_3$ and $C_4$ plants (Epstein and others, 1997; Huang and others, 2001). The processes responsible for the apparent decrease in $\delta^{13}C$ of DIC over time in the MRGB are not understood. Regardless of the processes responsible for determining the $\delta^{13}C$ of DIC recharged to the MRGB, the ground-water chemistry clearly documents recharge of DIC to the MRGB that has been relatively enriched in $^{13}C$ throughout most of the past 25 ka.

# SUMMARY OF IMPLICATIONS FROM GEOCHEMICAL AND ISOTOPIC DATA FOR THE CONCEPTUAL MODEL OF THE AQUIFER SYSTEM

The chemical and isotopic data collected for ground water in the MRGB as a result of this study have enabled evaluation and refinement of the conceptual model of the aquifer system of the basin. Specifically, the data have been used to examine the following aspects of the system: (1) the major locations of recharge to the basin, (2) the long-term historic direction of ground-water flow, and relation of that flow to the predevelopment water levels, (3) possible origins of the ground-water trough, (4) the effects of major structural and stratigraphic features of the basin on ground-water flow, and (5) implications for the mechanism of recharge and timing of paleo-environmental conditions in the basin. The radiocarbon ages and locations of the hydrochemical zone boundaries from this study also have been used to help calibrate a ground-water-flow model for the basin (Sanford and others, 2004). Modifications to the conceptual model based on geochemical data now available for the basin also have been incorporated into a recent revision of the USGS flow model (McAda and Barroll, 2002). This section summarizes some of the major implications of the geochemical and isotopic data for the conceptual model of the flow system and, where appropriate, describes how the previous conceptual model has changed as a result of this study. As was stated earlier in this report, the geochemical data used in this study were collected from wells completed in the upper few thousand feet of the Santa Fe Group aquifer system, so that the findings presented here may not all apply throughout the entire depth of the basin.

## Tracing Sources of Water Through the Basin

This study has shown that ground water of the MRGB can be grouped into zones of distinctly different chemical "signatures" that typically have well-defined boundaries. These zones enable the delineation of waters having separate recharge sources, and their extents facilitate determination of the relative importance of each recharge source. In most cases, ground water having separate recharge sources differs in both major-/minor-element chemistry and isotopic composition. In other cases, the use of isotopic data, particularly $^{2}H$, $^{18}O$, and $^{14}C$, is essential to differentiating waters of separate origin. The individual chemical and isotopic "signatures" within the basin can be associated with the observed composition of recharge water from particular sources, or with the expected composition based on the geology and physiography of a potential recharge area. This study has demonstrated that, because the sediments of the Santa Fe Group aquifer system are relatively unreactive, the chemical composition of ground water in the basin generally changes little along a flow path. This consistency in composition allows source-water associations to be traced over long distances through the aquifer system.

The distribution and extent of the 13 hydrochemical zones defined for the MRGB (the chemical and isotopic "signatures" of which have been discussed in the section "Tracing Sources of Water in the Middle Rio Grande Basin-- Definition of Hydrochemical Zones and Water sources") indicate the presence of multiple sources of recharge to the aquifer system of the basin. Mountain-front recharge sources appear to dominate over large areas of the basin, particularly along the northern and eastern margins of the basin, as well as in the southwestern corner. Mountain-front recharge was previously known to be important along the Sandia, Manzanita, and Manzano Mountains of the eastern basin margin (Kernodle and others, 1995). Mountain-front recharge was also suspected to contribute water to the aquifer system along the Ladron Mountains in the southwest (Kernodle and Scott, 1986), but no previous studies presented direct evidence of the importance of this source. The importance of mountain-front recharge water as opposed to ground-water inflow along the Jemez Mountains in the north also does not appear to have been well characterized previously. Although mountain-front recharge appears to occur along the entire northern boundary of the basin that is bordered by the Jemez Mountains, the chemical composition of recharge water along the boundary is not uniform, which indicates that the recharge mechanisms and/or characteristics of the flow paths may vary. In particular, water of the West-Central zone, which originates in the western part of the Jemez Mountains and extends southward through most of the length of the basin (fig. 78), differs considerably in chemical and isotopic composition from water recharging in the eastern part of the mountains. Most water of the West-Central zone may actually enter the basin as underflow even though the water apparently originated at high altitude, as indicated by $^{2}H$ and $^{18}O$. This water may have infiltrated in the area of the Valles Caldera and migrated to a substantial depth before reaching the basin.

Another important source of recharge to the aquifer system of the MRGB, particularly in the area of Albuquerque, is infiltration from the Rio Grande. This study has helped to define both the extent and age of water sourced at the river. The $^{2}H$ and $^{18}O$ compositions of ground water have been particularly useful in delineating the river's area of influence, as indicated by the boundaries of the Central zone, which has been shown to extend from about San Felipe on the north to near Abo Arroyo on the south (fig. 78). Ground water of the Central zone extends 2 to 3 miles beyond the flood plain of the Rio Grande—particularly to the east—and has been identified at substantial depth (on the order of 2,000 feet). This study indicates that water has been entering the aquifer system from the Rio Grande for tens of thousands of years and has historically flowed primarily north to south under the Albuquerque area (figs. 64, 74, and 78). Therefore, movement of infiltration from the Rio Grande beyond the flood plain has not occurred primarily as the result of water-level declines associated with intense pumping of ground water for municipal supply. The long-term contribution of this source of recharge to a large part of the central area of the basin is probably of greater magnitude than previously thought.

This study has confirmed that infiltration from ephemeral streams can be an important source of recharge in some areas of the MRGB. In particular, recharge from the Rio Puerco appears to be one of the primary sources of water to the aquifer system in the western part of the basin. The chemical and isotopic composition of ground water associated with the Rio Puerco can be identified across a large area extending both east and west of the present stream channel. Such a large area of influence does not appear to have been previously recognized, and may result partly from a lack of other substantial recharge sources in the western part of the basin. Similarly, infiltration through Abo Arroyo has been shown to have a large area of influence in the southeastern part of the basin. Ground water that has infiltrated from Tijeras Arroyo also can be identified by its chemical and isotopic composition, but has extended over only a fairly limited area compared to infiltration from the Rio Puerco and Abo Arroyo, possibly because of a high quantity of mountain-front recharge in the area. Infiltration from the Jemez River appears to be limited primarily to a relatively narrow and shallow area located directly along the river, which differs from the previous assumption that the Jemez River is an important source of recharge to the aquifer system in the northern part of the basin (Kernodle and others, 1995).

The underflow of ground water from adjacent basins has been confirmed to contribute water to the aquifer system of the MRGB along its western margin, as well as in limited areas of the eastern margin. Ground water from Paleozoic and Mesozoic rocks to the west appears to leak into the basin and mix with a greater quantity of water that infiltrates locally, possibly from ephemeral streams. Ground water also leaks into the northeastern part of the MRGB from the Mesozoic rocks of the Hagan Basin. The area that shows evidence of this underflow is not extensive, which indicates that the quantity of ground water entering the MRGB from the Hagan Basin probably is relatively small. In the area of the Tijeras Fault Zone, mineralized water associated with the fault system appears to leak into the basin. This water then mixes with local mountain-front recharge over a fairly broad area, and perhaps migrates to depth below the more plentiful and more dilute mountain-front water. Overall, the results of this study have shown that the quantity of underflow entering the MRGB along the western and eastern margins is probably less than previously determined (Kernodle and others, 1995). However, as mentioned above, underflow from the area of the Jemez Mountains may contribute a substantial quantity of recharge to the basin.

## Direction of Ground-Water Flow

Both conservative geochemical tracers and boundaries between hydrochemical zones indicate that ground-water flow in the MRGB has historically been directed primarily north-south through the center of the basin, with a greater east-west component near the basin margins. As discussed in the section "Chemical and Isotopic Composition of Ground Water in the Middle Rio Grande Basin", values of specific conductance, Cl, and the stable isotopes of water indicate that the dominant component of ground-water flow in the basin is from north to south. Similarly, the orientations of the Central, West-Central, and Rio Puerco hydrochemical zones in particular demonstrate the importance of north-south flow (fig. 78).

Although predevelopment hydraulic head maps for the MRGB (Titus, 1961; Bjorklund and Maxwell, 1961; Bexfield and Anderholm, 2000) are broadly consistent with the primary direction of ground-water flow indicated by geochemical data, there are some apparent inconsistencies. In particular, predevelopment hydraulic heads indicate greater east-west components of flow through the center of the basin than is indicated by the orientation of the hydrochemical zones. The differences in flow direction indicated by hydraulic heads and geochemical tracers likely are associated with the different time horizons and depths represented by the two types of information.

Carbon-14 data from this study of the MRGB indicate that most ground water resides in the aquifer system for thousands to tens of thousands of years. Therefore, the hydrochemical zones defined on the basis of current ground-water chemistry in the basin probably reflect aquifer-system conditions (including ground-water-flow directions) present on the order of thousands of years into the past, and may not yet reflect the current hydraulic-head distribution. In addition, predevelopment hydraulic-head maps for the basin were based on conditions primarily in the shallow part of the aquifer system (to a depth of at most a few hundred feet), whereas geochemical data were collected from wells reaching greater depths, where ground-water flow directions may differ.

As a result of this study, the conceptual model of how ground water moves through the aquifer system of the MRGB has been refined. The geochemical data indicate that ground water in the Albuquerque area has not flowed almost directly west from the eastern mountain front to the inner valley of the Rio Grande, as previously reported (Kernodle and Scott, 1986). Instead, the water chemistry beneath Albuquerque indicates that ground water flows mostly north to south through the city area, and this flow has occurred over at least the past 20,000 years. The rather distinct boundary between water sourced from the Rio Grande and mountain-front recharge water to the east (as most clearly indicated by a substantial difference in $^{2}H$ and $^{18}O$ across a short distance, 1 to 2 miles) indicates that similar flow conditions prevailed in the area for many thousands of years, relatively unaffected by dispersion or mixing. However, recharge from the Rio Grande does not appear to have moved a substantial distance toward the ground-water trough that is shown by hydraulic-head maps present in the western part of the basin. Previous conceptual models assumed that much of the ground water in the area of the trough was sourced at the river (Yapp, 1985; Logan, 1990), or possibly even the mountain front (Logan, 1990).

## Origin of the Ground-Water Trough

The predevelopment hydraulic-head maps of Meeks (1949), Titus (1961), Bjorklund and Maxwell (1961), and Bexfield and Anderholm (2000) have all indicated the presence of a ground-water trough in the western part of the MRGB, extending from near the Jemez River on the north to Belen on the south, and from a series of major faults on the west to near the Rio Grande on the east (fig. 9). Water levels in the trough can be as much as 50 feet lower than the level of the Rio Grande directly to the east. Geochemical data from this study show that ground water flowing along the axis of the trough occurs within the West-Central hydrochemical zone and likely originated in the area of the Jemez Mountains during the last glacial period. Although hydraulic heads indicate that water sourced both at the western margin of the basin and at the Rio Grande should be flowing into the trough, the geochemical data indicate that this flow has not occurred. The lack of evidence that these waters have reached the axis of the trough appears to contradict one conceptual model that the trough is present primarily as the result of a large thickness of permeable materials near its axis as compared to along its flanks (though still quite impermeable compared with other parts of the basin) (Kernodle and others, 1995). Such a configuration would cause the area to act as a sort of "drain" for the aquifer system in the western part of the basin. Recent geohydrologic data for the area do not support this conclusion (Hawley, 1996).

One possible explanation for the presence of the trough that would be consistent with the observed geochemical data is that the trough is a transient feature of the aquifer system in the MRGB. As mentioned above, changes with time in the quantity and distribution of recharge around the basin could result in a change in the distribution of hydraulic head. If the trough developed relatively recently as a result of such changes, water sourced at the western margin of the basin and at the Rio Grande may not yet have moved into the trough area. Radiocarbon ages of waters sourced from the western margin that are located today just west of the trough, and Rio Grande waters just east of the trough, are approximately 10 ka. Waters younger than 10 ka are observed farther to the west and east toward the Rio Puerco and Rio Grande sources, respectively. This suggests that water has been flowing toward the trough from the Rio Puerco and Rio Grande since the beginning of the Holocene. Using a ground-water-flow model for the MRGB, Sanford and others (2001) found that the trough could be simulated merely by lowering the quantities of recharge from certain known sources of water to the basin.

Another factor that could contribute to the presence of the trough could be the existence of features that limit ground-water flow into the trough from the east and west. Such features could include major faults that are relatively impermeable or low-conductivity geologic strata. Most major faults within the MRGB trend north to south; therefore, cementation of any of several major faults could be consistent with the restriction of east-west ground-water flow. Also, the presence of a dipping geologic layer of low permeability could retard east-west flow. For example, Connell and others (1998) have shown that the fine-grained Atrisco Member of the Arroyo Ojito Formation dips downward from west to east beneath the Albuquerque area. This layer could restrict flow of infiltration from the Rio Grande westward toward the trough. The same or a similar layer of low-permeability material might possibly also restrict the eastward flow of water infiltrating through the Rio Puerco. Further research would be necessary to conclude whether these types of restrictions are present in such a configuration that would contribute to the presence of the trough. Such restrictions would act only to limit flow toward the trough and not to prevent it entirely. Therefore, even if flow restrictions are important, the absence of water sourced from the Rio Grande and from the western margin near the axis of trough indicates that the trough is likely a transient rather than a long-term feature.

## Ground-Water Flow in Relation to Faults and Other Structural Features

Because ground-water chemistry in the MRGB enables delineation both of waters from particular recharge sources and of ground-water-flow directions, chemistry can be used to investigate the possible effects of faults on regional ground-water flow in the basin. In particular, correspondence of a boundary between hydrochemical zones with the location of a fault could be an indication that horizontal ground-water flow is restricted across that fault. Flow across a fault can be restricted by reduced permeability and hydraulic conductivity in the fault zone resulting from cementation and/or sediment deformation, or by the juxtaposition of relatively high-conductivity aquifer materials on the upgradient side of the fault against relatively low-conductivity materials on the downgradient side. Alternatively, correspondence of a chemical boundary with a fault could indicate that recharge rates and hydraulic properties of the aquifer materials differ substantially on either side of the fault. For example, if recharge rates and hydraulic conductivity are much greater on one side of the fault than the other, the quantity of water from the low-recharge source that can mix with water from the high-recharge source will be relatively small and will probably have little effect on the water chemistry on the high-conductivity, high-recharge side of the fault (fig.118). Where either horizontal flow across a fault is restricted, or recharge rates and hydraulic conductivity differ greatly on either side of a fault, a hydraulic discontinuity may result, as would be indicated by a substantial difference in water-level altitudes across the fault (fig.118).

In the MRGB, a few boundaries between hydrochemical zones appear to correspond fairly closely in places with “major” faults identified by Mark Hudson and Scott Minor (U.S. Geological Survey, written commun., 1999). Such regional differences in ground-water chemistry in the vicinity of faults, indicating possible effects of faults on ground-water flow, do not appear to have been previously identified in the basin. Two examples are the boundary between the Rio Puerco and West-Central zones and the boundary between the Tijeras Fault Zone and Eastern Mountain Front zones. In the northern half of the basin, the boundary between the Rio Puerco and West-Central zones corresponds fairly well in places with the Tenorio and Sand Hill faults identified by Kelley (1977). The boundary between the Tijeras Fault Zone and Eastern Mountain Front zones corresponds fairly well in places with the Tijeras and Colorada faults, also identified by Kelley (1977). In the areas of both the Tenorio/Sand Hill faults and the Tijeras/Colorada faults, the predevelopment water-level map of Bexfield and Anderholm (2000) shows the occurrence of hydraulic discontinuities that indicate the likely effects of these faults on ground-water flow.

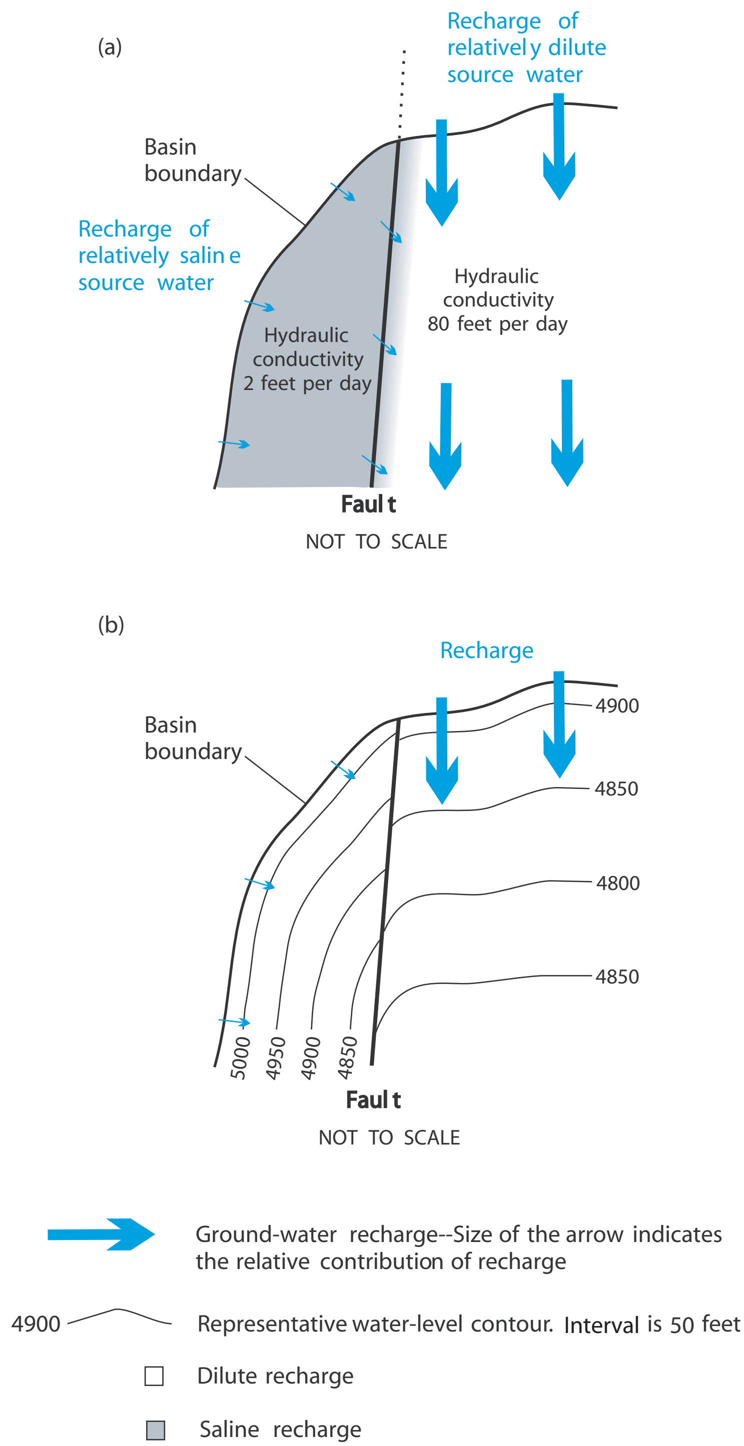



**Figure 118.** Schematic diagrams of (a) representative change in water chemistry across a fault in the Middle Rio Grande Basin, New Mexico, with greater recharge rates and hydraulic conductivity on one side of the fault relative to the other, and (b) representative discontinuity in the water levels across the fault.

The general correspondence of differences in ground-water chemistry with particular fault locations may indicate that horizontal ground-water flow is restricted across those faults—flow being primarily from west to east in the case of the Tenorio/Sand Hill faults, and from east to west in the case of the Tijeras/Colorada faults. The area surrounding the Sand Hill fault has been shown to include a zone of deformation that might reduce horizontal flow across the fault (Rawlings and Goodwin, 2001); also, the Sand Hill fault zone has been shown to be preferentially cemented by calcite (Mozley and Goodwin, 1995; Heynekamp and others, 1999). The Tijeras/Colorada faults offset different geologic units by hundreds to thousands of feet, and a contrast in hydraulic properties between the juxtaposed units (as opposed to cementation or deformation in the fault zone) could be the primary explanation for any restriction to horizontal ground-water flow in the area of these faults. However, in the case of both the Tenorio/Sand Hill faults and the Tijeras/Colorada faults, the aquifer materials on the downgradient side of the fault zone are much thicker and more conductive than materials on the upgradient side. Also, in both cases, recharge to the hydrochemical zone on the downgradient side (the West-Central zone or Eastern Mountain Front zone) is believed to be much greater than recharge to the zone on the upgradient side (the Rio Puerco zone or Tijeras Fault Zone zone). Therefore, the chemical differences observed across the faults at the boundaries between the hydrochemical zones could result from mixing of a relatively small quantity of water from the upgradient zone with a much higher quantity of water from the downgradient zone (as described earlier in this section).

Whereas differences in ground-water chemistry appear across sections of the “major” faults mentioned above, differences in chemistry are not evident in other areas where important—even basin-bounding—faults are present. For example, the water-level map of Bexfield and Anderholm (2000) indicates the presence of a hydraulic discontinuity along the Sandia fault adjacent to the front of the Sandia Mountains. However, the data available in the area from this study indicate that the distinct chemical boundary between water sourced from the Rio Grande and water sourced along the eastern mountain front occurs several miles west of the Sandia fault and is apparently unrelated to the location of the fault. The data do not show a difference in ground-water chemistry across the fault itself, indicating that ground-water flow is not restricted across the fault. The hydraulic discontinuity in this area is probably the result of the large saturated thickness of conductive materials on the west side of the fault relative to the small saturated thickness of materials of similar hydraulic conductivity on the east side of the fault. This configuration results in a much greater transmissivity and a correspondingly flatter hydraulic gradient on the west side of the fault. Therefore, not all “major” faults in the basin appear to have characteristics that appreciably limit ground-water flow across them. Similarly, there appears to be little indication from either chemistry or water levels indicating that “minor” faults with small offset of similar sediments substantially limit horizontal ground-water flow, at least on a regional scale.

As discussed in earlier sections, the geochemical data from this study have provided new information that the presence of major faults may actually enhance or cause vertical ground-water flow in some areas of the MRGB. Elevated water temperatures and Cl and As concentrations, in particular, usually are in close proximity to “major” faults in the basin, especially at locations in the northern part of the basin, the northeastern part of Albuquerque, and the southeastern part of the basin. These elevated concentrations appear to be indicative of ground water from a deep source that is moving upward to mix with water at shallower depths of the aquifer system. The association of these elevated concentrations with the locations of faults indicates that vertical movement of ground water could be enhanced in fault zones by increased vertical conductivity resulting from deformation. Elevated Cl and As concentrations also are common in the vicinity of the structural highs located near the northern and southern extents of Albuquerque that separate the subbasins within the MRGB, as well as near the structural high/constriction that separates the MRGB from the Socorro Basin to the south. The thinning of Santa Fe Group deposits (which are relatively conductive compared to basement rocks) across structural highs could result in upward movement of ground water, both along faults that bound these highs and within the entire aquifer system. Ground water would tend to move to shallower depths of the aquifer system across structural highs in order to maintain flow within the more conductive sediments. Upward movement of ground water along faults and near structural highs/constrictions was not previously a part of the conceptual model for the basin.

## Stratigraphic Controls on Ground-Water Flow

The geochemical data collected for this study indicate that stratigraphy may be important in controlling ground-water flow in some areas of the basin. Several deep piezometer nests show substantial variability in ground-water chemistry (including ground-water age) with depth. In some cases, water from different depths in the same piezometer nest belong to different hydrochemical zones, and, therefore, have different recharge sources and flow paths. Such variability indicates a lack of vertical mixing in some areas of the aquifer system, which could be the result of anisotropy and/or differences in hydraulic properties of aquifer materials with depth. Therefore, evidence from this study suggests that stratigraphic controls may act to substantially limit vertical ground-water movement on a regional scale in the basin. However, as mentioned in the previous section on ground-water flow related to faults, it also appears that stratigraphy/structure may actually enhance vertical ground-water movement in areas where structural highs cause relatively impermeable materials to be present closer to the land surface and/or in areas where major faults are present.

As mentioned above in relation to the ground-water trough west of Albuquerque, extensive layers of particularly fine-grained material may affect not only the vertical, but also the horizontal direction of ground-water flow in the MRGB on a regional scale. For example, because the fine-grained Atrisco Member dips to the east across the center of the basin and is present at depth below more conductive materials, it could limit both downward and westward movement of water sourced at the Rio Grande. Similarly, extensive coarse-grained layers also may affect ground-water flow. For example, in the vicinity of Albuquerque, Hawley and Haase (1992) identified the presence of a thick section of north-south trending coarse-grained ancestral Rio Grande deposits extending several miles east from the Rio Grande. Ground-water chemistry data and analysis from this study indicate that water sourced at the Rio Grande has historically flowed primarily north to south through this general area, which may be largely attributed to the presence of these high-conductivity sediments.

## Source, Mechanism, and Timing of Recharge to the Middle Rio Grande Basin

The stable isotope data, in conjunction with the dissolved gas recharge temperatures and radiocarbon ages, have been useful in interpretation of source, mechanism and timing of recharge to the aquifer system. Recharge temperatures calculated from measured concentrations of dissolved $N_2$ and Ar vary widely throughout the MRGB. The minimum in the calculated $N_2$-Ar recharge temperatures for a particular hydrochemical zone appears to be near the mean annual temperature for the assumed recharge area for that zone, and the maximum recharge temperature approaches that of ground water beneath the relatively deep unsaturated zones. Apparently, the dissolved gas recharge temperatures demonstrate cases of both focused (cold recharge temperatures) and diffuse flow (warm recharge temperatures) recharge mechanisms in semiarid regions such as the MRGB.

Some interesting patterns in paleo-recharge temperatures emerge when the recharge temperatures are examined spatially in the MRGB. Relatively warm recharge temperatures are found for most waters recharged along the northern margin of the basin (western parts of the Northern Mountain Front zone and throughout the Northwestern zone), indicating recharge primarily by diffuse infiltration through relatively deep and warm unsaturated zones. Waters from the northeast part of the Northern Mountain Front zone have cold recharge temperatures indicative of relatively shallow and/or focused recharge. Many of the waters from the West-Central zone have cold recharge temperatures, as cold as the expected 3-4$^{o}$C for waters recharged at 8,000 feet along the flanks of the Jemez Mountains during the LGM. The waters from the West-Central zone with cold recharge temperatures were found beneath Northwestern zone waters in the northern part of the basin and traced south throughout the basin along the eastern-most half of the West-Central zone. Waters with relatively warm recharge temperatures also were measured in the West-Central zone and can be traced along the western-most half of the West-Central zone. The axis of the ground-water trough approximately divides West-Central zone waters with warm recharge temperatures (on the west side of the trough) from West-Central zone waters with cold recharge temperatures (on the east side of the trough).

During the last glacial period, water recharged to the West-Central zone varied widely in stable isotope composition and recharge temperature, indicating both diffuse and focused recharge of low- and high-altitude precipitation. The range in $\delta^2H$ of West-Central zone waters from the LGM suggests recharge that occurred over a 4,000-foot range in altitude.

Ground water in the Central zone was recharged by direct infiltration from the Rio Grande, and apparently records surface-water temperature at the time of recharge. The indication from the dissolved $N_2$-Ar data is that the long-term average temperature of the Rio Grande that infiltrated into the Central zone varied only ± 1°C from the modern mean annual temperature at Albuquerque over the past 27 ka, even though the regional mean annual temperature was likely some 5°C colder during the LGM than today. The stable isotope composition of paleo Rio Grande water was relatively depleted in $^2H$ during the mid-Holocene warm period and relatively enriched in $^2H$ in the pluvial following the LGM. These observations may indicate that during the past, the timing of the spring runoff of northern New Mexico and southern Colorado snowmelt varied, coming late into early- to mid-summer during cold periods and overlapping, in part, with the summer monsoon season (currently July-October). During warm periods, such as modern times, the peak discharge of the Rio Grande occurred in mid- to late-spring, in advance of the summer monsoon season. These observations indicate that the Central zone is recharged primarily during the season of peak runoff of mountain snowmelt and that the season of peak runoff has shifted by as much as 2 months between the LGM and modern times.

During the last 5 ka, the $\delta^2H$ isotopic composition of Eastern Mountain Front recharge has decreased about 7 per mil, suggesting an average cooling of about 1.4°C following the mid-Holocene warm period. Over the same time span, the $\delta^2H$ isotopic composition of Rio Grande water has increased approximately 6 per mil, consistent with a shift in the season of peak snowmelt into the beginnings of the summer monsoon season.

# SUMMARY

A large number of measurements of the chemical and isotopic composition of ground water and surface water were used to refine the conceptual model of ground-water flow in about the upper 2,000 feet of the Santa Fe Group aquifer system of the MRGB, and improve understanding of the water resources of the basin, as discussed in the previous section of this report. The extensive regional coverage, supplemented with data from the USGS National Water Information System and City of Albuquerque water-quality database, permitted definition and mapping of the spatial extents of 12 regional sources of water to the MRGB, and estimation of radiocarbon ages.

The chemical and isotopic analyses indicate that the composition of most ground water in the basin changed little after recharge, and can be traced over large distances (tens of miles) through the primarily siliciclastic sediment of the aquifer system. Radiocarbon ages adjusted for geochemical reactions in the aquifer system are nearly identical to the unadjusted radiocarbon ages and range from less than 1 ka to more than 30 ka.

Predominant sources of water to the basin include (1) recharge from mountains along the northern, eastern and southwestern basin margins (median age 5-9 ka); (2) seepage from the Rio Grande and Rio Puerco (median age 4-8 ka), and from Abo and Tijeras Arroyos (median age 3-9 ka); (3) inflow of saline water along the southwestern basin margin (median age 20.4 ka); and (4) inflow along the northern basin margin (median age 19.9 ka) that probably represents recharge from the Jemez Mountains during the last glacial period.

Piezometer nests provided critical information on variations in chemical and isotopic composition with depth to nearly 1,500 feet below the water table, particularly in the vicinity of Albuquerque. In some cases, the data from piezometers and other wells permitted characterization of the three-dimensional aspects of water composition. For example, the data indicate that paleowater (approximately 20 ka), present at the water table through the west-central part of the basin, extends beneath more recent mountain-front recharge in northern parts of the basin, and beneath water of Rio Grande origin under western parts of Albuquerque.

Age gradients from all available piezometer nests ranged from 0.1 to 2 yr $cm^{-1}$. Age gradients from two piezometer nests indicate "modern" (past few thousand years) recharge rates of approximately 3 cm $yr^{-1}$ for infiltration from the Rio Grande at Albuquerque and recharge along the eastern mountain front at Albuquerque. Historically, there have been higher amounts of recharge to the Eastern Mountain Front zone at Albuquerque than to vicinities either north or south of Albuquerque along the eastern mountain front.

Chlorofluorocarbon and/or tritium concentrations were measured in water samples at all wells where $^{14}C$ samples were taken. These measurements permitted identification of samples that might be contaminated with nuclear bomb-era $^{14}C$ or drilling fluid, and that might consequently have a young bias in radiocarbon age. Gradients in $^{14}C$ activity of dissolved inorganic carbon with depth were determined from the piezometer nests and used to estimate uncertainty in radiocarbon age in mixtures of ground water pumped from wells that are open to hundreds of feet of the aquifer system.

Detailed study of the $^{2}H$ and $^{18}O$ isotopic composition of source waters to the basin helped to delineate flow directions and boundaries between water sources. The stable isotope data for ground water in the vicinity of Albuquerque indicate little movement of ground water in response to withdrawals from production wells during the past 20 years, even though, in places, the modern water table has fallen as much as 140 feet below the predevelopment potentiometric surface. Small shifts over the past 20 years in stable isotope composition of water discharged from public supply wells along the boundaries between the West-Central zone (paleowater) and Central zone (Rio Grande water) west of the Rio Grande, and along the boundary between the Central zone and Eastern Mountain Front zone east of the Rio Grande, indicate local areas where paleowater of Rio Grande origin likely is beginning to spread west and east in response to ground-water pumping in the vicinity of Albuquerque.

The geochemical data show that ground water flowing along the axis of a ground-water trough in the western part of the MRGB, extending from near the Jemez River on the north to Belen on the south, and from a series of major faults on the west to near the Rio Grande on the east, originated in the area of the Jemez Mountains during the last glacial period. Although hydraulic heads indicate that water sourced both at the western margin of the basin and at the Rio Grande

should be flowing into the trough, the geochemical data indicate that this flow has not occurred. The absence of water sourced from the Rio Grande and from the western margin near the axis of ground-water trough indicates that the trough is probably a transient rather than a long-term feature of the aquifer system.

Over the past 5 ka, the isotopic composition of water recharged along the eastern mountain front has become depleted in $^{2}H$ by about 7 per mil, consistent with an average cooling of about 1.4°C. Over the same period, $\delta^{2}H$ of ground water recharged from the Rio Grande increased by nearly 6 per mil from a minimum near –98 per mil. Seasonal shifts in the timing of peak discharge and/or historical changes in the amounts of low-altitude precipitation along the basin margins may account for the long-term trends in the stable isotopic composition of Rio Grande water. The $\delta^{2}H$ of water recharged from the Rio Grande to the Central ground-water zone (ground water of Rio Grande origin) was low at approximately 5 ka B.P., a maximum at about 15 ka B.P., and a minimum at about 22 ka B.P.

The recharge temperatures calculated from dissolved $N_2$ and Ar concentrations in paleowater recharged from the Rio Grande indicate that the long-term average water temperature at the time of predominant infiltration was nearly constant for the past 27 ka, and within about ±1°C of the modern mean annual temperature. This observation is consistent with seasonal shifts in the timing of peak discharge on the river. Where infiltration occurs through deep (greater than 300 feet deep) unsaturated zones, the dissolved-gas recharge temperatures are biased warm by as much as 10°C relative to the mean annual temperature (13.6°C at Albuquerque).

The $\delta^{13}C$ isotopic composition of dissolved inorganic carbon in ground water is remarkably constant throughout most of the basin, indicating a nearly constant historical predominance of $C_4$ over $C_3$ plants in recharge areas for the aquifer system, and little effect of geochemical reactions on radiocarbon age. However, during the past 1 ka, or perhaps even more recently, the $\delta^{13}C$ isotopic composition of dissolved inorganic carbon of water recharged along the basin margins and at the Rio Grande has become depleted in $^{13}C$. This $^{13}C$ depletion could indicate a recent increase in $C_3$ plant abundance relative to $C_4$ plants, as has been observed in other parts of the southwest U.S.

Extensive chemical and isotopic datasets, such as obtained for the MRGB during this and previous studies, are uncommon in the hydrologic sciences. This study demonstrates the benefits of obtaining a diverse and extensive chemical and isotopic dataset when characterizing hydrochemical processes in ground-water systems, retrieving historical environmental information from ground water, and/or refining conceptual models of ground-water systems.

## REFERENCES


Adams, A.I., Goff, F., and Counce, D., 1995, Chemical and isotopic variations of precipitation in the Los Alamos Region, New Mexico: Los Alamos National Laboratory, Report LA-12895-MS, Los Alamos, NM, 35p.

Allen, B.D., and Anderson, R.Y., 2000, A continuous, high-resolution record of late Pleistocene climate variability from the Estancia basin, New Mexico: Geological Society of America Bulletin, v. 112, no. 9, p. 1444-1458.

Anderholm, S.K., 1985, Clay-size fraction and powdered whole-rock X-ray analyses of alluvial-basin deposits in central and southern New Mexico: U.S. Geological Survey Open-File Report 85-173, 18 p.

----- 1988, Ground-water geochemistry of the Albuquerque-Belen Basin, Central New Mexico: U.S. Geological Survey Water-Resources Investigations Report 86-4094, 110 p.

----- 1994, Ground-water recharge near Santa Fe, north-central New Mexico: U.S. Geological Survey Water-Resources Investigations Report 94-4078, 68 p.

---- 1997, Water-quality assessment of the Rio Grande valley, Colorado, New Mexico, and Texas— Shallow ground-water quality and land use in the Albuquerque area, central New Mexico, 1993: U.S. Geological Survey Water-Resources Investigations Report 97-4067, 73 p.

----- 2001, Mountain-front recharge along the east side of the Albuquerque Basin, Central New Mexico (revised): U.S. Geological Survey Water-Resources Investigations Report 00-4010, 36 p.

Bard, E., Arnold, M., Fairbanks, R.G., and Hamelin, B., 1993, $^{230}$Th-$^{234}$U and $^{14}$C ages obtained by mass spectrometry on corals: Radiocarbon, v. 35, p. 191-199.

Bard, E., Arnold, M., Hamelin, B., Tisnerat-Laborde, N., and Cabioch, G., 1998, Radiocarbon calibration by means of mass spectrometric $^{230}$Th/$^{234}$U and $^{14}$C ages of corals: An updated database including samples from Barbados, Mururoa and Tahiti: Radiocarbon, v. 40, no. 3, p. 1085-1092.

Bard, E., Hamelin, B., Fairbanks, R., and Zindler, A., 1990, Calibration of the $^{14}$C timescale over the past 30,000 yr using mass spectrometric U-Th ages from Barbados corals: Nature, v. 345, p. 405-410.

Bard, Edouard, 2001, Extending the calibrated radiocarbon record: Science, v. 292, p. 2443-2444.

Bartlein, P.J., Edwards, M.E., Shafer, S.L., and Barker, E.D., Jr., 1995, Calibration of radiocarbon ages and the interpretation of paleoenvironmental records: Quarternary Research, v. 44, p. 417-424.

Bartolino, J.R., and Cole, J.C., 2002, Ground-water resources of the Middle Rio Grande Basin, New Mexico: U.S. Geological Survey Circular 1222, 132 p.

Bartolino, J.R., and Niswonger, R.G., 1999, Numerical simulation of vertical ground-water flux of the Rio Grande from ground-water temperature profiles, central New Mexico: U.S. Geological Survey Water-Resources Investigations Report 99-4212, 34 p.

Bayer, R., Schlosser, P., Bönisch, G., Rupp, H., Zaucker, F., and Zimmek, G., 1989, Performance and blank components of a mass spectrometric system for routine measurement of helium isotopes and tritium by the $^{3}$He in-growth method: Sitzungsberichte der Heidelberger Akademie der Wissenschaften, Mathematisch-naturwissenschaftliche Klasse, Jahrgang 1989, 5. Abhandlung, Springer-Verlag, 42 p.

Beck, J.W., Richards, D.A., Edwards, R.L., Silverman, B.W., Smart, P.L., Donahue, D.J., Hererra-Osterheld, S., Burr, G.S., Calsoyas, L. Jull, A.J.T., and Biddulph, D., 2001, Extremely large variations of atmospheric $^{14}$C concentration during the last glacial period: Science, v. 292, p. 2453-2458.

Benson, L.V., Currey, D.R., Dorn, R.I., Lajoie, K.R., Oviatt, C.G., Robinson, S.W., Smith, G.I., and Stine, S., 1990, Chronology of expansion and contraction of four Great Basin lake systems during the past 35,000 years: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 78, p. 241-286.

Benson, L.V., May, H.M., Antweiler, R.C., and Brinton, T.I., 1998, Continuous lake-sediment records of glaciation in the Sierra Nevada between 52,600 and 12,500 $^{14}$C yr B.P.: Quaternary Research, v. 50, p. 113-127.

Benson, L., 2004, Western lakes: *in* Gillespie, A.R., Porter, S.C., and Atwater, B., eds., The Quaternary Period in the United States-Develpoments in Quaternary Science: Elsevier, v. 1, p. 185-204.

Betancourt, J.L., Rylander, K.A., Penalba, C., and McVickar, J.L., 2001, Late Quaternary vegetation history of Rough Canyon, south-central New Mexico, USA: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 165, p. 71-95.

Bexfield, L.M., and Anderholm, S.K., 1997, Water-quality assessment of the Rio Grande Valley, Colorado, New Mexico, and Texas—Ground-water quality in the Rio Grande flood plain, Cochiti Lake, New Mexico, to El Paso, Texas, 1995: U.S. Geological Survey Water-Resources Investigations Report 96-4249, 93 p.

Bexfield, L.M., and Anderholm, S.K., 2000, Predevelopment water-level map of the Santa Fe Group aquifer system in the Middle Rio Grande Basin between Cochiti Lake and San Acacia, New Mexico: U.S. Geological Survey Water-Resources Investigations Report 00-4249, 1 sheet.

Bexfield, L.M., and Anderholm, S.K., 2002a, Spatial patterns and temporal variability in water quality from City of Albuquerque drinking-water supply wells and piezometer nests, with implications for the ground-water flow system: U.S. Geological Survey Water-Resources Investigations Report 01-4244, 101 p.

Bexfield, L.M., and Anderholm., S.K., 2002b, Estimated water-level declines in the Santa Fe Group aquifer system in the Albuquerque area, central New Mexico, predevelopment to 2002: U.S. Geological Survey Water-Resources Investigations Report 02-4233, 1 sheet.

Bexfield, L.M., Lindberg, W.E., and Anderholm, S.K., 1999, Summary of water-quality data for City of Albuquerque drinking-water supply wells, 1988-97: U.S. Geological Survey Open-File Report 99-195, 138 p.

Bexfield, L.M., and Plummer, L.N., 2002, Occurrence of arsenic in ground water of the Middle Rio Grande Basin, central New Mexico, *in* Welch, A.H., and Stollenwerk, K.G., eds., Arsenic in ground water: Geochemistry and occurrence: New York, Kluwer Academic Publishers, p. 295-327.

Bjorklund, L.J., and Maxwell, B.W., 1961, Availability of ground water in the Albuquerque area, Bernalillo and Sandoval Counties, New Mexico: New Mexico State Engineer Technical Report 21, 117 p.

Böhlke, J.K., Ericksen, G.E., and Revesz, K., 1997, Stable isotope evidence for an atmospheric origin of desert nitrate deposits in northern Chile and southern California, U.S.A.: Chemical Geology, v. 136, p. 135-152.

Boutton, T.W., Archer, S.R., Midwood, A.J., Zitzer, S.F., and Bol, R., 1998, $^{13}C$ values of soil organic carbon and their use in documenting vegetation change in a subtropical savanna ecosystem: Geoderma, v. 82, p. 5-41.

Brenner-Tourtelot, E.F., and Machette, M.N., 1979, The mineralogy and geochemistry of lithium in the Popotosa Formation, Socorro County, New Mexico: U.S. Geological Survey Open-File Report 79-839, 27 p.

Buck, B.J., and Monger, H.C., 1999, Stable isotopes and soil geomorsphology as indicators of Holocene climate change, northern Chihuahuan Desert: Journal of Arid Environments, v. 43, p. 357-373.

Busby, J.F., Plummer, L.N., Lee, R.W., and Hanshaw, B.B., 1991, Geochemical evolution of water in the Madison aquifer in parts of Montana, South Dakota, and Wyoming: U.S. Geological Survey Professional Paper 1273-F, 89 p.

Busenberg, E., and Plummer, L.N., 1992, Use of chlorofluoromethanes ($CCl_3F$ and $CCl_2F_2$) as hydrologic tracers and age-dating tools: Example- the alluvium and terrace system of Central Oklahoma: Water Resources Research, v. 28, p. 2257-2283.

Busenberg, E., Plummer, L.N., Bartholomay, R.C., and Wayland, J.E., 1998, Chlorofluorocarbons, sulfur hexafluoride and dissolved permanent gases in ground water from selected sites at and near the Idaho National Engineering and Environmental Laboratory, Idaho, 1994 – 97: U.S. Geological Survey Open-File Report 98-274, 72 p.

Busenberg, E., Plummer, L.N., Doughten, M. W., Widman, P. K., and Bartholomay, R.C., 2000, Chemical and isotopic composition and gas concentrations of ground water and surface water from selected sites at and near the Idaho National Engineering and Environmental Laboratory, Idaho, 1994-97: U.S. Geological Survey Open-File Report 00-81, 55 p.

Busenberg, E., and L.N. Plummer, 2000, Dating young ground water with sulfur hexafluoride— Natural and anthropogenic sources of sulfur hexafluoride: Water Resources Research, v. 36, p. 3011-3030.

Busenberg, E., Weeks, E.P., Plummer, L.N., and Bartholemay, R.C., 1993, Age dating ground water by use of chlorofluorocarbons ($CCl_3F$ and $CCl_2F_2$), and distribution of chlorofluorocarbons in the unsaturated zone, Snake River Plain aquifer, Idaho National Engineering Laboratory, Idaho: U.S. Geological Survey Water-Resources Investigations Report 93-4054, 47 p.

Carmody, R.W., Plummer, L.N., Busenberg, E., and Coplen, T.B., 1998, Methods for collection of dissolved sulfate and sulfide and analysis of their sulfur isotopic composition: U.S. Geological Survey Open-File Report 97-234, 91 p.

Clark, Ian D. and Fritz, Peter, 1997, Environmental Isotopes in Hydrogeology: New York, Lewis Publishers, 328 p.

Clarke, W.B., Jenkins, W.J., and Top, Z., 1976, Determination of tritium by mass spectrometric measurement of $^3He$: International Journal of Applied Radiation and Isotopes, v. 27, p. 515-522.

Claypool, G.E., Holser, W.T., Kaplan, I.R., Sakai, H., and Zak, I, 1980, The age curves of sulfur and oxygen isotopes in marine sulfate and their mutual interpretation: Chemical Geology, v. 28, p. 199-260.

Committee on Extension to the Standard Atmosphere, 1976, U.S. Standard Atmosphere, 1976: Washington, D.C., Government Printing Office, 227 p.

Connell, S.D., 1997, Geology of Alameda quadrangle, Bernalillo and Sandoval Counties, New Mexico: Socorro, New Mexico Bureau of Mines and Mineral Resources Open-File Digital Map Series OF-DM-10, last modified September 16, 1999, 1 sheet.

Connell, S.D., Allen, B.D., and Hawley, J.W., 1998, Subsurface stratigraphy of the Santa Fe Group from borehole geophysical logs, Albuquerque area, New Mexico: New Mexico Geology, v. 17, No. 4, p. 79-87.

Connell, S.D., Koning, D.J., and Cather, S.M., 1999, Revisions to the stratigraphic nomenclature of the Santa Fe Group, northwestern Albuquerque Basin, New Mexico, *in* Pazzaglia, F.J., and Lucas, S.G., eds., Albuquerque Geology, New Mexico Geological Society Fiftieth Annual Field Conference, September 22-25, 1999: New Mexico Geological Society, p. 337-353.

Connell, S.D., 2001, Stratigraphy of the Albuquerque Basin, Rio Grande Rift, central New Mexico--A progress report, *in* Connell, S.D., Lucas, S.G., and Love, D.W., eds., Stratigraphy and tectonic development of the Albuquerque Basin, central Rio Grande Rift: Socorro, New Mexico, New Mexico Bureau of Mines and Mineral Resources Open-File Report 454B, p. A1-A27.

Connin, S.L., Betancourt, J., and Quade, J., 1998, Late Pleistocene $C_4$ plant dominance and summer rainfall in the southwestern United States from isotopic study of herbivore teeth: Quaternary Research, v. 50, p. 179-193.

Constantz, J., and Thomas, C.L., 1996, The use of streambed temperature profiles to estimate the depth, duration, and rate of percolation beneath arroyos: Water Resources Research, v. 32(12), p. 3597-3602.

Coplen, T.B. and Hopple, J.A., 1995, Audit of VSMOW distributed by the United States National Institute of Standards and Technology, *in* Reference and intercomparison materials for stable isotopes of light elements: Vienna, International Atomic Energy Agency, IAEA-TECDOC-825, p. 35-38

Coplen, T.B., 1988, Normalization of oxygen and hydrogen isotope data: Chemical Geology, v. 72, no. 4, p. 293-297.

Coplen, T.B., 1996, New guidelines for reporting stable hydrogen, carbon, and oxygen isotope-ratio data: Geochimica Cosmochimica Acta, v. 60, p. 3359-3360.

Coplen, T.B., and Krouse, H.R., 1998, Sulfur isotope data consistency improved: Nature, v. 392, p. 32.

Coplen, T.B., Herczeg, A.L., and Barnes, C., 1999, Isotope Engineering—Using stable isotopes of the water molecule to solve practical problems, *in* Cook, P.G. and Herczeg, A.L., eds., Environmental Tracers in Subsurface Hydrology, Chapter 3: Amsterdam**,** Kluwer Academic Press, p. 79-110.

Craigg, S.D., 1992, Water resources on the Pueblos of Jemez, Zia, and Santa Ana, Sandoval County, New Mexico: U.S. Geological Survey Water-Resources Investigations Report 89-4091, 122 p.

Crawford, C.S., Cully, A.C., Leutheuser, R., Sifuentes, M.S., White, L.H., and Wilber, J.P., 1993, Middle Rio Grande ecosystem—Bosque biological management plan: Albuquerque, Middle Rio Grande Bosque Biological Interagency Team, 291 p.

Dansgaard, W., 1964, Stable isotopes in precipitation: Tellus, v. 16, p. 436-468.

Davis, S.N., 1964, Silica in streams and ground waters: American Journal of Science, v. 262, p. 870-891.

Dawson, T.E., 1993, Water sources of plants as determined frm xylem-water isotopic compositions: Perspectives on plant competition, distribution, and water relations, *in* Ehleringer, J.R., Hall, A.E., and Farquhar, G.D., eds., Stable Isotopes and Plant Carbon-Water relations: New York, Academic Press, p. 465-496.

Dean, W.E., 1997, Rates, timing and cyclicity of Holocene eolian activity in north-central United States: Evidence from varved lake sediments: Geology, v. 25, p. 331-334.

Dean, W.E., Ahlbrandt, T.S., Anderson, R.Y., and Bradbury, J.P., 1996, Regional aridity in North America during the middle Holocene: The Holocene, v. 6, p. 145-155.

Deines, P., 1980, The isotopic composition of reduced organic carbon, *in* Fritz, P. and Fontes, J.-Ch.,eds., Handbook of Environmnetal Isotope Geochemistry: Amsterdam, Elsevier Scientific Publishing Company, p. 329-406.

Dettinger, M.D., 1989, Reconnaissance estimates of natural recharge to desert basins in Nevada, U.S.A., by using chloride-balance calculations: Journal of Hydrology, v. 106, p. 55-78.

Doney, S.C., Glover, D.M., and Jenkins, W.J., 1992, A model function of the global bomb tritium distribution in precipitation, 1960-1986: Journal Geophysical Research, v. 97, no. C4, p. 5481-5492.

Ehleringer, J.R., and Dawson, T.E., 1992, Water uptake by plants: Perspectives from stable isotope composition. Plant, Cell, and Environment, v. 15, p. 1073-1082.

Ekwurzel, B., Schlosser, P., Smethie, W.M., Jr., Plummer, L.N., Busenberg, E., Michel, R.L., Weppernig, R., and Stute, M., 1994, Dating of shallow groundwater: Comparison of the transient tracers $^3H/^3He$, chlorofluorocarbons and $^{85}Kr$: Water Resources Research, v. 30, no. 6, p.1693-1708.

Elliot, J.G., Gellis, A.C., and Aby, S.B., 1999, Evolution of arroyos—Incised channels of the southwestern United States, *in* Darby, S.E., and Simon, A., eds., Incised River Channels—Processes, Forms, Engineering, and Management: New York, John Wiley & Sons, p. 153-185.

Ellis, S.R., Levings, G.W., Carter, L.F., Richey, S.F., and Radell, M.J., 1993, Rio Grande Valley, Colorado, New Mexico, and Texas: American Water Resources Association, Water Resources Bulletin, v. 29, no. 4, August 1993, p. 617-646.

Epstein, H.E., Lauenroth, W.K., Burke, I.C., and Coffin, D.P., 1997, Productivity patterns of $C_3$ and $C_4$ functional types in the U.S. Great Plains: Ecology, v. 78, no. 3, p. 722-731.

Faires, L.M., 1992, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of metals in water by inductively coupled plasma-mass spectroscopy: U.S. Geological Survey Open-File Report 92-634, 28 p.

Finley, J.B., Drever, J.I., and Turk, J.T., 1995, Sulfur isotope dynamics in a high-elevation catchment, West Glacier Lake, Wyoming: Water, Air and Soil Pollution, v. 79, p. 227-241.

Flint, A.F., Flint, L.E., Kwicklis, E.M., Fabryka-Martin, J.T., and Bodvarsson, G.S., 2002, Estimating recharge at Yucca Mountain, Nevada, USA: Comparison of methods: Hydrogeology Journal, v. 10, p. 180-204.

Fontes, J.-Ch., 1990, Chemical and isotopic constraints on C-14 dating of groundwater, *in* Taylor, R.E., Long, A., and Kra, R., eds, Radiocarbon After Four Decades: New York, Springer-Verlag, p. 242-261.

Fontes, J.-Ch., and Garnier, J.-M., 1979, Determination of the initial $^{14}C$ activity of the total dissolved carbon: A review of the existing models and a new approach: Water Resources Research, v. 15, p. 399-413.

Francey, R.J., Allison, C.E., Etheridge, D.M., Trudinger, C.M., Enting, I.G., Leuenberger, M., Langenfelds, R.L., Michel, E., and Steele, L.P., 1999, A 1000-year high precision record of $^{13}C$ in atmospheric $CO_2$: Tellus, v. 51B, p. 170-193.

Gat, J.R., 1981, Isotopic fractionation, *in* Stable Isotope Hydrology, Deuterium and Oxygen-18 in the water cycle: Vienna, International Atomic Energy Agency, Technical Reports Series No. 210, p. 21-33.

Gautier, D.L., 1987, Isotopic composition of pyrite: Relationship to organic matter type and iron availability in some North American Cretaceous shales: Chemical Geology, v. 65, p. 293-303.

Gee, G. W., and Hillel, D., 1988, Ground-water recharge in arid regions: Review and critique of estimation methods: Hydrological Processes, v. 2, p. 255-266.

Giesemann, A., Jager, H.-J., Norman, A.L., Krouse, H.R., and Brand, W.A., 1994, On-line sulfur isotope determination using an elemental analyzer coupled to a mass spectrometer: Analytical Chemistry, v. 66, p. 2816-2819.

Gilath, Ch., and Gonfiantini, R., 1983, Lake dynamics, *in* Guidebook on Nuclear Techniques in Hydrology, 1983 Edition: Vienna, International Atomic Energy Agency, Technical Reports Series No. 91, p. 129-161.

Goff, R., McCormick, R., Gardner, J.N., Trujillo, P.E., Counce, D., Vidale, R., and Charles, R., 1983, Water geochemistry of the Lucero uplift, New Mexico—A geothermal investigation of low-temperature mineralized fluids: Los Alamos National Laboratory report LA-9738-OBES, 26 p.

Gonfiantini, R., 1986, Environmental isotopes in lake studies, *in* Fritz, P. and Fontes, J.-Ch., eds., Amsterdam, Handbook of Environmental Isotope Geochemistry, v. 2, Terrestrial Environment, B:, Elsevier, p. 113-168.

Gonfiantini, R., Stichler, W., and Rozanski, K., 1995, Standards and intercomparison materials distributed by the International Atomic Energy Agency for stable isotope measurements, *in* Reference and intercomparison materials for stable isotopes of light elements: Vienna, International Atomic Energy Agency, IAEA-TECDOC-825, p. 13-30.

GRAM, Inc., and William Lettis & Associates, Inc., 1995, Conceptual geologic model of the Sandia National Laboratories and Kirtland Air Force Base, Contractor report for the Site Wide Hydrogeologic Characterization Project: Albuquerque, NM, Sandia National Laboratories, variously paged.

Grauch, V.J.S., Gillespie, C.L., and Keller, G.R., 1999, Discussion of new gravity maps for the Albuquerque Basin area, *in* Pazzaglia, F.J., and Lucas, S.G., eds., Albuquerque Geology, New Mexico Geological Society Fiftieth Annual Field Conference, September 22-25, 1999: New Mexico Geological Society, p. 119-124.

Grauch, V.J.S., Sawyer, D.A., Keller, G.R., and Gillespie, C.L., 2001, Contributions of gravity and aeromagnetic studies to improving the understanding of subsurface hydrogeology, Middle Rio Grande Basin, New Mexico, *in* Cole, J.C., ed., U.S. Geological Survey Middle Rio Grande Basin Study—Proceedings of the fourth annual workshop, Albuquerque, New Mexico, February 15-16, 2000, U.S. Geological Survey Open-File Report 00-488, p. 3-4.

Grissino-Mayer, H., 1995, Tree-ring reconstructions of climate and fire history at El Malpais National Monument, New Mexico: Tucson, The University of Arizona, Ph.D. dissertation, 407 p.

Grissino-Mayer, H., 1996, A 2129-year reconstruction of precipitation for northwestern New Mexico, U.S.A., *in* Tree Rings, Environment and Humanity, Dean, J.S., Meko, D.M., and Swetnam, T.W., eds., Tucson, Arizona, Radiocarbon, p. 191-204.

Grover, H.D., and Musick, H.B., 1990, Shrubland encroachment in southern New Mexico, U.S.A.: An analysis of desertification processes in the American southwest: Climatic Change, v. 17, p. 305-330.

Habicht, K.S., and Canfield, D.E., 1997, Sulfur isotope fractionation during bacterial sulfate reduction in organic-rich sediments: Geochimica et Cosmochimica Acta, v. 61, p. 5351-5361.

Haneberg, W.C., and Hawley, J.W., eds, 1996, Characterization of hydrogeologic units in the Northern Albuquerque Basin, New Mexico, in Hawley, J.W., Haneberg, W.C., and Whitworth, T.M., compilers, Hydrogeologic Investigations in the Albuquerque Basin, Central New Mexico, 1992-1995: Socorro, New Mexico, New Mexico Bureau of Mines and Mineral Resources Open-File Report 402, Section 402C.

Hawley, J.W., and Haase, C.S., 1992, Hydrogeologic framework of the northern Albuquerque Basin: Socorro, New Mexico Bureau of Mines and Mineral Resources Open-File Report 387, variously paged.

Hawley, J.W., Haase, C.S., and Lozinsky, R.P., 1995, An underground view of the Albuquerque Basin, *in* Ortega-Klett, C.T., ed., The water future of Albuquerque and the Middle Rio Grande Basin: Las Cruces, New Mexico Water Resources Research Institute Report 290, p. 34-55.

Hawley, J.W., 1996, Hydrogeologic framework of potential recharge areas in the Albuquerque Basin, central Valencia County, New Mexico, *in* Hawley, J.W. and Whitworth, T.M., eds., Hydrogeology of potential recharge areas for the basin- and valley-fill aquifer systems, and hydrogeochemical modelling of proposed artificial recharge of the upper Santa Fe aquifer, northern Albuquerque Basin, New Mexico: Socorro, New Mexico Bureau of Geology and Mineral Resources Open-File Report 402-D, 608 p.

Heaton, T.H.E., 1981, Dissolved Gases: Some Applications to Groundwater Research: Transactions of the Geological Society of South Africa, v. 84, p. 91-97.

Heaton, T.H.E., Talma, A.S., and Vogel, J.C., 1983, Origin and history of nitrate in confined groundwater in the Western Kalahari: Journal of Hydrology, v. 62, p. 243-262.

Heaton, T.H.E., and Vogel, J.C., 1981, "Excess air" in groundwater: Journal of Hydrology, v. 50, p. 201-216.

Helsel, D.R., and Hirsch, R.M., 1995, Statistical methods in water resources: New York, Elsevier Science B.V., 529 p.

Herzberg O., and Mazor, E., 1979, Hydrological applications of noble gases and temperatures measurements in underground water systems: examples from Israel: Journal of Hydrology, v. 41, p. 217-231.

Heynekamp, M.R., Goodwin, L.B., Mozley, P.S., and Haneberg, W.C., 1999, Controls on fault-zone architecture in poorly lithified sediments, Rio Grande Rift, New Mexico: Implication for fault-zone permeability and fluid flow, *in* Haneberg, W.C., Mozley, P.S., Moore, J.C., and Goodwin, L.B., eds., Faults and subsurface fluid flow in the shallow crust: American Geophysical Union, Geophysical Monograph 113, p. 27-49.

Heywood, C.E., 1992, Isostatic residual gravity anomalies of New Mexico: U.S. Geological Survey Water-Resources Investigations Report 91-4065, 27 p.

Hoefs, J., 1987, Stable Isotope Geochemistry, 3rd Ed.: Berlin, Springer-Verlag, 241 p.

Holser, W.T., and Kaplan, I.R., 1966, Isotope geochemistry of sedimentary sulfates: Chemical Geology, v. 1, p. 93-135.

Huang, Y., Street-Perrott, F.A., Metcalf, S.E., Brenner, M., Moreland, M., and Freeman, K.H., 2001, Climate change as the dominant control on glacial-interglacial variations in $C_3$ and $C_4$ plant abundance: Science, v. 293, p. 1647-1651.

IAEA, 2001, Isotope Hydrology Information System. The ISOHIS Database: Vienna, Austria, International Atomic Energy Agency, Accessible at: http://isohis.iaea.org.

Jamieson, R.E., and Wadleigh, M.A., 2000, Tracing sources of precipitation sulfate in eastern Canada using stable isotopes and trace metals: Journal of Geophysical Research, v. 105, no. D16, p. 20549-20556.

Kalin, R.M., 1999, Radiocarbon dating of groundwater systems, *in* Cook, P.G., and Herczeg, A.L., eds., Environmental Tracers in Subsurface Hydrology: New York, Kluwer Academic Publishers, Chapter 4, p. 111-144.

Kelley, V.C., 1977, Geology of Albuquerque Basin, New Mexico: Socorro, New Mexico Bureau of Mines and Mineral Resources Memoir 33, 60 p.

Kernodle, J.M., 1998, Simulation of ground-water flow in the Albuquerque Basin, central New Mexico, 1901-95, with projections to 2020: U.S. Geological Survey Open-File Report 96-209, 54 p.

Kernodle, J.M., and Scott, W.B., 1986, Three-dimensional model simulation of steady-state ground-water flow in the Albuquerque-Belen Basin, New Mexico: U.S. Geological Survey Water-Resources Investigations Report 84-4353, 58 p.

Kernodle, J.M., McAda, D.P., and Thorn, C.R., 1995, Simulation of ground-water flow in the Albuquerque Basin, central New Mexico, 1901-1994, with projections to 2020: U.S. Geological Survey Water-Resources Investigations Report 94-4251, 114 p.

Kernodle, J.M., Miller, R.S., and Scott, W.B., 1987, Three-dimensional model simulation of transient ground-water flow in the Albuquerque-Belen Basin, New Mexico: U.S. Geological Survey Water-Resources Investigations Report 86-4194, 86 p.

Kitagawa, H., and van der Plicht, J., 1998a, Atmospheric radiocarbon calibration to 45,000 yr B.P.: Late glacial fluctuations and cosmogenic isotope production: Science, v. 279, p. 1187-1190.

Kitagawa, H., and van der Plicht, J., 1998b, A 40,000-year varve chronology from Lake Suigetsu, Japan: Extension of the $^{14}C$ calibration curve: Radiocarbon, v. 40, no. 3, p. 505-515.

Kitagawa, H., and van der Plicht, J., 2000, Atmospheric radiocarbon calibration beyond 11,900 cal BP from Lake Suigetsu laminated sediments: Radiocarbon, v. 42, no. 3, p. 369-380.

Krouse, H.R., and Coplen, T.B., 1997, Reporting of relative sulfur isotope-ratio data: Pure and Applied Chemistry, v. 69, p. 293-295.

Lambert, S.J., and Balsley, S.D., 1997, Stable-isotopes of groundwaters from the Albuquerque, New Mexico, basin: one decade later: Environmental Geology, v. 31, no. 3-4 p. 199-204.

Langmuir, D., 1997, Aqueous Environmental Geochemistry: New Jersey, Prentice Hall, 600 p.

Levin, I., and Kromer, B., 1997, Twenty years of atmospheric $^{14}CO_2$ observations at Schauinsland station, Germany: Radiocarbon, v. 39, no. 2, p. 205-218.

Levin, I., Kromer, B., Schoch-Fischer, H., Bruns, M., Münnich, M., Berdau, D., Vogel, J.C., and Münnich, K.O., 1994, $^{14}CO_2$ record from sites in Central Europe, *in* Boden, T.A., Kaiser, D.P., Sepanski, R.J., and Stoss, F.W., eds., Trends '93: A Compendium of Data on Global Change: Oak Ridge, Tenn., Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, p. 203-222,

Liu, B., Phillips, F.M., and Campbell, A.R., 1996, Stable carbon and oxygen isotopes in pedogenic carbonates, Ajo Mountains, southern Arizona: implications for paleoenvironmental change: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 124, p. 233-246.

Logan, L.M., 1990, Geochemistry of the Albuquerque municipal area, Albuquerque, New Mexico: Socorro, New Mexico Institute of Mining and Technology, Independent study, 234 p.

Lozinsky, R.P., 1988, Stratigraphy, sedimentology, and sand petrology of the Santa Fe Group and Pre-Santa Fe Tertiary deposits in the Albuquerque Basin, Central New Mexico: Socorro, New Mexico Institute of Mining and Technology, Ph.D. dissertation, 298 p.

Ludin, A., Weppering, R., Bönisch, G., and Schlosser, P., 1998, Mass spectroscopic measurements od helium isotopes and tritium in water samples: Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY, Technical Report 98.6. http://www.ldeo.columbia.edu/~noblegas/ms_ms/Ludin_et_MS_paper.html.

MacKay, W.P., and Elias, S.A., 1992, Late Quaternary ant fossils from packrat middens (Hymenoptera Formicidae): Implications for climatic change in the Chihuahuan Desert: Psyche, v. 99, p. 169-184.

Mast, M.A., Turk, J.T., Ingersoll, G.P., Clow, D.W., and Kester, C.L., 2001, Use of stable sulfur isotopes to identify sources of sulfate in Rocky Mountain snowpacks: Atmospheric Environments, v. 35, p. 3303-3313.

McAda, D.P., 1996, Plan of study to quantify the hydrologic relations between the Rio Grande and the Santa Fe Group aquifer system near Albuquerque, central New Mexico: U.S. Geological Survey Water-Resources Investigations Report 96-4006, 58 p.

McAda, D.P., and Barroll, P., 2002, Simulation of ground-water flow in the Middle Rio Grande Basin between Cochiti and San Acacia, New Mexico: U.S. Geological Survey Water-Resources Investigations Report 02-4200, 81 p.

McPherson. G.R., Boutton, T.W., and Midwood, A.J., 1993, Stable carbon isotope analysis of soil organic matter illustrates vegetation change at the grassland/woodland boundary in southeastern Arizona, USA: Oecologia, v. 93, p. 95-101.

Meeks, T.O., 1949, The occurrence of ground water in the Tijeras Soil Conservation District, Bernalillo County, New Mexico: U.S. Department of Agriculture Regional Bulletin 109, Geological Series I, Soil Conservation Service Region 6, variously paged.

Meyer, H.W., 1992, Lapse rates and other variables applied to estimating paleoaltitudes from fossil floras: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 99, p. 71-99.

Minor, S.A., and Shock, N.A., 1998, Characterizing faults in the Middle Rio Grande Basin: Results from the Cochiti and Santo Domingo Pueblos: U.S. Geological Survey Open-File Report 98-337, p. 22-23.

Monger, H.C., Cole, D.R., Gish, J.W., and Giordano, T.H., 1998, Stable carbon and oxygen isotopes in Quaternary soil carbonates as indicators of ecogeomorphic changes in the northern Chihuahuan Desert, U.S.A.: Geoderma, v. 82, p. 137-172.

Mook, W.G., 1972, On the reconstruction of the initial 14C content of groundwater from the chemical and isotopic composition, *in* Proceedings of Eighth International Conference on Radiocarbon Dating, v. 1, Royal Society of New Zealand, Wellington, New Zealand, p. 342-352.

Mook , W.G. and van der Plicht, J., 1999, Reporting $^{14}C$ activities and concentrations: Radiocarbon, v. 41, p. 227-239.

Mook, W.G., 1980, Carbon-14 in hydrogeological studies, *in* Fritz, P., and Fontes, J.-Ch., eds., Handbook of Environmnetal Isotope Geochemistry: New York, Elsevier Scientific Publishing Company, p. 49-74.

Moore, D., 1999, Precipitation chemistry data on the Sevilleta National Wildlife Refuge, 1989-1995: Sevilleta LTER Database, accessed March 2, 1999, at http://sevilleta.unm.edu/research/local/nutrient/precipitation/#data.

Morgan, M.E., Kingston, J.D., and Marino, B.D., 1994, Carbon isotopic evidence for the emergence of C4 plants in the Neogene from Pakistan and Kenya: Nature, v. 367, p. 162-165.

Mozley, P., Beckner, J., and Whitworth, T.M., 1995, Spatial distribution of calcite cement in the Santa Fe Group, Albuquerque Basin, NM—Implications for ground-water resources: New Mexico Geology, v. 17, p. 88-93.

Mozley, P.S., and Goodwin, L.B., 1995, Patterns of cementation along a Cenozoic normal fault—A record of paleoflow orientations: Geology, v. 23, no. 6, p. 539-542.

Niswonger, R., and Constantz, J., 2001, Determination of streamflow loss to estimate mountain-front recharge at Bear Canyon, New Mexico, *in* Cole, J.C., U.S. Geological Survey Middle Rio Grande Basin Study—Proceedings of the fourth annual workshop, Albuquerque, New Mexico, February 15-16, 2000, U.S. Geological Survey Open-File Report 00-488, p. 38-40.

Nordt, L.C., Boutton, T.W., Hallmark, C.T., and Waters, M.R., 1994, Late Quaternary vegetation and climatic changes in central Texas based on the isotopic composition of organic carbon: Quaternary Research, v. 41, p. 109-120.

Norman, V.W., 1968, Trends of suspended sediments in the upper Rio Grande Basin in New Mexico: Albuquerque, University of New Mexico, Master's thesis, 108 p.

Ortiz, D., Lange, K., and Beal, L., 1999, Water resources data, New Mexico, water year 1998—Volume 1. The Rio Grande Basin, the Mimbres River Basin, and the Tularosa Valley Basin: U.S. Geological Survey Water-Data Report NM-98-1, 404 p.

Oviatt, C.G., Currey, D.R., and Sack, D., 1992, Radiocarbon chronology of Lake Bonneville, Eastern Great Basin, USA: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 99, p. 225-241.

Panichi, C., and Gonfiantini, R., 1981, Geothermal waters, *in* Stable Isotope Hydrology, Deuterium and Oxygen-18 in the water cycle: International Atomic Energy Agency, Technical Reports Series No. 210, Vienna, p. 241-271.

Parkhurst, D.L., 1995, User's guide to PHREEQC—A computer program for speciation, reaction-path, advective-transport, and inverse geochemical calculations: U.S. Geological Survey Water-Resources Investigations Report 95-4227, 143 p.

Parkhurst, D.L., and Plummer, L.N., 1993, Geochemical Models, *in* Alley, W.M., ed., Regional Ground-water Quality, Chapter 9, Van Nostrand Reinhold, p. 199-225.

Parkhurst, D.L., Christenson, S., and Breit, G.N., 1995, Ground-water-quality assessment of the Central Oklahoma aquifer, Oklahoma—Geochemical and geohydrologic investigations: U.S. Geological Survey Water-Supply Paper 2357, 101 p.

Pearson, F.J., Jr., and Rightmire, C.T., 1980, Sulfur and oxygen isotopes in aqueous sulfur compounds, *in* Fritz, P. and Fontes, J.-Ch., eds., Handbook of Environmental Isotope Geochemistry, Vol. 1. The Terrestrial Environment, A., New York, Elsevier Scienticif Publishing Company, p. 227-258.

Peng, T.-H., 1985, Atmospheric $CO_2$ variations based on the tree-ring $^{13}C$ record, *in* Sundquist, E.T., and Broecker, W.S., eds., The Carbon Cycle and Atmospheric CO2: Natural Variations Archean to Present, Washington, D.C., American Geophysical Union, Geophysical Monograph 32, p. 123-131.

Phillips, F.M., Peeters, L.A., Tansey, M.K., and Davis, S.N., 1986, Paleoclimatic inferences from an isotopic investigation of groundwater in the San Juan Basin, New Mexico: Quaternary Research, v. 26, p. 179-193.

Phillips, F.M., Campbell, A.R., Kruger, C., Johnson, P., Roberts, R., and Keyes, E., 1992, A reconstruction of the response of the water balance in western United States lake basins to climatic change: New Mexico Water Resources Research Institute Report 269, 167 p.

Phillips, F.M., Tansey, M.K., and Peeters, L.A., 1989, An isotopic investigation of groundwater in the central San Juan Basin, New Mexico: Carbon 14 dating as a basis for numerical flow modeling: Water Resources Research, v. 25, no. 10, p. 2259-2273.

Phillips, F.M., Hogan, J., Mills, S., and Hendrickx, J.M.H., 2003, Environmental tracers applied to quantifying causes of salinity in arid-region rivers: Preliminary results from the Rio Grande, southwestern USA: *in* Water Resource Perspectives: Evaluation, Management, and Policy (ed. A. S. Alsharhan and W. W. Wood), Developments in Water Science, v. 50, Elsevier Science, Amsterdam, p. 327-334.

Plummer, L.N., Bexfield, L.M., Anderholm, S.K., Sanford, W.E., and Busenberg, E., 2001, Geochemical characterization of ground-water flow in parts of the Santa Fe Group aquifer system, Middle Rio Grande Basin, New Mexico, *in* Cole, J.C., ed., U.S. Geological Survey Middle Rio Grande Basin Study -- Proceedings of the Fourth Annual Workshop, Albuquerque, New Mexico, February 15-16, 2000: U.S. Geological Survey Open-File Report 00-488, p. 7-10.

Plummer, L.N., Busby, J.F., Lee, R.W., and Hanshaw, B.B., 1990, Geochemical modeling of the Madison aquifer in parts of Montana, Wyoming, and South Dakota: Water Resources Research, v. 26, no. 9, p. 1981-2014.

Plummer, L.N., E.C. Prestemon, and D.L. Parkhurst, 1994, An Interactive Code (NETPATH) for Modeling NET Geochemical Reactions Along a Flow PATH. Version 2.0: Reston, Virginia, U.S. Geological Survey Water-Resources Investigations Report 94-4169, 130 p.

Plummer, L.N., Parkhurst, D.L., and Thorstenson, D.C., 1983, Development of reaction models for ground-water systems: Geochimica et Cosmochimica Acta, v. 47, p. 665-686.

Plummer, L.N. and Busenberg, E., 1999, Chlorofluorocarbons, *in* Cook, P. and Herczeg, A., eds., Environmental Tracers in Subsurface Hydrology, Chapter 15: Amsterdam, Kluwer Academic Press, p. 441-478.

Plummer, L.N., and Sprinkle, C.L., 2001, Radiocarbon dating of dissolved inorganic carbon in groundwater from confined parts of the Upper Floridan aquifer, Florida, USA: Hydrogeology Journal, v. 9, p. 127-150.

Polyak, V.J., Cokendolpher, J.C., Norton, R.A., Asmerom, Y., 2001, Wetter and cooler late Holocene climate in the southwestern United States from mites preserved in stalagmites: Geology, v. 29, no. 7, p. 643-646.

Popp, C.J., Ohline, R.W., Brandvold, D.K., and Brandvold, L.A., 1984, Nature of precipitation and atmostpheric particulates in central and northern New Mexico, *in* Hicks, B.B., ed., Deposition both wet and dry—Acid precipitation series: Boston, Butterworth Publishers, v. 4, p. 79-95.

Rabinowitz, D.D., and Gross, G.W., 1972, Environmental tritium as a hydrometeorologic tool in the Roswell Basin, New Mexico: New Mexico Water Resources Research Institute, Technical Completion Report OWRR A-037-NMEX, Las Cruces, New Mexico, 268 p.

Rankama, K., and Sahama, T.G., 1950, Geochemistry: Chicago, The University of Chicago Press, 912 p.

Rao, U., Fehn, U., Teng, R.T.D., and Goff, F., 1996, Sources of chloride in hydrothermal fluids from the Valles caldera, New Mexico: a $^{36}Cl$ study: Journal of Volcanology and Geothermal Research, v. 72, p. 59-70.

Rawlings, G.C., and Goodwin, L.B., 2001, The nature of cataclastic deformation and its structural and hydrologic implications, Sand Hill fault zone, Albuquerque Basin, New Mexico, USA [abs.]: Geological Society of America, 2001, Abstracts with Programs, Rocky Mountain and South-Central Sections, v. 33, no. 5, p. 8.

Reeder, H.O., Bjorklund, L.J., and Dinwiddie, G.A., 1967, Quantitative analysis of water resources in the Albuquerque area, New Mexico--Computed effects on the Rio Grande of pumpage of ground water, 1960-2000: New Mexico State Engineer Technical Report 33, 34 p.

Reiter, M., 2001, Using precision temperature logs to estimate horizontal and vertical groundwater flow components: Water Resources Research, v. 37, no. 3, p. 663-674.

Risser, D.W., and Lyford, F.P., 1983, Water resources on the Pueblo of Laguna, west-central New Mexico: U.S. Geological Survey Water-Resources Investigations Report 83-4038, 308 p.

Robertson, F.N., 1991, Geochemistry of ground water in alluvial basins of Arizona and adjacent parts of Nevada, New Mexico, and California: U.S. Geological Survey Professional Paper 1406-C, 90 p.

Rozanski, K., Gonfiantini, R., and Araguás-Araguás, L., 1991, Tritium in the global atmosphere: Distribution patterns and recent trends: Journal of Physics G: Nuclear and Particle Physics, v. 17, p. S523-S536.

Rozanski, K., Araguás-Araguás, L., and Gonfiantini, R., 1993, Isotopic patterns in modern global precipitation, *in* Smart, P.K., Lohmann, K.C., McKenzie, J., and Savin, S., eds., Climate Change in Continental Isotopic Records: Washington, D.C., American Geophysical Union, Geophysical Monograph 78, p. 1-36.

Russell, L.R., and Snelson, S., 1990, Structural style and tectonic evolution of the Albuquerque Basin segment of the Rio Grande Rift, *in* Pinet, B., and Bois, C., eds., The potential of deep seismic profiling for hydrocarbon exploration: Editions Technip, Paris, French Petroleum Institute Research Conference Proceedings, p. 175-207.

Rust Geotech, 1995, Geochemical study of groundwater at Sandia National Laboratories/New Mexico and Kirtland Air Force Base: Contractor report prepared under DOE contract no. DE-AC04-94AL96907, variously paged.

Rye, R.O., Back, W., Hanshaw, B.B., Rightmire, C.T., and Pearson, F.J., Jr., 1981, The origin and isotopic composition of dissolved sulfide in groundwater from carbonate aquifers in Florida and Texas: Geochimica et Cosmochimica Acta, v. 45, p. 1941-1950.

Sanford, W.E., Plummer, L.N., McAda, D.P., Bexfield, L.M., and Anderholm, S.K., 2001, Estimation of hydrologic parameters for the ground-water model of the Middle Rio Grande Basin Using carbon-14 and water-level data, in Cole, J.C., ed., U.S. Geological Survey Middle Rio Grande Basin Study -- Proceedings of the Fourth Annual Workshop, Albuquerque, New Mexico, February 15-16, 2000: U.S. Geological Survey Open-File Report 00-488, p. 4-6.

Sanford, W.E., Plummer, L.N., McAda, D.P., Bexfield, L.M., and Anderholm, S.K., 2004, Use of environmental tracers to estimate parameters for a predevelopment-ground-water-flow model of the Middle Rio Grande Basin, New Mexico: U. S. Geological Survey Water-Resources Investigations Report 03-4286.

Scanlon, B.R., Healy, R.W., and Cook, P.G., 2002, Choosing appropriate techniques for quantifying groundwater recharge: Hydrogeology Jour., v. 10, p. 18-39.

Schlosser, P., Stute, M., Dorr, H., Sonntag, C., Munnich, K.O., 1988, Tritium/$^3$He dating of shallow groundwater: Earth and Planetary Science Letters, v. 89, p. 353-362.

Schlosser, P., Stute, M., Sonntag, C., Munnich, K.O., 1989, Tritiogenic $^3$He in shallow groundwater: Earth and Planetary Science Letters, v. 94, p. 245-256.

Schlosser, P., Shapiro, S.D., Stute, M., Aeschbach-Hertig, W., Plummer, N., and Busenberg, E., 1998, Tritium/$^3$He measurements in young groundwater-- chronologies for environmental records, *in* Isotope Techniques in the Study of Environmental Changes: Vienna, Austria, International Atomic Energy Agency, p. 165-189.

Solomon, D.K., Cook, P.G., 1999, $^3$H and $^3$He, *in* Cook, P., and Herczeg, A., eds., Environmental Tracers in Subsurface Hydrology: Amsterdam, Kluwer Academic Press, p. 397-424.

Solomon, D.K., and Sudicky, E.A., 1991, Tritium and helium 3 isotope ratios for direct estimation of spatial variations in groundwater recharge: Water Resources Research, v. 27, p. 2309-2319.

Solomon, D.K., Schiff, S.L., Poreda, R.J., Clark, W.B., 1993, A validation of the $^3$H/$^3$He method for determining groundwater recharge: Water Resources Research, v. 29, p. 2951-2962.

Spiegel, Z., 1955, Geology and ground-water resources of northeastern Socorro County, New Mexico: Socorro, New Mexico Bureau of Mines and Mineral Resources Ground-Water Report 4, 99 p.

Stone, B.D., Allen, B.D., Mikolas, M., Hawley, J.W., Haneberg, W.C., Johnson, P.S., Allred, B, and Thorn, C.R., 1998, Preliminary lithostratigraphy, interpreted geophysical logs, and hydrogeologic characteristics of the 98$^{th}$ Street core hole, Albuquerque, New Mexico: U.S. Geological Survey Open-File Report 98-210, 82 p.

Stuiver, M., and Reimer, P.J., 1993, Extended $^{14}$C data base and revised CALIB 3.0 $^{14}$C age calibration program: Radiocarbon, v. 8, p. 534-540.

Stuiver, M., Kromer, B., Becker, B., and Ferguson, C.W., 1986, Radiocarbon age calibration back to 13,300 years B.P. and the $^{14}$C age matching of the German oak and U.S. Bristlecone pine chronologies: Radiocarbon, v. 28, p. 980-021.

Stuiver, M., Reimer, P.J., Bard, E., Beck, J.W., Burr, G.S., Hughen, K.A., Kromer, B., McCormac, G., van der Plicht, J., and Spurk, M., 1998, INTCAL98 Radiocarbon Age Calibration, 24,000-0 cal BP: Radiocarbon, v. 40, no. 3, p. 1041-1083.

Stuiver, M., and Polach, H.A., 1977, Discussion-- Reporting of $^{14}$C Data: Radiocarbon, v. 19, no. 3, p. 355-363.

Stuiver, M., and Robinson, S.W., 1974, University of Washington Geosecs North Atlantic carbon-14 results: Earth and Planetary Sciences Letters, v. 23, p. 87-90.

Stute, M., and Schlosser, P., 1999, Atmospheric noble gases, *in* Cook, P., and Herczeg, A., eds., Environmental Tracers in Subsurface Hydrology: Amsterdam, Kluwer Academic Press, p. 349-377.

Stute, M., Schlosser, P., Clark, J.F., and Broecker, W.S., 1992, Paleotemperatures in the southwestern United States derived from noble gases in ground water: Science, v. 256, p. 1000-1003.

Stute, M., Clark, J.F., Schlosser, P., Broecker, W.S., and Bonani, G., 1995, A 30,000 yr continental paleotemperature record derived from noble gases dissolved in groundwater from the San Juan Basin, New Mexico: Quaternary Research, v. 43, p. 209-220.

Sugisaki, R., Takeda, H., Kawabe, I., and Miyazaki, H., 1982, Simplified gas chromatographic analysis of $H_2$, He, Ne, Ar, $N_2$, and $CH_4$ in subsurface gases for seismo-geochemical studies: Chemical Geology, v. 36, p. 217-226.

Tan, S.H., and Horlick, G., 1986, Background spectral features in inductively coupled plasma/mass spectrometry: Applied Spectroscopy, v. 40, p. 445-460.

Thatcher, L.L., 1962, The distribution of tritium fallout in precipitation over North America: International Association of Scientific Hydrology, v. VII, no. 2, p. 48-58.

Thatcher, L.L., Janzer, V.J., and Edwards, K.W., 1977, Methods for determination of radioactive substances in water and fluvial sediments, *in* Techniques of Water-Resources Investigations of the U.S. Geological Survey, Chap. A5: Washington, D.C., U.S. Government Printing Office,. p. 79-81.

Thomas, C.L., 1995, Infiltration and quality of water for two arroyo channels, Albuquerque, New Mexico, 1988-92: U.S. Geological Survey Water-Resources Investigations Report 95-4070, 63 p.

Thomas, J.M., Welch, A.H., and Dettinger, M.D., 1996, Geochemistry and isotope hydrology of representative aquifers in the Great Basin region of Nevada, Utah, and adjacent states: U.S. Geological Survey Professional Paper 1409-C, 100 p.

Thompson, R.S., Whitlock, C., Bartlein, P.J., Harrison, S.P., and Spaulding, W.G., 1993, Climatic changes in the western United States since 18,000 yr B.P., *in* Wright, H.E., Jr., Kutzbach, J.E., Webb, T., III, Ruddiman, W.F., Street-Perrott, F.A., and Bartlein, P.J., eds., Global Climates since the Last Glacial Maximum: Minneapolis, University of Minnesota Press, p. 468-513.

Thompson, R.S., Anderson, K.H., and Bartlein, P.J., 1999, Quantitative paleoclimatic reconstructions from late Pleistocene plant macrofossils of the Yucca Mountain Region: U.S. Geological Survey Open-File Report 99-338, 38 p.

Thorn, C.R., McAda, D.P., and Kernodle, J.M., 1993, Geohydrologic framework and hydrologic conditions in the Albuquerque Basin, central New Mexico: U.S. Geological Survey Water-Resources Investigations Report 93-4149, 106 p.

Thorn, C.R., 2000, Results of well-bore flow logging for six water-production wells completed in the Santa Fe Group aquifer system, Albuquerque, New Mexico, 1996-98. U.S. Geological Survey Water-Resources Investigations Report 00-4157, 16 p.

Tiedeman, C.R., Kernodle, J.M., and McAda, D.P., 1998, Application of nonlinear-regression methods to a ground-water flow model of the Albuquerque Basin, New Mexico: U.S. Geological Survey Water-Resources Investigations Report 98-4172, 90 p.

Titus, F.B., 1961, Ground-water geology of the Rio Grande trough in north-central New Mexico, *with sections on* the Jemez Caldera and Lucero Uplift, *in* Northrop, S.A., ed., Guidebook of the Albuquerque country: New Mexico Geological Society, 12th Field Conference, p. 186-192.

----- 1963, Geology and ground-water conditions in Eastern Valencia County, New Mexico: Socorro, New Mexico Bureau of Mines and Mineral Resources Ground-Water Report 7, 113 p.

Toomey, R.S., III, Blum, M.D., and Valastro, S., Jr., 1993, Late Quaternary climates and environments of the Edwards Plateau, Texas: Global & Planetary Change, v. 7, p. 299-320.

Trainer, F.W., Rogers, R.J., and Sorey, M.L., 2000, Geothermal hydrology of Valles Caldera and the southwestern Jemez Mountains, New Mexico: U.S. Geological Survey Water-Resources Investigations Report 00-4067, 115 p.

Turk, J.T., Campbell, D.H., and Spahr, N.E., 1993, Use of chemistry and stable sulfur isotopes to determine sources of trends in sulfate of Colorado lakes: Water, Air, and Soil Pollution, v. 67, p. 415-431.

U.S. Census Bureau, 2001, Metropolitan areas ranked by population—2000 U.S. Census Bureau data available on the World Wide Web, accessed September 26, 2001, at URL http://www.census.gov/population/www/cen2000/phc-t3.html

U.S. Environmental Protection Agency, 1994, Methods for the determination of metals in environmental samples—Supplement 1: EPA-600/R-94-111.

U.S. Geological Survey, 1960, Compilation of records of surface waters of the United States through September 1950, Part 8, Western Gulf of Mexico Basins: U.S. Geological Survey Water-Supply Paper 1312, 633 p.

U.S. Geological Survey, 1998, National Field Manual for the Collection of Water-Quality Data: U.S. Geological Survey, Techniques of Water-Resources Investigations, Book 9, Chapters A1-A9.

van der Straaten, C.M., and Mook, W.G., 1983, Stable isotopic composition of precipitation and climatic variability, *in* Palaeoclimates and Palaeowaters: A Collection of Environmental Isotope Studies: Vienna, Austria, International Atomic Energy Agency, p. 53-64.

Vogel, J.C., and Van Urk, H., 1975, Isotopic composition of groundwater in semi-arid regions of southern Africa: Journal of Hydrology, v. 25, p. 23-36.

von Buttlar, H., and Wendt, I., 1958, Ground-water studies in New Mexico using tritium as a tracer: Transactions, American Geophysical Union, v. 39, no. 4, p. 660-668.

Vuataz, F.D., and Goff, F., 1986, Isotope geochemistry of thermal and nonthermal waters in the Valles Caldera, Jemez Mountains, northern New Mexico: Journal of Geophysical Research, v. 91, no. B2, p. 1835-1853.

White, J.W.C., Cook, E.R., Lawrence, J.R., and Broecker, W.S., 1985, The D/H ratio of sap in trees: Implications for water sources and tree ring D/H ratios: Geochimica et Cosmochimica Acta, v. 49, p. 237-246.

Wigley, T.M.L., and Muller, A.B., 1981, Fractionation corrections in radiocarbon dating: Radiocarbon, v. 23, no. 2, p. 173-190.

Wigley, T.M.L., Plummer, L.N., and Pearons, F.J., Jr., 1979, Errata: Geochimica et Cosmochimica Acta, v. 43, p. 1395.

Wigley, T.M.L., Plummer, L.N., and Pearson, F.J., Jr., 1978, Mass transfer and carbon isotope evolution in natural water systems: Geochimica et Cosmochimica Acta, v. 42, p. 1117-1139.

Wilkins, D.E., and Currey, D.R., 1997, Timing and extent of late Quaternary paleolakes in the Trans-Pecos closed basin, west Texas and south-central New Mexico: Quaternary Research, v. 47, p. 306-315.

Wilkins, D.E., and Currey, D.R., 1999, Radiocarbon chronology and $^{13}C$ analysis of mid- to late Holocene Aeolian environments, Guadalupe Mountains National Park, Texas, U.S.A.: The Holocene, v. 9, p. 363-371.

Wilson, B.C., and Lucero, A.A., 1997, Water use by categories in New Mexico counties and river basins, and irrigated acreage in 1995: Sante Fe, New Mexico State Engineer Office Technical Report 49, 149p.

Yapp, C. J., 1985, D/H variations of meteoric waters in Albuquerque, New Mexico, U.S.A.: Journal of Hydrology, v. 76, p. 63-84.

Zhu, C., Winterle, J.R., and Love, E.I. , 2003, Late Pleistocene and Holocene groundwater recharge from the chloride mass balance method and chlorine-36 data: Water Resources Research, v. 39(7), p. 1182, doi: 10.1029/2003WR001987, 2003

# Appendix A. Chemical and isotopic data of ground water collected from the Middle Rio Grande Basin, June 1996 through August 1998

# **Table A1.** Location and well-construction information for ground-water sites

[Monitoring Well ID, See figs. 58 and 69; Hydrochemical Zone "E", exotic water, no primary or secondary zone assigned; dms, degrees/minutes/seconds; bls, below land surface; na, not applicable; nd, not determined; PVC, polyvinylchloride; PW, production well; WW, windmill; DW, domestic well; MW, monitoring well; SW, stock well; SP, spring; SXXX, No site number assigned; A sampling pump was used when a fixed pump was not available.]

| Site no. | Mon-itor-ing Well ID | Site name | Primary hydro-chem-ical zone | Secon-dary hydro-chemical zone | Lati-tude (dms) | Longi-tude (dms) | Land surface alti-tude (feet) | Local well no. | USGS site ID | Depth (feet bls) | Water level (feet bls) | Water level date | Depth to top of screen (feet bls) | Depth to bottom of screen (feet bls) | Screen length (feet) | Well type | Fixed pump type | Sample pump type | Casing mater-ial | Casing dia-meter (inches) | Date constr-ucted |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Zone 1: Northern Mountain Front** | | | | | | | | | | | | | | | | | | | |
| S027 | | CEPO 02 | 1 | na | 353736 | 1062104 | 5,335 | 16N.06E.07.332 | 353736106210401 | 320 | 121.13 | 8/3/1998 | 270 | 315 | 45 | MW | na | Grundfos | PVC | 4 | nd |
| S034 | | Private Production Well #04 | 1 | na | 353657 | 1062116 | 5,298 | 16N.06E.18.311 | 353657106211601 | 250 | 190. | nd | nd | nd | nd | PW | submersible | na | steel | nd | nd |
| S035 | | Windmill #37 | 1 | na | 353805 | 1062329 | 5,533 | 16N.05E.10.242 | 353805106232901 | 290 | 150. | nd | nd | nd | nd | WW | windmill | na | steel | 6 | nd |
| S036 | | Private Production Well #03 | 1 | na | 353443 | 1061913 | 5,362 | 16N.06E.32.224 | 353443106191301 | 300 | 160. | 5/25/1967 | 250 | 300 | 50 | PW | submersible | na | steel | 6 | 5/25/1967 |
| S065 | | Domestic Well #05 | 1 | na | 351901 | 1063458 | 5,172 | 13N.03E.36.113 | 351901106345801 | 330 | 160. | 9/2/1994 | 320 | 330 | 10 | DW | submersible | na | PVC | 4 | 9/2/1994 |
| S187 | | Rio Rancho 12 | 1 | na | 351915 | 1063529 | 5,240 | 13N.03E.26.433 | 351915106352801 | 1,487 | 226. | 1994 | 800 | 1,435 | 635 | PW | turbine | na | steel | nd | 3/3/1987 |
| S206 | | Windmill #38 | 1 | 3 | 352556 | 1062929 | 5,542 | 14N.04E.23.143 | 352448106294601 | 535 | 460.58 | 2/9/1995 | nd | nd | nd | WW | windmill | na | steel | nd | nd |
| S216 | | Windmill #09 | 1 | na | 352759 | 1063627 | 5,725 | 14N.03E.03.434 | 352757106362301 | 637 | 585. | 6/10/1958 | nd | nd | nd | WW | windmill | na | steel | nd | 6/1/1958 |
| S221 | | Windmill #45 | 1 | na | 353340 | 1062547 | 5,632 | 15N.05E.05.243 | 353340106254701 | 555 | nd | nd | nd | nd | nd | WW | windmill | na | steel | nd | nd |
| S222 | | Windmill #39 | 1 | 3 | 353458 | 1063037 | 6,107 | 16N.04E.27.333 | 353455106304201 | 260 | nd | nd | nd | nd | nd | WW | windmill | na | steel | nd | nd |
| S254 | | Private Production Well #12 | 1 | na | 353856 | 1062000 | 5,525 | 16N.06E.05.132 | 353856106200001 | 690 | 265. | nd | 356 | 690 | 334 | PW | turbine | na | steel | nd | nd |
| S277 | | Windmill #40 | 1 | na | 353338 | 1063228 | 5,946 | 15N.04E.05.143 | 353337106323301 | 100 | 36.6 | 4/21/1998 | nd | nd | nd | WW | windmill | na | steel | 6 | 1937 |
| S279 | | Windmill #42 | 1 | na | 353605 | 1063404 | 6,275 | 16N.03E.24.421 | 353608106340401 | 56 | 13.18 | 1/11/1984 | nd | nd | nd | WW | windmill | na | steel | 8 | 2/13/1959 |
| S281 | | Windmill #43 | 1 | 3 | 353230 | 1063440 | 6,281 | 15N.03E.12.322 | 353238106342901 | 1,109 | 990.99 | 11/7/1994 | nd | nd | nd | WW | windmill | na | steel | 8 | 2/1/1960 |
| | | **Zone 2: Northwestern** | | | | | | | | | | | | | | | | | | | |
| S103 | A | Lincoln D | 2 | na | 351515 | 1064104 | 5,450 | 12N.02E.24.144 | 351515106410401 | 1,260 | 495.5 | 9/2/1997 | 1,200 | 1,240 | 40 | MW | na | Bennett | steel | 2 | 8/30/1997 |
| S104 | A | Lincoln M | 2 | na | 351515 | 1064104 | 5,450 | 12N.02E.24.144A | 351515106410402 | 835 | 494.3 | 9/2/1997 | 810 | 830 | 20 | MW | na | Bennett | steel | 2 | 8/30/1997 |
| S105 | A | Lincoln S | 2 | na | 351515 | 1064104 | 5,450 | 12N.02E.24.144B | 351515106410403 | 595 | 485.5 | 9/10/1997 | 490 | 590 | 100 | MW | na | Bennett | steel | 2 | 8/30/1997 |
| S191 | | Rio Rancho 4 | 2 | 3 | 351459 | 1064034 | 5,415 | 12N.03E.24.442 | 351459106403401 | 990 | 396. | 9/1/1969 | 670 | 990 | 320 | PW | turbine | na | steel | 16 | 9/1/1969 |
| S192 | | Rio Rancho 8 | 2 | 3 | 351625 | 1064357 | 5,827 | 12N.02E.16.214 | 351627106435301 | 1,618 | 880. | 8/21/1978 | 982 | 1,599 | 617 | PW | turbine | na | steel | 18 | 8/3/1978 |
| S189 | | Rio Rancho 15 | 2 | na | 352117 | 1064057 | 5,794 | 13N.02E.13.322 | 352117106405701 | 1,310 | 775. | 8/8/1993 | 820 | 1,290 | 470 | PW | turbine | na | steel | nd | nd |
| S276 | | Windmill #12 | 2 | na | 353302 | 1063856 | 5,970 | 15N.03E.08.123 | 353255106385601 | 727 | 667. | 6/4/1981 | 715 | 725 | 10 | WW | windmill | na | steel | 6 | 4/22/1970 |
| S278 | | Windmill #41 | 2 | na | 352542 | 1064203 | 5,618 | 14N.02E.23.321 | 352542106420401 | 448 | 373.3 | 1/23/1984 | nd | nd | nd | WW | windmill | na | steel | 5 | 10/10/1939 |
| S280 | | Windmill #13 | 2 | na | 352811 | 1064523 | 5,554 | 14N.02E.05.323 | 352810106452201 | 240 | 116. | 4/18/1957 | 125 | 135 | 10 | WW | windmill | na | steel | 6 | 10/3/1955 |
| S286 | | Private Production Well #13 | 2 | na | 353106 | 1064214 | 5,615 | 15N.02E.23.141 | 353106106421401 | 572 | 242. | 10/16/1995 | 392 | 552 | 160 | PW | submersible | na | steel | nd | 10/16/1995 |
| S287 | | Private Production Well #14 | 2 | na | 353041 | 1064255 | 5,525 | 15N.02E.22.414 | 353044106425101 | 320 | 150. | 4/11/1983 | 260 | 320 | 60 | PW | submersible | na | steel | 5 | 3/9/1971 |
| | | **Zone 3: West Central** | | | | | | | | | | | | | | | | | | | |
| S003 | F | 98th St. D | 3 | na | 350530 | 1064452 | 5,320 | 10N.02E.17.44 | 350530106445201 | 1,544 | 421.46 | 4/21/1997 | 1,534 | 1,539 | 5 | MW | na | Bennett | PVC | 3 | 2/15/1997 |
| S004 | F | 98th St. MD | 3 | na | 350530 | 1064452 | 5,320 | 10N.02E.17.44A | 350530106445202 | 1,112 | 422.69 | 4/21/1997 | 1,102 | 1,107 | 5 | MW | na | Bennett | PVC | 3 | 2/15/1997 |
| S005 | F | 98th St. MS | 3 | na | 350530 | 1064452 | 5,320 | 10N.02E.17.44B | 350530106445203 | 749 | 416. | 4/21/1997 | 739 | 744 | 5 | MW | na | Bennett | PVC | 3 | 2/15/1997 |
| S006 | F | 98th St. S | 3 | na | 350530 | 1064452 | 5,320 | 10N.02E.17.44C | 350530106445204 | 438 | 391.3 | 4/21/1997 | 388 | 433 | 45 | MW | na | Bennett | PVC | 3 | 2/15/1997 |
| S008 | | Private Production Well #01 | 3 | na | 350336 | 1064751 | 5,725 | 10N.01E.25.333 | 350336106475101 | 1,292 | 834. | 10/31/1987 | 1,078 | 1,272 | 194 | PW | submersible | na | steel | 6 | 10/31/1987 |
| S010 | | Private Production Well #16 | 3 | na | 350112 | 1064902 | 5,688 | 09N.01E.10.422 | 350112106490201 | 1,300 | 781. | 6/4/1965 | 1,242 | 1,294 | 52 | PW | submersible | na | steel | 6 | 6/4/1965 |
| S018 | | Domestic Well #21 | 3 | na | 344701 | 1065050 | 5,320 | 07N.01E.33.334 | 344701106505001 | 660 | 475. | 10/14/1983 | 640 | 660 | 20 | DW | submersible | na | PVC | 5 | 10/14/1983 |
| S019 | | Belen 4 | 3 | 5 | 343917 | 1064747 | 4,920 | 05N.01E.13.33 | 343917106474701 | 504 | 150. | 12/1/1967 | 150 | 504 | 354 | PW | submersible | na | steel | 14 | 12/1/1967 |
| S020 | | Belen 5 | 3 | 5 | 344017 | 1064754 | 4,930 | 05N.01E.12.313 | 344017106475401 | 600 | 144. | nd | 435 | 600 | 165 | PW | submersible | na | steel | nd | nd |
| S029 | | Cerro Colorado Landfill PW | 3 | 5 | 350121 | 1065208 | 5,830 | 09N.01E.07.244 | 350121106520801 | 1,661 | 898. | 5/3/1990 | 1,355 | 1,655 | 300 | PW | turbine | na | steel | 10 | 5/3/1990 |
| S037 | | College 2 | 3 | na | 350647 | 1064400 | 5,226 | 10N.02E.09.232 | 350647106440001 | 1,605 | 329. | 1993 | 550 | 1,564 | 1,014 | PW | turbine | na | steel | nd | 9/10/1978 |
| S066 | | Gonzales 1 | 3 | 12 | 350641 | 1064232 | 5,111 | 10N.02E.11.131 | 350642106422801 | 970 | 167.2 | 11/1/1992 | 350 | 950 | 600 | PW | turbine | na | steel | 20 | 11/1/1992 |
| S086 | G | Isleta D | 3 | na | 345650 | 1064159 | 4,900 | 08N.02E.02.413 | 345650106415901 | 1,340 | 17.89 | 12/18/1997 | 1,330 | 1,335 | 5 | MW | na | Bennett | PVC | 2 | 12/16/1997 |
| S101 | | Leavitt 1 | 3 | na | 350310 | 1064350 | 5,076 | 10N.02E.33.232 | 350309106434501 | 1,140 | 193. | 1993 | 288 | 1,128 | 840 | PW | turbine | na | steel | nd | 1973 |
| S108 | | Los Lunas 3 | 3 | 12 | 344915 | 1064528 | 4,965 | 07N.02E.20.133 | 344915106452801 | 605 | 182. | nd | 332 | 562 | 230 | PW | na | na | steel | nd | nd |
| S109 | | Los Lunas 4 | 3 | 12 | 345009 | 1064503 | 4,981 | 07N.02E.17.232 | 345009106450301 | 610 | 129. | 6/28/1979 | 278 | 582 | 304 | PW | na | na | steel | 14 | 6/28/1979 |
| S145 | | NM Utilities 1 | 3 | na | 351137 | 1064417 | 5,390 | 11N.02E.09.324 | 351137106441701 | 1,050 | 533. | 1992 | 648 | 1,050 | 402 | PW | turbine | na | steel | 16 | 5/24/1960 |
| S147 | | NM Utilities 3 | 3 | na | 351302 | 1064247 | 5,460 | 11N.02E.03.221 | 351302106424701 | 1,364 | 489. | 4/1/1980 | 650 | 1,351 | 701 | PW | turbine | na | steel | 16 | 4/1/1980 |
| S148 | | NM Utilities 4 | 3 | na | 351215 | 1064413 | 5,455 | 11N.02E.04.344 | 351215106441301 | 1,357 | 539. | 9/30/1994 | 692 | 1,339 | 647 | PW | turbine | na | steel | 16 | 9/30/1994 |
| S166 | | Rabbit Hill | 3 | na | 353534 | 1064251 | 5,655 | 16N.02E.27.213A | 353534106425101 | 608 | 102.27 | 8/4/1998 | 353 | 603 | 250 | MW | na | Grundfos | PVC | 2 | nd |
| S167 | | Domestic Well #12 | 3 | na | 344851 | 1064928 | 5,358 | 07N.01E.22.431 | 344851106492801 | 985 | 530. | 3/14/1991 | 965 | 980 | 15 | DW | submersible | na | steel | 5 | 3/14/1991 |
| S174 | | Rio Bravo 1 D | 3 | na | 350137 | 1064105 | 4,931 | 09N.02E.12.214A | 350137106410501 | 149 | 11.31 | 1/24/1996 | 139 | 144 | 5 | MW | na | Bennett | steel | 5 | nd |
| S175 | | Rio Bravo 1 M | 3 | 12 | 350137 | 1064105 | 4,931 | 09N.02E.12.214B | 350137106410502 | 104 | 11.21 | 1/24/1996 | 94 | 99 | 5 | MW | na | Bennett | steel | 5 | nd |
| S172 | D | Rio Bravo 5 D | 3 | 12 | 350140 | 1064016 | 4,958 | 09N.03E.07.114B | 350138106401103 | 515 | 12.1 | 12/2/1992 | 500 | 510 | 10 | MW | na | Grundfos | PVC | 4 | 9/24/1992 |
| S186 | | Rio Rancho 10 | 3 | na | 351623 | 1063946 | 5,504 | 12N.03E.18.231 | 351623106394601 | 1,470 | 556. | 1994 | 825 | 1,450 | 625 | PW | turbine | na | steel | nd | 12/21/1985 |
| S188 | | Rio Rancho 13 | 3 | na | 351630 | 1064812 | 6,055 | 12N.01E.14.212 | 351630106481201 | 1,920 | 1,101.15 | 12/20/1989 | 1,343 | 1,721 | 378 | PW | turbine | na | steel | nd | 12/20/1989 |
| S193 | | Rio Rancho 9 | 3 | na | 351923 | 1064707 | 6,054 | 13N.01E.25.432 | 351922106470601 | 1,540 | 1,082. | 10/31/1984 | 1,120 | 1,520 | 400 | PW | turbine | na | steel | 18 | 7/10/1984 |
| S196 | | Windmill #05 | 3 | na | 345406 | 1065030 | 5,470 | 08N.01E.21.431 | 345406106503001 | 620 | 598.9 | 5/11/1993 | nd | nd | nd | WW | windmill | na | steel | 6 | 5/1/1964 |
| S200 | | Private Production Well #08 | 3 | na | 343103 | 1064827 | 4,840 | 03N.01E.02.23 | 343103106482701 | 249 | 92. | 7/3/1984 | 224 | 249 | 25 | PW | submersible | na | steel | 6 | 7/3/1984 |
| S217 | B | Santa Ana Boundary D | 3 | na | 352710 | 1063945 | 5,322 | 14N.03E.07.431A | 352708106394301 | 750 | 6.35 | 8/16/1985 | 730 | 750 | 20 | MW | na | Bennett | steel | 2 | nd |

**Table A1.** Location and well-construction information for ground-water sites-- Continued

| Site no. | Mon-itor-ing Well ID | Site name | Primary hydro-chem-ical zone | Secon-dary hydro-chemical zone | Lati-tude (dms) | Longi-tude (dms) | Land surface alti-tude (feet) | Local well no. | USGS site ID | Depth (feet bls) | Water level (feet bls) | Water level date | Depth to top of screen (feet bls) | Depth to bottom of screen (feet bls) | Screen length (feet) | Well type | Fixed pump type | Sample pump type | Casing mater-ial | Casing dia-meter (inches) | Date constr-ucted |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S218 | B | Santa Ana Boundary M | 3 | na | 352710 | 1063945 | 5,322 | 14N.03E.07.431B | 352708106394302 | 492 | 15.96 | 8/16/1985 | 472 | 492 | 20 | MW | na | Bennett | steel | 2 | nd |
| S219 | B | Santa Ana Boundary S | 3 | na | 352710 | 1063945 | 5,322 | 14N.03E.07.431C | 352708106394303 | 210 | 31.22 | 8/16/1985 | 190 | 210 | 20 | MW | na | Bennett | steel | 2 | nd |
| S230 | H | Sierra Vista D | 3 | na | 350910 | 1064148 | 5,110 | 11N.03E.26.243 | 350910106414801 | 1,644 | 178.75 | 8/8/1997 | 1,634 | 1,639 | 5 | MW | na | Bennett | PVC | 2 | 7/20/1997 |
| S236 | | SAF (Soil Amendment Facility) | 3 | na | 350855 | 1064928 | 5,866 | 11N.01E.27.421 | 350846106492601 | 1,463 | 922.11 | 4/25/1988 | 1,116 | 1,429 | 313 | PW | turbine | na | steel | 10 | 3/12/1988 |
| S241 | | SWAB Test Hole #1 D | 3 | 1 | 350449 | 1064931 | 5796 | 10N.01E.22.322C | 350449106493103 | 1179 | 884.95 | 4/12/1994 | 1,139 | 1,179 | 40 | MW | na | swab | PVC | 2 | 6/25/1981 |
| S242 | | SWAB Test Hole #1 S | 3 | 1 | 350449 | 1064931 | 5796 | 10N.01E.22.322B | 350449106493102 | 1121 | 886.8 | 4/12/1994 | 980 | 1,121 | 141 | MW | na | swab | PVC | 2 | 6/25/1981 |
| S243 | | SWAB Test Hole #2 D | 3 | na | 351046 | 1064648 | 5730 | 11N.02E.18.313D | 351046106464704 | 1805 | 796.97 | 4/12/1994 | 1,525 | 1,795 | 270 | MW | na | swab | PVC | 2 | 11/1/1981 |
| S263 | | Volcano Cliff 1 | 3 | na | 350935 | 1064343 | 5,335 | 11N.02E.28.222 | 350950106434001 | 1,200 | 458. | 1993 | 528 | 1,056 | 528 | PW | turbine | na | steel | nd | 9/24/1968 |
| S266 | E | West Bluff Nest 1 Well 1 | 3 | na | 350638 | 1064137 | 5,100 | 10N.02E.11.244 | 350638106413701 | 1,095 | 173.11 | 10/24/1996 | 1,085 | 1,090 | 5 | MW | na | Grundfos | PVC | 3 | 7/18/1996 |
| S272 | | West Mesa 3 | 3 | na | 350444 | 1064354 | 5,145 | 10N.02E.21.412 | 350443106395801 | 1,365 | 239. | 4/1/1974 | 405 | 1,353 | 948 | PW | turbine | na | steel | 16 | 1974 |
| S283 | C | Zia Ball Park D | 3 | na | 353000 | 1064350 | 5,397 | 15N.02E.28.421A | 353000106435001 | 770 | 14.36 | 8/16/1985 | 750 | 770 | 20 | MW | na | Bennett | steel | 2 | nd |
| S284 | C | Zia Ball Park M | 3 | na | 353000 | 1064350 | 5,397 | 15N.02E.28.421B | 353000106435002 | 506 | 15.11 | 9/9/1985 | 486 | 506 | 20 | MW | na | Bennett | steel | 2 | nd |
| S285 | C | Zia Ball Park S | 3 | 2 | 353000 | 1064350 | 5,397 | 15N.02E.28.421C | 353000106435003 | 300 | 19.21 | 8/16/1985 | 280 | 300 | 20 | MW | na | Bennett | steel | 2 | nd |
| S288 | | Zia BMT D | 3 | na | 353208 | 1064059 | 5,740 | 15N.02E.13.122 | 353208106405901 | 800 | nd | nd | 750 | 800 | 50 | MW | na | Bennett | steel | 2 | nd |
| | | **Zone 4: Western Boundary** | | | | | | | | | | | | | | | | | | | |
| S031 | | Windmill #18 | 4 | na | 342924 | 1065505 | 4,850 | 03N.01W.14.114 | 342922106550301 | 143 | 112.47 | 2/9/1995 | nd | nd | nd | WW | windmill | na | steel | 6 | nd |
| S039 | | Windmill #20 | 4 | na | 343539 | 1070055 | 5,249 | 04N.02W.02.433 | 343539107005501 | 439 | nd | nd | nd | nd | nd | WW | pump jack | na | steel | nd | 1947 |
| S059 | | Windmill #21 | 4 | na | 343907 | 1065729 | 5,190 | 05N.01W.20.222 | 343907106572901 | 395 | 349. | 3/24/1963 | 390 | 395 | 5 | WW | pump jack | na | steel | 5 | nd |
| S074 | | Windmill #23 | 4 | na | 343841 | 1070244 | 5,434 | 05N.02W.21.422 | 343839107024401 | 620 | 545.49 | 5/24/1956 | nd | nd | nd | WW | pump jack | na | steel | 8 | 1953 |
| S169 | | Rest Area | 4 | na | 341841 | 1065317 | 4,905 | 01N.01W.13.244 | 341839106531601 | 212 | 164.08 | 10/31/1995 | 173 | 212 | 39 | PW | submersible | na | steel | nd | 8/23/1976 |
| S201 | | Windmill #26 | 4 | na | 342934 | 1070604 | 5,654 | 03N.03W.12.443 | 342934107060401 | 630 | nd | nd | nd | nd | nd | WW | windmill | na | steel | nd | nd |
| S252 | | Windmill #10 | 4 | na | 343649 | 1065738 | 5,188 | 05N.01W.32.423 | 343650106573501 | 428 | 370.5 | 10/18/1993 | 388 | 428 | 40 | WW | pump jack | na | PVC | 6 | 10/18/1993 |
| S260 | | Windmill #33 | 4 | na | 343230 | 1065707 | 5,004 | 04N.01W.28.323 | 343230106570301 | 281 | 207.33 | 5/8/1956 | 269 | 279 | 10 | WW | windmill | na | steel | 6 | 1956 |
| | | **Zone 5: Rio Puerco** | | | | | | | | | | | | | | | | | | | |
| S032 | | Windmill #17 | 5 | na | 342707 | 1065325 | 4,771 | 03N.01W.25.441 | 342707106532202 | 61 | 34.44 | 2/2/1993 | nd | nd | nd | WW | windmill | na | steel | 6 | nd |
| S069 | | Domestic Well #06 | 5 | na | 343748 | 1065021 | 5,191 | 05N.01E.28.41 | 343748106502101 | 590 | 385. | 10/31/1995 | 590 | 590 | nd | DW | submersible | na | steel | 5 | 10/31/1995 |
| S073 | | Windmill #03 | 5 | na | 343447 | 1065545 | 5,035 | 04N.01W.15.211 | 343447106554201 | 268 | 224.79 | 5/9/1956 | nd | nd | nd | WW | windmill | na | steel | nd | 1933 |
| S082 | | Windmill #36 | 5 | na | 345231 | 1065617 | 5,570 | 08N.01W.34.311 | 345231106561701 | 720 | 599.2 | 5/11/1993 | nd | nd | nd | WW | windmill | na | steel | 8 | 10/1/1960 |
| S085 | | Windmill #35 | 5 | na | 345132 | 1065452 | 5,423 | 07N.01W.02.342 | 345132106545201 | 700 | 580.2 | 1/25/1993 | nd | nd | nd | WW | windmill | na | steel | 8 | 11/1/1934 |
| S111 | | Domestic Well #10 | 5 | na | 343634 | 1064951 | 5,169 | 05N.01E.34.33 | 343634106495101 | 657 | 400. | 7/27/1994 | 637 | 657 | 20 | DW | submersible | na | PVC | 4 | 7/27/1994 |
| S185 | | Domestic Well #31 | 5 | na | 350204 | 1065623 | 5,280 | 09N.01W.04.424 | 350204106562301 | 150 | 75.25 | 10/30/1995 | nd | nd | nd | DW | submersible | na | PVC | 5 | 1957 |
| S198 | | Windmill #07 | 5 | na | 345218 | 1070018 | 5,125 | 08N.02W.36.341 | 345218107001801 | 212 | 133.6 | 5/7/1993 | nd | nd | nd | WW | windmill | na | steel | 6 | 5/1/1968 |
| S215 | | Sandoval Spring | 5 | 4 | 352136 | 1065622 | 5,860 | 13N.01W.16.224 | 352136106562201 | na | na | na | na | na | na | SP | na | peristaltic | na | na | nd |
| S237 | | Windmill #30 | 5 | 4 | 343053 | 1065518 | 5,010 | 03N.01W.02.311 | 343053106551801 | 440 | nd | nd | nd | nd | nd | WW | windmill | na | steel | nd | nd |
| S238 | | Windmill #31 | 5 | na | 343146 | 1065340 | 4,849 | 04N.01W.36.233 | 343145106533601 | 90 | 52.1 | 11/21/1949 | nd | nd | nd | WW | windmill | na | steel | 6 | 1949 |
| | | **Zone 6: Southwestern Mountain Front** | | | | | | | | | | | | | | | | | | | |
| S022 | | Windmill #02 | 6 | na | 342426 | 1065559 | 5,080 | 02N.01W.10.341 | 342426106555901 | 316 | nd | nd | nd | nd | nd | WW | windmill | na | steel | nd | nd |
| | | **Zone 7: Abo Arroyo** | | | | | | | | | | | | | | | | | | | |
| S021 | | Stock Well #01 | 7 | na | 342732 | 1063133 | 5,373 | 03N.04E.28.244 | 342723106312001 | 192 | 170.95 | 6/23/1997 | nd | nd | nd | SW | submersible | na | steel | 8 | 1955 |
| S024 | | Domestic Well #02 | 7 | 8 | 342914 | 1063719 | 5,181 | 03N.03E.15.131 | 342914106371901 | 400 | nd | nd | nd | nd | nd | DW | submersible | na | steel | nd | 7/1/1919 |
| S090 | | Domestic Well #08 | 7 | na | 342516 | 1064260 | 5,032 | 12N.02E.03.43 | 342516106430001 | 360 | 280. | 3/12/1996 | 320 | 360 | 40 | DW | submersible | na | PVC | 5 | 3/12/1996 |
| S093 | | Domestic Well #09 | 7 | 8 | 343024 | 1064431 | 4,910 | 03N.02E.09.11 | 343024106443101 | 350 | 150. | 7/26/1992 | 340 | 350 | 10 | DW | submersible | na | PVC | 4 | 7/26/1992 |
| | | **Zone 8: Eastern Mountain Front** | | | | | | | | | | | | | | | | | | | |
| S007 | | Domestic Well #01 | 8 | na | 350860 | 1062746 | 6,490 | 11N.04E.25.424 | 350900106274401 | 55 | 30.49 | 6/21/1996 | nd | nd | nd | DW | submersible | na | PVC | nd | nd |
| S013 | | Windmill #14 | 8 | na | 344103 | 1063218 | 5,450 | 05N.04E.05.432 | 344103106321801 | 270 | 220. | 5/17/1995 | 260 | 270 | 10 | WW | windmill | na | PVC | 5 | 5/17/1995 |
| S014 | | Private Production Well #17 | 8 | na | 352148 | 1062733 | 5,320 | 13N.05E.18.111 | 352148106273301 | 360 | 240. | 6/21/1983 | 310 | 360 | 50 | PW | submersible | na | nd | 6 | 6/21/1983 |
| S015 | | Windmill #01 | 8 | na | 344132 | 1063050 | 5,634 | 05N.04E.03.114 | 344133106304801 | 42 | 13.02 | 1957 | nd | nd | nd | WW | windmill | na | steel | nd | 1945 |
| S030 | | Charles 4 | 8 | na | 350559 | 1063339 | 5,324 | 10N.04E.18.211 | 350602106333201 | 1,055 | 386. | 1968 | 456 | 1,032 | 576 | PW | turbine | na | steel | nd | 7/31/1968 |
| S042 | | Domestic Well #03 | 8 | na | 344451 | 1063734 | 5,067 | 06N.03E.16.243 | 344451106373401 | 480 | 350. | nd | 460 | 480 | 20 | DW | submersible | na | PVC | 5 | 3/8/1995 |
| S055 | | Elena Gallegos | 8 | na | 351000 | 1062816 | 6,455 | 11N.04E.24.124 | 351020106282001 | 95 | 28. | 6/3/1983 | 20 | 95 | 75 | PW | submersible | na | nd | 5 | 6/3/1983 |
| S056 | | Embudito Spring | 8 | na | 350804 | 1062829 | 6,440 | 11N.04E.36.323 | 350804106282901 | na | na | na | na | na | na | SP | na | peristaltic | na | na | nd |
| S071 | | Domestic Well #07 | 8 | na | 350955 | 1063003 | 5,988 | 11N.04E.22.423 | 350955106300301 | 600 | 392. | 7/24/1993 | 570 | 590 | 20 | DW | submersible | na | PVC | 4 | 7/24/1993 |
| S083 | | Windmill #34 | 8 | na | 344945 | 1063726 | 5,142 | 07N.03E.16.442 | 344945106372601 | 440 | 313.1 | 5/18/1993 | nd | nd | nd | WW | windmill | na | steel | 8 | 3/1/1958 |
| S095 | | Kirtland 1 | 8 | na | 350302 | 1063332 | 5,383 | 10N.04E.31.411 | 350258106332801 | 1,199 | 427. | 8/1/1949 | 550 | 800 | 250 | PW | submersible | na | steel | 12 | 8/1/1949 |
| S106 | | Domestic Well #23 | 8 | na | 343236 | 1064605 | 4,781 | 04N.02E.30.243 | 343238106460501 | 160 | 8. | 6/24/1991 | 150 | 160 | 10 | DW | submersible | na | PVC | 4 | 6/24/1991 |
| S110 | | Love 1 | 8 | na | 350517 | 1063145 | 5,462 | 10N.04E.16.334 | 350517106314401 | 1,170 | 589. | 1993 | 596 | 1,096 | 500 | PW | turbine | na | steel | 14 | 11/8/1954 |
| S113 | | Domestic Well #11 | 8 | na | 343323 | 1063826 | 5,055 | 04N.03E.21.31 | 343323106382601 | 352 | 240. | 1/30/1991 | 337 | 352 | 15 | DW | submersible | na | PVC | 4 | 1/30/1991 |
| S114 | J | Matheson D | 8 | na | 350653 | 1063116 | 5,575 | 10N.04E.09.214 | 350653106311601 | 1,520 | 727.44 | 7/18/1997 | 1,460 | 1,500 | 40 | MW | na | Bennett | steel | 2 | 7/16/1997 |
| S115 | J | Matheson M | 8 | na | 350653 | 1063116 | 5,575 | 10N.04E.09.214A | 350653106311602 | 1,045 | 720.38 | 7/18/1997 | 1,020 | 1,040 | 20 | MW | na | Bennett | steel | 2 | 7/16/1997 |

## Table A1. Location and well-construction information for ground-water sites-- Continued

| Site no. | Mon-itor-ing Well ID | Site name | Primary hydro-chem-ical zone | Secon-dary hydro-chemical zone | Lati-tude (dms) | Longi-tude (dms) | Land surface alti-tude (feet) | Local well no. | USGS site ID | Depth (feet bls) | Water level (feet bls) | Water level date | Depth to top of screen (feet bls) | Depth to bottom of screen (feet bls) | Screen length (feet) | Well type | Fixed pump type | Sample pump type | Casing mater-ial | Casing dia-meter (inches) | Date constr-ucted |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S116 | J | Matheson S | 8 | na | 350653 | 1063116 | 5,575 | 10N.04E.09.214B | 350653106311603 | 705 | 582.64 | 7/18/1997 | 600 | 700 | 100 | MW | na | Bennett | steel | 2 | 7/16/1997 |
| S117 | | Domestic Well #25 | 8 | na | 350857 | 1062954 | 5,985 | 11N.04E.27.424 | 350857106295401 | 447 | 373. | 2/22/1972 | 439 | 445 | 6 | DW | submersible | na | steel | 6 | 2/22/1972 |
| S118 | | Windmill #24 | 8 | na | 342047 | 1063708 | 5,512 | 01N.03E.03.12 | 342045106370701 | 196 | 114.65 | 7/26/1949 | nd | nd | nd | WW | windmill | na | steel | 8 | 10/1/1948 |
| S119 | | Domestic Well #26 | 8 | 11 | 352137 | 1062338 | 5,760 | 13N.05E.15.223 | 352137106233801 | 150 | 70. | nd | nd | nd | nd | DW | submersible | na | steel | 6 | 1964 |
| S122 | K | Mesa Del Sol S | 8 | na | 345758 | 1063642 | 5,326 | 09N.03E.10.342B | 345758106364003 | 525 | 406.76 | 6/20/1997 | 420 | 520 | 100 | MW | na | Bennett | steel | 3 | 6/6/1997 |
| S140 | | MRN 1 | 8 | na | 345848 | 1063357 | 5,304 | 09N.04E.30.132 | 345848106335701 | 607 | 417.46 | 7/5/1997 | 547 | 587 | 40 | MW | na | Bennett | steel | 5 | 1/22/1995 |
| S141 | | National Utility 7 | 8 | na | 344822 | 1063160 | 5,510 | 07N.04E.28.133 | 344822106320001 | 150 | 80. | 2/5/1964 | nd | nd | nd | PW | submersible | na | steel | 8 | 2/5/1964 |
| S149 | I | Nor Este D | 8 | na | 351114 | 1063306 | 5,460 | 11N.04E.18.222 | 351114106330601 | 1,525 | 538.48 | 6/6/1997 | 1,515 | 1,520 | 5 | MW | na | Bennett | PVC | 3 | 6/3/1997 |
| S150 | I | Nor Este M | 8 | na | 351114 | 1063306 | 5,460 | 11N.04E.18.222A | 351114106330602 | 1,193 | 540.22 | 6/6/1997 | 1,183 | 1,188 | 5 | MW | na | Bennett | PVC | 3 | 6/3/1997 |
| S162 | | Stock Well #03 | 8 | na | 343530 | 1063343 | 5,320 | 04N.04E.07.233 | 343530106334301 | 460 | nd | nd | nd | nd | nd | SW | submersible | na | steel | nd | nd |
| S163 | | PL 2 | 8 | na | 350042 | 1063353 | 5,330 | 09N.04E.18.114 | 350042106335301 | 617 | 451.16 | 7/7/1997 | 577 | 597 | 20 | MW | na | Bennett | steel | 5 | 11/18/1994 |
| S164 | | Ponderosa 1 | 8 | na | 350931 | 1063156 | 5,647 | 11N.04E.28.111 | 350931106315501 | 1,800 | 754. | 1993 | 964 | 1,693 | 729 | PW | turbine | na | steel | 18 | 4/28/1979 |
| S165 | | Windmill #25 | 8 | na | 343802 | 1063233 | 5,440 | 05N.04E.29.142 | 343756106324301 | 420 | 335. | 1962 | nd | nd | nd | WW | windmill | na | steel | nd | 1962 |
| S168 | | Domestic Well #30 | 8 | na | 343338 | 1063553 | 5,137 | 04N.03E.23.411 | 343338106355301 | 400 | 290. | 7/16/1988 | 390 | 400 | 10 | DW | submersible | na | PVC | 4 | 7/16/1988 |
| S170 | | Ridgecrest 3 | 8 | na | 350413 | 1063313 | 5,385 | 10N.04E.30.243 | 350401106331401 | 1,475 | 472. | 11/15/1974 | 620 | 1,436 | 816 | PW | turbine | na | steel | 16 | 11/15/1974 |
| S195 | | Domestic Well #13 | 8 | na | 344832 | 1063618 | 5,176 | 07N.03E.26.113 | 344832106361801 | 600 | 320. | 2/15/1996 | 580 | 600 | 20 | DW | submersible | na | PVC | 4 | 2/15/1996 |
| S199 | | Windmill #08 | 8 | na | 345504 | 1063313 | 5,350 | 08N.04E.18.424 | 345504106331301 | 44 | 22.7 | 5/18/1993 | nd | nd | nd | WW | windmill | na | steel | 6 | 8/1/1969 |
| S209 | | Domestic Well #33 | 8 | na | 343524 | 1064120 | 4,970 | 04N.02E.11.244 | 343524106412001 | 480 | 320. | 6/8/1996 | 460 | 480 | 20 | DW | submersible | na | PVC | 4 | 6/8/1996 |
| S212 | | Sandia Peak 1 | 8 | na | 351031 | 1063007 | 5,978 | 11N.04E.15.434 | 351031106300701 | 800 | 361. | 7/17/1988 | 560 | 760 | 200 | PW | turbine | na | steel | 14 | 7/17/1988 |
| S213 | | Sandia Peak 3 | 8 | na | 351031 | 1063007 | 5,978 | 11N.04E.15.434A | 351031106300702 | 603 | 360. | 7/8/1988 | 383 | 583 | 200 | PW | turbine | na | steel | 14 | 7/8/1988 |
| S224 | | Domestic Well #14 | 8 | na | 351903 | 1062917 | 5,462 | 13N.04E.35.122 | 351903106291701 | 580 | 324. | 12/14/1994 | 560 | 580 | 20 | DW | submersible | na | PVC | 4 | 12/14/1994 |
| S229 | | SH03 UNM | 8 | na | 350950 | 1062948 | 6,060 | 11N.04E.23.331 | 350950106294801 | 495 | 445.16 | 7/28/1998 | 420 | 490 | 70 | MW | na | Bennett | PVC | 4 | nd |
| S233 | | Domestic Well #16 | 8 | na | 351838 | 1063052 | 5,338 | 13N.04E.33.422 | 351838106305201 | 400 | 225. | 11/24/1993 | 375 | 395 | 20 | DW | submersible | na | PVC | 4 | 11/24/1993 |
| S239 | | Domestic Well #17 | 8 | na | 352001 | 1062353 | 6,080 | 13N.05E.27.211 | 352001106235301 | 300 | 225. | 6/16/1982 | 260 | 300 | 40 | DW | submersible | na | PVC | 5 | 6/16/1982 |
| S240 | | Domestic Well #18 | 8 | na | 351115 | 1063027 | 5,943 | 11N.04E.15.122 | 351115106302701 | 550 | 400. | 8/6/1992 | 510 | 530 | 20 | DW | submersible | na | PVC | 4 | 8/6/1992 |
| S246 | | Windmill #32 | 8 | na | 344012 | 1063617 | 5,160 | 05N.03E.11.331 | 344015106362201 | 380 | nd | nd | nd | nd | nd | WW | windmill | na | steel | nd | nd |
| S247 | | Domestic Well #19 | 8 | na | 343142 | 1063232 | 5,380 | 04N.04E.32.24 | 343142106323201 | 640 | 390. | 8/29/1994 | 598 | 638 | 40 | DW | submersible | na | PVC | 4 | 8/29/1994 |
| S248 | | Thomas 6 | 8 | na | 350720 | 1063305 | 5,408 | 10N.04E.06.422 | 350720106330401 | 1,536 | 536. | 1993 | 760 | 1,520 | 760 | PW | turbine | na | steel | nd | 11/14/1988 |
| S255 | | Tramway East | 8 | na | 351136 | 1063050 | 5,880 | 11N.04E.10.313 | 351136106305001 | 1,100 | 474. | 1/19/1966 | 698 | 1,098 | 400 | PW | turbine | na | steel | 12 | 1/19/1966 |
| S264 | | Walker 1 | 8 | na | 351025 | 1063140 | 5,699 | 11N.04E.21.121 | 351025106323801 | 1,723 | 802. | 1993 | 991 | 1,711 | 720 | PW | turbine | na | steel | 18 | 1980 |
| S274 | | Domestic Well #20 | 8 | na | 344629 | 1063827 | 5,050 | 06N.03E.05.422 | 344629106382701 | 368 | 220. | 11/5/1993 | 348 | 368 | 20 | DW | submersible | na | PVC | 4 | 11/5/1993 |
| | | **Zone 9: Tijeras Fault Zone** | | | | | | | | | | | | | | | | | | | |
| S041 | | Coyote Spring | 9 | na | 345957 | 1062812 | 5,840 | 09N.04E.24.211 | 345957106281201 | na | na | na | na | na | na | SP | na | Bennett | na | na | nd |
| S072 | | Hubbell Spring | 9 | 8 | 345555 | 1063151 | 5,437 | 08N.04E.09.314 | 345555106314701 | na | na | na | na | na | na | SP | na | peristaltic | na | na | nd |
| S098 | | KAFB-1902 | 9 | na | 345757 | 1062905 | 5,790 | 09N.04E.35.241 | 345757106290501 | 114 | 85.8 | 12/6/1993 | 79 | 104 | 25 | MW | na | Bennett | steel | 4 | 7/2/1992 |
| S197 | | Windmill #06 | 9 | na | 345335 | 1062932 | 5,725 | 08N.04E.26.144 | 345335106293201 | 295 | 203.6 | 5/18/1993 | nd | nd | nd | WW | windmill | na | steel | 5 | 6/1/1967 |
| S227 | | SFR 3D | 9 | na | 345650 | 1063122 | 5,494 | 08N.04E.04.413 | 345650106312201 | 362 | 162.61 | 11/3/1995 | 312 | 352 | 40 | MW | na | Bennett | PVC | 2 | 11/5/1992 |
| S228 | | SFR 3S | 9 | na | 345650 | 1063122 | 5,494 | 08N.04E.04.413A | 345650106312202 | 222 | 163.5 | 11/3/1995 | 182 | 212 | 30 | MW | na | Bennett | PVC | 2 | 11/10/1992 |
| | | **Zone 10: Tijeras Arroyo** | | | | | | | | | | | | | | | | | | | |
| S001 | | 4Hills-1 | 10 | 8 | 350340 | 1062940 | 5,669 | 10N.04E.26.331 | 350339106294001 | 70 | 57.25 | 1994 | 25 | 65 | 40 | MW | na | Bennett | PVC | 4 | nd |
| S002 | | Private Production Well #15 | 10 | 8 | 350319 | 1063014 | 5,647 | 10N.04E.34.214 | 350317106300901 | 1,200 | 616.17 | 9/30/1957 | 650 | 1,180 | 530 | PW | turbine | | steel | 18 | 10/1/1957 |
| S058 | | Eubank 1 | 10 | 8 | 350259 | 1063158 | 5,457 | 10N.04E.32.422 | 350259106315801 | 615 | 566.33 | 5/10/1964 | 550 | 610 | 60 | MW | na | Bennett | steel | 4 | nd |
| S096 | | Kirtland 11 | 10 | 8 | 350230 | 1063124 | 5,466 | 09N.04E.04.213 | 350228106312401 | 1,327 | 545. | 2/27/1972 | 670 | 1,327 | 657 | PW | na | na | steel | 16 | 1/18/1972 |
| S107 | | Lomas 1 | 10 | na | 350431 | 1063028 | 5,595 | 10N.04E.22.342 | 350430106302401 | 1,300 | 731. | 1993 | 700 | 1,300 | 600 | PW | turbine | na | steel | 16 | 1962 |
| | | **Zone 11: Northeastern** | | | | | | | | | | | | | | | | | | | |
| S016 | | Windmill #15 | 11 | na | 352633 | 1062018 | 5,520 | 14N.06E.18.422 | 352633106201801 | 55 | 25.08 | 1979 | nd | nd | nd | WW | windmill | na | steel | 6 | nd |
| S017 | | Windmill #16 | 11 | na | 352617 | 1061624 | 5,780 | 14N.06E.14.431 | 352617106162401 | 300 | 240. | nd | nd | nd | nd | WW | windmill | na | steel | 8 | 1965 |
| S053 | | Private Production Well #18 | 11 | na | 353025 | 1062122 | 5,382 | 15N.05E.25.222 | 353025106212201 | nd | nd | nd | nd | nd | nd | PW | submersible | na | nd | nd | nd |
| S144 | | Private Production Well #06 | 11 | na | 352713 | 1062056 | 5,496 | 14N.06E.07.341 | 352713106205601 | 800 | 347.2 | 4/8/1993 | 520 | 760 | 240 | PW | submersible | na | steel | 8 | 4/8/1993 |
| S204 | | Windmill #28 | 11 | na | 352345 | 1062516 | 5,320 | 14N.05E.33.341 | 352344106251201 | 175 | 115. | 1956 | nd | nd | nd | WW | windmill | na | steel | nd | 1956 |
| S207 | | Private Production Well #22 | 11 | na | 352506 | 1062400 | 5,260 | 14N.05E.27.124 | 352506106240001 | 286 | 130. | 10/31/1979 | 268 | 286 | 18 | PW | submersible | na | steel | 6 | 10/31/1979 |
| S223 | | Windmill #29 | 11 | na | 352820 | 1061559 | 5,594 | 14N.06E.01.311 | 352820106155901 | 292 | nd | nd | nd | nd | nd | WW | windmill | na | steel | nd | nd |
| | | **Zone 12: Central** | | | | | | | | | | | | | | | | | | | |
| S011 | | Atris-1 | 12 | na | 350533 | 1064131 | 4,960 | 10N.02E.14.424A | 350533106413101 | 31 | 12.55 | 1994 | 26 | 31 | 5 | MW | na | Bennett | steel | 2 | 3/1/1990 |
| S012 | | Atrisco 3 | 12 | 3 | 350516 | 1064121 | 4,950 | 10N.02E.24.112 | 350508106411901 | 813 | 13. | 1993 | 180 | 804 | 624 | PW | turbine | na | steel | 16 | 8/18/1958 |
| S025 | | Burton 2 | 12 | na | 350421 | 1063613 | 5,284 | 10N.03E.26.111 | 350421106361001 | 857 | 418. | 1993 | 425 | 845 | 420 | PW | turbine | na | steel | 18 | 1962 |
| S026 | | Burton 5 | 12 | na | 350355 | 1063517 | 5,275 | 10N.03E.26.422 | 350355106351501 | 1,170 | 415.1 | 12/5/1996 | 550 | 1,150 | 600 | PW | turbine | na | steel | nd | 1991 |
| S033 | | Private Production Well #02 | 12 | na | 345205 | 1063942 | 4,974 | 07N.03E.06.212 | 345205106384201 | 182 | 121. | nd | 142 | 172 | 30 | PW | submersible | na | steel | 8 | nd |
| S040 | | Coronado 1 | 12 | na | 351023 | 1063418 | 5,288 | 11N.03E.24.221 | 351025106341601 | 1,186 | 384. | 1993 | 479 | 1,184 | 705 | PW | turbine | na | steel | 18 | 1/8/1974 |
| S043 | Q | Del Sol D | 12 | na | 350534 | 1063547 | 5,210 | 11N.03E.14.324 | 350534106354701 | 1,567 | 336.69 | 10/24/1996 | 1,557 | 1,562 | 5 | MW | na | Bennett | PVC | 3 | 5/7/1996 |

**Table A1.** Location and well-construction information for ground-water sites-- Continued

| Site no. | Mon-itor-ing Well ID | Site name | Primary hydro-chem-ical zone | Secon-dary hydro-chemical zone | Lati-tude (dms) | Longi-tude (dms) | Land surface alti-tude (feet) | Local well no. | USGS site ID | Depth (feet bls) | Water level (feet bls) | Water level date | Depth to top of screen (feet bls) | Depth to bottom of screen (feet bls) | Screen length (feet) | Well type | Fixed pump type | Sample pump type | Casing mater-ial | Casing dia-meter (inches) | Date constr-ucted |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S044 | Q | Del Sol M | 12 | na | 350534 | 1063547 | 5,210 | 11N.03E.14.324A | 350534106354702 | 842 | 345.61 | 10/24/1996 | 832 | 837 | 5 | MW | na | Bennett | PVC | 3 | 5/7/1996 |
| S045 | Q | Del Sol S | 12 | na | 350534 | 1063547 | 5,210 | 11N.03E.14.324B | 350534106354703 | 425 | 348.66 | 10/24/1996 | 315 | 415 | 100 | MW | na | Bennett | PVC | 3 | 5/7/1996 |
| S046 | | Duranes 1 | 12 | na | 350641 | 1064006 | 4,960 | 10N.03E.07.141 | 350642106401101 | 1,000 | 34. | 1993 | 204 | 924 | 720 | PW | turbine | na | steel | 16 | 12/8/1959 |
| S047 | | Duranes 7 | 12 | na | 350656 | 1064112 | 4,954 | 10N.02E.12.121 | 350655106395001 | 950 | 4. | 2/1/1953 | 144 | 950 | 806 | PW | turbine | na | steel | nd | 4/21/1953 |
| S048 | | Duranes Yard 1 | 12 | na | 350628 | 1064122 | 5,100 | 10N.02E.12.312 | 350628106412201 | 105 | 6.62 | 2/27/1997 | 95 | 100 | 5 | MW | na | Grundfos | PVC | 3 | 1/12/1997 |
| S049 | | Duranes Yard 2 | 12 | na | 350628 | 1064122 | 5,100 | 10N.02E.12.312A | 350628106412202 | 75 | 7.07 | 2/27/1997 | 65 | 70 | 5 | MW | na | Grundfos | PVC | 3 | 1/13/1997 |
| S050 | | Duranes Yard 3 | 12 | na | 350628 | 1064122 | 5,100 | 10N.02E.12.312B | 350628106412203 | 50 | 6.78 | 2/27/1997 | 40 | 45 | 5 | MW | na | peristaltic | PVC | 3 | 1/14/1997 |
| S051 | | Duranes Yard 4 | 12 | na | 350628 | 1064122 | 5,100 | 10N.02E.12.312C | 350628106412204 | 30 | 7.09 | 2/27/1997 | 20 | 25 | 5 | MW | na | peristaltic | PVC | 3 | 1/16/1997 |
| S052 | | Duranes Yard 5 | 12 | na | 350628 | 1064122 | 5,100 | 10N.02E.12.312D | 350628106412205 | 25 | 7.21 | 2/27/1997 | 15 | 20 | 5 | MW | na | peristaltic | PVC | 3 | 1/16/1997 |
| S060 | N | Garfield D | 12 | 3 | 350706 | 1063903 | 4,964 | 10N.03E.05.341 | 350706106390301 | 1,020 | 49.44 | 10/24/1996 | 995 | 1,010 | 15 | MW | na | Grundfos | PVC | 3 | 9/11/1996 |
| S061 | N | Garfield M | 12 | na | 350706 | 1063903 | 4,964 | 10N.03E.05.341A | 350706106390302 | 582 | 48.28 | 10/24/1996 | 552 | 572 | 20 | MW | na | Grundfos | PVC | 3 | 9/11/1996 |
| S062 | N | Garfield S | 12 | na | 350706 | 1063903 | 4,964 | 10N.03E.05.341B | 350706106390303 | 93 | 43.51 | 10/24/1996 | 43 | 83 | 40 | MW | na | Grundfos | PVC | 3 | 9/11/1996 |
| S064 | | Domestic Well #22 | 12 | na | 351421 | 1063822 | 5,230 | 12N.03E.29.422 | 351421106382201 | 315 | 221.5 | 6/20/1997 | 300 | 315 | 15 | DW | submersible | na | PVC | 4 | 6/1/1992 |
| S068 | | Griegos 3 | 12 | na | 350811 | 1064003 | 4,968 | 11N.02E.36.442 | 350802106402901 | 916 | 20. | 1993 | 260 | 916 | 656 | PW | turbine | na | steel | nd | 11/19/1954 |
| S075 | O | Hunter Ridge Nest 1 Well 1 | 12 | 3 | 351200 | 1064008 | 5,110 | 11N.03E.07.141 | 351201106400501 | 1,518 | 162.73 | 10/24/1996 | 1,508 | 1,513 | 5 | MW | na | Grundfos | PVC | 3 | 6/14/1996 |
| S076 | O | Hunter Ridge Nest 1 Well 2 | 12 | na | 351200 | 1064008 | 5,110 | 11N.03E.07.141A | 351201106400502 | 855 | 158.61 | 10/24/1996 | 845 | 850 | 5 | MW | na | Grundfos | PVC | 3 | 6/14/1996 |
| S077 | O | Hunter Ridge Nest 1 Well 3 | 12 | na | 351200 | 1064008 | 5,110 | 11N.03E.07.141B | 351201106400503 | 238 | 146.11 | 10/24/1996 | 148 | 228 | 80 | MW | na | Grundfos | PVC | 3 | 6/14/1996 |
| S078 | O | Hunter Ridge Nest 2 Well 1 | 12 | na | 351200 | 1064008 | 5,110 | 11N.03E.07.141C | 351201106400504 | 359 | 150.65 | 10/24/1996 | 349 | 354 | 5 | MW | na | Grundfos | PVC | 3 | 6/23/1996 |
| S079 | O | Hunter Ridge Nest 2 Well 2 | 12 | na | 351200 | 1064008 | 5,110 | 11N.03E.07.141D | 351201106400505 | 305 | 147.95 | 10/24/1996 | 295 | 300 | 5 | MW | na | Grundfos | PVC | 3 | 6/23/1996 |
| S080 | O | Hunter Ridge Nest 2 Well 3 | 12 | na | 351200 | 1064008 | 5,110 | 11N.03E.07.141E | 351201106400506 | 268 | 147.39 | 10/24/1996 | 238 | 258 | 20 | MW | na | Grundfos | PVC | 3 | 6/23/1996 |
| S081 | | Private Production Well #19 | 12 | na | 351318 | 1063918 | 5,227 | 12N.03E.32.3312 | 351306106394001 | 2,020 | 269. | 4/26/1994 | 730 | 2,000 | 1,270 | PW | turbine | na | steel | 36 | 7/11/1994 |
| S084 | | Windmill #04 | 12 | na | 345345 | 1064513 | 5,016 | 08N.02E.29.213 | 345346106451201 | 167 | 150.1 | 1/26/1996 | 147 | 167 | 20 | WW | windmill | na | steel | nd | 2/1/1916 |
| S087 | G | Isleta MD | 12 | 3 | 345650 | 1064159 | 4,900 | 08N.02E.02.413A | 345650106415902 | 815 | 7.26 | 12/18/1997 | 805 | 810 | 5 | MW | na | Bennett | PVC | 2 | 12/16/1997 |
| S088 | G | Isleta MS | 12 | na | 345650 | 1064159 | 4,900 | 08N.02E.02.413B | 345650106415903 | 185 | 6.08 | 12/18/1997 | 175 | 180 | 5 | MW | na | Bennett | PVC | 2 | 12/16/1997 |
| S089 | G | Isleta S | 12 | na | 345650 | 1064159 | 4,900 | 08N.02E.02.413C | 345650106415904 | 50 | 6.42 | 12/18/1997 | 10 | 40 | 30 | MW | na | Bennett | PVC | 2 | 12/16/1997 |
| S092 | | JMC-1 | 12 | na | 350404 | 1063825 | 4,997 | 10N.03E.29.242A | 350404106382502 | 163 | 114.67 | 1994 | 148 | 158 | 10 | MW | na | Bennett | PVC | 4 | 1988 |
| S097 | | Kirtland 14 | 12 | na | 350301 | 1063546 | 5,322 | 10N.03E.35.322 | 350302106354301 | 1,000 | 360. | 1969 | 380 | 1,000 | 620 | PW | submersible | na | steel | 16 | 1969 |
| S100 | | LALF-9 | 12 | na | 351038 | 1063552 | 5,093 | 11N.03E.14.341 | 351038106355201 | 233 | 145.64 | 1994 | 218 | 228 | 10 | MW | na | Bennett | PVC | 4 | nd |
| S102 | | Leyendecker 1 | 12 | na | 350752 | 1063423 | 5,285 | 11N.03E.36.443 | 350752106342101 | 1,000 | 413. | 1993 | 468 | 996 | 528 | PW | turbine | na | steel | 18 | 11/13/1959 |
| S120 | K | Mesa Del Sol D | 12 | na | 345758 | 1063642 | 5,326 | 09N.03E.10.342 | 345758106364001 | 1,630 | 400.56 | 6/20/1997 | 1,580 | 1,620 | 40 | MW | na | Bennett | steel | 3 | 6/6/1997 |
| S121 | K | Mesa Del Sol M | 12 | na | 345758 | 1063642 | 5,326 | 09N.03E.10.342A | 345758106364002 | 1,015 | 412.48 | 6/20/1997 | 990 | 1,010 | 20 | MW | na | Bennett | steel | 3 | 6/6/1997 |
| S123 | | MONT - 5A | 12 | na | 350810 | 1063719 | 5,018 | 11N.03E.33.424A | 350810106371901 | 200 | 116.21 | 1994 | 185 | 195 | 10 | MW | na | Bennett | PVC | 4 | 1989 |
| S124 | | Montaňo 2 D | 12 | na | 350836 | 1063956 | 4,970 | na | 350836106395601 | 147 | 20.7 | 1/24/1996 | 138 | 143 | 5 | MW | na | Bennett | steel | 5 | nd |
| S125 | | Montaňo 2 M | 12 | na | 350836 | 1063956 | 4,970 | na | 350836106395602 | 99 | 17.1 | 1/24/1996 | 90 | 95 | 5 | MW | na | Bennett | steel | 5 | nd |
| S126 | | Montaňo 2 S | 12 | na | 350836 | 1063956 | 4,970 | na | 350836106395603 | 40 | 14.28 | 1/24/1996 | 30 | 35 | 5 | MW | na | Bennett | steel | 5 | nd |
| S127 | | Montaňo 4 D | 12 | na | 350821 | 1063837 | 4,975 | 11N.03E.32.234A | 350821106383701 | 132 | 45.33 | 1/24/1996 | 123 | 128 | 5 | MW | na | Bennett | steel | 5 | nd |
| S128 | | Montaňo 4 M | 12 | na | 350821 | 1063837 | 4,974 | 11N.03E.32.234B | 350821106383702 | 94 | 42.8 | 1/24/1996 | 85 | 90 | 5 | MW | na | Bennett | steel | 5 | nd |
| S130 | | Montaňo 5 D | 12 | na | 350859 | 1064019 | 4,977 | 11N.03E.30.313B | 350859106401603 | 150 | 9.79 | 12/17/1992 | 135 | 145 | 10 | MW | na | Bennett | PVC | 4 | nd |
| S131 | | Montaňo 5 M | 12 | na | 350859 | 1064019 | 4,977 | 11N.03E.30.313A | 350859106401602 | 75 | 7.39 | 12/17/1992 | 60 | 70 | 10 | MW | na | Bennett | PVC | 4 | nd |
| S132 | | Montaňo 5 S | 12 | na | 350859 | 1064019 | 4,977 | 11N.03E.30.313 | 350859106401601 | 25 | 7.46 | 12/17/1992 | 10 | 20 | 10 | MW | na | Bennett | PVC | 4 | nd |
| S133 | L | Montaňo 6 D | 12 | na | 350834 | 1063958 | 4,970 | 11N.03E.31.213A | 350836106395401 | 983 | 31. | 11/10/1994 | 972 | 978 | 6 | MW | na | Bennett | PVC | 2 | nd |
| S134 | L | Montaňo 6 MD | 12 | na | 350834 | 1063958 | 4,970 | 11N.03E.31.213B | 350836106395402 | 836 | 30.01 | 11/10/1994 | 826 | 831 | 5 | MW | na | Bennett | PVC | 2 | nd |
| S135 | L | Montaňo 6 MS | 12 | na | 350834 | 1063958 | 4,970 | 11N.03E.31.213C | 350836106395403 | 568 | 28.25 | 11/10/1994 | 558 | 563 | 5 | MW | na | Bennett | PVC | 2 | nd |
| S136 | L | Montaňo 6 S | 12 | na | 350834 | 1063958 | 4,970 | 11N.03E.31.213D | 350836106395404 | 182 | 20.62 | 11/10/1994 | 172 | 177 | 5 | MW | na | Bennett | PVC | 2 | nd |
| S137 | R | Montesa M | 12 | na | 350056 | 1063701 | 5,100 | 09N.03E.10.342A | 350056106370102 | 708 | 216.06 | 10/2/1997 | 698 | 703 | 5 | MW | na | Bennett | PVC | 2 | 9/10/1997 |
| S138 | R | Montesa S | 12 | na | 350056 | 1063701 | 5,100 | 09N.03E.10.342B | 350056106370103 | 330 | 211.22 | 10/2/1997 | 260 | 320 | 60 | MW | na | Bennett | PVC | 2 | 9/10/1997 |
| S139 | | Domestic Well #27 | 12 | na | 350949 | 1064242 | 5,197 | 11N.02E.22.441 | 350946106424601 | 326 | 264.49 | 6/17/1997 | nd | nd | nd | DW | submersible | na | steel | 6 | nd |
| S142 | | Domestic Well #28 | 12 | na | 351019 | 1064040 | 5,064 | 11N.02E.24.223 | 351019106404001 | 275 | 103.05 | 10/30/1995 | 259 | 274 | 15 | DW | submersible | na | PVC | 4 | 1/18/1983 |
| S146 | | NM Utilities 2 | 12 | na | 351215 | 1064216 | 5,280 | 11N.02E.02.343 | 351215106421601 | 1,000 | 302. | 10/5/1963 | 350 | 800 | 450 | PW | turbine | na | steel | 16 | 6/26/1963 |
| S151 | I | Nor Este S | 12 | na | 351114 | 1063306 | 5,460 | 11N.04E.18.222B | 351114106330603 | 608 | 540.73 | 6/6/1997 | 538 | 598 | 60 | MW | na | Bennett | PVC | 3 | 6/3/1997 |
| S153 | | Open Space | 12 | 10 | 350107 | 1063543 | 5,145 | 09N.03E.11.324 | 350107106354301 | 462 | 262. | 1/6/1982 | 305 | 410 | 105 | PW | turbine | na | steel | 16 | 1/6/1982 |
| S154 | | ORLF-2 | 12 | na | 350329 | 1063917 | 4,940 | 10N.03E.32.111 | 350329106391701 | 51 | 17.65 | 1994 | 46 | 51 | 5 | MW | na | Bennett | steel | 2 | 1989 |
| S155 | | Domestic Well #29 | 12 | na | 344818 | 1064007 | 4,895 | 07N.03E.30.321 | 344817106401001 | 210 | 55.4 | 4/3/1995 | 200 | 210 | 10 | DW | submersible | na | PVC | 5 | 6/4/1993 |
| S156 | | Paseo 2D | 12 | na | 351057 | 1063842 | 4,989 | 11N.03E.17.233 | 351057106384201 | 150 | 16.42 | 12/17/1992 | 135 | 145 | 10 | MW | na | Bennett | PVC | 4 | nd |
| S157 | | Paseo 2MD | 12 | na | 351057 | 1063842 | 4,989 | 11N.03E.17.233A | 351057106384202 | 95 | 11.63 | 12/17/1992 | 80 | 90 | 10 | MW | na | Bennett | PVC | 4 | nd |
| S158 | | Paseo 2MS | 12 | na | 351057 | 1063842 | 4,989 | 11N.03E.17.233B | 351057106384203 | 45 | 11.81 | 12/17/1992 | 30 | 40 | 10 | MW | na | Bennett | PVC | 4 | nd |
| S159 | | Paseo 2S | 12 | na | 351057 | 1063842 | 4,990 | 11N.03E.17.233D | 351057106384204 | 23 | 10.6 | 8/2/1993 | 13 | 23 | 10 | MW | na | Bennett | PVC | 2 | nd |
| S160 | M | Paseo 3D | 12 | na | 351035 | 1063647 | 5,006 | 11N.03E.15.344C | 351035106364703 | 544 | 69.95 | 8/24/1993 | 539 | 544 | 5 | MW | na | Bennett | PVC | 2 | nd |
| S161 | M | Paseo 3M | 12 | na | 351035 | 1063647 | 5,006 | 11N.03E.15.344C | 351035106364702 | 144 | 53.2 | 8/24/1993 | 139 | 144 | 5 | MW | na | Bennett | PVC | 4 | nd |
| S171 | | Ridgecrest 4 | 12 | na | 350445 | 1063341 | 5,344 | 10N.04E.19.322 | 350445106334001 | 1,424 | 431. | 12/11/1974 | 572 | 1,412 | 840 | PW | turbine | na | steel | 16 | 11/11/1974 |
| S173 | D | Rio Bravo 5 M | 12 | 3 | 350140 | 1064016 | 4,958 | 09N.03E.07.114 | 350138106401101 | 150 | 7.3 | 1/9/1992 | 135 | 145 | 10 | MW | na | Grundfos | PVC | 4 | 1/8/1992 |
| S176 | | Rio Bravo 1 S | 12 | na | 350137 | 1064105 | 4,931 | 09N.02E.12.214C | 350137106410503 | 38 | 10.5 | 4/4/1995 | 28 | 33 | 5 | MW | na | Bennett | steel | 5 | nd |

## Table A1. Location and well-construction information for ground-water sites-- Continued

| Site no. | Mon-itor-ing Well ID | Site name | Primary hydro-chem-ical zone | Secon-dary hydro-chemical zone | Lati-tude (dms) | Longi-tude (dms) | Land surface alti-tude (feet) | Local well no. | USGS site ID | Depth (feet bls) | Water level (feet bls) | Water level date | Depth to top of screen (feet bls) | Depth to bottom of screen (feet bls) | Screen length (feet) | Well type | Fixed pump type | Sample pump type | Casing mater-ial | Casing dia-meter (inches) | Date constr-ucted |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S177 | | Rio Bravo 2 D | 12 | na | 350138 | 1063955 | 4,929 | 09N.03E.07.131A | 350138106395501 | 154 | 12.23 | 1/24/1996 | 144 | 149 | 5 | MW | na | Bennett | steel | 5 | nd |
| S178 | | Rio Bravo 2 M | 12 | na | 350138 | 1063955 | 4,929 | 09N.03E.07.131B | 350138106395502 | 91 | 11.47 | 1/24/1996 | 81 | 86 | 5 | MW | na | Bennett | steel | 5 | nd |
| S179 | | Rio Bravo 2 S | 12 | na | 350138 | 1063955 | 4,929 | 09N.03E.07.131C | 350138106395503 | 49 | 11.31 | 1/24/1996 | 39 | 44 | 5 | MW | na | Bennett | steel | 5 | nd |
| S181 | | Rio Bravo 4 M | 12 | na | 350135 | 1063906 | 4,933 | 09N.03E.08.144B | 350135106390602 | 124 | 23.79 | 1/24/1996 | 114 | 119 | 5 | MW | na | Bennett | steel | 5 | nd |
| S180 | | Rio Bravo 4 D | 12 | na | 350135 | 1063906 | 4,933 | 09N.03E.08.144A | 350135106390601 | 149 | 22.55 | 1/24/1996 | 139 | 144 | 5 | MW | na | Bennett | steel | 5 | nd |
| S183 | | Rio Grande Utility 5 | 12 | 3 | 343940 | 1064238 | 4,958 | 05N.02E.15.244 | 343940106423801 | 670 | 158. | 5/14/1984 | 290 | 660 | 370 | PW | na | na | steel | 8 | 5/14/1984 |
| S184 | | Rio Grande Utility 6 | 12 | na | 344355 | 1064100 | 5,010 | 06N.02E.24.144 | 344355106410001 | 602 | 190.5 | 8/31/1985 | 330 | 590 | 260 | PW | na | na | steel | 14 | 8/31/1985 |
| S190 | | Rio Rancho 2 | 12 | na | 351340 | 1064014 | 5,266 | 12N.03E.31.132 | 351340106401401 | 751 | 295. | 7/1/1963 | 508 | 751 | 243 | PW | turbine | na | steel | 12 | 7/1/1963 |
| S203 | | Private Production Well #20 | 12 | na | 352552 | 1062701 | 5,050 | 14N.05E.19.231 | 352552106270101 | 110 | 23. | 7/15/1977 | 65 | 100 | 35 | PW | submersible | na | steel | 8 | 7/15/1977 |
| S205 | | Private Production Well #21 | 12 | na | 352552 | 1062701 | 5,050 | 14N.09E.19.231A | 352552106270102 | 557 | 14.8 | 12/5/1986 | 517 | 547 | 30 | PW | submersible | na | steel | 8 | 12/5/1986 |
| S208 | | San Jose 2 | 12 | 3 | 350338 | 1063832 | 4,992 | 10N.03E.29.443 | 350336106383201 | 1,000 | 96. | 1993 | 264 | 996 | 732 | PW | turbine | na | steel | 16 | 1960 |
| S210 | S | Sandia D | 12 | na | 351357 | 1063230 | 5,440 | 12N.04E.29.433 | 351357106323001 | 1,305 | 485.77 | 6/26/1998 | 1,295 | 1,300 | 5 | MW | na | Bennett | PVC | 2 | nd |
| S214 | S | Sandia S | 12 | na | 351357 | 1063230 | 5,440 | 12N.04E.29.433B | 351357106323003 | 535 | 479.12 | 6/26/1998 | 485 | 525 | 40 | MW | na | Bennett | PVC | 2 | nd |
| S220 | | Santa Barbara 1 | 12 | na | 350648 | 1063625 | 5,139 | 10N.03E.10.223 | 350648106362501 | 1,000 | 257. | 1993 | 312 | 984 | 672 | PW | turbine | na | steel | 16 | 11/18/1963 |
| S231 | H | Sierra Vista M | 12 | 3 | 350910 | 1064148 | 5,110 | 11N.03E.26.243A | 350910106414802 | 928 | 153.04 | 8/8/1997 | 918 | 923 | 5 | MW | na | Bennett | PVC | 2 | 7/20/1997 |
| S232 | H | Sierra Vista S | 12 | na | 350910 | 1064148 | 5,110 | 11N.03E.26.243B | 350910106414803 | 210 | 148.79 | 8/8/1997 | 140 | 200 | 60 | MW | na | Bennett | PVC | 2 | 7/20/1997 |
| S234 | P | Sister Cities D | 12 | na | 350908 | 1063444 | 5,340 | 11N.03E.25.322 | 350908106344401 | 1,308 | 348.09 | 10/24/1996 | 1,298 | 1,303 | 5 | MW | na | Bennett | PVC | 3 | 3/31/1996 |
| S235 | P | Sister Cities M | 12 | na | 350908 | 1063444 | 5,340 | 11N.03E.25.322A | 350908106344402 | 799 | 348.34 | 10/24/1996 | 789 | 794 | 5 | MW | na | Bennett | PVC | 3 | 3/31/1996 |
| S244 | | SWAB #3 - 760 | 12 | na | 351051 | 1063953 | 4995 | 11N.03E.18.411C | 351051106395303 | 840 | 41.9 | 6/28/1996 | 710 | 790 | 80 | MW | na | Bennett | PVC | 2 | 11/6/1981 |
| S245 | | SWAB #3 - 980 | 12 | na | 351051 | 1063953 | 4995 | 11N.03E.18.411D | 351051106395304 | 1,055 | 43.71 | 6/28/1996 | 870 | 1,050 | 180 | MW | na | Bennett | PVC | 2 | 11/6/1981 |
| S253 | T | Tome D | 12 | na | 344431 | 1063934 | 5,020 | 06N.03E.18.442 | 344431106393401 | 1,200 | 195.98 | 8/6/1998 | 1,185 | 1,195 | 10 | MW | na | Grundfos | PVC | 2 | 8/11/1998 |
| S257 | | Domestic Well #34 | 12 | na | 345934 | 1064033 | 4,920 | 09N.02E.24.244 | 345934106403301 | 109 | 12.25 | 12/18/1980 | nd | nd | nd | DW | submersible | na | PVC | 4 | 12/18/1980 |
| S259 | | VGP-1 | 12 | na | 350030 | 1064221 | 4,923 | 09N.02E.14.134A | 350030106422101 | 64 | 8.24 | 1994 | 59 | 64 | 5 | MW | na | Bennett | steel | 2 | 1990 |
| S261 | | Vol Andia 2 | 12 | na | 350732 | 1063504 | 5,208 | 10N.03E.01.133 | 350732106350101 | 1,016 | 332. | 1993 | 360 | 852 | 492 | PW | turbine | na | steel | 16 | 11/5/1960 |
| S262 | | Vol Andia 5 | 12 | na | 350805 | 1063611 | 5,112 | 11N.03E.35.313 | 350809106360901 | 1,020 | 222. | 1993 | 260 | 900 | 640 | PW | turbine | na | steel | 16 | 9/4/1960 |
| S265 | | Webster 1 | 12 | na | 351029 | 1063320 | 5,436 | 11N.04E.18.434 | 351029106332001 | 1,484 | 530. | 1993 | 620 | 1,345 | 725 | PW | turbine | na | steel | nd | 10/18/1977 |
| S267 | E | West Bluff Nest 1 Well 2 | 12 | 3 | 350638 | 1064137 | 5,100 | 10N.02E.11.244A | 350638106413702 | 689 | 161.91 | 10/24/1996 | 679 | 684 | 5 | MW | na | Grundfos | PVC | 3 | 7/18/1996 |
| S268 | E | West Bluff Nest 1 Well 3 | 12 | na | 350638 | 1064137 | 5,100 | 10N.02E.11.244B | 350638106413703 | 437 | 155.32 | 10/24/1996 | 422 | 427 | 5 | MW | na | Grundfos | PVC | 3 | 7/18/1996 |
| S269 | E | West Bluff Nest 2 Well 1 | 12 | na | 350638 | 1064137 | 5,100 | 10N.02E.11.244C | 350638106413704 | 328 | 155.25 | 10/24/1996 | 318 | 323 | 5 | MW | na | Grundfos | PVC | 3 | 8/18/1996 |
| S270 | E | West Bluff Nest 2 Well 2 | 12 | na | 350638 | 1064137 | 5,100 | 10N.02E.11.244D | 350638106413705 | 254 | 155.57 | 10/24/1996 | 244 | 249 | 5 | MW | na | Grundfos | PVC | 3 | 8/18/1996 |
| S271 | E | West Bluff Nest 2 Well 3 | 12 | na | 350638 | 1064137 | 5,100 | 10N.02E.11.244E | 350638106413706 | 173 | 155.51 | 10/24/1996 | 143 | 163 | 20 | MW | na | Grundfos | PVC | 3 | 8/18/1996 |
| S275 | | Yale 1 | 12 | na | 350427 | 1063729 | 5,159 | 10N.03E.21.443 | 350426106372601 | 1,000 | 267. | 1993 | 336 | 960 | 624 | PW | turbine | na | steel | 16 | 1963 |
| SXXX | | Geoprobe 1 | 12 | na | 351658 | 1063552 | 4,982 | nd | nd | 45.5-20.2 | nd | nd | nd | nd | 1 | MW | na | peristaltic | steel | 1 | 7/1/1996 |
| SXXX | | Geoprobe 2 | 12 | na | 351658 | 1063554 | 5,054 | nd | nd | 40.5-23.4 | nd | nd | nd | nd | 1 | MW | na | peristaltic | steel | 1 | 7/1/1996 |
| | | **Zone 13: Discharge** | | | | | | | | | | | | | | | | | | | |
| S143 | | Private Production Well #05 | 13 | na | 342608 | 1064647 | 4,755 | 03N.02E.31.333 | 342608106464701 | 258 | 20. | 12/7/1995 | 238 | 258 | 20 | PW | submersible | na | PVC | 6 | 12/7/1995 |
| S194 | | Domestic Well #32 | 13 | na | 342010 | 1065043 | 4,730 | 01N.01E.04.342 | 342013106503901 | 130 | 20. | 7/26/1983 | 120 | 130 | 10 | DW | submersible | na | PVC | 5 | 7/25/1983 |
| S226 | | Domestic Well #15 | 13 | na | 342104 | 1065301 | 4,860 | 02N.01E.31.313 | 342107106530401 | 223 | 136.64 | 10/31/1995 | 210 | 220 | 10 | DW | submersible | na | PVC | 4 | 7/2/1975 |
| | | **No Zone: Exotic Water** | | | | | | | | | | | | | | | | | | | |
| S009 | | Arroyo Salado Spring | E | E | 344148 | 1070704 | 5,744 | 06N.03W.35.443 | 344148107070401 | na | na | na | na | na | na | SP | na | peristaltic | na | na | nd |
| S023 | | Burn Site Well | E | E | 350017 | 1062423 | 6,369 | 09N.05E.16.233 | 350017106242301 | 341 | 68. | 2/20/1986 | 231 | 341 | 110 | PW | na | na | PVC | 4 | 2/20/1986 |
| S028 | | Cerro Colorado Landfill MW | E | E | 350020 | 1065308 | 5,488 | 09N.01E.18.333 | 350021106531101 | 746 | 570. | 11/10/1988 | 555 | 616 | 61 | MW | submersible | na | steel | 4 | 1981 |
| S038 | | Windmill #19 | E | E | 352147 | 1065911 | 5,720 | 13N.01W.18.121 | 352147106591101 | 100 | nd | nd | nd | nd | nd | WW | windmill | na | steel | nd | nd |
| S054 | | Domestic Well #04 | E | E | 343030 | 1064046 | 5,065 | 03N.02E.01.44 | 343030106404601 | 390 | nd | nd | nd | nd | nd | DW | submersible | na | PVC | 4 | 1989 |
| S057 | | Embudo Spring | E | E | 350547 | 1062744 | 6,600 | 10N.04E.13.242 | 350548106274901 | na | na | na | na | na | na | SP | na | peristaltic | na | na | nd |
| S063 | | Windmill #22 | E | E | 342424 | 1063129 | 5,980 | 02N.04E.16.222 | 342413106311701 | 180 | nd | nd | nd | nd | nd | WW | windmill | na | steel | nd | nd |
| S067 | | Granite Hill | E | E | 350343 | 1062821 | 5,749 | 10N.04E.25.324 | 350343106280901 | 89 | 32.23 | 10/26/1995 | nd | nd | nd | MW | na | Grundfos | steel | 6 | 11/1/1975 |
| S070 | | HERTF | E | E | 345830 | 1062636 | 6,227 | 09N.05E.30.322 | 345830106263601 | 500 | 405. | 7/13/1990 | 449 | 500 | 51 | PW | submersible | na | steel | 5 | 7/13/1990 |
| S091 | | Private Production Well #23 | E | E | 353701 | 1064358 | 5,525 | 16N.02E.16.411 | 353700106435701 | 81 | 5. | 3/19/1982 | 19 | 81 | 62 | PW | submersible | na | steel | 10 | 1959 |
| S094 | | Stock Well #02 | E | E | 351627 | 1065512 | 5,700 | 12N.01W.14.111 | 351627106550401 | 120 | 107.17 | 6/20/1980 | nd | nd | nd | SW | submersible | na | steel | nd | nd |
| S099 | | LALF-1 | E | E | 351105 | 1063612 | 5,064 | 11N.03E.15.242 | 351105106361201 | 146 | 98.34 | 1992 | 101 | 141 | 40 | MW | na | Bennett | steel | 2 | nd |
| S112 | | Domestic Well #24 | E | E | 343020 | 1063825 | 5,131 | 03N.03E.09.111 | 343020106382501 | 560 | 460. | 5/19/1997 | 540 | 560 | 20 | DW | submersible | na | PVC | 4 | 5/19/1997 |
| S129 | | Montaño 4 S | E | E | 350821 | 1063837 | 4,975 | 11N.03E.32.234C | 350821106383703 | 50 | 43.2 | 1/24/1996 | 40 | 45 | 5 | MW | na | Bennett | steel | 5 | nd |
| S152 | | Private Production Well #07 | E | E | 352558 | 1063638 | 5,350 | 14N.03E.22.124A | 352558106363801 | 440 | 141. | nd | 200 | 380 | 180 | PW | submersible | peristaltic | steel | 6 | nd |
| S182 | | Rio Bravo 4 S | E | E | 350135 | 1063906 | 4,933 | 09N.03E.08.144C | 350135106390603 | 49 | 24.09 | 1/24/1996 | 39 | 44 | 5 | MW | na | Bennett | steel | 5 | nd |
| S202 | | Windmill #27 | E | E | 342801 | 1071054 | 5,911 | 03N.03W.20.314 | 342801107105401 | nd | nd | nd | nd | nd | nd | WW | windmill | na | steel | nd | nd |
| S211 | S | Sandia M | E | E | 351357 | 1063230 | 5,440 | 12N.04E.29.433A | 351357106323002 | 1,025 | 485.58 | 6/26/1998 | 1,015 | 1,020 | 5 | MW | na | Bennett | PVC | 2 | nd |
| S225 | | SBM-1 | E | E | 350610 | 1063814 | 4,985 | 10N.03E.09.333A | 350610106381401 | 150 | 93.44 | 1994 | 135 | 145 | 10 | MW | na | Bennett | PVC | 4 | 1988 |
| S249 | | Private Production Well #09 | E | E | 351229 | 1062905 | 6,610 | 11N.04E.02.414 | 351229106290501 | 240 | 206.1 | 7/2/1996 | 60 | 240 | 180 | PW | submersible | na | PVC | 5 | 10/31/1989 |
| S250 | | Private Production Well #10 | E | E | 351240 | 1062909 | 6,630 | 11N.04E.02.234 | 351240106290901 | 287 | 194.12 | 7/2/1996 | 225 | 280 | 55 | PW | submersible | na | nd | 5 | 8/27/1976 |
| S251 | | Private Production Well #11 | E | E | 351229 | 1062853 | 6,760 | 11N.04E.02.424 | 351229106285301 | 320 | 225. | 7/2/1996 | 60 | 320 | 260 | PW | submersible | na | nd | 5 | 10/23/1985 |

**Table A1.** Location and well-construction information for ground-water sites-- Continued

| Site no. | Monitoring Well ID | Site name | Primary hydrochemical zone | Secondary hydrochemical zone | Latitude (dms) | Longitude (dms) | Land surface altitude (feet) | Local well no. | USGS site ID | Depth (feet bls) | Water level (feet bls) | Water level date | Depth to top of screen (feet bls) | Depth to bottom of screen (feet bls) | Screen length (feet) | Well type | Fixed pump type | Sample pump type | Casing material | Casing diameter (inches) | Date constructed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S256 | | Tunnel Spring | E | E | 351728 | 1062624 | 6,410 | 12N.05E.05.334 | 351728106262001 | na | na | na | na | na | na | SP | na | peristaltic | na | na | nd |
| S258 | | Vallecito Springs | E | E | 353822 | 1064104 | 5,840 | 16N.02E.01.334 | 353822106410401 | na | na | na | na | na | na | SP | na | peristaltic | na | na | nd |
| S273 | | Windmill #11 | E | E | 342509 | 1070022 | 5,680 | 02N.02W.12.112 | 342509107002201 | 280 | nd | nd | nd | nd | nd | WW | windmill | na | steel | nd | nd |
| S282 | | Windmill #44 | E | E | 352804 | 1064142 | 5,400 | 14N.02E.02.422 | 352813106412701 | 147 | 85.04 | 1/23/1984 | nd | nd | nd | WW | windmill | na | steel | 6 | 11/1/1968 |
| SXXX | | Soda Dam Spring | E | E | 354733 | 1064112 | 6383 | nd | nd | nd | nd | nd | na | na | na | SP | na | peristaltic | steel | 0.5 | 8/20/1996 |
| SXXX | | Jemez Spring | E | E | 354620 | 1064128 | 6215 | nd | nd | nd | nd | nd | na | na | na | SP | na | peristaltic | steel | 0.5 | 8/20/1996 |

**Table A2.** Summary of field parameters and major-element chemistry

[SXXX, no site no. assigned; Hydrochemical Zone "E", exotic water, no primary or secondary zone assigned; Temp., field water temperature; ºC, degrees Celsius; $O_2$, dissolved oxygen; mg/L, milligrams per liter; Sp. Cond., specific conductance in µS/cm, microsiemens per centimeter at 25º C; $Ca^{2+}$, calcium; $Mg^{2+}$, magnesium, $Na^{+}$, sodium; $K^{+}$, potassium; $Cl^{-}$, chloride; $Br^{-}$, bromide; $SO_4^{2-}$, sulfate; $HCO_3^{-}$, total titration alkalinity as bicarbonate; na, not applicable; nd, not determined]

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secon-dary hydro-chemical zone | Date sampled | Temp (ºC) | $O_2$ (mg/L) | pH | Sp. Cond. (µS/cm) | $Ca^{2+}$ (mg/L) | $Mg^{2+}$ (mg/L) | $Na^{+}$ (mg/L) | $K^{+}$ (mg/L) | $Cl^{-}$ (mg/L) | $Br^{-}$ (mg/L) | $SO_4^{2-}$ (mg/L) | $HCO_3^{-}$ (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Zone 1: Northern Mountain Front** | | | | | | | | | | | | | | | |
| S027 | NM486 | CEPO 02 | 1 | na | 8/3/1998 | 19.8 | 3.5 | 7.6 | 250 | 28.6 | 3.67 | 16.4 | 4.3 | 5.0 | 0.07 | 16.5 | 124.1 |
| S034 | NM027 | Private Production Well #04 | 1 | na | 8/28/1996 | 18.5 | 5.7 | 7.7 | 226 | 24.6 | 3.93 | 15.8 | 4.2 | 4.4 | 0.09 | 14.1 | 112.1 |
| S035 | NM487 | Windmill #37 | 1 | na | 7/31/1998 | 17.7 | 7.0 | 7.2 | 211 | 26.5 | 3.85 | 6.49 | 3.8 | 1.7 | nd | 17.8 | 104.3 |
| S036 | NM026 | Private Production Well #03 | 1 | na | 8/28/1996 | 15.6 | 6.2 | 7.4 | 323 | 41.3 | 6.62 | 19.8 | 2.8 | 4.1 | 0.08 | 17.6 | 178.4 |
| S065 | NM055 | Domestic Well #05 | 1 | na | 8/17/1996 | 18.9 | 4.9 | 7.7 | 774 | 61.9 | 8.66 | 68.1 | 7.1 | 178. | 0.46 | 20.9 | 101.6 |
| S187 | NM131 | Rio Rancho 12 | 1 | na | 8/13/1996 | 26.7 | 2.5 | 7.9 | 772 | 42.2 | 2.60 | 107. | 6.1 | 152. | 0.36 | 56.1 | 103.6 |
| S206 | NM510 | Windmill #38 | 1 | 3 | 8/3/1998 | 25.5 | 6.2 | 8.0 | 409 | 22.0 | 6.65 | 57.3 | 8.2 | 7.4 | 0.10 | 38.1 | 197.0 |
| S216 | NM143 | Windmill #09 | 1 | na | 8/27/1996 | 20.1 | 5.4 | 7.8 | 357 | 42.5 | 7.02 | 16.1 | 6.3 | 11.6 | 0.17 | 52.1 | 128.2 |
| S221 | NM530 | Windmill #45 | 1 | na | 8/20/1998 | 20.4 | 5.5 | 7.1 | 550 | 64.0 | 10.3 | 39.0 | 7.0 | 13.4 | 0.07 | 29.1 | 304.3 |
| S222 | NM514 | Windmill #39 | 1 | 3 | 8/6/1998 | 17.1 | 1.3 | 6.6 | 784 | 81.8 | 9.69 | 69.6 | 12.9 | 33.5 | 0.10 | 84.7 | 339.0 |
| S254 | NM168 | Private Production Well #12 | 1 | na | 8/28/1996 | 18.4 | 6.8 | 7.1 | 174 | 16.9 | 3.33 | 12.0 | 2.4 | 3.2 | nd | 7.27 | 91.4 |
| S277 | NM525 | Windmill #40 | 1 | na | 7/28/1998 | 19.4 | 4.7 | 7.4 | 429 | 53.3 | 8.45 | 20.2 | 5.2 | 14.1 | 0.08 | 28.5 | 202.8 |
| S279 | NM527 | Windmill #42 | 1 | na | 7/28/1998 | 18.5 | nd | 7.0 | 255 | 35.6 | 5.63 | 8.80 | 4.3 | 2.4 | 0.02 | 11.1 | 146.2 |
| S281 | NM528 | Windmill #43 | 1 | 3 | 7/28/1998 | 20.7 | 2.6 | 7.8 | 286 | 26.4 | 2.15 | 30.9 | 4.5 | 4.9 | 0.08 | 9.34 | 160.4 |
| | | **Zone 2: Northwestern** | | | | | | | | | | | | | | | |
| S103 | NM497 | Lincoln D | 2 | na | 7/23/1998 | 21.8 | 4.1 | 7.4 | 400 | 21.4 | 2.64 | 60.0 | 6.6 | 7.7 | 0.11 | 42.5 | 155.3 |
| S104 | NM498 | Lincoln M | 2 | na | 7/23/1998 | 21.1 | 6.5 | 8.1 | 318 | 19.0 | 2.98 | 43.0 | 6.7 | 4.4 | 0.07 | 28.7 | 122.9 |
| S105 | NM499 | Lincoln S | 2 | na | 7/23/1998 | 20.8 | 6.7 | 7.8 | 293 | 28.9 | 4.98 | 21.8 | 7.4 | 4.6 | 0.06 | 17.2 | 123.2 |
| S191 | NM326 | Rio Rancho 4 | 2 | 3 | 6/20/1997 | 20.9 | 3.8 | 8.1 | 415 | 19.1 | 3.04 | 58.5 | 5.9 | 10.1 | 0.10 | 58.4 | 156.9 |
| S192 | NM128 | Rio Rancho 8 | 2 | 3 | 8/13/1996 | 26.4 | 4.9 | 8.0 | 395 | 17.7 | 3.47 | 57.2 | 4.2 | 9.3 | 0.13 | 66.2 | 127.3 |
| S189 | NM133 | Rio Rancho 15 | 2 | na | 8/13/1996 | 25.2 | 6.1 | 7.6 | 777 | 37.3 | 3.84 | 117. | 5.7 | 78.2 | 0.22 | 100. | 202.2 |
| S276 | NM179 | Windmill #12 | 2 | na | 8/27/1996 | 17.2 | 12. | 8.1 | 250 | 33.7 | 1.56 | 15.3 | 3.9 | 3.9 | 0.07 | 10.4 | 107.6 |
| S278 | NM526 | Windmill #41 | 2 | na | 7/29/1998 | 19.5 | 6.9 | 7.7 | 456 | 40.2 | 5.25 | 49.9 | 4.7 | 12.8 | 0.07 | 60.6 | 184.0 |
| S280 | NM180 | Windmill #13 | 2 | na | 8/27/1996 | 18.6 | 7.8 | 7.9 | 381 | 47.5 | 6.13 | 17.5 | 6.5 | 4.7 | 0.05 | 28.6 | 138.7 |
| S286 | NM184 | Private Production Well #13 | 2 | na | 8/26/1996 | 20.4 | 7.9 | 7.8 | 331 | 34.0 | 4.71 | 32.3 | 4.6 | 2.7 | nd | 24.7 | 159.7 |
| S287 | NM185 | Private Production Well #14 | 2 | na | 8/26/1996 | 20.3 | 7.7 | 7.7 | 400 | 28.1 | 4.32 | 54.3 | 7.0 | 10.4 | 0.08 | 40.4 | 180.6 |
| | | **Zone 3: West Central** | | | | | | | | | | | | | | | |
| S003 | NM481 | 98th St. D | 3 | na | 8/4/1998 | 26.3 | <0.1 | 8.0 | 1695 | 5.6 | 1.09 | 360. | 3.5 | 194. | 0.27 | 243. | 363.2 |
| S003 | NM251 | 98th St. D | 3 | na | 6/17/1997 | 25.7 | 0.2 | 8.4 | 1,701 | 7.0 | 1.13 | 362. | 3.6 | 203. | 0.44 | 252. | 362.2 |
| S004 | NM482 | 98th St. MD | 3 | na | 8/4/1998 | 27.6 | <0.1 | 8.4 | 622 | 1.8 | 0.09 | 140. | 1.2 | 12.7 | 0.08 | 87.8 | 252.4 |
| S004 | NM252 | 98th St. MD | 3 | na | 6/18/1997 | 26.6 | 0.3 | 9.1 | 631 | 2.3 | 0.12 | 137. | 1.4 | 11.1 | 0.10 | 90.3 | 252.6 |
| S005 | NM483 | 98th St. MS | 3 | na | 8/4/1998 | 27.2 | 0.1 | 7.8 | 714 | 5.3 | 0.72 | 162. | 2.8 | 4.0 | 0.05 | 95.7 | 331.0 |
| S005 | NM253 | 98th St. MS | 3 | na | 7/4/1997 | 26.8 | 0.1 | 8.3 | 734 | 5.7 | 0.62 | 157. | 4.4 | 4.6 | 0.44 | 97.5 | 331.4 |
| S006 | NM484 | 98th St. S | 3 | na | 8/5/1998 | 23.2 | 3.0 | 9.0 | 500 | 8.5 | 0.05 | 99.9 | 2.4 | 8.4 | 0.11 | 66.2 | 182.0 |
| S006 | NM254 | 98th St. S | 3 | na | 6/17/1997 | 25.0 | 2.8 | 8.9 | 507 | 7.3 | 0.09 | 108. | 3.8 | 8.9 | 0.13 | 83.1 | 199.9 |
| S008 | NM003 | Private Production Well #01 | 3 | na | 8/12/1996 | 30.1 | 4.0 | 8.2 | 474 | 13.4 | 0.81 | 82.6 | 3.4 | 9.9 | nd | 96.5 | 134.3 |
| S010 | NM255 | Private Production Well #16 | 3 | na | 6/23/1997 | 20.6 | 5.1 | 8.9 | 485 | 7.1 | 0.83 | 89.3 | 3.8 | 8.6 | 0.09 | 114. | 120.5 |
| S018 | NM260 | Domestic Well #21 | 3 | na | 6/26/1997 | 25.7 | 5.3 | 8.1 | 649 | 19.4 | 7.55 | 106. | 6.1 | 15.8 | 0.12 | 145. | 178.4 |
| S019 | NM007 | Belen 4 | 3 | 5 | 8/16/1996 | 21.9 | 3.3 | 7.7 | 762 | 38.0 | 13.4 | 96.3 | 7.2 | 26.2 | 0.02 | 193. | 176.2 |
| S020 | NM008 | Belen 5 | 3 | 5 | 8/16/1996 | 21.8 | 3.9 | 7.8 | 693 | 29.7 | 10.8 | 94.9 | 7.1 | 19.4 | 0.14 | 171. | 171.4 |

**Table A2.** Summary of field parameters and major-element chemistry-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secon-dary hydro-chemical zone | Date sampled | Temp (ºC) | $O_2$ (mg/L) | pH | Sp. Cond. (µS/cm) | $Ca^{2+}$ (mg/L) | $Mg^{2+}$ (mg/L) | $Na^{+}$ (mg/L) | $K^{+}$ (mg/L) | $Cl^{-}$ (mg/L) | $Br^{-}$ (mg/L) | $SO_4^{2-}$ (mg/L) | $HCO_3^{-}$ (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S029 | NM015 | Cerro Colorado Landfill PW | 3 | 5 | 8/12/1996 | 31.0 | 2.4 | 7.4 | 1,018 | 35.5 | 4.19 | 149. | 7.5 | 36.9 | 0.11 | 260. | 162.0 |
| S037 | NM264 | College 2 | 3 | na | 6/19/1997 | 31.9 | 5.0 | 8.9 | 482 | 3.8 | 0.38 | 100. | 1.4 | 6.6 | 0.11 | 62.4 | 184.3 |
| S066 | NM056 | Gonzales 1 | 3 | 12 | 6/20/1996 | 23.2 | 3.0 | 8.3 | 460 | 14.1 | 2.53 | 72.1 | 5.8 | 11.2 | 0.09 | 78.8 | 156.7 |
| S086 | NM492 | Isleta D | 3 | na | 7/29/1998 | 22.5 | 0.1 | 8.4 | 548 | 3.6 | 0.32 | 113. | 1.6 | 22.1 | 0.13 | 115. | 122.1 |
| S101 | NM294 | Leavitt 1 | 3 | na | 6/26/1997 | 24.2 | 4.9 | 8.6 | 464 | 7.4 | 1.21 | 100. | 2.2 | 12.9 | 0.14 | 70.5 | 175.6 |
| S108 | NM076 | Los Lunas 3 | 3 | 12 | 8/14/1996 | 20.8 | 0.3 | 8.2 | 470 | 10.1 | 3.19 | 86.4 | 6.3 | 11.3 | 0.07 | 71.8 | 183.5 |
| S109 | NM077 | Los Lunas 4 | 3 | 12 | 8/14/1996 | 20.0 | 0.5 | 8.1 | 438 | 11.0 | 3.44 | 75.7 | 6.2 | 13.0 | 0.08 | 56.9 | 178.9 |
| S145 | NM308 | NM Utilities 1 | 3 | na | 6/18/1997 | 23.6 | 5.0 | 8.0 | 351 | 24.7 | 7.15 | 33.8 | 5.3 | 9.6 | 0.10 | 38.7 | 137.6 |
| S147 | NM310 | NM Utilities 3 | 3 | na | 6/18/1997 | 24.4 | 2.2 | 8.2 | 453 | 15.1 | 2.62 | 75.7 | 7.1 | 10.4 | 0.08 | 67.8 | 164.6 |
| S148 | NM311 | NM Utilities 4 | 3 | na | 6/18/1997 | 25.7 | 3.8 | 8.1 | 389 | 21.0 | 5.66 | 51.6 | 4.1 | 6.5 | 0.07 | 53.0 | 148.6 |
| S166 | NM509 | Rabbit Hill | 3 | na | 8/4/1998 | 21.2 | 3.6 | 7.4 | 858 | 36.4 | 6.98 | 160. | 8.9 | 13.4 | 0.12 | 90.9 | 445.4 |
| S167 | NM107 | Domestic Well #12 | 3 | na | 8/14/1996 | 26.7 | 0.9 | 8.3 | 582 | 10.2 | 2.76 | 105. | 4.0 | 7.6 | 0.08 | 144. | 146.8 |
| S172 | NM322 | Rio Bravo 5 D | 3 | na | 7/4/1997 | 21.7 | <0.1 | 8.8 | 674 | 10.4 | 0.21 | 114. | 2.1 | 54.9 | 0.24 | 141. | 75.9 |
| S174 | NM109 | Rio Bravo 1 D | 3 | 12 | 6/17/1996 | 20.9 | 0.1 | 8.5 | 694 | 13.1 | 1.44 | 129. | 4.3 | 32.7 | 0.20 | 167. | 123.8 |
| S175 | NM110 | Rio Bravo 1 M | 3 | 12 | 6/17/1996 | 18.8 | 0.1 | 8.5 | 620 | 13.6 | 1.99 | 115. | 4.6 | 27.1 | 0.17 | 152. | 118.8 |
| S186 | NM130 | Rio Rancho 10 | 3 | na | 8/13/1996 | 25.7 | 6.3 | 7.7 | 622 | 25.5 | 1.78 | 102. | 5.1 | 22.0 | 0.15 | 94.8 | 217.4 |
| S188 | NM132 | Rio Rancho 13 | 3 | na | 8/13/1996 | 28.0 | 6.5 | 8.7 | 424 | 3.0 | 0.08 | 88.1 | 1.7 | 4.6 | 0.08 | 75.2 | 142.7 |
| S193 | NM129 | Rio Rancho 9 | 3 | na | 8/13/1996 | 26.1 | 7.3 | 8.5 | 359 | 4.3 | 0.13 | 72.8 | 2.0 | 6.0 | 0.07 | 47.8 | 137.2 |
| S196 | NM135 | Windmill #05 | 3 | na | 8/21/1996 | 24.7 | 3.0 | 7.7 | 503 | 9.3 | 3.18 | 90.3 | 4.3 | 14.1 | 0.09 | 97.4 | 147.7 |
| S200 | NM139 | Private Production Well #08 | 3 | na | 8/29/1996 | 21.4 | 0.2 | 8.0 | 689 | 19.7 | 7.00 | 111. | 5.6 | 18.6 | 0.15 | 186. | 149.7 |
| S217 | NM144 | Santa Ana Boundary D | 3 | na | 8/22/1996 | 18.0 | 2.7 | 9.0 | 444 | 4.4 | 0.25 | 92.8 | 3.3 | 2.8 | nd | 41.1 | 227.2 |
| S218 | NM145 | Santa Ana Boundary M | 3 | na | 8/22/1996 | 17.4 | 3.9 | 8.5 | 412 | 6.3 | 0.40 | 85.3 | 3.4 | 1.6 | nd | 29.7 | 226.3 |
| S219 | NM146 | Santa Ana Boundary S | 3 | na | 8/22/1996 | 18.1 | 4.8 | 8.3 | 472 | 12.0 | 0.74 | 92.4 | 4.1 | 15.8 | nd | 36.3 | 229.5 |
| S230 | NM516 | Sierra Vista D | 3 | na | 7/22/1998 | 24.8 | <0.1 | 8.7 | 858 | 6.2 | 0.50 | 172. | 1.6 | 39.3 | 0.23 | 183. | 180.8 |
| S236 | NM155 | SAF (Soil Amendment Facility) | 3 | na | 8/12/1996 | 29.4 | 4.9 | 8.2 | 700 | 13.5 | 0.88 | 129. | 3.9 | 8.7 | 0.08 | 209. | 119.2 |
| S241 | NM519 | SWAB Test Hole 1 D | 3 | 1 | 8/5/1998 | 29.3 | 0.9 | 7.8 | 1,239 | 28.9 | 3.94 | 226. | 8.8 | 96.3 | 0.22 | 259. | 243.9 |
| S242 | NM520 | SWAB Test Hole 1 S | 3 | 1 | 8/1/1998 | 28.5 | 2.0 | 8.4 | 589 | 6.8 | 0.41 | 117. | 3.3 | 17.9 | 0.09 | 119. | 154.8 |
| S243 | NM521 | SWAB Test Hole 2 D | 3 | na | 8/7/1998 | 21.8 | 4.0 | 8.1 | 322 | 15.2 | 2.29 | 52.6 | 4.3 | 6.0 | 0.08 | 33.9 | 136.3 |
| S263 | NM346 | Volcano Cliff 1 | 3 | na | 6/19/1997 | 23.7 | 3.9 | 8.1 | 381 | 20.7 | 4.27 | 49.1 | 7.7 | 8.4 | 0.08 | 50.8 | 147.1 |
| S266 | NM347 | West Bluff Nest 1 Well 1 | 3 | na | 6/23/1997 | 26.0 | 0.1 | 8.7 | 780 | 7.0 | 0.16 | 147. | 2.4 | 50.8 | 0.28 | 169. | 131.0 |
| S272 | NM353 | West Mesa 3 | 3 | na | 6/19/1997 | 25.8 | 4.7 | 8.8 | 460 | 5.2 | 0.55 | 92.9 | 2.3 | 8.8 | 0.09 | 53.4 | 189.8 |
| S283 | NM181 | Zia Ball Park D | 3 | na | 8/26/1996 | 19.4 | 5.3 | 8.3 | 614 | 8.3 | 1.01 | 125. | 5.6 | 6.8 | 0.06 | 66.0 | 273.1 |
| S284 | NM182 | Zia Ball Park M | 3 | na | 8/26/1996 | 18.6 | 3.9 | 8.6 | 598 | 7.8 | 1.29 | 124. | 5.6 | 7.2 | 0.06 | 61.8 | 270.2 |
| S285 | NM183 | Zia Ball Park S | 3 | 2 | 8/26/1996 | 17.4 | 4.5 | 8.1 | 1,509 | 65.2 | 9.96 | 238. | 9.2 | 205. | 0.46 | 208. | 279.4 |
| S288 | NM186 | Zia BMT D | 3 | na | 8/27/1996 | 20.1 | 0.3 | 8.5 | 789 | 10.0 | 0.73 | 162. | 4.0 | 9.1 | 0.14 | 133. | 311.3 |
| | | **Zone 4: Western Boundary** | | | | | | | | | | | | | | | |
| S031 | NM263 | Windmill #18 | 4 | na | 6/24/1997 | 29.5 | 3.2 | 7.7 | 3,091 | 72.8 | 31.5 | 526. | 15.4 | 533. | 0.57 | 554. | 259.2 |
| S039 | NM266 | Windmill #20 | 4 | na | 6/21/1997 | 19.8 | 3.4 | 7.6 | 4,738 | 60.0 | 21.3 | 1,076. | 41.5 | 650. | 0.38 | 919. | 923.7 |
| S059 | NM278 | Windmill #21 | 4 | na | 6/23/1997 | 23.5 | 7.4 | 7.4 | 3,735 | 303. | 99.0 | 364. | 13.4 | 798. | 0.69 | 793. | 143.9 |
| S074 | NM285 | Windmill #23 | 4 | na | 6/21/1997 | 16.5 | 2.3 | 7.3 | 4,405 | 126. | 45.3 | 809. | 30.7 | 881. | 0.38 | 583. | 632.2 |
| S169 | NM320 | Rest Area | 4 | na | 6/30/1997 | 20.3 | 12. | 7.6 | 2,766 | 135. | 50.0 | 375. | 9.9 | 408. | 0.44 | 571. | 179.4 |
| S201 | NM329 | Windmill #26 | 4 | na | 7/2/1997 | 23.1 | 4.8 | 7.8 | 1,783 | 227. | 56.4 | 165. | 5.3 | 38.9 | 0.22 | 936. | 147.6 |
| S252 | NM167 | Windmill #10 | 4 | na | 8/29/1996 | 22.2 | 5.8 | 7.8 | 1,598 | 32.9 | 13.4 | 270. | 10.0 | 94.9 | 0.43 | 414. | 240.1 |
| S260 | NM345 | Windmill #33 | 4 | na | 6/25/1997 | 27.6 | 2.9 | 7.8 | 3,510 | 68.5 | 28.6 | 651. | 16.4 | 519. | 0.31 | 672. | 433.2 |

**Table A2.** Summary of field parameters and major-element chemistry-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secon-dary hydro-chemical zone | Date sampled | Temp (ºC) | $O_2$ (mg/L) | pH | Sp. Cond. (µS/cm) | $Ca^{2+}$ (mg/L) | $Mg^{2+}$ (mg/L) | $Na^{+}$ (mg/L) | $K^{+}$ (mg/L) | $Cl^{-}$ (mg/L) | $Br^{-}$ (mg/L) | $SO_4^{2-}$ (mg/L) | $HCO_3^{-}$ (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Zone 5: Rio Puerco** | | | | | | | | | | | | | | | |
| S032 | NM262 | Windmill #17 | 5 | na | 6/24/1997 | 25.0 | 4.3 | 7.6 | 3,804 | 153. | 64.2 | 610. | 15.0 | 582. | 0.60 | 903. | 309.4 |
| S069 | NM058 | Domestic Well #06 | 5 | na | 8/16/1996 | 25.8 | 4.2 | 7.4 | 1,379 | 142. | 42.3 | 124. | 8.7 | 108. | 0.31 | 490. | 141.8 |
| S073 | NM062 | Windmill #03 | 5 | na | 8/16/1996 | 22.2 | 5.0 | 7.3 | 3,234 | 307. | 101. | 328. | 13.2 | 442. | 0.70 | 1,060. | 203.0 |
| S082 | NM409 | Windmill #36 | 5 | na | 9/10/1997 | 20.0 | 2.0 | 7.8 | 2,250 | 316. | 70.3 | 131. | 10.4 | 38.9 | 0.17 | 1,180. | 118.3 |
| S085 | NM408 | Windmill #35 | 5 | na | 9/10/1997 | 22.0 | 6.5 | 6.5 | 1,275 | 80.8 | 36.1 | 133. | 7.2 | 20.3 | 0.13 | 543. | 64.7 |
| S111 | NM079 | Domestic Well #10 | 5 | na | 8/16/1996 | 26.0 | <0.1 | 7.5 | 1,893 | 193. | 65.4 | 154. | 12.6 | 172. | 0.35 | 702. | 102.3 |
| S185 | NM324 | Domestic Well #31 | 5 | na | 6/16/1997 | 18.0 | 0.2 | 7.3 | 2,378 | 298. | 88.6 | 290. | 8.3 | 118. | 0.28 | 1,107. | 485.7 |
| S198 | NM137 | Windmill #07 | 5 | na | 8/21/1996 | 19.5 | 0.4 | 7.1 | 5,420 | 372. | 149. | 831. | 15.2 | 591. | 1.19 | 2,130. | 350.6 |
| S215 | NM335 | Sandoval Spring | 5 | 4 | 7/1/1997 | 21.3 | 1.2 | 7.5 | 1,120 | 60.3 | 16.9 | 165. | 3.3 | 11.5 | 0.09 | 291. | 354.6 |
| S237 | NM341 | Windmill #30 | 5 | 4 | 6/24/1997 | 19.0 | 4.7 | 7.7 | 2,502 | 150. | 53.5 | 279. | 14.4 | 486. | 0.73 | 490. | 102.2 |
| S238 | NM342 | Windmill #31 | 5 | na | 6/24/1997 | 21.5 | 4.1 | 7.2 | 3,457 | 339. | 105. | 341. | 18.0 | 346. | 0.68 | 1,303. | 256.9 |
| | | **Zone 6: Southwestern Mountain Front** | | | | | | | | | | | | | | | |
| S022 | NM009 | Windmill #02 | 6 | na | 8/19/1996 | 30.7 | 4.4 | 8.3 | 447 | 37.1 | 12.0 | 36.6 | 2.5 | 23.0 | 0.21 | 70.9 | 135.1 |
| | | **Zone 7: Abo Arroyo** | | | | | | | | | | | | | | | |
| S021 | NM261 | Stock Well #01 | 7 | na | 6/23/1997 | 18.5 | 5.6 | 7.4 | 1,583 | 181. | 71.7 | 84.4 | 2.4 | 42.1 | 0.29 | 687. | 198.1 |
| S024 | NM011 | Domestic Well #02 | 7 | 8 | 8/17/1996 | 22.1 | 7.0 | 7.2 | 819 | 91.0 | 32.2 | 43.6 | 2.5 | 23.8 | 0.18 | 264. | 171.0 |
| S090 | NM064 | Domestic Well #08 | 7 | na | 8/19/1996 | 23.6 | 6.8 | 7.5 | 922 | 90.1 | 33.7 | 49.2 | 3.4 | 22.2 | 0.16 | 311. | 146.5 |
| S093 | NM067 | Domestic Well #09 | 7 | 8 | 8/15/1996 | 22.8 | 3.9 | 8.0 | 400 | 31.9 | 6.04 | 39.8 | 6.2 | 8.9 | 0.12 | 78.0 | 115.2 |
| | | **Zone 8: Eastern Mountain Front** | | | | | | | | | | | | | | | |
| S007 | NM002 | Domestic Well #01 | 8 | na | 6/21/1996 | 12.0 | 9.2 | 7.5 | 401 | 71.0 | 14.8 | 13.9 | 2.7 | 6.5 | 0.07 | 42.3 | 269.6 |
| S013 | NM256 | Windmill #14 | 8 | na | 6/24/1997 | 17.8 | 0.2 | 9.8 | 128 | 7.40 | 5.53 | 8.4 | 1.1 | 4.5 | 0.09 | 10.7 | 50.5 |
| S014 | NM257 | Private Production Well #17 | 8 | na | 6/19/1997 | 19.1 | 8.2 | 7.5 | 455 | 74.3 | 4.31 | 10.4 | 1.3 | 7.5 | 0.09 | 58.4 | 202.4 |
| S015 | NM006 | Windmill #01 | 8 | na | 8/24/1996 | 18.1 | 7.7 | 7.7 | 273 | 35.7 | 5.60 | 14.6 | 0.6 | 6.0 | 0.08 | 26.8 | 129.9 |
| S030 | NM022 | Charles 4 | 8 | na | 6/27/1996 | 20.7 | 4.0 | 7.6 | 379 | 42.5 | 3.37 | 28.1 | 2.5 | 30.2 | 0.12 | 25.6 | 147.2 |
| S030 | NM021 | Charles 4 | 8 | na | 6/27/1996 | 20.5 | 4.0 | 7.6 | 376 | 42.7 | 3.36 | 27.8 | 2.5 | 30.0 | 0.12 | 26.7 | 147.4 |
| S030 | NM024 | Charles 4 | 8 | na | 6/27/1996 | 21.1 | 4.1 | 7.7 | 381 | 43.6 | 3.30 | 28.7 | 2.4 | 31.0 | 0.12 | 26.7 | 147.8 |
| S030 | NM020 | Charles 4 | 8 | na | 6/27/1996 | 20.3 | 4.5 | 7.6 | 364 | 41.0 | 3.36 | 27.8 | 2.4 | 26.4 | 0.11 | 26.7 | 147.5 |
| S030 | NM019 | Charles 4 | 8 | na | 6/27/1996 | 20.0 | 5.2 | 7.6 | 342 | 40.8 | 3.17 | 25.3 | 2.3 | 16.4 | 0.10 | 26.7 | 149.5 |
| S030 | NM018 | Charles 4 | 8 | na | 6/27/1996 | 19.8 | 5.5 | 7.6 | 334 | 40.9 | 3.20 | 24.6 | 2.4 | 14.9 | 0.09 | 26.7 | 148.9 |
| S030 | NM017 | Charles 4 | 8 | na | 6/27/1996 | 19.7 | 5.6 | 7.6 | 335 | 39.9 | 3.26 | 23.6 | 2.4 | 15.1 | 0.10 | 26.7 | 149.0 |
| S030 | NM023 | Charles 4 | 8 | na | 6/27/1996 | 21.1 | 4.0 | 7.6 | 382 | 42.9 | 3.29 | 29.0 | 2.5 | 31.7 | 0.12 | 27.0 | 147.3 |
| S030 | NM016 | Charles 4 | 8 | na | 6/22/1996 | 20.5 | 4.0 | 7.7 | 381 | 44.1 | 3.54 | 30.4 | 2.6 | 33.4 | 0.12 | 27.4 | 149.6 |
| S042 | NM031 | Domestic Well #03 | 8 | na | 8/14/1996 | 22.8 | 4.2 | 7.9 | 254 | 27.0 | 5.31 | 17.5 | 2.4 | 6.7 | 0.09 | 20.1 | 120.9 |
| S055 | NM042 | Elena Gallegos | 8 | na | 6/25/1996 | 17.0 | 6.2 | 7.4 | 543 | 84.8 | 13.2 | 17.6 | 2.3 | 7.0 | 0.09 | 43.9 | 303.8 |
| S056 | NM227 | Embudito Spring | 8 | na | 4/29/1997 | 9.70 | 7.2 | 8.2 | 494 | 65.8 | 16.5 | 14.8 | 3.6 | 5.9 | 0.06 | 43.7 | 250.8 |
| S056 | NM239 | Embudito Spring | 8 | na | 5/27/1997 | 11.9 | 6.9 | 8.1 | 504 | 70.8 | 17.0 | 17.2 | 3.7 | 5.9 | 0.07 | 44.8 | 265.5 |
| S056 | NM213 | Embudito Spring | 8 | na | 3/21/1997 | 6.20 | 7.8 | 8.1 | 539 | 69.4 | 17.9 | 18.2 | 3.3 | 6.8 | 0.00 | 57.4 | 270.6 |
| S056 | NM214 | Embudito Spring | 8 | na | 3/21/1997 | 7.50 | 9.9 | 8.4 | 535 | 70.0 | 17.9 | 17.9 | 3.4 | 6.8 | 0.00 | 57.4 | 271.3 |
| S056 | NM043 | Embudito Spring | 8 | na | 7/2/1996 | 17.7 | 3.4 | 7.3 | 884 | 127. | 30.8 | 22.1 | 6.0 | 10.3 | 0.23 | 98.6 | 468.4 |
| S056 | NM364 | Embudito Spring | 8 | na | 7/17/1997 | 19.0 | 3.0 | 7.5 | 785 | 108. | 29.0 | 45.4 | 3.9 | 112. | 0.39 | 125. | 166.5 |
| S056 | NM240 | Embudito Spring | 8 | na | 5/27/1997 | 15.3 | 7.7 | 8.5 | 507 | nd | nd | nd | nd | nd | nd | nd | nd |
| S071 | NM060 | Domestic Well #07 | 8 | na | 6/19/1996 | 17.8 | 8.7 | 7.4 | 402 | 66.5 | 7.21 | 12.5 | 1.8 | 6.0 | 0.10 | 20.2 | 224.3 |
| S083 | NM407 | Windmill #34 | 8 | na | 9/10/1997 | 21.5 | 4.7 | 7.7 | 517 | 55.8 | 9.34 | 34.4 | 3.1 | 27.0 | 0.20 | 55.0 | 205.8 |

**Table A2.** Summary of field parameters and major-element chemistry-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secon-dary hydro-chemical zone | Date sampled | Temp (ºC) | $O_2$ (mg/L) | pH | Sp. Cond. (µS/cm) | $Ca^{2+}$ (mg/L) | $Mg^{2+}$ (mg/L) | $Na^{+}$ (mg/L) | $K^{+}$ (mg/L) | $Cl^{-}$ (mg/L) | $Br^{-}$ (mg/L) | $SO_4^{2-}$ (mg/L) | $HCO_3^{-}$ (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S095 | NM068 | Kirtland 1 | 8 | na | 6/25/1996 | 21.4 | 7.2 | 7.6 | 392 | 49.0 | 7.35 | 22.4 | 3.0 | 9.1 | 0.12 | 52.8 | 171.5 |
| S106 | NM295 | Domestic Well #23 | 8 | na | 6/26/1997 | 19.0 | 0.6 | 8.0 | 413 | 26.0 | 5.89 | 55.6 | 6.2 | 23.9 | 0.11 | 49.4 | 153.7 |
| S110 | NM078 | Love 1 | 8 | na | 6/22/1996 | 24.2 | 5.7 | 7.5 | 288 | 29.9 | 2.21 | 29.3 | 2.4 | 7.7 | 0.10 | 24.3 | 133.2 |
| S113 | NM080 | Domestic Well #11 | 8 | na | 8/15/1996 | 25.8 | 3.6 | 8.1 | 284 | 16.2 | 5.74 | 36.4 | 1.7 | 4.8 | 0.06 | 34.7 | 124.6 |
| S114 | NM500 | Matheson D | 8 | na | 7/31/1998 | 21.9 | 1.3 | 7.2 | 264 | 26.2 | 1.01 | 29.3 | 2.4 | 4.8 | 0.08 | 19.5 | 131.0 |
| S115 | NM501 | Matheson M | 8 | na | 8/1/1998 | 21.1 | 2.9 | 7.4 | 322 | 20.9 | 1.40 | 49.3 | 2.5 | 5.5 | 0.05 | 19.6 | 168.9 |
| S116 | NM502 | Matheson S | 8 | na | 8/1/1998 | 20.7 | 5.5 | 7.3 | 311 | 40.1 | 3.56 | 20.8 | 2.1 | 4.7 | 0.10 | 17.6 | 163.6 |
| S117 | NM298 | Domestic Well #25 | 8 | na | 6/17/1997 | 17.4 | 8.0 | 7.6 | 390 | 59.4 | 8.68 | 14.9 | 1.6 | 6.3 | 0.07 | 27.9 | 210.3 |
| S118 | NM299 | Windmill #24 | 8 | na | 6/27/1997 | 20.8 | 7.0 | 8.1 | 479 | 40.8 | 16.6 | 34.7 | 1.3 | 31.2 | 0.33 | 55.0 | 152.7 |
| S119 | NM300 | Domestic Well #26 | 8 | 11 | 6/19/1997 | 16.1 | 5.8 | 7.3 | 714 | 84.4 | 16.7 | 54.2 | 2.6 | 20.1 | 0.19 | 92.6 | 332.0 |
| S122 | NM505 | Mesa Del Sol S | 8 | na | 7/25/1998 | 23.1 | 2.0 | 7.4 | 357 | 30.8 | 7.47 | 30.8 | 5.0 | 18.5 | 0.08 | 26.1 | 153.0 |
| S122 | NM304 | Mesa Del Sol S | 8 | na | 6/29/1997 | 28.3 | 0.4 | 8.9 | 484 | 5.6 | 0.16 | 93.6 | 1.4 | 21.3 | 0.10 | 66.0 | 160.9 |
| S140 | NM306 | MRN 1 | 8 | na | 7/5/1997 | 21.3 | 5.6 | 7.4 | 515 | 58.8 | 15.3 | 22.9 | 4.6 | 15.1 | 0.17 | 70.2 | 196.0 |
| S141 | NM095 | National Utility 7 | 8 | na | 8/14/1996 | 18.0 | 7.8 | 7.7 | 264 | 36.3 | 2.53 | 16.7 | 1.4 | 3.3 | 0.06 | 12.1 | 140.4 |
| S149 | NM312 | Nor Este D | 8 | na | 7/3/1997 | 22.8 | 0.2 | 8.1 | 816 | 27.9 | 4.97 | 118. | 5.4 | 153. | 0.38 | 66.4 | 110.2 |
| S150 | NM313 | Nor Este M | 8 | na | 7/2/1997 | 22.5 | 0.3 | 7.8 | 843 | 41.5 | 8.02 | 102. | 8.0 | 178. | 0.35 | 44.1 | 98.0 |
| S162 | NM317 | Stock Well #03 | 8 | na | 6/30/1997 | 23.1 | 7.2 | 8.1 | 214 | 22.6 | 2.99 | 17.3 | 1.0 | 5.9 | 0.09 | 13.2 | 100.0 |
| S163 | NM318 | PL 2 | 8 | na | 7/7/1997 | 20.5 | 5.2 | 7.6 | 416 | 48.4 | 7.91 | 23.4 | 3.4 | 10.7 | 0.14 | 55.6 | 168.9 |
| S164 | NM106 | Ponderosa 1 | 8 | na | 6/20/1996 | 27.0 | 1.6 | 7.6 | 562 | 60.5 | 2.70 | 47.4 | 5.0 | 79.3 | 0.24 | 33.8 | 150.5 |
| S165 | NM328 | Windmill #25 | 8 | na | 6/24/1997 | 20.3 | 1.8 | 8.6 | 368 | 9.06 | 1.85 | 65.5 | 1.2 | 11.5 | 0.17 | 52.6 | 137.3 |
| S168 | NM319 | Domestic Well #30 | 8 | na | 6/27/1997 | 21.9 | 5.2 | 8.5 | 224 | 12.6 | 2.70 | 29.9 | 0.9 | 8.3 | 0.13 | 29.5 | 86.3 |
| S170 | NM108 | Ridgecrest 3 | 8 | na | 6/22/1996 | 22.7 | 4.6 | 7.8 | 329 | 38.6 | 4.41 | 22.1 | 3.4 | 24.9 | 0.11 | 22.1 | 132.4 |
| S170 | NM412 | Ridgecrest 3 | 8 | na | 11/18/1997 | 21.7 | 4.1 | 7.9 | 341 | 38.1 | 4.40 | 22.6 | 3.1 | 25.9 | 0.13 | 23.7 | 131.9 |
| S195 | NM134 | Domestic Well #13 | 8 | na | 8/14/1996 | 23.1 | 3.2 | 7.8 | 317 | 31.4 | 7.40 | 20.4 | 2.2 | 17.2 | 0.17 | 30.8 | 123.7 |
| S199 | NM138 | Windmill #08 | 8 | na | 8/23/1996 | 18.0 | nd | 7.6 | 532 | 74.2 | 12.6 | 21.2 | 1.4 | 22.4 | 0.25 | 80.7 | 195.8 |
| S209 | NM336 | Domestic Well #33 | 8 | na | 6/27/1997 | 23.6 | 0.2 | 7.9 | 383 | 27.4 | 5.37 | 40.0 | 3.6 | 26.4 | 0.12 | 51.0 | 124.8 |
| S212 | NM141 | Sandia Peak 1 | 8 | na | 6/26/1996 | 21.2 | 7.6 | 7.5 | 314 | 49.3 | 5.32 | 16.0 | 1.4 | 4.8 | 0.07 | 14.3 | 188.5 |
| S213 | NM142 | Sandia Peak 3 | 8 | na | 6/26/1996 | 20.3 | 7.8 | 7.4 | 379 | 58.2 | 6.74 | 18.7 | 1.7 | 7.4 | 0.12 | 30.4 | 202.0 |
| S224 | NM148 | Domestic Well #14 | 8 | na | 8/23/1996 | 20.6 | 4.3 | 7.5 | 385 | 61.1 | 6.50 | 14.7 | 1.8 | 3.5 | nd | 31.3 | 213.2 |
| S229 | NM515 | SH03 UNM | 8 | na | 7/28/1998 | 16.6 | 8.8 | 7.1 | 437 | 67.0 | 8.04 | 13.1 | 1.6 | 5.1 | 0.09 | 31.2 | 231.1 |
| S233 | NM153 | Domestic Well #16 | 8 | na | 8/23/1996 | 25.6 | 1.9 | 7.3 | 543 | 65.2 | 4.79 | 44.1 | 4.5 | 22.8 | 0.10 | 42.6 | 253.8 |
| S239 | NM156 | Domestic Well #17 | 8 | na | 8/17/1996 | 17.4 | 6.8 | 7.1 | 490 | 60.7 | 13.4 | 31.6 | 2.0 | 7.5 | 0.08 | 35.9 | 267.0 |
| S240 | NM157 | Domestic Well #18 | 8 | na | 6/19/1996 | 21.4 | 8.0 | 7.6 | 288 | 42.2 | 2.63 | 17.6 | 1.5 | 5.2 | 0.07 | 14.3 | 163.0 |
| S246 | NM343 | Windmill #32 | 8 | na | 6/24/1997 | 25.0 | 5.8 | 7.9 | 388 | 42.4 | 4.06 | 29.5 | 2.2 | 9.8 | 0.16 | 70.8 | 122.6 |
| S247 | NM161 | Domestic Well #19 | 8 | na | 8/15/1996 | 25.9 | 5.8 | 8.5 | 371 | 4.5 | 0.21 | 78.8 | 1.4 | 7.6 | 0.09 | 35.7 | 176.8 |
| S248 | NM162 | Thomas 6 | 8 | na | 6/21/1996 | 22.9 | 1.4 | 7.6 | 521 | 58.2 | 4.68 | 37.0 | 3.3 | 67.0 | 0.20 | 31.1 | 154.9 |
| S255 | NM523 | Tramway East | 8 | na | 7/30/1998 | 22.6 | 5.6 | 7.6 | 295 | 48.2 | 4.61 | 24.7 | 1.8 | 6.0 | 0.07 | 16.8 | 156.9 |
| S264 | NM174 | Walker 1 | 8 | na | 6/18/1996 | 26.8 | 2.5 | 7.7 | 448 | 50.4 | 2.50 | 34.7 | 3.1 | 64.7 | 0.20 | 24.6 | 123.4 |
| S274 | NM177 | Domestic Well #20 | 8 | na | 8/15/1996 | 21.2 | 4.9 | 7.5 | 445 | 46.1 | 11.6 | 27.7 | 4.5 | 23.6 | 0.21 | 43.6 | 182.2 |
| | | **Zone 9: Tijeras Fault Zone** | | | | | | | | | | | | | | | |
| S041 | NM029 | Coyote Spring | 9 | na | 6/28/1996 | 17.5 | 2.8 | 6.5 | 3,500 | 322. | 70.3 | 382. | 43.7 | 581. | 2.45 | 140. | 1,305. |
| S041 | NM030 | Coyote Spring | 9 | na | 7/1/1996 | 17.3 | 1.7 | 6.1 | 3,243 | nd | nd | nd | nd | nd | nd | nd | nd |
| S072 | NM061 | Hubbell Spring | 9 | 8 | 8/23/1996 | 18.2 | 4.8 | 7.5 | 849 | 77.3 | 31.2 | 58.3 | 1.9 | 35.1 | 0.36 | 211. | 229.7 |
| S098 | NM071 | KAFB-1902 | 9 | na | 6/28/1996 | 19.4 | 4.5 | 7.3 | 1,360 | 156. | 27.7 | 100. | 9.1 | 82.7 | 0.71 | 292. | 277.9 |
| S197 | NM136 | Windmill #06 | 9 | na | 8/23/1996 | 20.3 | 0.3 | 8.2 | 1,405 | 22.1 | 14.0 | 260. | 3.2 | 90.9 | 1.19 | 326. | 270.4 |
| S227 | NM151 | SFR 3D | 9 | na | 8/24/1996 | 19.8 | 5.7 | 6.6 | 1,407 | 171. | 39.6 | 90.1 | 6.7 | 140. | 0.66 | 92.6 | 599.3 |

**Table A2.** Summary of field parameters and major-element chemistry-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secon-dary hydro-chemical zone | Date sampled | Temp (ºC) | $O_2$ (mg/L) | pH | Sp. Cond. (µS/cm) | $Ca^{2+}$ (mg/L) | $Mg^{2+}$ (mg/L) | $Na^{+}$ (mg/L) | $K^{+}$ (mg/L) | $Cl^{-}$ (mg/L) | $Br^{-}$ (mg/L) | $SO_4^{2-}$ (mg/L) | $HCO_3^{-}$ (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S228 | NM152 | SFR 3S | 9 | na | 8/24/1996 | 20.7 | 5.5 | 6.9 | 1,189 | 127. | 30.6 | 84.7 | 5.4 | 139. | 0.65 | 90.2 | 426.4 |
| | | **Zone 10: Tijeras Arroyo** | | | | | | | | | | | | | | | |
| S001 | NM001 | 4Hills-1 | 10 | 8 | 6/29/1996 | 16.4 | 5.0 | 7.3 | 1,214 | 146. | 49.1 | 45.1 | 4.9 | 108. | 0.73 | 287. | 240.2 |
| S002 | NM250 | Private Production Well #15 | 10 | 8 | 7/3/1997 | 15.8 | 15. | 7.5 | 717 | 98.9 | 31.3 | 26.5 | 2.7 | 77.6 | 0.35 | 130. | 240.4 |
| S058 | NM277 | Eubank 1 | 10 | 8 | 7/4/1997 | 19.7 | 6.4 | 7.7 | 474 | 56.4 | 10.0 | 23.8 | 1.8 | 12.2 | 0.16 | 85.1 | 155.7 |
| S096 | NM069 | Kirtland 11 | 10 | 8 | 6/25/1996 | 23.4 | 7.0 | 7.4 | 517 | 67.8 | 12.2 | 29.3 | 3.2 | 17.1 | 0.21 | 83.1 | 205.1 |
| S107 | NM075 | Lomas 1 | 10 | 8 | 6/22/1996 | 22.2 | 7.4 | 7.3 | 507 | 63.1 | 13.1 | 28.4 | 3.8 | 35.6 | 0.35 | 94.3 | 183.8 |
| S107 | NM410 | Lomas 1 | 10 | na | 11/18/1997 | 21.8 | 7.2 | 7.5 | 596 | 75.2 | 12.5 | 26.5 | 4.0 | 33.6 | 0.43 | 95.0 | 181.5 |
| | | **Zone 11: Northeastern** | | | | | | | | | | | | | | | |
| S016 | NM258 | Windmill #15 | 11 | na | 6/18/1997 | 18.7 | 11. | 8.4 | 1,252 | 24.9 | 4.67 | 236. | 3.8 | 66.1 | 0.67 | 284. | 289.8 |
| S017 | NM259 | Windmill #16 | 11 | na | 6/18/1997 | 19.4 | 6.6 | 8.2 | 528 | 28.4 | 2.81 | 76.3 | 1.8 | 15.9 | 0.25 | 97.9 | 159.7 |
| S053 | NM276 | Private Production Well #18 | 11 | na | 6/25/1997 | 16.8 | 2.8 | 7.2 | 1,282 | 146. | 31.8 | 91.4 | 5.8 | 16.4 | 0.12 | 540. | 162.9 |
| S144 | NM097 | Private Production Well #06 | 11 | na | 8/28/1996 | 20.9 | 0.2 | 7.4 | 1,284 | 135. | 35.2 | 94.0 | 9.4 | 22.0 | 0.22 | 476. | 240.1 |
| S204 | NM332 | Windmill #28 | 11 | na | 7/3/1997 | 19.5 | 14. | 7.6 | 538 | 71.1 | 14.5 | 27.3 | 3.0 | 10.3 | 0.09 | 104. | 201.8 |
| S207 | NM334 | Private Production Well #22 | 11 | na | 7/3/1997 | 19.3 | 6.7 | 7.3 | 1,579 | 279. | 57.1 | 87.3 | 4.4 | 21.5 | 0.15 | 877. | 173.7 |
| S223 | NM338 | Windmill #29 | 11 | na | 6/25/1997 | 18.6 | 6.3 | 7.6 | 1,079 | 104. | 30.0 | 73.7 | 5.1 | 23.4 | 0.27 | 399. | 147.4 |
| | | **Zone 12: Central** | | | | | | | | | | | | | | | |
| S011 | NM004 | Atris-1 | 12 | na | 6/22/1996 | 19.3 | 0.1 | 7.6 | 390 | 42.8 | 6.98 | 26.3 | 4.7 | 12.2 | 0.06 | 63.6 | 149.7 |
| S012 | NM005 | Atrisco 3 | 12 | 3 | 6/20/1996 | 18.6 | 0.2 | 8.0 | 450 | 29.6 | 5.43 | 56.7 | 7.3 | 14.5 | 0.07 | 80.7 | 155.3 |
| S025 | NM012 | Burton 2 | 12 | na | 6/19/1996 | 21.2 | 2.9 | 7.8 | 378 | 40.0 | 7.52 | 24.0 | 5.5 | 32.7 | 0.13 | 38.7 | 130.6 |
| S026 | NM013 | Burton 5 | 12 | na | 6/19/1996 | 21.9 | 0.4 | 7.8 | 361 | 37.7 | 7.30 | 23.6 | 4.8 | 32.2 | 0.10 | 28.7 | 129.0 |
| S033 | NM025 | Private Production Well #02 | 12 | na | 8/21/1996 | 17.4 | 0.8 | 7.4 | 859 | 125. | 14.4 | 44.9 | 5.3 | 33.6 | 0.19 | 149. | 289.8 |
| S040 | NM028 | Coronado 1 | 12 | na | 6/18/1996 | 22.8 | 0.7 | 7.9 | 558 | 36.0 | 7.79 | 62.1 | 7.9 | 72.7 | 0.22 | 44.3 | 146.1 |
| S043 | NM488 | Del Sol D | 12 | na | 7/21/1998 | 21.1 | 0.5 | 7.7 | 489 | 22.0 | 5.34 | 75.6 | 7.3 | 48.6 | 0.11 | 41.7 | 155.2 |
| S043 | NM267 | Del Sol D | 12 | na | 7/1/1997 | 22.3 | 0.5 | 7.9 | 500 | 20.5 | 4.93 | 70.2 | 7.1 | 51.2 | 0.16 | 45.4 | 154.3 |
| S044 | NM489 | Del Sol M | 12 | na | 7/21/1998 | 21.2 | 0.5 | 7.4 | 516 | 48.9 | 7.55 | 46.6 | 5.6 | 55.5 | 0.13 | 42.6 | 160.4 |
| S044 | NM268 | Del Sol M | 12 | na | 6/26/1997 | 20.3 | 0.6 | 7.7 | 515 | 50.0 | 7.41 | 41.3 | 5.7 | 55.4 | 0.16 | 46.3 | 160.5 |
| S045 | NM269 | Del Sol S | 12 | na | 6/26/1997 | 18.4 | 2.9 | 7.6 | 715 | 80.0 | 15.0 | 26.4 | 5.7 | 103. | 1.07 | 98.8 | 95.5 |
| S045 | NM490 | Del Sol S | 12 | na | 7/21/1998 | 18.6 | 3.3 | 7.4 | 753 | 90.2 | 16.4 | 25.3 | 5.6 | 108. | 1.25 | 109. | 94.9 |
| S046 | NM032 | Duranes 1 | 12 | na | 6/20/1996 | 20.2 | <0.1 | 7.6 | 593 | 45.0 | 9.55 | 59.1 | 10.6 | 19.7 | 0.09 | 117. | 187.3 |
| S046 | NM035 | Duranes 1 | 12 | na | 6/29/1996 | 18.2 | 0.1 | 7.2 | 727 | 64.2 | 15.1 | 65.3 | 11.8 | 24.9 | 0.11 | 156. | 222.9 |
| S046 | NM036 | Duranes 1 | 12 | na | 6/29/1996 | 18.4 | 0.1 | 7.3 | 708 | 66.6 | 15.3 | 64.8 | 12.2 | 24.6 | 0.11 | 156. | 224.0 |
| S046 | NM033 | Duranes 1 | 12 | na | 6/29/1996 | 18.1 | 0.1 | 7.4 | 728 | 63.6 | 14.7 | 64.3 | 12.0 | 24.9 | 0.11 | 156. | 223.2 |
| S046 | NM037 | Duranes 1 | 12 | na | 6/29/1996 | 18.4 | 0.1 | 7.3 | 704 | 64.7 | 15.3 | 63.6 | 13.4 | 24.9 | 0.11 | 157. | 225.0 |
| S046 | NM039 | Duranes 1 | 12 | na | 6/29/1996 | 18.9 | <0.1 | 7.2 | 717 | 65.3 | 14.2 | 57.9 | 12.9 | 24.6 | 0.11 | 159. | 225.0 |
| S046 | NM038 | Duranes 1 | 12 | na | 6/29/1996 | 18.4 | 0.1 | 7.3 | 711 | 65.9 | 14.6 | 61.8 | 12.6 | 24.9 | 0.11 | 159. | 225.7 |
| S046 | NM040 | Duranes 1 | 12 | na | 6/29/1996 | 18.9 | 0.1 | 7.3 | 731 | 63.2 | 13.6 | 60.9 | 13.0 | 24.9 | 0.11 | 159. | 224.1 |
| S046 | NM034 | Duranes 1 | 12 | na | 6/29/1996 | 18.3 | 0.2 | 7.4 | 735 | 64.0 | 14.7 | 62.3 | 11.6 | 24.6 | 0.11 | 159. | 224.6 |
| S047 | NM270 | Duranes 7 | 12 | na | 6/26/1997 | 17.7 | 0.2 | 7.9 | 415 | 32.5 | 6.28 | 42.1 | 7.8 | 10.2 | 0.07 | 66.5 | 155.7 |
| S048 | NM271 | Duranes Yard 1 | 12 | na | 7/5/1997 | 15.8 | 0.1 | 7.8 | 385 | 40.2 | 7.73 | 23.3 | 6.8 | 10.4 | 0.05 | 62.2 | 142.3 |
| S049 | NM272 | Duranes Yard 2 | 12 | na | 7/5/1997 | 17.2 | 0.1 | 7.8 | 388 | 41.6 | 6.68 | 24.8 | 5.6 | 11.1 | 0.06 | 60.8 | 148.2 |
| S050 | NM273 | Duranes Yard 3 | 12 | na | 7/5/1997 | 16.4 | 0.1 | 7.8 | 408 | 45.9 | 7.70 | 22.4 | 5.2 | 9.6 | 0.06 | 70.7 | 155.2 |
| S051 | NM274 | Duranes Yard 4 | 12 | na | 7/5/1997 | 14.9 | <0.1 | 7.7 | 424 | 50.0 | 7.99 | 23.5 | 3.7 | 14.0 | 0.07 | 67.9 | 163.3 |
| S052 | NM275 | Duranes Yard 5 | 12 | na | 7/5/1997 | 15.9 | <0.1 | 7.7 | 414 | 47.6 | 7.76 | 22.2 | 3.5 | 16.5 | 0.07 | 62.7 | 152.6 |
| S060 | NM279 | Garfield D | 12 | 3 | 6/19/1997 | 26.7 | 0.2 | 8.1 | 425 | 14.6 | 2.29 | 67.5 | 6.4 | 8.6 | 0.06 | 60.8 | 169.5 |

**Table A2.** Summary of field parameters and major-element chemistry-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secondary hydro-chemical zone | Date sampled | Temp (ºC) | $O_2$ (mg/L) | pH | Sp. Cond. (µS/cm) | $Ca^{2+}$ (mg/L) | $Mg^{2+}$ (mg/L) | $Na^+$ (mg/L) | $K^+$ (mg/L) | $Cl^-$ (mg/L) | $Br^-$ (mg/L) | $SO_4^{2-}$ (mg/L) | $HCO_3^-$ (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S061 | NM280 | Garfield M | 12 | na | 6/19/1997 | 22.9 | 0.2 | 8.0 | 368 | 21.0 | 5.01 | 45.4 | 8.2 | 8.0 | 0.03 | 43.1 | 162.8 |
| S062 | NM491 | Garfield S | 12 | na | 7/28/1998 | 17.8 | 0.1 | 6.8 | 881 | 123. | 21.3 | 43.2 | 6.7 | 17.5 | 0.08 | 208. | 306.0 |
| S062 | NM281 | Garfield S | 12 | na | 6/19/1997 | 18.8 | 0.3 | 7.2 | 947 | 128. | 25.1 | 41.4 | 7.9 | 19.7 | 0.06 | 224. | 326.9 |
| S064 | NM283 | Domestic Well #22 | 12 | na | 6/20/1997 | 17.8 | 0.1 | 7.7 | 498 | 54.1 | 9.12 | 23.1 | 7.2 | 15.7 | 0.09 | 81.6 | 168.7 |
| S068 | NM057 | Griegos 3 | 12 | na | 6/21/1996 | 19.4 | 0.2 | 6.8 | 399 | 34.9 | 6.29 | 37.9 | 7.7 | 12.2 | 0.06 | 69.7 | 142.9 |
| S075 | NM286 | Hunter Ridge Nest 1 Well 1 | 12 | 3 | 6/20/1997 | 23.1 | 0.2 | 8.0 | 423 | 19.3 | 2.98 | 69.7 | 6.4 | 11.3 | 0.06 | 65.1 | 177.7 |
| S076 | NM287 | Hunter Ridge Nest 1 Well 2 | 12 | na | 6/21/1997 | 20.6 | 0.2 | 7.7 | 354 | 42.7 | 7.32 | 18.3 | 8.0 | 7.3 | 0.05 | 40.6 | 163.2 |
| S077 | NM288 | Hunter Ridge Nest 1 Well 3 | 12 | na | 6/20/1997 | 19.8 | 3.1 | 7.7 | 652 | 67.3 | 15.6 | 40.5 | 6.7 | 20.5 | 0.17 | 156. | 168.8 |
| S078 | NM289 | Hunter Ridge Nest 2 Well 1 | 12 | na | 6/21/1997 | 19.5 | 0.2 | 7.8 | 446 | 48.9 | 8.31 | 28.1 | 6.5 | 9.0 | 0.06 | 84.6 | 156.5 |
| S079 | NM290 | Hunter Ridge Nest 2 Well 2 | 12 | na | 6/21/1997 | 18.6 | 0.1 | 7.7 | 483 | 57.1 | 11.4 | 26.3 | 5.7 | 12.5 | 0.11 | 93.5 | 165.4 |
| S080 | NM291 | Hunter Ridge Nest 2 Well 3 | 12 | na | 6/21/1997 | 18.7 | 1.1 | 7.6 | 589 | 72.2 | 15.3 | 29.2 | 6.1 | 19.8 | 0.19 | 137. | 165.5 |
| S081 | NM292 | Private Production Well #19 | 12 | na | 7/2/1997 | 20.3 | 0.3 | 7.8 | 378 | 39.7 | 5.94 | 29.7 | 7.3 | 11.9 | 0.08 | 44.4 | 160.4 |
| S084 | NM063 | Windmill #04 | 12 | na | 8/21/1996 | 18.0 | 3.2 | 7.5 | 451 | 32.2 | 6.83 | 52.0 | 7.5 | 18.0 | 0.10 | 57.4 | 184.4 |
| S087 | NM493 | Isleta MD | 12 | 3 | 7/29/1998 | 20.2 | <0.1 | 7.8 | 425 | 10.8 | 1.55 | 85.3 | 5.1 | 11.8 | 0.06 | 46.2 | 189.8 |
| S088 | NM494 | Isleta MS | 12 | na | 7/29/1998 | 18.4 | <0.1 | 7.6 | 291 | 30.2 | 4.68 | 22.0 | 5.1 | 8.8 | nd | 30.0 | 127.8 |
| S089 | NM495 | Isleta S | 12 | na | 7/29/1998 | 17.4 | <0.1 | 7.2 | 875 | 119. | 16.1 | 59.2 | 7.5 | 33.7 | 0.14 | 140. | 357.3 |
| S092 | NM066 | JMC-1 | 12 | na | 6/28/1996 | 19.8 | <0.1 | 7.6 | 653 | 76.1 | 15.3 | 35.5 | 7.9 | 24.1 | 0.11 | 123. | 227.5 |
| S097 | NM070 | Kirtland 14 | 12 | na | 6/25/1996 | 21.7 | 0.7 | 7.8 | 336 | 37.9 | 6.81 | 20.5 | 4.0 | 25.8 | 0.08 | 26.8 | 127.6 |
| S100 | NM073 | LALF-9 | 12 | na | 6/29/1996 | 16.1 | 0.1 | 7.7 | 715 | 115. | 13.4 | 26.7 | 6.6 | 20.5 | 0.09 | 120. | 297.0 |
| S102 | NM074 | Leyendecker 1 | 12 | na | 6/21/1996 | 19.1 | 0.9 | 7.9 | 311 | 43.4 | 3.63 | 18.3 | 2.6 | 10.9 | 0.07 | 32.0 | 132.9 |
| S120 | NM301 | Mesa Del Sol D | 12 | na | 6/29/1997 | 25.9 | 3.3 | 7.8 | 400 | 27.4 | 6.02 | 49.9 | 4.9 | 20.2 | 0.09 | 42.6 | 162.7 |
| S120 | NM503 | Mesa Del Sol D | 12 | na | 8/2/1998 | 27.9 | <0.1 | 8.4 | 458 | 3.5 | 0.09 | 95.3 | 1.1 | 21.3 | 0.11 | 65.6 | 143.0 |
| S120 | NM303 | Mesa Del Sol D | 12 | na | 6/28/1997 | 25.7 | 0.8 | 7.8 | 490 | 13.9 | 2.11 | 103. | 4.3 | 26.3 | 0.09 | 73.0 | 204.9 |
| S121 | NM504 | Mesa Del Sol M | 12 | na | 7/25/1998 | 23.6 | <0.1 | 8.1 | 428 | 4.5 | 0.22 | 86.2 | 1.0 | 34.6 | 0.11 | 32.5 | 149.8 |
| S121 | NM302 | Mesa Del Sol M | 12 | na | 6/28/1997 | 28.4 | 0.1 | 8.6 | 440 | 5.5 | 0.26 | 88.7 | 1.2 | 35.0 | 0.12 | 37.0 | 158.6 |
| S123 | NM081 | MONT - 5A | 12 | na | 6/27/1996 | 17.6 | <0.1 | 7.8 | 500 | 69.4 | 14.4 | 20.0 | 5.5 | 33.9 | 0.17 | 140. | 119.9 |
| S124 | NM082 | Montaňo 2 D | 12 | na | 6/19/1996 | 16.7 | 0.1 | 7.6 | 477 | 56.6 | 14.9 | 18.2 | 9.1 | 19.0 | 0.08 | 74.0 | 194.7 |
| S125 | NM083 | Montaňo 2 M | 12 | na | 6/19/1996 | 15.4 | <0.1 | 7.5 | 629 | 75.2 | 19.8 | 21.2 | 12.0 | 21.6 | 0.09 | 101. | 257.5 |
| S126 | NM084 | Montaňo 2 S | 12 | na | 6/19/1996 | 15.7 | <0.1 | 7.5 | 673 | 92.3 | 12.9 | 37.9 | 7.9 | 16.9 | 0.08 | 97.7 | 300.6 |
| S127 | NM085 | Montaňo 4 D | 12 | na | 6/20/1996 | 17.3 | 0.1 | 7.7 | 429 | 50.8 | 11.4 | 18.3 | 8.2 | 19.2 | 0.10 | 63.3 | 166.9 |
| S128 | NM086 | Montaňo 4 M | 12 | na | 6/19/1996 | 17.4 | 0.1 | 7.2 | 914 | 123. | 26.6 | 45.6 | 9.8 | 14.8 | 0.10 | 173. | 345.5 |
| S130 | NM088 | Montaňo 5 D | 12 | na | 6/24/1996 | 18.1 | 0.1 | 7.6 | 417 | 41.7 | 9.76 | 26.7 | 7.8 | 10.4 | 0.06 | 67.5 | 166.2 |
| S131 | NM089 | Montaňo 5 M | 12 | na | 6/24/1996 | 14.3 | 0.1 | 7.7 | 378 | 44.8 | 7.41 | 20.5 | 3.5 | 8.3 | 0.05 | 57.1 | 156.5 |
| S132 | NM090 | Montaňo 5 S | 12 | na | 6/24/1996 | 22.4 | 0.1 | 7.4 | 370 | 41.2 | 7.59 | 21.8 | 4.2 | 6.4 | 0.04 | 67.3 | 138.7 |
| S133 | NM091 | Montaňo 6 D | 12 | na | 6/18/1996 | 18.4 | 0.1 | 7.9 | 374 | 33.5 | 6.37 | 35.8 | 8.7 | 10.0 | 0.04 | 57.1 | 149.5 |
| S134 | NM092 | Montaňo 6 MD | 12 | na | 6/18/1996 | 20.5 | 0.1 | 8.8 | 311 | 32.0 | 5.68 | 24.4 | 9.2 | 8.8 | 0.04 | 44.9 | 124.5 |
| S135 | NM093 | Montaňo 6 MS | 12 | na | 6/18/1996 | 18.2 | 0.1 | 8.8 | 311 | 37.2 | 7.62 | 17.0 | 7.9 | 12.9 | 0.05 | 49.8 | 117.0 |
| S136 | NM094 | Montaňo 6 S | 12 | na | 6/18/1996 | 16.8 | 0.1 | 8.3 | 393 | 44.2 | 12.3 | 17.5 | 8.1 | 15.1 | 0.07 | 73.9 | 144.4 |
| S137 | NM506 | Montesa M | 12 | na | 7/27/1998 | 23.8 | <0.1 | 7.5 | 359 | 30.8 | 7.23 | 26.7 | 8.0 | 26.2 | 0.08 | 31.2 | 129.5 |
| S138 | NM507 | Montesa S | 12 | na | 7/27/1998 | 20.9 | 1.6 | 7.5 | 315 | 31.6 | 4.31 | 26.0 | 4.2 | 11.9 | nd | 30.7 | 136.4 |
| S139 | NM305 | Domestic Well #27 | 12 | na | 6/17/1997 | 23.8 | 1.2 | 7.7 | 377 | 37.4 | 7.66 | 26.1 | 9.2 | 8.9 | 0.05 | 45.2 | 164.8 |
| S142 | NM307 | Domestic Well #28 | 12 | na | 6/17/1997 | 18.6 | 1.0 | 7.8 | 500 | 61.7 | 9.34 | 20.0 | 9.3 | 24.5 | 0.14 | 105. | 130.4 |
| S146 | NM309 | NM Utilities 2 | 12 | na | 6/18/1997 | 21.7 | 1.0 | 7.9 | 391 | 31.2 | 5.54 | 38.5 | 7.8 | 13.5 | 0.10 | 42.2 | 164.0 |
| S151 | NM508 | Nor Este S | 12 | na | 7/20/1998 | 21.0 | 0.4 | 7.7 | 373 | 26.1 | 4.23 | 48.7 | 4.5 | 9.5 | 0.06 | 37.6 | 165.8 |
| S151 | NM314 | Nor Este S | 12 | na | 7/2/1997 | 20.8 | 0.7 | 7.9 | 385 | 19.3 | 3.00 | 61.0 | 3.8 | 12.7 | 0.06 | 45.0 | 169.9 |
| S153 | NM411 | Open Space | 12 | na | 11/18/1997 | 18.0 | 2.4 | 8.0 | 282 | 35.3 | 3.85 | 16.9 | 2.2 | 7.0 | nd | 28.9 | 130.8 |

**Table A2.** Summary of field parameters and major-element chemistry-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secon-dary hydro-chemical zone | Date sampled | Temp (ºC) | $O_2$ (mg/L) | pH | Sp. Cond. (µS/cm) | $Ca^{2+}$ (mg/L) | $Mg^{2+}$ (mg/L) | $Na^+$ (mg/L) | $K^+$ (mg/L) | $Cl^-$ (mg/L) | $Br^-$ (mg/L) | $SO_4^{2-}$ (mg/L) | $HCO_3^-$ (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S153 | NM315 | Open Space | 12 | 10 | 6/17/1997 | 20.4 | nd | 8.0 | 289 | 35.8 | 3.84 | 17.9 | 2.2 | 6.8 | 0.00 | 31.6 | 127.3 |
| S154 | NM099 | ORLF-2 | 12 | na | 6/27/1996 | 18.1 | <0.1 | 8.0 | 331 | 41.2 | 7.44 | 22.8 | 6.6 | 8.7 | 0.05 | 53.7 | 154.3 |
| S155 | NM316 | Domestic Well #29 | 12 | na | 6/27/1997 | 19.2 | 0.1 | 7.8 | 357 | 40.2 | 9.51 | 16.6 | 2.7 | 16.1 | 0.55 | 48.3 | 133.8 |
| S156 | NM100 | Paseo 2D | 12 | na | 6/26/1996 | 16.0 | <0.1 | 8.2 | 354 | 42.9 | 7.20 | 14.8 | 4.1 | 16.1 | 0.06 | 59.1 | 119.5 |
| S157 | NM101 | Paseo 2MD | 12 | na | 6/26/1996 | 16.5 | <0.1 | 7.9 | 461 | 60.9 | 8.55 | 18.7 | 3.2 | 13.4 | 0.06 | 85.9 | 166.2 |
| S158 | NM102 | Paseo 2MS | 12 | na | 6/26/1996 | 18.0 | <0.1 | 8.0 | 487 | 59.1 | 7.87 | 30.6 | 4.1 | 13.1 | 0.06 | 81.9 | 196.1 |
| S159 | NM103 | Paseo 2S | 12 | na | 6/26/1996 | 17.8 | <0.1 | 7.7 | 673 | 89.8 | 12.1 | 33.3 | 6.7 | 17.4 | 0.07 | 103. | 283.6 |
| S160 | NM104 | Paseo 3D | 12 | na | 6/21/1996 | 18.1 | 0.2 | 6.8 | 268 | 32.1 | 6.82 | 14.4 | 3.8 | 7.3 | 0.03 | 26.8 | 123.8 |
| S161 | NM105 | Paseo 3M | 12 | na | 6/21/1996 | 17.7 | 0.1 | 6.8 | 812 | 121. | 16.0 | 39.4 | 7.2 | 25.4 | 0.10 | 125. | 360.4 |
| S171 | NM321 | Ridgecrest 4 | 12 | na | 6/26/1997 | 21.4 | 1.5 | 7.8 | 393 | 44.9 | 5.64 | 24.8 | 3.5 | 39.5 | 0.12 | 31.6 | 132.8 |
| S173 | NM323 | Rio Bravo 5 M | 12 | 3 | 7/4/1997 | 15.5 | <0.1 | 8.2 | 439 | 18.2 | 4.18 | 69.5 | 6.9 | 11.9 | 0.06 | 69.1 | 163.5 |
| S176 | NM111 | Rio Bravo 1 S | 12 | na | 6/17/1996 | 20.2 | 0.1 | 7.3 | 596 | 85.8 | 10.9 | 27.9 | 5.8 | 20.6 | 0.08 | 99.4 | 238.7 |
| S177 | NM112 | Rio Bravo 2 D | 12 | 3 | 6/25/1996 | 19.0 | 0.1 | 8.1 | 429 | 26.9 | 6.52 | 49.1 | 10.7 | 13.1 | 0.06 | 70.4 | 162.8 |
| S178 | NM113 | Rio Bravo 2 M | 12 | na | 6/25/1996 | 19.9 | 0.1 | 7.8 | 619 | 56.5 | 13.6 | 48.0 | 12.0 | 42.2 | 0.14 | 107. | 186.5 |
| S179 | NM114 | Rio Bravo 2 S | 12 | na | 6/25/1996 | 20.7 | 0.1 | 7.7 | 610 | 59.7 | 12.4 | 47.8 | 9.9 | 22.1 | 0.09 | 101. | 229.7 |
| S180 | NM115 | Rio Bravo 4 D | 12 | na | 6/25/1996 | 21.7 | <0.1 | 8.0 | 339 | 39.7 | 7.90 | 14.5 | 6.8 | 22.9 | 0.07 | 29.4 | 135.3 |
| S181 | NM116 | Rio Bravo 4 M | 12 | na | 6/25/1996 | 20.4 | <0.1 | 7.4 | 819 | 96.3 | 19.8 | 22.5 | 10.5 | 97.1 | 0.28 | 137. | 122.7 |
| S183 | NM126 | Rio Grande Utility 5 | 12 | 3 | 8/15/1996 | 26.1 | 0.6 | 7.7 | 467 | 32.1 | 7.96 | 50.1 | 8.0 | 28.3 | 0.11 | 63.1 | 160.9 |
| S184 | NM127 | Rio Grande Utility 6 | 12 | na | 8/15/1996 | 22.8 | 0.1 | 7.7 | 316 | 30.8 | 8.64 | 17.7 | 5.6 | 8.0 | nd | 31.8 | 143.6 |
| S190 | NM325 | Rio Rancho 2 | 12 | na | 6/20/1997 | 17.8 | 1.6 | 7.7 | 472 | 58.6 | 9.19 | 20.2 | 6.5 | 36.0 | 0.31 | 59.2 | 138.5 |
| S203 | NM331 | Private Production Well #20 | 12 | na | 7/3/1997 | 16.0 | 1.1 | 7.6 | 527 | 81.8 | 12.8 | 27.2 | 4.7 | 13.2 | 0.09 | 121. | 226.6 |
| S205 | NM333 | Private Production Well #21 | 12 | na | 7/3/1997 | 17.1 | 0.1 | 7.4 | 298 | 38.1 | 7.12 | 12.1 | 3.9 | 4.4 | 0.03 | 37.4 | 139.7 |
| S208 | NM140 | San Jose 2 | 12 | 3 | 6/20/1996 | 27.0 | 0.6 | 7.9 | 418 | 30.7 | 6.57 | 41.4 | 9.5 | 26.4 | 0.09 | 58.4 | 133.6 |
| S210 | NM511 | Sandia D | 12 | na | 7/30/1998 | 21.1 | 1.1 | 7.4 | 622 | 24.1 | 6.78 | 92.9 | 7.4 | 62.0 | 0.16 | 58.3 | 181.3 |
| S214 | NM513 | Sandia S | 12 | na | 7/30/1998 | 18.6 | 0.1 | 8.5 | 735 | 79.5 | 12.6 | 51.9 | 8.6 | 97.5 | 0.24 | 78.8 | 187.8 |
| S220 | NM147 | Santa Barbara 1 | 12 | na | 6/19/1996 | 20.4 | 0.3 | 7.9 | 313 | 34.4 | 4.74 | 22.4 | 4.2 | 10.7 | 0.06 | 36.8 | 128.6 |
| S220 | NM337 | Santa Barbara 1 | 12 | na | 6/26/1997 | 19.8 | 0.3 | 7.9 | 324 | 34.4 | 4.67 | 20.9 | 4.2 | 11.5 | 0.09 | 41.2 | 128.5 |
| S231 | NM517 | Sierra Vista M | 12 | 3 | 7/22/1998 | 22.4 | 0.1 | 8.4 | 416 | 8.0 | 1.13 | 83.8 | 5.9 | 8.1 | 0.05 | 49.4 | 178.8 |
| S232 | NM518 | Sierra Vista S | 12 | na | 7/22/1998 | 19.2 | 4.6 | 7.6 | 462 | 30.4 | 5.62 | 62.2 | 6.5 | 17.7 | 0.15 | 61.2 | 199.1 |
| S234 | NM339 | Sister Cities D | 12 | na | 6/30/1997 | 20.5 | 0.7 | 7.7 | 544 | 29.5 | 8.24 | 62.3 | 9.2 | 47.7 | 0.14 | 52.8 | 176.7 |
| S235 | NM340 | Sister Cities M | 12 | na | 6/27/1997 | 18.6 | 0.1 | 7.8 | 289 | 32.5 | 5.01 | 17.0 | 2.8 | 7.0 | 0.03 | 22.0 | 136.6 |
| S244 | NM158 | SWAB 3 - 760 | 12 | na | 7/1/1996 | 16.5 | <0.1 | 9.0 | 250 | 16.0 | 1.74 | 32.7 | 3.2 | 11.7 | 0.07 | 13.3 | 124.8 |
| S245 | NM159 | SWAB 3 - 980 | 12 | na | 7/1/1996 | 16.5 | <0.1 | 8.7 | 208 | 17.0 | 3.51 | 19.3 | 6.2 | 9.1 | 0.05 | 6.3 | 109.5 |
| S245 | NM160 | SWAB 3 - 980 | 12 | na | 7/1/1996 | 16.6 | <0.1 | 8.9 | 195 | 15.8 | 3.13 | 20.9 | 5.9 | 8.8 | 0.04 | 8.2 | 110.3 |
| S253 | NM522 | Tome D | 12 | na | 8/6/1998 | 27.6 | <0.1 | 7.5 | 478 | 20.2 | 5.26 | 69.4 | 5.8 | 41.3 | 0.11 | 43.7 | 155.9 |
| S257 | NM344 | Domestic Well #34 | 12 | na | 6/17/1997 | 16.0 | 0.1 | 7.4 | 688 | 77.5 | 12.6 | 48.6 | 9.1 | 31.5 | 0.16 | 92.7 | 258.7 |
| S259 | NM171 | VGP-1 | 12 | na | 6/27/1996 | 18.1 | <0.1 | 7.5 | 951 | 125. | 17.8 | 50.2 | 9.1 | 21.0 | 0.11 | 167. | 355.4 |
| S261 | NM172 | Vol Andia 2 | 12 | na | 6/21/1996 | 19.6 | 0.6 | 7.9 | 300 | 42.0 | 4.15 | 15.9 | 2.4 | 10.4 | 0.07 | 34.0 | 121.3 |
| S262 | NM173 | Vol Andia 5 | 12 | na | 6/18/1996 | 18.0 | 0.3 | 7.9 | 371 | 48.6 | 5.83 | 17.7 | 3.0 | 16.1 | 0.08 | 67.0 | 123.6 |
| S265 | NM175 | Webster 1 | 12 | na | 6/18/1996 | 22.1 | 1.1 | 7.8 | 441 | 32.8 | 5.72 | 48.2 | 5.9 | 43.1 | 0.11 | 38.3 | 154.8 |
| S267 | NM348 | West Bluff Nest 1 Well 2 | 12 | 3 | 6/23/1997 | 24.4 | 0.2 | 7.8 | 412 | 25.4 | 4.09 | 50.5 | 8.8 | 11.1 | 0.06 | 56.8 | 160.6 |
| S268 | NM349 | West Bluff Nest 1 Well 3 | 12 | na | 6/24/1997 | 20.0 | 0.2 | 7.9 | 400 | 30.5 | 4.86 | 42.5 | 9.0 | 10.8 | 0.05 | 55.5 | 157.1 |
| S269 | NM350 | West Bluff Nest 2 Well 1 | 12 | na | 6/24/1997 | 18.7 | 0.1 | 7.8 | 461 | 39.4 | 7.07 | 40.8 | 9.1 | 14.1 | 0.07 | 91.9 | 139.7 |
| S270 | NM351 | West Bluff Nest 2 Well 2 | 12 | na | 6/24/1997 | 17.0 | 0.2 | 7.8 | 430 | 43.9 | 8.16 | 31.9 | 8.4 | 11.9 | 0.07 | 79.9 | 150.5 |
| S271 | NM352 | West Bluff Nest 2 Well 3 | 12 | na | 6/24/1997 | 16.4 | 1.4 | 7.4 | 447 | 53.7 | 8.64 | 24.6 | 4.5 | 14.3 | 0.09 | 60.4 | 175.2 |
| S275 | NM178 | Yale 1 | 12 | na | 6/19/1996 | 22.0 | 1.6 | 7.8 | 376 | 41.7 | 7.31 | 24.3 | 6.0 | 24.9 | 0.12 | 47.2 | 127.6 |

**Table A2.** Summary of field parameters and major-element chemistry-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secon-dary hydro-chemical zone | Date sampled | Temp (ºC) | $O_2$ (mg/L) | pH | Sp. Cond. (µS/cm) | $Ca^{2+}$ (mg/L) | $Mg^{2+}$ (mg/L) | $Na^+$ (mg/L) | $K^+$ (mg/L) | $Cl^-$ (mg/L) | $Br^-$ (mg/L) | $SO_4^{2-}$ (mg/L) | $HCO_3^-$ (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SXXX | NM045 | Geoprobe #1 (45.3') | 12 | na | 7/1/1996 | 15.2 | 0.1 | 8.0 | 384 | 43.8 | 6.43 | 22.8 | 4.6 | 8.2 | 0.10 | 58.8 | 155.3 |
| SXXX | NM046 | Geoprobe #1 (40.8') | 12 | na | 7/1/1996 | 15.1 | 0.0 | 8.1 | 364 | nd | nd | nd | nd | nd | nd | nd | nd |
| SXXX | NM047 | Geoprobe #1 (35.8') | 12 | na | 7/1/1996 | 15.5 | 0.0 | 8.1 | 375 | nd | nd | nd | nd | nd | nd | nd | nd |
| SXXX | NM048 | Geoprobe #1 (30.5') | 12 | na | 7/1/1996 | 16.1 | 0.0 | 8.1 | 359 | nd | nd | nd | nd | nd | nd | nd | nd |
| SXXX | NM049 | Geoprobe #1 (25') | 12 | na | 7/1/1996 | 16.7 | 0.1 | 8.0 | 363 | 39.1 | 6.46 | 21.3 | 3.4 | 7.4 | 0.07 | 51.3 | 150.9 |
| SXXX | NM050 | Geoprobe #1 (20.2') | 12 | na | 7/1/1996 | 17.0 | 0.1 | 8.0 | 365 | nd | nd | nd | nd | nd | nd | nd | nd |
| SXXX | NM051 | Geoprobe #2 (40.5') | 12 | na | 7/1/1996 | 16.0 | 0.1 | 7.9 | 399 | 48.0 | 6.28 | 26.2 | 4.4 | 10.8 | 0.06 | 58.8 | 160.3 |
| SXXX | NM052 | Geoprobe #2 (35.3') | 12 | na | 7/1/1996 | 16.3 | 0.0 | 7.8 | 355 | nd | nd | nd | nd | nd | nd | nd | nd |
| SXXX | NM053 | Geoprobe #2 (30.2') | 12 | na | 7/1/1996 | 16.5 | 0.1 | 8.0 | 369 | nd | nd | nd | nd | nd | nd | nd | nd |
| SXXX | NM054 | Geoprobe #2 (23.4') | 12 | na | 7/1/1996 | 15.7 | 0.1 | 7.9 | 397 | nd | nd | nd | nd | nd | nd | nd | nd |
| | | **Zone 13: Discharge** | | | | | | | | | | | | | | | |
| S143 | NM096 | Private Production Well #05 | 13 | na | 8/19/1996 | 23.0 | 0.1 | 7.7 | 1,157 | 64.5 | 21.1 | 124. | 19.3 | 152. | 0.37 | 203. | 135.5 |
| S194 | NM327 | Domestic Well #32 | 13 | na | 6/30/1997 | 20.9 | 1.8 | 7.6 | 2,452 | 238. | 53.2 | 212. | 10.5 | 685. | 0.59 | 290. | 60.5 |
| S226 | NM150 | Domestic Well #15 | 13 | na | 8/19/1996 | 20.6 | 0.1 | 7.7 | 3,076 | 93.0 | 49.0 | 495. | 8.5 | 692. | 0.53 | 450. | 188.0 |
| | | **No Zone: Exotic Water** | | | | | | | | | | | | | | | |
| S009 | NM485 | Arroyo Salado Spring | E | E | 8/6/1998 | 21.4 | 7.4 | 6.7 | 27,860 | 607. | 513. | 5,910. | 149. | 8,070. | 2.07 | 3,750. | 1,180. |
| S023 | NM010 | Burn Site Well | E | E | 6/25/1996 | 17.9 | 3.6 | 7.2 | 1,060 | 137. | 43.8 | 32.9 | 3.8 | 66.1 | 0.90 | 165. | 297.3 |
| S028 | NM014 | Cerro Colorado Landfill MW | E | E | 8/12/1996 | 25.4 | 0.8 | 6.2 | 11,680 | 561. | 108. | 2,190. | 135. | 2,680. | 3.09 | 2,190. | 861.5 |
| S038 | NM265 | Windmill #19 | E | E | 7/1/1997 | 17.1 | 0.6 | 8.4 | 5,180 | 32.5 | 4.77 | 1,177. | 7.5 | 195. | 0.28 | 2,134. | 302.2 |
| S054 | NM041 | Domestic Well #04 | E | E | 8/17/1996 | 27.0 | 0.1 | 7.0 | 8,200 | 185. | 25.7 | 1,530. | 107. | 2,520. | 1.78 | 296. | 181.6 |
| S057 | NM242 | Embudo Spring | E | E | 5/27/1997 | 12.1 | 8.2 | 8.2 | 494 | 71.0 | 15.6 | 14.0 | 2.8 | 4.7 | 0.08 | 46.2 | 254.7 |
| S057 | NM241 | Embudo Spring | E | E | 5/27/1997 | 12.4 | 2.4 | 7.4 | 542 | 76.5 | 17.2 | 16.0 | 3.2 | 5.1 | 0.07 | 48.6 | 284.0 |
| S057 | NM228 | Embudo Spring | E | E | 4/29/1997 | 11.0 | 4.4 | 7.5 | 646 | 88.0 | 21.6 | 18.4 | 3.8 | 6.8 | 0.09 | 63.8 | 325.7 |
| S057 | NM365 | Embudo Spring | E | E | 7/17/1997 | 15.4 | 4.2 | 7.4 | 648 | 105. | 26.4 | 24.4 | 4.8 | 9.7 | 0.13 | 70.8 | 406.3 |
| S057 | NM044 | Embudo Spring | E | E | 7/2/1996 | 16.3 | 0.1 | 7.1 | 775 | 110. | 25.4 | 18.3 | 4.0 | 8.5 | 0.18 | 94.8 | 399.4 |
| S057 | NM215 | Embudo Spring | E | E | 3/21/1997 | 8.50 | 4.3 | 7.3 | 756 | 102. | 25.7 | 22.0 | 3.5 | 9.4 | 0.15 | 103. | 353.4 |
| S063 | NM282 | Windmill #22 | E | E | 6/28/1997 | 19.2 | 3.6 | 7.4 | 1,255 | 163. | 41.8 | 60.1 | 4.0 | 84.9 | 1.06 | 344. | 277.5 |
| S067 | NM284 | Granite Hill | E | E | 7/4/1997 | 18.6 | 0.1 | 7.4 | 777 | 91.4 | 23.6 | 40.5 | 8.9 | 23.0 | 0.35 | 153. | 272.8 |
| S070 | NM059 | HERTF | E | E | 6/28/1996 | 24.0 | 3.0 | 7.0 | 795 | 100. | 24.5 | 25.8 | 2.6 | 59.6 | 0.55 | 85.0 | 204.5 |
| S091 | NM496 | Private Production Well #23 | E | E | 8/4/1998 | 14.5 | nd | 7.4 | 819 | 62.1 | 14.6 | 92.0 | 14.5 | 75.1 | 0.24 | 40.7 | 348.3 |
| S094 | NM293 | Stock Well #02 | E | E | 6/20/1997 | 20.6 | 5.2 | 7.5 | 960 | 26.4 | 7.72 | 183. | 2.5 | 5.6 | 0.05 | 170. | 382.1 |
| S099 | NM072 | LALF-1 | E | E | 6/29/1996 | 18.6 | <0.1 | 7.3 | 1,296 | 175. | 27.0 | 56.7 | 9.5 | 44.9 | 0.19 | 280. | 380.1 |
| S112 | NM296 | Domestic Well #24 | E | E | 6/21/1997 | 53.8 | nd | nd | nd | 94.8 | 32.2 | 63.0 | 9.5 | 95.6 | 0.20 | 247. | 175.8 |
| S112 | NM297 | Domestic Well #24 | E | E | 6/21/1997 | 53.8 | nd | 7.0 | 1,075 | 97.9 | 33.4 | 63.1 | 8.6 | 95.6 | 0.20 | 247. | 174.8 |
| S129 | NM087 | Montaňo 4 S | E | E | 6/19/1996 | 18.8 | 0.2 | 7.1 | 1,340 | 202. | 40.4 | 74.1 | 10.7 | 25.7 | 0.11 | 312. | 449.6 |
| S152 | NM098 | Private Production Well #07 | E | E | 8/22/1996 | 18.6 | 1.8 | 7.2 | 1,127 | 138. | 22.7 | 46.4 | 7.7 | 185. | 0.49 | 107. | 240.4 |
| S182 | NM117 | Rio Bravo 4 S | E | E | 6/25/1996 | 20.7 | <0.1 | 6.9 | 1,251 | 164. | 32.4 | 73.9 | 10.7 | 66.4 | 0.35 | 271. | 305.8 |
| S202 | NM330 | Windmill #27 | E | E | 7/2/1997 | 18.5 | 4.9 | 7.8 | 1,305 | 132. | 98.1 | 67.5 | 4.6 | 41.5 | 0.44 | 672. | 133.5 |
| S211 | NM512 | Sandia M | E | E | 7/30/1998 | 21.3 | 0.8 | 7.6 | 748 | 24.3 | 4.83 | 122. | 8.5 | 128. | 0.27 | 45.5 | 147.5 |
| S225 | NM149 | SBM-1 | E | E | 6/29/1996 | 20.4 | <0.1 | 6.7 | 2,010 | 328. | 51.1 | 90.8 | 12.7 | 75.6 | 0.38 | 573. | 417.4 |
| S249 | NM164 | Private Production Well #09 | E | E | 6/26/1996 | nd | nd | nd | nd | 49.4 | 7.84 | 13.3 | 1.3 | 9.4 | 0.07 | 29.3 | 172.4 |
| S249 | NM163 | Private Production Well #09 | E | E | 6/26/1996 | 18.3 | 5.3 | 7.4 | 365 | 51.0 | 7.85 | 13.3 | 1.3 | 9.6 | 0.07 | 30.0 | 173.6 |
| S250 | NM165 | Private Production Well #10 | E | E | 6/26/1996 | 18.3 | 0.1 | 7.3 | 483 | 62.9 | 10.6 | 25.1 | 1.4 | 11.9 | 0.17 | 62.1 | 218.3 |
| S251 | NM166 | Private Production Well #11 | E | E | 6/26/1996 | 17.7 | 6.0 | 7.2 | 382 | 51.0 | 9.74 | 15.3 | 1.8 | 5.8 | 0.09 | 38.4 | 186.8 |
| S256 | NM170 | Tunnel Spring 2 | E | E | 6/18/1996 | 12.9 | 5.2 | 7.4 | 407 | 108. | 5.68 | 3.54 | 0.9 | 2.2 | 0.04 | 19.5 | 325.4 |

**Table A2.** Summary of field parameters and major-element chemistry-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secon-dary hydro-chemical zone | Date sampled | Temp (ºC) | $O_2$ (mg/L) | pH | Sp. Cond. (µS/cm) | $Ca^{2+}$ (mg/L) | $Mg^{2+}$ (mg/L) | $Na^+$ (mg/L) | $K^+$ (mg/L) | $Cl^-$ (mg/L) | $Br^-$ (mg/L) | $SO_4^{2-}$ (mg/L) | $HCO_3^-$ (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S256 | NM169 | Tunnel Spring 1 | E | E | 6/18/1996 | 12.9 | 6.2 | 7.5 | 381 | 106. | 5.66 | 3.49 | 0.9 | 2.2 | 0.04 | 19.5 | 325.7 |
| S258 | NM524 | Vallecito Springs | E | E | 8/4/1998 | 17.4 | nd | 6.9 | 463 | 45.9 | 9.09 | 39.2 | 10.7 | 6.0 | 0.08 | 35.4 | 249.4 |
| S273 | NM176 | Windmill #11 | E | E | 8/19/1996 | 22.6 | 3.0 | 7.8 | 727 | 41.0 | 43.7 | 51.5 | 3.9 | 29.4 | 0.41 | 89.3 | 324.3 |
| S282 | NM529 | Windmill #44 | E | E | 7/29/1998 | 18.8 | 3.8 | 7.2 | 4,399 | 650. | 87.4 | 199. | 21.2 | 980. | 1.90 | 829. | 189.6 |
| SXXX | NM065 | Jemez Spring | E | E | 8/20/1996 | 55.5 | nd | 6.3 | 3,931 | 158. | 7.32 | 560. | 75.0 | 873. | 2.41 | 41.6 | 755.7 |
| SXXX | NM154 | Soda Dam Spring | E | E | 8/20/1996 | 40.6 | 2.0 | 6.6 | 6,540 | 353. | 32.5 | 834. | 181. | 1,500. | 4.29 | 42.1 | 1,538. |

**Table A3.** Summary of minor-element chemistry

[SXXX, no site number assigned; Hydrochemical Zone "E", exotic water, no primary or secondary zone assigned; Sr, strontium, $SiO_2$, silica; Fe, iron; $NO_3$ as N, dissolved nitrate as nitrogen; Mn, manganese; F, fluoride; mg/L, milligrams per liter; nd, not determined; na, not applicable]

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secon-dary hydro-chemical zone | Date | Sr (mg/L) | $SiO_2$ (mg/L) | Fe (mg/L) | Mn (mg/L) | $NO_3$ as N (mg/L) | F (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Zone 1: Northern Mountain Front** | | | | | | | | | |
| S027 | NM486 | CEPO 02 | 1 | na | 8/3/1998 | 0.17 | 65.7 | 0.03 | <0.001 | 0.59 | 0.76 |
| S034 | NM027 | Private Production Well #04 | 1 | na | 8/28/1996 | 0.16 | 65.2 | 0.03 | <0.004 | 0.83 | 0.46 |
| S035 | NM487 | Windmill #37 | 1 | na | 7/31/1998 | 0.09 | 52.8 | 0.06 | 0.008 | 0.26 | 0.18 |
| S036 | NM026 | Private Production Well #03 | 1 | na | 8/28/1996 | 0.26 | 29.7 | 0.02 | <0.004 | 0.88 | 0.33 |
| S065 | NM055 | Domestic Well #05 | 1 | na | 8/17/1996 | 0.55 | 41.9 | 0.06 | <0.004 | 0.96 | 0.96 |
| S187 | NM131 | Rio Rancho 12 | 1 | na | 8/13/1996 | 0.80 | 31.0 | 0.05 | <0.004 | 0.52 | 0.36 |
| S206 | NM510 | Windmill #38 | 1 | 3 | 8/3/1998 | 0.36 | 61.2 | 0.13 | 0.005 | 2.16 | 0.55 |
| S216 | NM143 | Windmill #09 | 1 | na | 8/27/1996 | 0.51 | 60.1 | 0.06 | 0.015 | 0.91 | 0.65 |
| S221 | NM530 | Windmill #45 | 1 | na | 8/20/1998 | 0.25 | 76.4 | 0.11 | 0.028 | 0.53 | 0.15 |
| S222 | NM514 | Windmill #39 | 1 | 3 | 8/6/1998 | 1.1 | 35.9 | 3.18 | 0.193 | 0.04 | 0.34 |
| S254 | NM168 | Private Production Well #12 | 1 | na | 8/28/1996 | 0.08 | 53.7 | 0.03 | <0.004 | 0.62 | 0.28 |
| S277 | NM525 | Windmill #40 | 1 | na | 7/28/1998 | 0.63 | 38.3 | 0.09 | 0.005 | 3.03 | 0.29 |
| S279 | NM527 | Windmill #42 | 1 | na | 7/28/1998 | 0.15 | 54.3 | 0.15 | 0.009 | 0.02 | 0.18 |
| S281 | NM528 | Windmill #43 | 1 | 3 | 7/28/1998 | 0.74 | 26.5 | 0.17 | 0.004 | 0.38 | 0.28 |
| | | **Zone 2: Northwestern** | | | | | | | | | |
| S103 | NM497 | Lincoln D | 2 | na | 7/23/1998 | 0.57 | 57.1 | 0.02 | 0.003 | 4.72 | 0.99 |
| S104 | NM498 | Lincoln M | 2 | na | 7/23/1998 | 0.53 | 70.6 | 0.02 | <0.001 | 5.81 | 0.76 |
| S105 | NM499 | Lincoln S | 2 | na | 7/23/1998 | 0.85 | 65.9 | 0.02 | <0.001 | 5.60 | 0.61 |
| S191 | NM326 | Rio Rancho 4 | 2 | 3 | 6/20/1997 | 0.70 | 55.4 | 0.09 | 0.006 | 1.58 | 0.82 |
| S192 | NM128 | Rio Rancho 8 | 2 | 3 | 8/13/1996 | 0.66 | 20.3 | 0.05 | <0.004 | 2.53 | 0.67 |
| S189 | NM133 | Rio Rancho 15 | 2 | na | 8/13/1996 | 0.55 | 30.2 | 0.06 | <0.004 | 1.36 | 1.08 |
| S276 | NM179 | Windmill #12 | 2 | na | 8/27/1996 | 0.68 | 24.4 | 0.03 | <0.004 | 5.80 | 0.14 |
| S278 | NM526 | Windmill #41 | 2 | na | 7/29/1998 | 0.57 | 22.5 | 0.04 | 0.004 | 1.35 | 0.77 |
| S280 | NM180 | Windmill #13 | 2 | na | 8/27/1996 | 1.2 | 24.0 | 0.03 | 0.005 | 11.5 | 0.35 |
| S286 | NM184 | Private Production Well #13 | 2 | na | 8/26/1996 | 0.48 | 27.2 | 0.01 | <0.004 | 5.60 | 0.37 |
| S287 | NM185 | Private Production Well #14 | 2 | na | 8/26/1996 | 0.42 | 28.2 | 0.01 | <0.004 | 2.35 | 0.77 |
| | | **Zone 3: West Central** | | | | | | | | | |
| S003 | NM481 | 98th St. D | 3 | na | 8/4/1998 | 0.53 | 27.4 | 0.02 | 0.005 | 0.04 | 2.10 |
| S003 | NM251 | 98th St. D | 3 | na | 6/17/1997 | 0.56 | 28.0 | 0.03 | 0.009 | 0.01 | 2.10 |
| S004 | NM482 | 98th St. MD | 3 | na | 8/4/1998 | 0.07 | 20.2 | 0.01 | 0.009 | 0.04 | 1.11 |
| S004 | NM252 | 98th St. MD | 3 | na | 6/18/1997 | 0.08 | 20.5 | 0.02 | 0.003 | 0.03 | 1.18 |
| S005 | NM253 | 98th St. MS | 3 | na | 7/4/1997 | 0.23 | 17.8 | 0.02 | 0.009 | 0.01 | 2.28 |
| S005 | NM483 | 98th St. MS | 3 | na | 8/4/1998 | 0.20 | 16.5 | 0.02 | 0.039 | 0.01 | 2.08 |
| S006 | NM484 | 98th St. S | 3 | na | 8/5/1998 | 0.18 | 33.4 | 0.01 | <0.001 | 3.14 | 1.14 |
| S006 | NM254 | 98th St. S | 3 | na | 6/17/1997 | 0.21 | 29.5 | 0.02 | <0.001 | 2.78 | 1.15 |
| S008 | NM003 | Private Production Well #01 | 3 | na | 8/12/1996 | 0.34 | 32.1 | 0.05 | <0.004 | 1.61 | 0.81 |
| S010 | NM255 | Private Production Well #16 | 3 | na | 6/23/1997 | 0.32 | 12.7 | 0.12 | 0.007 | 0.02 | 0.71 |
| S018 | NM260 | Domestic Well #21 | 3 | na | 6/26/1997 | 0.46 | 57.1 | 0.05 | <0.001 | 2.04 | 1.02 |
| S019 | NM007 | Belen 4 | 3 | 5 | 8/16/1996 | 0.83 | 35.7 | 0.01 | <0.004 | 1.65 | 0.98 |
| S020 | NM008 | Belen 5 | 3 | 5 | 8/16/1996 | 0.65 | 42.1 | 0.05 | <0.004 | 1.76 | 1.11 |
| S029 | NM015 | Cerro Colorado Landfill PW | 3 | 5 | 8/12/1996 | 1.1 | 26.3 | 0.01 | <0.004 | 1.57 | 0.52 |
| S037 | NM264 | College 2 | 3 | na | 6/19/1997 | 0.07 | 30.6 | 0.02 | 0.000 | 2.30 | 0.99 |
| S066 | NM056 | Gonzales 1 | 3 | 12 | 6/20/1996 | 0.22 | 53.5 | 0.02 | <0.004 | 1.27 | 1.15 |
| S086 | NM492 | Isleta D | 3 | na | 7/29/1998 | 0.04 | 22.9 | 0.02 | 0.004 | 1.17 | 1.96 |
| S101 | NM294 | Leavitt 1 | 3 | na | 6/26/1997 | 0.09 | 33.4 | 0.02 | 0.001 | 2.78 | 1.19 |
| S108 | NM076 | Los Lunas 3 | 3 | 12 | 8/14/1996 | 0.20 | 57.3 | 0.02 | <0.004 | 0.02 | 0.94 |
| S109 | NM077 | Los Lunas 4 | 3 | 12 | 8/14/1996 | 0.18 | 59.7 | 0.03 | <0.004 | 0.03 | 0.79 |
| S145 | NM308 | NM Utilities 1 | 3 | na | 6/18/1997 | 0.42 | 65.0 | 0.05 | 0.005 | 2.88 | 0.73 |
| S147 | NM310 | NM Utilities 3 | 3 | na | 6/18/1997 | 0.27 | 68.7 | 0.05 | 0.005 | 1.10 | 0.94 |
| S148 | NM311 | NM Utilities 4 | 3 | na | 6/18/1997 | 0.33 | 56.7 | 0.06 | 0.005 | 2.90 | 0.81 |
| S166 | NM509 | Rabbit Hill | 3 | na | 8/4/1998 | 0.82 | 25.5 | 0.04 | <0.001 | 1.83 | 0.58 |
| S167 | NM107 | Domestic Well #12 | 3 | na | 8/14/1996 | 0.21 | 32.5 | 0.03 | <0.004 | 0.98 | 0.78 |
| S172 | NM322 | Rio Bravo 5 D | 3 | na | 7/4/1997 | 0.14 | 18.0 | 0.05 | 0.006 | 0.01 | 1.78 |

**Table A3.** Summary of minor-element chemistry-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secon-dary hydro-chemical zone | Date | Sr (mg/L) | $SiO_2$ (mg/L) | Fe (mg/L) | Mn (mg/L) | $NO_3$ as N (mg/L) | F (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S174 | NM109 | Rio Bravo 1 D | 3 | 12 | 6/17/1996 | 0.14 | 31.2 | 0.05 | 0.004 | 1.10 | 1.45 |
| S175 | NM110 | Rio Bravo 1 M | 3 | 12 | 6/17/1996 | 0.16 | 36.4 | 0.03 | <0.004 | 1.00 | 1.57 |
| S186 | NM130 | Rio Rancho 10 | 3 | na | 8/13/1996 | 0.71 | 29.1 | 0.03 | <0.004 | 1.71 | 0.93 |
| S188 | NM132 | Rio Rancho 13 | 3 | na | 8/13/1996 | 0.08 | 21.8 | 0.05 | <0.004 | 1.50 | 0.90 |
| S193 | NM129 | Rio Rancho 9 | 3 | na | 8/13/1996 | 0.11 | 21.0 | 0.01 | <0.004 | 2.11 | 0.54 |
| S196 | NM135 | Windmill #05 | 3 | na | 8/21/1996 | 0.21 | 41.1 | 0.18 | 0.025 | 1.49 | 0.82 |
| S200 | NM139 | Private Production Well #08 | 3 | na | 8/29/1996 | 0.57 | 35.1 | 0.03 | <0.004 | 1.24 | 0.77 |
| S217 | NM144 | Santa Ana Boundary D | 3 | na | 8/22/1996 | 0.15 | 15.8 | 0.04 | <0.004 | 1.24 | 0.67 |
| S218 | NM145 | Santa Ana Boundary M | 3 | na | 8/22/1996 | 0.21 | 22.5 | 0.04 | <0.004 | 1.56 | 0.71 |
| S219 | NM146 | Santa Ana Boundary S | 3 | na | 8/22/1996 | 0.33 | 23.3 | 0.05 | <0.004 | 0.69 | 0.80 |
| S230 | NM516 | Sierra Vista D | 3 | na | 7/22/1998 | 0.14 | 18.5 | 0.02 | 0.008 | 0.02 | 0.89 |
| S236 | NM155 | SAF (Soil Amement Facility) | 3 | na | 8/12/1996 | 0.39 | 17.5 | 0.11 | <0.004 | 0.86 | 0.53 |
| S241 | NM519 | SWAB Test Hole 1 D | 3 | 1 | 8/5/1998 | 0.66 | 46.9 | 0.04 | 0.120 | 0.19 | 0.89 |
| S242 | NM520 | SWAB Test Hole 1 S | 3 | 1 | 8/1/1998 | 0.11 | 18.6 | 0.02 | 0.012 | 0.93 | 0.60 |
| S243 | NM521 | SWAB Test Hole 2 D | 3 | na | 8/7/1998 | 0.49 | 17.8 | 0.27 | 0.024 | 3.61 | 0.83 |
| S263 | NM346 | Volcano Cliff 1 | 3 | na | 6/19/1997 | 0.37 | 62.3 | 0.07 | 0.009 | 1.27 | 0.95 |
| S266 | NM347 | West Bluff Nest 1 Well 1 | 3 | na | 6/23/1997 | 0.14 | 19.1 | 0.04 | 0.007 | 0.76 | 1.29 |
| S272 | NM353 | West Mesa 3 | 3 | na | 6/19/1997 | 0.07 | 31.0 | 0.02 | 0.006 | 2.38 | 1.33 |
| S283 | NM181 | Zia Ball Park D | 3 | na | 8/26/1996 | 0.09 | 24.4 | 0.02 | 0.005 | 2.32 | 6.14 |
| S284 | NM182 | Zia Ball Park M | 3 | na | 8/26/1996 | 0.12 | 23.7 | 0.02 | <0.004 | 2.28 | 5.70 |
| S285 | NM183 | Zia Ball Park S | 3 | 2 | 8/26/1996 | 0.99 | 25.9 | 0.09 | <0.004 | 2.35 | 3.09 |
| S288 | NM186 | Zia BMT D | 3 | na | 8/27/1996 | 0.26 | 19.4 | 0.04 | <0.004 | 0.33 | 0.64 |
| | | **Zone 4: Western Boundary** | | | | | | | | | |
| S031 | NM263 | Windmill #18 | 4 | na | 6/24/1997 | 2.1 | 20.1 | 0.16 | 0.066 | 1.41 | 2.15 |
| S039 | NM266 | Windmill #20 | 4 | na | 6/21/1997 | 1.6 | 64.2 | 0.56 | 0.047 | 0.59 | 3.92 |
| S059 | NM278 | Windmill #21 | 4 | na | 6/23/1997 | 4.9 | 29.3 | 0.46 | 0.027 | 0.67 | nd |
| S074 | NM285 | Windmill #23 | 4 | na | 6/21/1997 | 2.1 | 23.1 | 0.90 | 0.141 | 1.55 | 2.05 |
| S169 | NM320 | Rest Area | 4 | na | 6/30/1997 | 3.5 | 27.0 | 0.30 | 0.015 | 6.87 | 1.20 |
| S201 | NM329 | Windmill #26 | 4 | na | 7/2/1997 | 12. | 18.5 | 1.1 | 0.074 | 0.01 | 1.07 |
| S252 | NM167 | Windmill #10 | 4 | na | 8/29/1996 | 0.84 | 18.4 | 0.01 | 0.008 | 1.09 | 1.64 |
| S260 | NM345 | Windmill #33 | 4 | na | 6/25/1997 | 1.4 | 22.0 | 0.21 | 0.036 | 1.04 | 2.12 |
| | | **Zone 5: Rio Puerco** | | | | | | | | | |
| S032 | NM262 | Windmill #17 | 5 | na | 6/24/1997 | 4.2 | 26.3 | 0.26 | 0.028 | 1.64 | 1.68 |
| S069 | NM058 | Domestic Well #06 | 5 | na | 8/16/1996 | 2.5 | 24.6 | 0.23 | 0.033 | 1.96 | 0.44 |
| S073 | NM062 | Windmill #03 | 5 | na | 8/16/1996 | 4.7 | 21.8 | 0.51 | 0.033 | 2.62 | 0.38 |
| S082 | NM409 | Windmill #36 | 5 | na | 9/10/1997 | 5.1 | 28.0 | 0.40 | 0.033 | 0.42 | 0.22 |
| S085 | NM408 | Windmill #35 | 5 | na | 9/10/1997 | 2.0 | 28.9 | 0.13 | 0.007 | 0.34 | 0.54 |
| S111 | NM079 | Domestic Well #10 | 5 | na | 8/16/1996 | 3.6 | 27.0 | 0.27 | 0.050 | 1.55 | 0.41 |
| S185 | NM324 | Domestic Well #31 | 5 | na | 6/16/1997 | 3.9 | 22.7 | 0.69 | 1.56 | 0.11 | 1.03 |
| S198 | NM137 | Windmill #07 | 5 | na | 8/21/1996 | 6.2 | 21.8 | 1.6 | 0.121 | 1.10 | 0.63 |
| S215 | NM335 | Sandoval Spring | 5 | 4 | 7/1/1997 | 0.82 | 30.6 | 0.17 | 0.047 | 0.09 | 1.44 |
| S237 | NM341 | Windmill #30 | 5 | 4 | 6/24/1997 | 3.9 | 22.9 | 0.31 | 0.031 | 1.72 | 1.22 |
| S238 | NM342 | Windmill #31 | 5 | na | 6/24/1997 | 6.2 | 29.7 | 0.50 | 0.036 | 1.48 | 0.41 |
| | | **Zone 6: Southwestern Mountain Front** | | | | | | | | | |
| S022 | NM009 | Windmill #02 | 6 | na | 8/19/1996 | 0.86 | 9.2 | 0.05 | 0.004 | 1.12 | 0.73 |
| | | **Zone 7: Abo Arroyo** | | | | | | | | | |
| S021 | NM261 | Stock Well #01 | 7 | na | 6/23/1997 | 2.1 | 16.2 | 0.37 | 0.036 | 0.99 | 0.89 |
| S024 | NM011 | Domestic Well #02 | 7 | 8 | 8/17/1996 | 1.2 | 21.8 | 0.11 | 0.010 | 1.38 | 0.48 |
| S090 | NM064 | Domestic Well #08 | 7 | na | 8/19/1996 | 1.8 | 23.5 | 0.13 | <0.004 | 1.48 | 1.27 |
| S093 | NM067 | Domestic Well #09 | 7 | 8 | 8/15/1996 | 0.51 | 42.8 | 0.02 | <0.004 | 3.32 | 0.51 |
| | | **Zone 8: Eastern Mountain Front** | | | | | | | | | |
| S007 | NM002 | Domestic Well #01 | 8 | na | 6/21/1996 | 0.18 | 23.3 | 0.08 | 0.006 | 1.00 | 1.30 |
| S013 | NM256 | Windmill #14 | 8 | na | 6/24/1997 | 0.02 | 0.3 | 0.02 | <0.004 | 0.01 | 0.13 |
| S014 | NM257 | Private Production Well #17 | 8 | na | 6/19/1997 | 0.30 | 27.0 | 0.04 | 0.004 | 0.75 | 0.25 |
| S015 | NM006 | Windmill #01 | 8 | na | 8/24/1996 | 0.20 | 18.5 | 0.12 | 0.005 | 0.01 | 0.19 |
| S030 | NM019 | Charles 4 | 8 | na | 6/27/1996 | 0.22 | 24.0 | 0.03 | <0.004 | 0.30 | 0.33 |

**Table A3.** Summary of minor-element chemistry-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secon-dary hydro-chemical zone | Date | Sr (mg/L) | $SiO_2$ (mg/L) | Fe (mg/L) | Mn (mg/L) | $NO_3$ as N (mg/L) | F (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S030 | NM024 | Charles 4 | 8 | na | 6/27/1996 | 0.26 | 24.4 | 0.03 | <0.004 | 0.27 | 0.32 |
| S030 | NM017 | Charles 4 | 8 | na | 6/27/1996 | 0.22 | 24.0 | 0.04 | <0.004 | 0.32 | 0.33 |
| S030 | NM018 | Charles 4 | 8 | na | 6/27/1996 | 0.22 | 24.2 | 0.04 | <0.004 | 0.33 | 0.33 |
| S030 | NM021 | Charles 4 | 8 | na | 6/27/1996 | 0.26 | 24.6 | 0.04 | <0.004 | 0.30 | 0.32 |
| S030 | NM020 | Charles 4 | 8 | na | 6/27/1996 | 0.25 | 24.6 | 0.04 | <0.004 | 0.28 | 0.32 |
| S030 | NM023 | Charles 4 | 8 | na | 6/27/1996 | 0.26 | 24.2 | 0.04 | <0.004 | 0.28 | 0.32 |
| S030 | NM016 | Charles 4 | 8 | na | 6/22/1996 | 0.29 | 29.5 | 0.04 | <0.004 | 0.27 | 0.33 |
| S030 | NM022 | Charles 4 | 8 | na | 6/27/1996 | 0.27 | 24.4 | 0.05 | <0.004 | 0.28 | 0.32 |
| S042 | NM031 | Domestic Well #03 | 8 | na | 8/14/1996 | 0.32 | 40.9 | 0.03 | <0.004 | 0.46 | 0.45 |
| S055 | NM042 | Elena Gallegos | 8 | na | 6/25/1996 | 0.23 | 23.5 | 0.05 | 0.005 | 0.16 | 1.97 |
| S056 | NM227 | Embudito Spring | 8 | na | 4/29/1997 | 0.19 | 24.4 | 0.04 | 0.004 | 0.05 | 1.36 |
| S056 | NM239 | Embudito Spring | 8 | na | 5/27/1997 | 0.22 | 28.9 | 0.06 | 0.003 | 0.01 | 1.39 |
| S056 | NM213 | Embudito Spring | 8 | na | 3/21/1997 | 0.22 | 25.0 | 0.07 | 0.004 | 0.02 | 1.61 |
| S056 | NM214 | Embudito Spring | 8 | na | 3/21/1997 | 0.22 | 25.2 | 0.08 | 0.005 | 0.01 | 1.58 |
| S056 | NM364 | Embudito Spring | 8 | na | 7/17/1997 | 0.37 | 35.9 | 0.08 | 0.007 | 0.01 | 1.38 |
| S056 | NM043 | Embudito Spring | 8 | na | 7/2/1996 | 0.34 | 32.7 | 0.14 | 0.021 | 0.44 | 0.98 |
| S071 | NM060 | Domestic Well #07 | 8 | na | 6/19/1996 | 0.15 | 21.6 | 0.04 | <0.004 | 2.80 | 1.62 |
| S083 | NM407 | Windmill #34 | 8 | na | 9/10/1997 | 0.51 | 36.2 | 0.05 | 0.006 | 0.22 | 0.41 |
| S095 | NM068 | Kirtland 1 | 8 | na | 6/25/1996 | 0.36 | 27.2 | 0.04 | <0.004 | 0.77 | 0.51 |
| S106 | NM295 | Domestic Well #23 | 8 | na | 6/26/1997 | 0.38 | 64.0 | 0.05 | 0.003 | 0.24 | 0.41 |
| S110 | NM078 | Love 1 | 8 | na | 6/22/1996 | 0.26 | 30.2 | 0.03 | <0.004 | 0.66 | 0.70 |
| S113 | NM080 | Domestic Well #11 | 8 | na | 8/15/1996 | 0.39 | 26.1 | 0.05 | <0.004 | 0.31 | 0.78 |
| S114 | NM500 | Matheson D | 8 | na | 7/31/1998 | 0.29 | 28.7 | 0.03 | 0.181 | 0.02 | 0.83 |
| S115 | NM501 | Matheson M | 8 | na | 8/1/1998 | 0.15 | 25.5 | 0.02 | 0.017 | 0.02 | 0.71 |
| S116 | NM502 | Matheson S | 8 | na | 8/1/1998 | 0.20 | 23.7 | 0.02 | 0.004 | 0.67 | 0.52 |
| S117 | NM298 | Domestic Well #25 | 8 | na | 6/17/1997 | 0.19 | 21.4 | 0.03 | <0.004 | 2.69 | 1.15 |
| S118 | NM299 | Windmill #24 | 8 | na | 6/27/1997 | 0.52 | 23.7 | 0.07 | <0.004 | 3.87 | 2.34 |
| S119 | NM300 | Domestic Well #26 | 8 | 11 | 6/19/1997 | 0.70 | 21.2 | 0.24 | 0.008 | 0.33 | 1.21 |
| S122 | NM505 | Mesa Del Sol S | 8 | na | 7/25/1998 | 0.31 | 61.4 | 0.03 | 0.058 | 0.24 | 0.67 |
| S122 | NM304 | Mesa Del Sol S | 8 | na | 6/29/1997 | 0.01 | 51.3 | 0.04 | 0.009 | 0.01 | 2.19 |
| S140 | NM306 | MRN 1 | 8 | na | 7/5/1997 | 0.85 | 29.1 | 0.08 | 0.006 | 3.78 | 0.42 |
| S141 | NM095 | National Utility 7 | 8 | na | 8/14/1996 | 0.14 | 16.5 | 0.03 | <0.004 | 2.07 | 0.17 |
| S149 | NM312 | Nor Este D | 8 | na | 7/3/1997 | 0.24 | 34.0 | 0.04 | 0.116 | 0.14 | 1.46 |
| S150 | NM313 | Nor Este M | 8 | na | 7/2/1997 | 0.34 | 44.1 | 0.05 | 0.063 | 0.10 | 0.55 |
| S162 | NM317 | Stock Well #03 | 8 | na | 6/30/1997 | 0.12 | 23.1 | 0.04 | 0.004 | 0.55 | 0.24 |
| S163 | NM318 | PL 2 | 8 | na | 7/7/1997 | 0.46 | 26.3 | 0.05 | 0.004 | 0.80 | 0.48 |
| S164 | NM106 | Ponderosa 1 | 8 | na | 6/20/1996 | 0.69 | 35.1 | 0.05 | 0.006 | 0.12 | 0.53 |
| S165 | NM328 | Windmill #25 | 8 | na | 6/24/1997 | 0.19 | 26.7 | 1.45 | 0.018 | 0.74 | 0.61 |
| S168 | NM319 | Domestic Well #30 | 8 | na | 6/27/1997 | 0.32 | 15.9 | 0.02 | 0.000 | 0.52 | 0.55 |
| S170 | NM108 | Ridgecrest 3 | 8 | na | 6/22/1996 | 0.39 | 31.0 | 0.03 | <0.004 | 0.40 | 0.50 |
| S170 | NM412 | Ridgecrest 3 | 8 | na | 11/18/1997 | 0.40 | 31.2 | 0.03 | 0.003 | 0.08 | 0.56 |
| S195 | NM134 | Domestic Well #13 | 8 | na | 8/14/1996 | 0.40 | 48.8 | 0.05 | <0.004 | 1.37 | 0.35 |
| S199 | NM138 | Windmill #08 | 8 | na | 8/23/1996 | 0.55 | 23.7 | 0.06 | <0.004 | 1.48 | 0.31 |
| S209 | NM336 | Domestic Well #33 | 8 | na | 6/27/1997 | 0.19 | 41.1 | 0.04 | 0.006 | 0.05 | 0.48 |
| S212 | NM141 | Sandia Peak 1 | 8 | na | 6/26/1996 | 0.16 | 28.7 | 0.03 | <0.004 | 0.28 | 0.52 |
| S213 | NM142 | Sandia Peak 3 | 8 | na | 6/26/1996 | 0.20 | 25.9 | 0.03 | <0.004 | 0.79 | 1.18 |
| S224 | NM148 | Domestic Well #14 | 8 | na | 8/23/1996 | 0.44 | 35.1 | 0.06 | <0.004 | 0.27 | 0.39 |
| S229 | NM515 | SH03 UNM | 8 | na | 7/28/1998 | 0.17 | 19.8 | 0.03 | <0.001 | 1.39 | 1.68 |
| S233 | NM153 | Domestic Well #16 | 8 | na | 8/23/1996 | 0.48 | 56.5 | 0.07 | <0.004 | 0.35 | 0.30 |
| S239 | NM156 | Domestic Well #17 | 8 | na | 8/17/1996 | 0.68 | 26.1 | 0.05 | <0.004 | 0.26 | 0.78 |
| S240 | NM157 | Domestic Well #18 | 8 | na | 6/19/1996 | 0.14 | 28.7 | 0.04 | <0.004 | 0.23 | 0.49 |
| S246 | NM343 | Windmill #32 | 8 | na | 6/24/1997 | 0.52 | 25.9 | 0.11 | 0.008 | 1.51 | 0.17 |
| S247 | NM161 | Domestic Well #19 | 8 | na | 8/15/1996 | 0.08 | 25.5 | 0.01 | <0.004 | 0.67 | 0.49 |
| S248 | NM162 | Thomas 6 | 8 | na | 6/21/1996 | 0.41 | 34.8 | 0.04 | 0.011 | 0.12 | 0.49 |
| S255 | NM523 | Tramway East | 8 | na | 7/30/1998 | 0.27 | 26.3 | 0.03 | 0.004 | 0.27 | 0.91 |
| S264 | NM174 | Walker 1 | 8 | na | 6/18/1996 | 0.37 | 31.4 | 0.04 | 0.004 | 0.16 | 0.71 |
| S274 | NM177 | Domestic Well #20 | 8 | na | 8/15/1996 | 0.55 | 45.1 | 0.03 | <0.004 | 1.24 | 0.34 |

**Table A3.** Summary of minor-element chemistry-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secon-dary hydro-chemical zone | Date | Sr (mg/L) | $SiO_2$ (mg/L) | Fe (mg/L) | Mn (mg/L) | $NO_3$ as N (mg/L) | F (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Zone 9: Tijeras Fault Zone** | | | | | | | | | |
| S041 | NM029 | Coyote Spring | 9 | na | 6/28/1996 | 1.6 | 16.9 | 0.35 | 1.39 | 0.28 | 1.90 |
| S072 | NM061 | Hubbell Spring | 9 | 8 | 8/23/1996 | 1.1 | 27.0 | 0.10 | 0.006 | 0.87 | 0.79 |
| S098 | NM071 | KAFB-1902 | 9 | na | 6/28/1996 | 0.87 | 19.7 | 0.12 | 0.031 | 1.13 | 3.01 |
| S197 | NM136 | Windmill #06 | 9 | na | 8/23/1996 | 0.72 | 12.4 | 0.22 | 0.034 | 0.14 | 1.23 |
| S227 | NM151 | SFR 3D | 9 | na | 8/24/1996 | 1.3 | 29.1 | 0.16 | <0.008 | 1.09 | 1.41 |
| S228 | NM152 | SFR 3S | 9 | na | 8/24/1996 | 1.1 | 27.6 | 0.12 | 0.015 | 0.90 | 1.31 |
| | | **Zone 10: Tijeras Arroyo** | | | | | | | | | |
| S001 | NM001 | 4Hills-1 | 10 | 8 | 6/29/1996 | 0.95 | 18.5 | 0.14 | 0.011 | 4.16 | 0.98 |
| S002 | NM250 | Private Production Well #15 | 10 | 8 | 7/3/1997 | 0.60 | 18.5 | 0.10 | 0.006 | 2.86 | 0.52 |
| S058 | NM277 | Eubank 1 | 10 | 8 | 7/4/1997 | 0.30 | 22.2 | 0.06 | 0.003 | 2.21 | 0.39 |
| S096 | NM069 | Kirtland 11 | 10 | 8 | 6/25/1996 | 0.47 | 27.4 | 0.07 | 0.004 | 4.16 | 0.55 |
| S107 | NM075 | Lomas 1 | 10 | 8 | 6/22/1996 | 0.39 | 22.9 | 0.05 | 0.005 | 3.80 | 0.43 |
| S107 | NM410 | Lomas 1 | 10 | na | 11/18/1997 | 0.38 | 23.7 | 0.06 | 0.005 | 0.84 | 0.49 |
| | | **Zone 11: Northeastern** | | | | | | | | | |
| S016 | NM258 | Windmill #15 | 11 | na | 6/18/1997 | 0.50 | 40.2 | 0.18 | 0.006 | 0.64 | 1.25 |
| S017 | NM259 | Windmill #16 | 11 | na | 6/18/1997 | 0.90 | 16.6 | 0.06 | 0.011 | 2.36 | 1.16 |
| S053 | NM276 | Private Production Well #18 | 11 | na | 6/25/1997 | 1.7 | 38.1 | 0.18 | 0.010 | 1.80 | 0.75 |
| S144 | NM097 | Private Production Well #06 | 11 | na | 8/28/1996 | 1.9 | 46.6 | 0.46 | 0.030 | 0.11 | 0.51 |
| S204 | NM332 | Windmill #28 | 11 | na | 7/3/1997 | 0.85 | 26.3 | 0.07 | 0.006 | 2.30 | 1.12 |
| S207 | NM334 | Private Production Well #22 | 11 | na | 7/3/1997 | 2.0 | 30.6 | 0.24 | 0.020 | 1.89 | 0.35 |
| S223 | NM338 | Windmill #29 | 11 | na | 6/25/1997 | 2.9 | 26.7 | 0.25 | 0.013 | 2.73 | 0.60 |
| | | **Zone 12: Central** | | | | | | | | | |
| S011 | NM004 | Atris-1 | 12 | na | 6/22/1996 | 0.42 | 30.4 | 0.06 | 0.538 | 0.03 | 0.38 |
| S012 | NM005 | Atrisco 3 | 12 | 3 | 6/20/1996 | 0.46 | 58.8 | 0.04 | 0.022 | 0.16 | 0.81 |
| S025 | NM012 | Burton 2 | 12 | na | 6/19/1996 | 0.40 | 55.6 | 0.03 | 0.006 | 0.44 | 0.44 |
| S026 | NM013 | Burton 5 | 12 | na | 6/19/1996 | 0.39 | 55.4 | 0.03 | 0.005 | 0.09 | 0.43 |
| S033 | NM025 | Private Production Well #02 | 12 | na | 8/21/1996 | 0.70 | 44.1 | 0.09 | 0.085 | 5.44 | 0.32 |
| S040 | NM028 | Coronado 1 | 12 | na | 6/18/1996 | 0.37 | 60.8 | 0.05 | <0.004 | 0.36 | 0.80 |
| S043 | NM488 | Del Sol D | 12 | na | 7/21/1998 | 0.29 | 74.4 | 0.03 | <0.001 | 0.53 | 1.00 |
| S043 | NM267 | Del Sol D | 12 | na | 7/1/1997 | 0.26 | 73.4 | 0.03 | 0.010 | 0.54 | 1.06 |
| S044 | NM489 | Del Sol M | 12 | na | 7/21/1998 | 0.48 | 55.0 | 0.06 | 0.081 | 0.48 | 0.56 |
| S044 | NM268 | Del Sol M | 12 | na | 6/26/1997 | 0.49 | 56.5 | 0.09 | 0.111 | 0.53 | 0.53 |
| S045 | NM490 | Del Sol S | 12 | na | 7/21/1998 | 0.75 | 38.3 | 0.06 | 0.001 | 4.11 | 0.31 |
| S045 | NM269 | Del Sol S | 12 | na | 6/26/1997 | 0.69 | 39.6 | 0.08 | 0.010 | 3.70 | 0.34 |
| S046 | NM032 | Duranes 1 | 12 | na | 6/20/1996 | 0.68 | 70.9 | 0.07 | 0.015 | 0.09 | 0.55 |
| S046 | NM034 | Duranes 1 | 12 | na | 6/29/1996 | 1.1 | 64.6 | 0.07 | 0.025 | 0.01 | 0.36 |
| S046 | NM033 | Duranes 1 | 12 | na | 6/29/1996 | 1.0 | 64.4 | 0.07 | 0.026 | 0.00 | 0.37 |
| S046 | NM035 | Duranes 1 | 12 | na | 6/29/1996 | 1.1 | 66.5 | 0.07 | 0.029 | 0.01 | 0.37 |
| S046 | NM037 | Duranes 1 | 12 | na | 6/29/1996 | 1.1 | 65.0 | 0.07 | 0.029 | 0.01 | 0.36 |
| S046 | NM039 | Duranes 1 | 12 | na | 6/29/1996 | 1.0 | 61.2 | 0.07 | 0.029 | 0.01 | 0.35 |
| S046 | NM038 | Duranes 1 | 12 | na | 6/29/1996 | 1.1 | 62.0 | 0.08 | 0.026 | 0.01 | 0.36 |
| S046 | NM036 | Duranes 1 | 12 | na | 6/29/1996 | 1.2 | 69.3 | 0.08 | 0.030 | 0.01 | 0.38 |
| S046 | NM040 | Duranes 1 | 12 | na | 6/29/1996 | 0.92 | 56.7 | 0.08 | 0.026 | 0.01 | 0.35 |
| S047 | NM270 | Duranes 7 | 12 | na | 6/26/1997 | 0.52 | 63.3 | 0.05 | 0.012 | 0.04 | 0.63 |
| S048 | NM271 | Duranes Yard 1 | 12 | na | 7/5/1997 | 0.52 | 56.7 | 0.05 | 0.247 | 0.01 | 0.47 |
| S049 | NM272 | Duranes Yard 2 | 12 | na | 7/5/1997 | 0.46 | 43.4 | 0.05 | 0.704 | 0.01 | 0.35 |
| S050 | NM273 | Duranes Yard 3 | 12 | na | 7/5/1997 | 0.46 | 24.8 | 0.05 | 0.724 | 0.01 | 0.32 |
| S051 | NM274 | Duranes Yard 4 | 12 | na | 7/5/1997 | 0.39 | 19.1 | 0.05 | 0.577 | 0.01 | 0.29 |
| S052 | NM275 | Duranes Yard 5 | 12 | na | 7/5/1997 | 0.35 | 19.8 | 0.05 | 0.053 | 0.01 | 0.31 |
| S060 | NM279 | Garfield D | 12 | 3 | 6/19/1997 | 0.21 | 50.9 | 0.04 | 0.025 | 0.16 | 0.97 |
| S061 | NM280 | Garfield M | 12 | na | 6/19/1997 | 0.33 | 75.9 | 0.06 | 0.117 | 0.07 | 0.97 |
| S062 | NM491 | Garfield S | 12 | na | 7/28/1998 | 0.88 | 37.2 | 2.23 | 2.84 | 0.02 | 0.54 |
| S062 | NM281 | Garfield S | 12 | na | 6/19/1997 | 0.97 | 37.2 | 2.62 | 3.69 | 0.01 | 0.53 |
| S064 | NM283 | Domestic Well #22 | 12 | na | 6/20/1997 | 0.57 | 52.2 | 0.07 | 0.007 | 1.08 | 0.35 |
| S068 | NM057 | Griegos 3 | 12 | na | 6/21/1996 | 0.47 | 68.5 | 0.04 | <0.004 | 0.03 | 0.41 |
| S075 | NM286 | Hunter Ridge Nest 1 Well 1 | 12 | 3 | 6/20/1997 | 0.56 | 61.4 | 0.05 | 0.016 | 0.08 | 0.59 |

**Table A3.** Summary of minor-element chemistry-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secon-dary hydro-chemical zone | Date | Sr (mg/L) | $SiO_2$ (mg/L) | Fe (mg/L) | Mn (mg/L) | $NO_3$ as N (mg/L) | F (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S076 | NM287 | Hunter Ridge Nest 1 Well 2 | 12 | na | 6/21/1997 | 0.37 | 63.1 | 0.12 | 0.045 | 0.01 | 0.32 |
| S077 | NM288 | Hunter Ridge Nest 1 Well 3 | 12 | na | 6/20/1997 | 0.60 | 43.2 | 0.09 | 0.016 | 0.78 | 0.42 |
| S078 | NM289 | Hunter Ridge Nest 2 Well 1 | 12 | na | 6/21/1997 | 0.37 | 47.9 | 0.07 | 0.085 | 0.01 | 0.37 |
| S079 | NM290 | Hunter Ridge Nest 2 Well 2 | 12 | na | 6/21/1997 | 0.50 | 44.1 | 0.08 | 0.017 | 0.07 | 0.39 |
| S080 | NM291 | Hunter Ridge Nest 2 Well 3 | 12 | na | 6/21/1997 | 0.57 | 42.8 | 0.09 | 0.012 | 0.29 | 0.39 |
| S081 | NM292 | Private Production Well #19 | 12 | na | 7/2/1997 | 0.50 | 66.5 | 0.06 | 0.002 | 0.27 | 0.30 |
| S084 | NM063 | Windmill #04 | 12 | na | 8/21/1996 | 0.46 | 65.5 | 0.17 | 0.006 | 0.24 | 0.46 |
| S087 | NM493 | Isleta MD | 12 | 3 | 7/29/1998 | 0.14 | 59.9 | 0.03 | 0.049 | 0.28 | 1.18 |
| S088 | NM494 | Isleta MS | 12 | na | 7/29/1998 | 0.29 | 37.9 | 0.03 | 0.074 | 0.02 | 0.45 |
| S089 | NM495 | Isleta S | 12 | na | 7/29/1998 | 0.91 | 38.7 | 0.43 | 1.26 | 0.02 | 0.40 |
| S092 | NM066 | JMC-1 | 12 | na | 6/28/1996 | 0.65 | 59.0 | 0.06 | 0.011 | 0.20 | 0.24 |
| S097 | NM070 | Kirtland 14 | 12 | na | 6/25/1996 | 0.34 | 49.8 | 0.03 | 0.006 | 0.33 | 0.40 |
| S100 | NM073 | LALF-9 | 12 | na | 6/29/1996 | 0.62 | 31.7 | 0.10 | 0.216 | 0.01 | nd |
| S102 | NM074 | Leyendecker 1 | 12 | na | 6/21/1996 | 0.26 | 34.0 | 0.02 | <0.004 | 0.79 | 0.45 |
| S120 | NM503 | Mesa Del Sol D | 12 | na | 8/2/1998 | 0.01 | 50.7 | 0.02 | 0.004 | 0.02 | 2.12 |
| S120 | NM303 | Mesa Del Sol D | 12 | na | 6/28/1997 | 0.11 | 60.3 | 0.05 | 0.085 | 0.01 | 0.78 |
| S120 | NM301 | Mesa Del Sol D | 12 | na | 6/29/1997 | 0.27 | 63.8 | 0.05 | 0.101 | 0.14 | 0.77 |
| S121 | NM504 | Mesa Del Sol M | 12 | na | 7/25/1998 | 0.02 | 37.2 | 0.03 | 0.008 | 0.02 | 1.34 |
| S121 | NM302 | Mesa Del Sol M | 12 | na | 6/28/1997 | 0.02 | 37.2 | 0.04 | 0.015 | 0.01 | 1.48 |
| S123 | NM081 | MONT - 5A | 12 | na | 6/27/1996 | 0.73 | 40.9 | 0.05 | 0.012 | 0.06 | 0.27 |
| S124 | NM082 | Montaňo 2 D | 12 | na | 6/19/1996 | 0.69 | 60.5 | 0.08 | 0.014 | 0.05 | 0.24 |
| S125 | NM083 | Montaňo 2 M | 12 | na | 6/19/1996 | 0.87 | 58.2 | 0.07 | 0.140 | 0.03 | 0.18 |
| S126 | NM084 | Montaňo 2 S | 12 | na | 6/19/1996 | 0.64 | 34.2 | 0.81 | 1.52 | 0.02 | 0.45 |
| S127 | NM085 | Montaňo 4 D | 12 | na | 6/20/1996 | 0.52 | 55.8 | 0.03 | 0.008 | 0.04 | 0.26 |
| S128 | NM086 | Montaňo 4 M | 12 | na | 6/19/1996 | 0.94 | 48.6 | 0.12 | 0.072 | 0.02 | 0.38 |
| S130 | NM088 | Montaňo 5 D | 12 | na | 6/24/1996 | 0.48 | 59.5 | 0.04 | 0.020 | 0.02 | 0.38 |
| S131 | NM089 | Montaňo 5 M | 12 | na | 6/24/1996 | 0.34 | 18.5 | 0.06 | 0.195 | 0.05 | 0.31 |
| S132 | NM090 | Montaňo 5 S | 12 | na | 6/24/1996 | 0.33 | 22.9 | 0.03 | <0.004 | 0.50 | 0.39 |
| S133 | NM091 | Montaňo 6 D | 12 | na | 6/18/1996 | 0.46 | 62.5 | 0.11 | 0.486 | 0.19 | 0.45 |
| S134 | NM092 | Montaňo 6 MD | 12 | na | 6/18/1996 | 0.53 | 87.7 | 0.03 | <0.004 | 0.01 | 0.40 |
| S135 | NM093 | Montaňo 6 MS | 12 | na | 6/18/1996 | 0.53 | 67.2 | 0.06 | 0.016 | 0.01 | 0.36 |
| S136 | NM094 | Montaňo 6 S | 12 | na | 6/18/1996 | 0.65 | 60.1 | 0.05 | 0.009 | 0.04 | 0.23 |
| S137 | NM506 | Montesa M | 12 | na | 7/27/1998 | 0.36 | 72.1 | 0.03 | 0.062 | 0.09 | 0.60 |
| S138 | NM507 | Montesa S | 12 | na | 7/27/1998 | 0.30 | 49.2 | 0.03 | 0.002 | 0.07 | 0.46 |
| S139 | NM305 | Domestic Well #27 | 12 | na | 6/17/1997 | 0.49 | 76.8 | 0.06 | 0.006 | 0.10 | 0.95 |
| S142 | NM307 | Domestic Well #28 | 12 | na | 6/17/1997 | 0.59 | 64.2 | 0.07 | 0.007 | 0.01 | 0.24 |
| S146 | NM309 | NM Utilities 2 | 12 | na | 6/18/1997 | 0.30 | 72.1 | 0.06 | 0.006 | 0.63 | 0.65 |
| S151 | NM314 | Nor Este S | 12 | na | 7/2/1997 | 0.22 | 49.2 | 0.03 | 0.098 | 0.02 | 0.72 |
| S151 | NM508 | Nor Este S | 12 | na | 7/20/1998 | 0.30 | 46.4 | 0.10 | 0.177 | 0.02 | 0.67 |
| S153 | NM411 | Open Space | 12 | na | 11/18/1997 | 0.16 | 34.4 | 0.05 | 0.007 | 0.08 | 0.47 |
| S153 | NM315 | Open Space | 12 | 10 | 6/17/1997 | 0.16 | 35.9 | 0.09 | 0.008 | 0.35 | 0.41 |
| S154 | NM099 | ORLF-2 | 12 | na | 6/27/1996 | 0.37 | 38.3 | 0.04 | 0.099 | 0.05 | 0.39 |
| S155 | NM316 | Domestic Well #29 | 12 | na | 6/27/1997 | 0.45 | 36.4 | 0.06 | 0.007 | 0.01 | 0.32 |
| S156 | NM100 | Paseo 2D | 12 | na | 6/26/1996 | 0.39 | 34.4 | 0.04 | 0.051 | 0.01 | 0.27 |
| S157 | NM101 | Paseo 2MD | 12 | na | 6/26/1996 | 0.44 | 27.2 | 0.04 | 0.449 | 0.01 | 0.23 |
| S158 | NM102 | Paseo 2MS | 12 | na | 6/26/1996 | 0.35 | 31.4 | 0.40 | 1.15 | 0.05 | 0.54 |
| S159 | NM103 | Paseo 2S | 12 | na | 6/26/1996 | 0.49 | 24.2 | 0.06 | 0.940 | 0.82 | 0.60 |
| S160 | NM104 | Paseo 3D | 12 | na | 6/21/1996 | 0.32 | 39.4 | 0.04 | 0.058 | 0.00 | 0.32 |
| S161 | NM105 | Paseo 3M | 12 | na | 6/21/1996 | 0.94 | 45.1 | 0.08 | 1.89 | 0.47 | 0.29 |
| S171 | NM321 | Ridgecrest 4 | 12 | na | 6/26/1997 | 0.40 | 33.8 | 0.06 | 0.005 | 0.12 | 0.34 |
| S173 | NM323 | Rio Bravo 5 M | 12 | 3 | 7/4/1997 | 0.28 | 70.0 | 0.04 | 0.007 | 0.01 | 0.69 |
| S176 | NM111 | Rio Bravo 1 S | 12 | na | 6/17/1996 | 0.58 | 31.4 | 0.22 | 0.646 | 0.01 | 0.40 |
| S177 | NM112 | Rio Bravo 2 D | 12 | 3 | 6/25/1996 | 0.34 | 78.7 | 0.05 | 0.015 | 0.10 | 0.99 |
| S178 | NM113 | Rio Bravo 2 M | 12 | na | 6/25/1996 | 0.75 | 83.0 | 0.06 | 0.018 | 0.06 | 0.38 |
| S179 | NM114 | Rio Bravo 2 S | 12 | na | 6/25/1996 | 0.52 | 60.5 | 0.06 | 0.160 | 0.01 | 0.76 |
| S180 | NM115 | Rio Bravo 4 D | 12 | na | 6/25/1996 | 0.38 | 60.8 | 0.11 | 0.488 | 0.05 | 0.45 |
| S181 | NM116 | Rio Bravo 4 M | 12 | na | 6/25/1996 | 0.89 | 61.0 | 0.09 | 0.048 | 3.09 | 0.36 |
| S183 | NM126 | Rio Grande Utility 5 | 12 | 3 | 8/15/1996 | 0.39 | 73.2 | 0.03 | <0.004 | 0.16 | 0.50 |

**Table A3.** Summary of minor-element chemistry-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secon-dary hydro-chemical zone | Date | Sr (mg/L) | $SiO_2$ (mg/L) | Fe (mg/L) | Mn (mg/L) | $NO_3$ as N (mg/L) | F (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S184 | NM127 | Rio Grande Utility 6 | 12 | na | 8/15/1996 | 0.41 | 58.6 | 0.04 | <0.004 | 0.01 | 0.38 |
| S190 | NM325 | Rio Rancho 2 | 12 | na | 6/20/1997 | 0.55 | 49.4 | 0.08 | 0.011 | 0.82 | 0.42 |
| S203 | NM331 | Private Production Well #20 | 12 | na | 7/3/1997 | 0.58 | 27.4 | 0.06 | 0.133 | 2.08 | 0.28 |
| S205 | NM333 | Private Production Well #21 | 12 | na | 7/3/1997 | 0.14 | 67.6 | 0.17 | 0.012 | 0.01 | 0.48 |
| S208 | NM140 | San Jose 2 | 12 | 3 | 6/20/1996 | 0.39 | 76.0 | 0.03 | <0.004 | 0.68 | 0.68 |
| S210 | NM511 | Sandia D | 12 | na | 7/30/1998 | 0.31 | 55.0 | 0.03 | 0.104 | 0.23 | 1.03 |
| S214 | NM513 | Sandia S | 12 | na | 7/30/1998 | 0.93 | 39.6 | 0.06 | 0.038 | 0.04 | 0.31 |
| S220 | NM147 | Santa Barbara 1 | 12 | na | 6/19/1996 | 0.29 | 46.4 | 0.03 | <0.004 | 0.17 | 0.49 |
| S220 | NM337 | Santa Barbara 1 | 12 | na | 6/26/1997 | 0.31 | 44.1 | 0.04 | 0.004 | 0.19 | 0.52 |
| S231 | NM517 | Sierra Vista M | 12 | 3 | 7/22/1998 | 0.14 | 73.2 | 0.02 | 0.034 | 0.06 | 1.10 |
| S232 | NM518 | Sierra Vista S | 12 | na | 7/22/1998 | 0.41 | 53.7 | 0.03 | 0.077 | 0.45 | 0.63 |
| S234 | NM339 | Sister Cities D | 12 | na | 6/30/1997 | 0.39 | 74.0 | 0.03 | 0.011 | 0.77 | 0.95 |
| S235 | NM340 | Sister Cities M | 12 | na | 6/27/1997 | 0.37 | 29.7 | 0.05 | 0.081 | 0.01 | 0.47 |
| S244 | NM158 | SWAB 3 - 760 | 12 | na | 7/1/1996 | 0.15 | 30.0 | 0.06 | 0.031 | 0.27 | 0.15 |
| S245 | NM159 | SWAB 3 - 980 | 12 | na | 7/1/1996 | 0.22 | 39.6 | 0.06 | 0.049 | 0.01 | 0.52 |
| S245 | NM160 | SWAB 3 - 980 | 12 | na | 7/1/1996 | 0.20 | 36.4 | 0.10 | 0.042 | 0.01 | 0.51 |
| S253 | NM522 | Tome D | 12 | na | 8/6/1998 | 0.28 | 58.2 | 0.02 | 0.036 | 0.02 | 0.88 |
| S257 | NM344 | Domestic Well #34 | 12 | na | 6/17/1997 | 0.60 | 52.6 | 0.11 | 0.062 | 2.27 | 0.43 |
| S259 | NM171 | VGP-1 | 12 | na | 6/27/1996 | 0.90 | 39.6 | 0.52 | 1.21 | 0.16 | 0.39 |
| S261 | NM172 | Vol Andia 2 | 12 | na | 6/21/1996 | 0.27 | 33.6 | 0.03 | <0.004 | 1.12 | 0.41 |
| S262 | NM173 | Vol Andia 5 | 12 | na | 6/18/1996 | 0.40 | 33.4 | 0.04 | 0.005 | 0.31 | 0.40 |
| S265 | NM175 | Webster 1 | 12 | na | 6/18/1996 | 0.33 | 57.1 | 0.04 | 0.006 | 0.14 | 0.77 |
| S267 | NM348 | West Bluff Nest 1 Well 2 | 12 | 3 | 6/23/1997 | 0.34 | 67.2 | 0.03 | 0.009 | 0.06 | 1.04 |
| S268 | NM349 | West Bluff Nest 1 Well 3 | 12 | na | 6/24/1997 | 0.47 | 68.0 | 0.04 | 0.010 | 0.05 | 1.08 |
| S269 | NM350 | West Bluff Nest 2 Well 1 | 12 | na | 6/24/1997 | 0.52 | 62.3 | 0.08 | 0.109 | 0.01 | 0.74 |
| S270 | NM351 | West Bluff Nest 2 Well 2 | 12 | na | 6/24/1997 | 0.46 | 59.7 | 0.05 | 0.015 | 0.01 | 0.81 |
| S271 | NM352 | West Bluff Nest 2 Well 3 | 12 | na | 6/24/1997 | 0.44 | 23.1 | 0.05 | 0.225 | 0.28 | 0.31 |
| S275 | NM178 | Yale 1 | 12 | na | 6/19/1996 | 0.37 | 61.0 | 0.04 | 0.005 | 0.63 | 0.45 |
| SXX | NM045 | Geoprobe #1 (45.3') | 12 | na | 7/1/1996 | 0.36 | 27.2 | 0.55 | 0.500 | 0.01 | 0.39 |
| SXX | NM049 | Geoprobe #1 (25') | 12 | na | 7/1/1996 | 0.29 | 22.0 | 0.46 | 1.15 | 0.01 | 0.38 |
| X | NM051 | Geoprobe #2 (40.5') | 12 | na | 7/1/1996 | 0.36 | 28.7 | 0.32 | 0.557 | 0.01 | 0.37 |
| | | **Zone 13: Discharge** | | | | | | | | | |
| S143 | NM096 | Private Production Well #05 | 13 | na | 8/19/1996 | 1.5 | 39.6 | 0.07 | 0.009 | 0.01 | 1.59 |
| S194 | NM327 | Domestic Well #32 | 13 | na | 6/30/1997 | 3.0 | 29.1 | 0.30 | 0.017 | 0.82 | 0.54 |
| S226 | NM150 | Domestic Well #15 | 13 | na | 8/19/1996 | 3.0 | 24.2 | 0.20 | <0.012 | 0.42 | 1.12 |
| | | **No Zone: Exotic Water** | | | | | | | | | |
| S009 | NM485 | Arroyo Salado Spring | E | E | 8/6/1998 | 17. | 17.2 | 1.5 | 0.019 | 0.02 | 0.50 |
| S023 | NM010 | Burn Site Well | E | E | 6/25/1996 | 1.1 | 16.0 | 0.12 | 0.014 | 23.3 | 0.49 |
| S028 | NM014 | Cerro Colorado Landfill MW | E | E | 8/12/1996 | 13. | 22.2 | 2.7 | 1.01 | 0.01 | 0.73 |
| S038 | NM265 | Windmill #19 | E | E | 7/1/1997 | 2.2 | 10.7 | 0.38 | 0.061 | 0.01 | 2.75 |
| S054 | NM041 | Domestic Well #04 | E | E | 8/17/1996 | 5.8 | 43.4 | 0.24 | 0.390 | 0.01 | 6.40 |
| S057 | NM228 | Embudo Spring | E | E | 4/29/1997 | 0.24 | 20.9 | 0.06 | 0.005 | 0.09 | 1.69 |
| S057 | NM241 | Embudo Spring | E | E | 5/27/1997 | 0.21 | 22.9 | 0.06 | <0.001 | 0.01 | 1.51 |
| S057 | NM365 | Embudo Spring | E | E | 7/17/1997 | 0.26 | 23.7 | 0.07 | 0.015 | 0.01 | 1.72 |
| S057 | NM242 | Embudo Spring | E | E | 5/27/1997 | 0.19 | 21.0 | 0.07 | 0.026 | 0.01 | 1.71 |
| S057 | NM215 | Embudo Spring | E | E | 3/21/1997 | 0.30 | 21.8 | 0.10 | 0.007 | 0.04 | 1.73 |
| S057 | NM044 | Embudo Spring | E | E | 7/2/1996 | 0.26 | 23.3 | 0.38 | 0.036 | 0.01 | 1.28 |
| S063 | NM282 | Windmill #22 | E | E | 6/28/1997 | 1.3 | 12.4 | 0.71 | 0.145 | 0.12 | 0.77 |
| S067 | NM284 | Granite Hill | E | E | 7/4/1997 | 0.44 | 25.9 | 0.11 | 0.113 | 0.03 | 2.57 |
| S070 | NM059 | HERTF | E | E | 6/28/1996 | 0.68 | 25.9 | 0.08 | 0.020 | 17.3 | 2.52 |
| S091 | NM496 | Private Production Well #23 | E | E | 8/4/1998 | 0.85 | 53.3 | 0.60 | 0.682 | 0.02 | 1.19 |
| S094 | NM293 | Stock Well #02 | E | E | 6/20/1997 | 0.60 | 29.7 | 0.09 | <0.004 | 7.64 | 1.32 |
| S099 | NM072 | LALF-1 | E | E | 6/29/1996 | 1.2 | 43.4 | 0.71 | 3.10 | 0.01 | nd |
| S112 | NM297 | Domestic Well #24 | E | E | 6/21/1997 | 1.3 | 43.0 | 0.31 | 0.056 | 0.04 | 0.43 |
| S112 | NM296 | Domestic Well #24 | E | E | 6/21/1997 | 1.5 | 47.1 | 0.36 | 0.077 | 0.04 | 0.43 |
| S129 | NM087 | Montaňo 4 S | E | E | 6/19/1996 | 1.3 | 47.5 | 0.71 | 4.03 | 0.05 | 0.69 |
| S152 | NM098 | Private Production Well #07 | E | E | 8/22/1996 | 1.8 | 32.5 | 0.13 | 0.007 | 0.23 | 0.11 |
| S182 | NM117 | Rio Bravo 4 S | E | E | 6/25/1996 | 0.91 | 63.6 | 0.14 | 0.036 | 0.02 | nd |

**Table A3.** Summary of minor-element chemistry-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secon-dary hydro-chemical zone | Date | Sr (mg/L) | $SiO_2$ (mg/L) | Fe (mg/L) | Mn (mg/L) | $NO_3$ as N (mg/L) | F (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S202 | NM330 | Windmill #27 | E | E | 7/2/1997 | 2.5 | 17.1 | 0.25 | 0.057 | 2.63 | 0.65 |
| S211 | NM512 | Sandia M | E | E | 7/30/1998 | 0.26 | 61.0 | 0.02 | 0.023 | 0.21 | 1.57 |
| S225 | NM149 | SBM-1 | E | E | 6/29/1996 | 1.84 | 59.9 | 0.26 | 0.031 | 0.01 | 1.10 |
| S249 | NM164 | Private Production Well #09 | E | E | 6/26/1996 | 0.13 | 19.5 | 0.04 | 0.005 | 1.42 | 2.08 |
| S249 | NM163 | Private Production Well #09 | E | E | 6/26/1996 | 0.12 | 18.1 | 0.06 | 0.009 | 1.47 | 2.03 |
| S250 | NM165 | Private Production Well #10 | E | E | 6/26/1996 | 0.25 | 27.0 | 0.05 | 0.041 | 0.04 | 2.42 |
| S251 | NM166 | Private Production Well #11 | E | E | 6/26/1996 | 0.16 | 21.8 | 0.06 | 0.006 | 0.38 | 2.46 |
| S256 | NM169 | Tunnel Spring 1 | E | E | 6/18/1996 | 0.23 | 10.6 | 0.05 | 0.006 | 0.33 | 0.41 |
| S256 | NM170 | Tunnel Spring 2 | E | E | 6/18/1996 | 0.23 | 10.7 | 0.06 | 0.007 | 0.33 | 0.41 |
| S258 | NM524 | Vallecito Springs | E | E | 8/4/1998 | 0.35 | 11.2 | 0.07 | 0.143 | 0.05 | 1.29 |
| S273 | NM176 | Windmill #11 | E | E | 8/19/1996 | 1.2 | 18.1 | 0.16 | 0.101 | 0.03 | 0.79 |
| S282 | NM529 | Windmill #44 | E | E | 7/29/1998 | 5.5 | 43.0 | 0.74 | 0.141 | 9.44 | 0.40 |
| SXX | NM154 | Soda Dam Spring | E | E | 8/20/1996 | 1.9 | 40.0 | 0.35 | 0.600 | 0.01 | 3.14 |
| SXX | NM065 | Jemez Spring | E | E | 8/20/1996 | 0.64 | 97.1 | 0.41 | 0.234 | 0.01 | 4.72 |

**Table A4.** Summary of trace-element chemistry

[SXXX, no site number assigned; Hydrochemical Zone "E", exotic water, no primary or secondary zone assigned; Al, aluminum; B, boron; Ba, barium; Li, lithium; Zn, zinc; Pb, lead; Cu, copper; Rb, rubidium; V, vanadium; Cr, chromium; Co, cobalt; Mo, molybdenum; As, arsenic; Se, selenium; U, uranium; mg/L, milligrams per liter; µg/L, micrograms per liter; nd, not determined]

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secon-dary hydro-chemical zone | Date | Al (µg/L) | B (mg/L) | Ba (mg/L) | Li (mg/L) | Zn (µg/L) | Pb (µg/L) | Cu (µg/L) | Rb (µg/L) | V (µg/L) | Cr (µg/L) | Co (µg/L) | Mo (µg/L) | As (µg/L) | Se (µg/L) | U (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Zone 1: Northern Mountain Front** | | | | | | | | | | | | | | | | | | |
| S027 | NM486 | CEPO 02 | 1 | na | 8/3/1998 | 8. | 0.024 | 0.025 | 0.030 | 2. | <0.05 | 0.2 | 1.7 | 9.0 | 7. | <0.05 | 1.6 | 4.5 | 2. | 0.8 |
| S034 | NM027 | Private Production Well #04 | 1 | na | 8/28/1996 | 5. | 0.023 | 0.094 | 0.026 | 2. | 0.12 | 0.5 | nd | 5.8 | 3. | nd | 1.8 | 1.7 | nd | 0.8 |
| S035 | NM487 | Windmill #37 | 1 | na | 7/31/1998 | 5. | 0.011 | 0.007 | 0.004 | 4,340. | 0.35 | 3.1 | 1.8 | 3.6 | <1. | <0.05 | 1.1 | 1.1 | <1. | 0.1 |
| S036 | NM026 | Private Production Well #03 | 1 | na | 8/28/1996 | 6. | 0.032 | 0.182 | 0.008 | 5. | 0.72 | 0.7 | nd | 7. | 1. | nd | 1.8 | 1.7 | nd | 3.3 |
| S065 | NM055 | Domestic Well #05 | 1 | na | 8/17/1996 | 4. | 0.197 | 0.163 | 0.289 | 3. | <0.1 | 1.7 | nd | 10. | 1. | nd | 6.6 | 7.6 | nd | 0.7 |
| S187 | NM131 | Rio Rancho 12 | 1 | na | 8/13/1996 | 3. | 0.159 | 0.120 | 0.180 | 3. | <0.1 | <0.1 | nd | 17. | 2. | nd | 1.0 | 45. | nd | 1.0 |
| S206 | NM510 | Windmill #38 | 1 | 3 | 8/3/1998 | 5. | 0.113 | 0.071 | 0.062 | 4,230. | 1.6 | 1.3 | 13. | 30. | 4. | <0.05 | 3.1 | 29. | 2. | 1.0 |
| S216 | NM143 | Windmill #09 | 1 | na | 8/27/1996 | 5. | 0.076 | 0.052 | 0.059 | 700. | 0.2 | 0.9 | nd | 9.3 | 6. | nd | 2.3 | 5.6 | nd | 3.1 |
| S221 | NM530 | Windmill #45 | 1 | na | 8/20/1998 | 3. | 0.118 | 0.141 | 0.058 | 388. | <0.05 | 0.4 | 3.8 | 2.8 | <1. | 0.52 | 1.0 | 1.7 | 1. | 3.5 |
| S222 | NM514 | Windmill #39 | 1 | 3 | 8/6/1998 | 4. | 0.173 | 0.009 | 0.208 | 1,140. | 0.07 | 0.7 | 67. | <0.1 | <1. | 1.4 | 6.9 | 15. | <1. | 4.1 |
| S254 | NM168 | Private Production Well #12 | 1 | na | 8/28/1996 | 3. | 0.019 | 0.129 | 0.016 | 18. | 0.19 | 1.3 | nd | 6.3 | <1. | nd | 0.7 | 2. | nd | 0.3 |
| S277 | NM525 | Windmill #40 | 1 | na | 7/28/1998 | 4. | 0.050 | 0.002 | 0.060 | 349. | 0.52 | 4.2 | 32. | 1.4 | <1. | 0.06 | 1.0 | 24. | <1. | 2.0 |
| S279 | NM527 | Windmill #42 | 1 | na | 7/28/1998 | 3. | 0.021 | 0.034 | 0.006 | 330. | 0.20 | 8.2 | 3.1 | 6.4 | <1. | 0.07 | 0.5 | 1.7 | 1. | 0.2 |
| S281 | NM528 | Windmill #43 | 1 | 3 | 7/28/1998 | 3. | 0.035 | 0.040 | 0.102 | 186. | 0.38 | 0.4 | 42. | 3.1 | <1. | 0.05 | 1.8 | 1.7 | <1. | 2.6 |
| | | **Zone 2: Northwestern** | | | | | | | | | | | | | | | | | | |
| S103 | NM497 | Lincoln D | 2 | na | 7/23/1998 | 7. | 0.166 | 0.082 | 0.089 | 5. | 0.05 | 0.4 | 6.9 | 18. | 4. | 0.07 | 8.4 | 10. | 1. | 2.7 |
| S104 | NM498 | Lincoln M | 2 | na | 7/23/1998 | 4. | 0.118 | 0.056 | 0.068 | 5. | <0.05 | 0.2 | 8.2 | 23. | 5. | <0.05 | 3.2 | 9.8 | <1. | 1.7 |
| S105 | NM499 | Lincoln S | 2 | na | 7/23/1998 | 4. | 0.080 | 0.067 | 0.057 | 8. | <0.05 | 0.2 | 13. | 13. | 2. | <0.05 | 1.8 | 5.4 | 1. | 2.8 |
| S189 | NM133 | Rio Rancho 15 | 2 | na | 8/13/1996 | 2. | 0.365 | 0.039 | 0.266 | 3. | <0.1 | 0.1 | nd | 13. | 4. | nd | 9.1 | 11. | nd | 3.0 |
| S191 | NM326 | Rio Rancho 4 | 2 | 3 | 6/20/1997 | 5. | 0.230 | 0.051 | 0.111 | 11. | <0.1 | 0.7 | 10. | 21. | 4. | <0.05 | 11. | 14. | <1. | 3.7 |
| S192 | NM128 | Rio Rancho 8 | 2 | 3 | 8/13/1996 | 5. | 0.174 | 0.052 | 0.054 | 4. | 0.11 | 0.4 | nd | 15. | 9. | nd | 4.8 | 5.0 | nd | 6.9 |
| S276 | NM179 | Windmill #12 | 2 | na | 8/27/1996 | 5. | 0.025 | 0.048 | 0.009 | 816. | 0.64 | 1.7 | nd | 16. | <1. | nd | 0.3 | 9.3 | nd | 0.9 |
| S278 | NM526 | Windmill #41 | 2 | na | 7/29/1998 | 4. | 0.177 | 0.046 | 0.168 | 2,080. | 0.18 | 1.2 | 3.6 | 7.4 | <1. | <0.05 | 3.4 | 3.2 | <1. | 4.6 |
| S280 | NM180 | Windmill #13 | 2 | na | 8/27/1996 | 3. | 0.088 | 0.068 | 0.022 | 255. | 0.49 | 0.9 | nd | 7.4 | <1. | nd | 1.5 | 4.8 | nd | 2.5 |
| S286 | NM184 | Private Production Well #13 | 2 | na | 8/26/1996 | 2. | 0.059 | 0.096 | 0.029 | 89. | 0.5 | <0.1 | nd | 21. | <1. | nd | 1.6 | 15. | nd | 2.3 |
| S287 | NM185 | Private Production Well #14 | 2 | na | 8/26/1996 | 3. | 0.161 | 0.056 | 0.088 | 9. | <0.1 | 0.2 | nd | 32. | 2. | nd | 4.9 | 19. | nd | 1.4 |
| | | **Zone 3: West Central** | | | | | | | | | | | | | | | | | | |
| S003 | NM251 | 98th St. D | 3 | na | 6/17/1997 | <5. | 1.02 | 0.041 | 0.282 | 5. | 0.22 | 0.3 | 2.3 | 55. | 14. | <0.1 | 15. | 40. | 3. | 16. |
| S003 | NM481 | 98th St. D | 3 | na | 8/4/1998 | 8. | 0.843 | 0.035 | 0.264 | <1. | <0.05 | 0.4 | 2.2 | 53. | 10. | <0.05 | 15. | 39. | 1. | 15. |
| S004 | NM252 | 98th St. MD | 3 | na | 6/18/1997 | 59. | 0.313 | 0.018 | 0.063 | 7. | <0.1 | 0.3 | 0.9 | 11. | 2. | <0.05 | 7.5 | 52. | <1. | 99. |
| S004 | NM482 | 98th St. MD | 3 | na | 8/4/1998 | 32. | 0.296 | 0.012 | 0.078 | <1. | <0.05 | <0.1 | 0.6 | 12. | 4. | <0.05 | 5.8 | 52. | <1. | 86. |
| S005 | NM253 | 98th St. MS | 3 | na | 7/4/1997 | 14. | 0.373 | 0.034 | 0.040 | 3. | <0.1 | 0.3 | 14. | 0.2 | <1. | <0.05 | 10. | 12. | <1. | 7.3 |
| S005 | NM483 | 98th St. MS | 3 | na | 8/4/1998 | 10. | 0.368 | 0.037 | 0.048 | <1. | <0.05 | 0.1 | 5.3 | <1. | <1. | <0.05 | 10. | 12. | <1. | 6.0 |
| S006 | NM254 | 98th St. S | 3 | na | 6/17/1997 | 43. | 0.243 | 0.029 | 0.030 | 16. | <0.1 | 0.8 | 4.4 | 48. | 17. | <0.05 | 14. | 21. | 3. | 5.2 |
| S006 | NM484 | 98th St. S | 3 | na | 8/5/1998 | 37. | 0.218 | 0.034 | 0.033 | <1. | <0.05 | 0.2 | 3.8 | 50. | 16. | <0.05 | 8.0 | 22. | 3. | 3.7 |
| S008 | NM003 | Private Production Well #01 | 3 | na | 8/12/1996 | 5. | 0.142 | 0.034 | 0.015 | 12. | 0.8 | 2.2 | nd | 27. | 10. | nd | 8.7 | 10. | nd | 2.6 |
| S010 | NM255 | Private Production Well #16 | 3 | na | 6/23/1997 | 4. | 0.128 | 0.015 | 0.010 | 20. | 1.2 | 18. | 2.9 | 4.5 | <1. | 0.17 | 7.3 | 2.9 | <1. | 1.0 |
| S018 | NM260 | Domestic Well #21 | 3 | na | 6/26/1997 | 9. | 0.268 | 0.025 | <0.001 | 50. | 0.5 | 4.9 | 14. | 28. | 18. | <0.05 | 15. | 8.3 | 2. | 4.9 |
| S019 | NM007 | Belen 4 | 3 | 5 | 8/16/1996 | 2. | 0.227 | 0.019 | 0.105 | 2. | <0.1 | 0.2 | nd | 8.7 | 8. | nd | 8.6 | 2.7 | nd | 3.8 |
| S020 | NM008 | Belen 5 | 3 | 5 | 8/16/1996 | 2. | 0.222 | 0.020 | 0.096 | 2. | <0.1 | 0.2 | nd | 10. | 10. | nd | 11. | 3.4 | nd | 3.6 |
| S029 | NM015 | Cerro Colorado Landfill PW | 3 | 5 | 8/12/1996 | 3. | 0.117 | 0.032 | 0.042 | 2. | <0.1 | 0.8 | nd | 13. | 5. | nd | 13. | 7.5 | nd | 4.1 |
| S037 | NM264 | College 2 | 3 | na | 6/19/1997 | 16. | 0.292 | 0.018 | <0.001 | 10. | <0.1 | 0.4 | 0.9 | 85. | 11. | <0.05 | 6.2 | 33. | 2. | 5.5 |
| S066 | NM056 | Gonzales 1 | 3 | 12 | 6/20/1996 | 5. | 0.214 | 0.035 | 0.053 | nd | <0.1 | 0.4 | nd | 46. | 4. | nd | 4.3 | 25. | nd | 4.2 |

**Table A4.** Summary of trace-element chemistry-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secon-dary hydro-chemical zone | Date | Al (µg/L) | B (mg/L) | Ba (mg/L) | Li (mg/L) | Zn (µg/L) | Pb (µg/L) | Cu (µg/L) | Rb (µg/L) | V (µg/L) | Cr (µg/L) | Co (µg/L) | Mo (µg/L) | As (µg/L) | Se (µg/L) | U (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S086 | NM492 | Isleta D | 3 | na | 7/29/1998 | 9. | 0.505 | 0.010 | 0.018 | 2. | <0.05 | 0.6 | 2.5 | 173. | <1. | <0.05 | 11. | 96. | 3. | 1.4 |
| S101 | NM294 | Leavitt 1 | 3 | na | 6/26/1997 | 4. | 0.212 | 0.024 | 0.033 | 2. | <0.1 | 0.6 | 1.8 | 66. | 5. | <0.05 | 4.5 | 37. | 3. | 6.6 |
| S108 | NM076 | Los Lunas 3 | 3 | 12 | 8/14/1996 | 5. | 0.181 | 0.031 | 0.022 | 3. | <0.1 | 0.4 | nd | 52. | 1. | nd | 5. | 18. | nd | 8.0 |
| S109 | NM077 | Los Lunas 4 | 3 | 12 | 8/14/1996 | 5. | 0.13 | 0.038 | 0.034 | <1. | 0.1 | 0.2 | nd | 41. | <1. | nd | 4.2 | 13. | nd | 9.3 |
| S145 | NM308 | NM Utilities 1 | 3 | na | 6/18/1997 | 5. | 0.111 | 0.071 | 0.032 | 5. | <0.1 | 0.5 | 6.7 | 20. | 3. | <0.05 | 2.8 | 7.9 | 2. | 8.2 |
| S147 | NM310 | NM Utilities 3 | 3 | na | 6/18/1997 | 9. | 0.190 | 0.038 | 0.052 | 7. | 0.3 | 0.9 | 5.5 | 50. | 6. | <0.05 | 4.0 | 28. | 1. | 3.7 |
| S148 | NM311 | NM Utilities 4 | 3 | na | 6/18/1997 | 3. | 0.178 | 0.059 | 0.037 | 8. | 0.2 | 0.5 | 4.6 | 23. | 7. | 0.20 | 5.9 | 10. | 2. | 8.6 |
| S166 | NM509 | Rabbit Hill | 3 | na | 8/4/1998 | 8. | 0.857 | 0.060 | 0.464 | 6. | <0.05 | 0.6 | 6.0 | 57. | 29. | <0.05 | 31. | 23. | 2. | 3.2 |
| S167 | NM107 | Domestic Well #12 | 3 | na | 8/14/1996 | 3. | 0.224 | 0.014 | 0.026 | 18. | <0.1 | <0.1 | nd | 43. | 11. | nd | 16. | 9.8 | nd | 5.0 |
| S172 | NM322 | Rio Bravo 5 D | 3 | na | 7/4/1997 | 5. | 0.411 | 0.024 | 0.051 | 2. | <0.1 | 0.6 | 1.0 | 17. | 3. | <0.1 | 13. | 24. | 1. | 1.2 |
| S174 | NM109 | Rio Bravo 1 D | 3 | 12 | 6/17/1996 | 49. | 0.442 | 0.033 | 0.049 | nd | 0.2 | 4.1 | nd | 40. | 11. | nd | 11. | 31. | nd | 4.3 |
| S175 | NM110 | Rio Bravo 1 M | 3 | 12 | 6/17/1996 | 10. | 0.330 | 0.017 | 0.052 | nd | 0.1 | 0.6 | nd | 48. | 10. | nd | 9.5 | 40. | nd | 4.0 |
| S186 | NM130 | Rio Rancho 10 | 3 | na | 8/13/1996 | 4. | 0.355 | 0.032 | 0.207 | 6. | <0.1 | 0.1 | nd | 13. | 5. | nd | 8. | 18. | nd | 4.7 |
| S188 | NM132 | Rio Rancho 13 | 3 | na | 8/13/1996 | 9. | 0.217 | 0.023 | 0.030 | 1. | 0.1 | 0.4 | nd | 72. | 11. | nd | 7.4 | 45. | nd | 1.7 |
| S193 | NM129 | Rio Rancho 9 | 3 | na | 8/13/1996 | 7. | 0.183 | 0.039 | 0.031 | <1. | <0.1 | 0.3 | nd | 42. | 6. | nd | 6.2 | 39. | nd | 1.9 |
| S196 | NM135 | Windmill #05 | 3 | na | 8/21/1996 | 2. | 0.175 | 0.001 | 0.024 | 76. | 0.6 | <0.1 | nd | 9.6 | 1. | nd | 17. | 4.3 | nd | 2.3 |
| S200 | NM139 | Private Production Well #08 | 3 | na | 8/29/1996 | 2. | 0.237 | 0.020 | 0.063 | 16. | 0.2 | 0.5 | nd | 23. | 2. | nd | 11. | 9.8 | nd | 6.3 |
| S217 | NM144 | Santa Ana Boundary D | 3 | na | 8/22/1996 | 5. | 0.209 | 0.051 | 0.090 | 179. | 3.1 | 0.3 | nd | 26. | 5. | nd | 1.7 | 111. | nd | 1.6 |
| S218 | NM145 | Santa Ana Boundary M | 3 | na | 8/22/1996 | 3. | 0.241 | 0.068 | 0.115 | 218. | 2.3 | 0.4 | nd | 119. | 8. | nd | 1.0 | 264. | nd | 1.3 |
| S219 | NM146 | Santa Ana Boundary S | 3 | na | 8/22/1996 | 4. | 0.249 | 0.066 | 0.147 | 147. | 2.8 | 0.3 | nd | 39. | 8. | nd | 1.2 | 230. | nd | 2.6 |
| S230 | NM516 | Sierra Vista D | 3 | na | 7/22/1998 | 22. | 0.464 | 0.024 | 0.099 | 2. | <0.05 | 0.9 | 0.9 | <0.1 | <1. | <0.05 | 8.2 | 24. | <1. | 2.3 |
| S236 | NM155 | SAF (Soil Amendment Facility) | 3 | na | 8/12/1996 | 5. | 0.122 | 0.021 | 0.026 | 2. | <0.1 | 0.6 | nd | 26. | 13. | nd | 12. | 11. | nd | 2.3 |
| S241 | NM519 | SWAB Test Hole 1 D | 3 | 1 | 8/5/1998 | 8. | 0.343 | 0.182 | 0.118 | 6. | <0.05 | 0.4 | 6.0 | 3.3 | <1. | 0.12 | 33. | 25. | 2. | 1.2 |
| S242 | NM520 | SWAB Test Hole 1 S | 3 | 1 | 8/1/1998 | 9. | 0.134 | 0.048 | 0.027 | 19. | 0.09 | 0.2 | 1.6 | 9.1 | <1. | 0.06 | 8.2 | 7.2 | 2. | 1.3 |
| S243 | NM521 | SWAB Test Hole 2 D | 3 | na | 8/7/1998 | 6. | 0.108 | 0.214 | 0.035 | 10. | 0.32 | 2.1 | 2.0 | 4.0 | 5. | <0.05 | 4.7 | 2.1 | 2. | 4.7 |
| S263 | NM346 | Volcano Cliff 1 | 3 | na | 6/19/1997 | 4. | 0.151 | 0.061 | 0.042 | 16. | <0.1 | 0.7 | 9.0 | 26. | 8. | <0.05 | 3.3 | 14. | 2. | 4.4 |
| S266 | NM347 | West Bluff Nest 1 Well 1 | 3 | na | 6/23/1997 | 2. | 0.457 | 0.025 | 0.023 | 3. | <0.1 | 0.2 | 0.8 | 59. | <1. | <0.05 | 15. | 36. | 3. | 2.7 |
| S272 | NM353 | West Mesa 3 | 3 | na | 6/19/1997 | <1. | 0.234 | 0.019 | 0.027 | 12. | <0.1 | 0.3 | 1.2 | 73. | <1. | <0.05 | 5.3 | 39. | 2. | 7.5 |
| S283 | NM181 | Zia Ball Park D | 3 | na | 8/26/1996 | 3. | 0.697 | 0.057 | 0.410 | 515. | 1.2 | 0.4 | nd | 22. | 3. | nd | 23. | 13. | nd | 0.4 |
| S284 | NM182 | Zia Ball Park M | 3 | na | 8/26/1996 | 5. | 0.619 | 0.034 | 0.397 | 132. | 1.6 | 0.2 | nd | 24. | 3. | nd | 18. | 21. | nd | 0.6 |
| S285 | NM183 | Zia Ball Park S | 3 | 2 | 8/26/1996 | 4. | 0.621 | 0.235 | 0.649 | 434. | 0.9 | 1.2 | nd | 17. | 3. | nd | 8.4 | 17. | nd | 0.4 |
| S288 | NM186 | Zia BMT D | 3 | na | 8/27/1996 | 1. | 0.211 | 0.051 | 0.105 | nd | <0.1 | 0.3 | nd | 16. | 16. | nd | 5.8 | 100. | nd | 1.2 |
| | | **Zone 4: Western Boundary** | | | | | | | | | | | | | | | | | | |
| S031 | NM263 | Windmill #18 | 4 | na | 6/24/1997 | <5. | 0.382 | 0.006 | 0.174 | 25. | <0.1 | 1.1 | 4.4 | 2.2 | 11. | 0.28 | 6.2 | <1. | 4. | 2.3 |
| S039 | NM266 | Windmill #20 | 4 | na | 6/21/1997 | <5. | 1.59 | 0.013 | 0.629 | 644. | 1.9 | 11. | 48. | 16. | 38. | <0.5 | 17. | <10. | <10. | 3.2 |
| S059 | NM278 | Windmill #21 | 4 | na | 6/23/1997 | <5. | 0.366 | 0.016 | 0.312 | 211. | 0.2 | 2.9 | 6.6 | 5.4 | 12. | 0.14 | 2.2 | <1. | 6. | 4.8 |
| S074 | NM285 | Windmill #23 | 4 | na | 6/21/1997 | <5. | 1.28 | 0.014 | 0.550 | 1,176. | 0.1 | 9.6 | 86. | 6.6 | <2. | 0.65 | 4.8 | <1. | 4. | 5.5 |
| S169 | NM320 | Rest Area | 4 | na | 6/30/1997 | <5. | 0.351 | 0.013 | 0.251 | 6. | <0.1 | 2.7 | 5.7 | 7.7 | 9. | <0.1 | 8.1 | 1.8 | 6. | 6.0 |
| S201 | NM329 | Windmill #26 | 4 | na | 7/2/1997 | <5. | 0.439 | 0.023 | 0.102 | 19. | <0.1 | 3.2 | 5.5 | 1.2 | 7. | 0.13 | 18. | 6.6 | 2. | 0.5 |
| S252 | NM167 | Windmill #10 | 4 | na | 8/29/1996 | <1. | 0.555 | 0.014 | 0.190 | 12. | <0.1 | 1.2 | nd | 4.3 | 10. | nd | 25. | 2. | nd | 4.1 |
| S260 | NM345 | Windmill #33 | 4 | na | 6/25/1997 | <5. | 1.11 | 0.010 | 0.433 | 275. | <1. | 3.6 | 6.2 | 6. | 11. | <0.5 | 12. | <10. | 10. | 10. |
| | | **Zone 5: Rio Puerco** | | | | | | | | | | | | | | | | | | |
| S032 | NM262 | Windmill #17 | 5 | na | 6/24/1997 | <5. | 0.881 | 0.011 | 0.327 | 51. | <0.1 | 6.3 | 5.0 | 4.1 | 11. | 0.15 | 7.2 | 1.3 | 19. | 12. |
| S069 | NM058 | Domestic Well #06 | 5 | na | 8/16/1996 | 3. | 0.222 | 0.013 | 0.191 | 49. | 0.1 | 1.4 | nd | 3.3 | 1. | nd | 2.1 | 0.9 | nd | 3.1 |
| S073 | NM062 | Windmill #03 | 5 | na | 8/16/1996 | 7. | 0.394 | 0.017 | 0.295 | 1,480. | 0.1 | 7.0 | nd | 3.1 | 9. | nd | 1.9 | 0.8 | nd | 9.0 |
| S082 | NM409 | Windmill #36 | 5 | na | 9/10/1997 | 11. | 0.095 | 0.018 | 0.041 | 3,560. | 1.4 | 4.6 | 5.5 | 3.3 | 2. | 0.22 | 0.7 | 1.2 | 9. | 6.0 |
| S085 | NM408 | Windmill #35 | 5 | na | 9/10/1997 | 5. | 0.139 | 0.014 | 0.069 | 886. | 1.4 | 2.9 | 5.1 | 11. | 14. | 0.14 | 8.1 | 1.5 | 4. | 1.0 |
| S111 | NM079 | Domestic Well #10 | 5 | na | 8/16/1996 | 4. | 0.213 | 0.013 | 0.253 | 8. | <0.1 | 2.3 | nd | 4. | 1. | nd | 3.2 | 1. | nd | 2.6 |

**Table A4.** Summary of trace-element chemistry-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secon-dary hydro-chemical zone | Date | Al (µg/L) | B (mg/L) | Ba (mg/L) | Li (mg/L) | Zn (µg/L) | Pb (µg/L) | Cu (µg/L) | Rb (µg/L) | V (µg/L) | Cr (µg/L) | Co (µg/L) | Mo (µg/L) | As (µg/L) | Se (µg/L) | U (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S185 | NM324 | Domestic Well #31 | 5 | na | 6/16/1997 | <5. | 0.267 | 0.015 | 0.074 | 9. | <0.1 | 4.4 | 1.4 | 1.5 | 9. | 0.23 | 7.0 | <1. | 3. | 1.5 |
| S198 | NM137 | Windmill #07 | 5 | na | 8/21/1996 | 7. | 1.11 | 0.007 | 0.767 | 180. | 0.2 | 0.7 | nd | 18. | <1. | nd | 18. | 6.2 | nd | 37. |
| S215 | NM335 | Sandoval Spring | 5 | 4 | 7/1/1997 | 7. | 0.210 | 0.038 | 0.067 | 18. | <0.1 | 0.7 | 0.5 | 3.7 | <1. | 0.13 | 7.5 | 1.6 | 2. | 11. |
| S237 | NM341 | Windmill #30 | 5 | 4 | 6/24/1997 | <5. | 0.344 | 0.014 | 0.253 | 650. | <0.1 | 3.4 | 14. | 3.4 | 3. | 0.21 | 9.3 | <1. | 8. | 2.1 |
| S238 | NM342 | Windmill #31 | 5 | na | 6/24/1997 | <5. | 0.315 | 0.008 | 0.289 | 117. | <0.1 | 13. | 5.3 | 3.2 | 4. | 0.62 | 0.8 | <1. | 8. | 13. |
| | | **Zone 6: Southwestern Mountain Front** | | | | | | | | | | | | | | | | | | |
| S022 | NM009 | Windmill #02 | 6 | na | 8/19/1996 | 3. | 0.177 | 0.059 | 0.041 | 252. | 0.4 | 9.3 | nd | 1. | 2. | nd | 3.0 | 0.4 | nd | 0.9 |
| | | **Zone 7: Abo Arroyo** | | | | | | | | | | | | | | | | | | |
| S021 | NM261 | Stock Well #01 | 7 | na | 6/23/1997 | <5. | 0.148 | 0.009 | 0.028 | 13. | <0.1 | 2.5 | 0.6 | 3.9 | 5. | 0.14 | 3.0 | 1.3 | 3. | 9.1 |
| S024 | NM011 | Domestic Well #02 | 7 | 8 | 8/17/1996 | 4. | 0.073 | 0.017 | 0.019 | 49. | <0.1 | 1.2 | nd | 10. | 1. | nd | 3.7 | 2.6 | nd | 3.2 |
| S090 | NM064 | Domestic Well #08 | 7 | na | 8/19/1996 | 2. | 0.160 | 0.016 | 0.049 | 4. | <0.1 | 1.5 | nd | 8.9 | 4. | nd | 6.5 | 7.7 | nd | 7.9 |
| S093 | NM067 | Domestic Well #09 | 7 | 8 | 8/15/1996 | 4. | 0.063 | 0.081 | 0.034 | 2. | 0.1 | 2.8 | nd | 18. | 7. | nd | 3. | 23. | nd | 1.2 |
| | | **Zone 8: Eastern Mountain Front** | | | | | | | | | | | | | | | | | | |
| S007 | NM002 | Domestic Well #01 | 8 | na | 6/21/1996 | 44. | 0.014 | 0.043 | 0.015 | nd | 0.4 | 3.6 | nd | 2. | <1. | nd | 1.6 | <1. | nd | 6.1 |
| S013 | NM256 | Windmill #14 | 8 | na | 6/24/1997 | 5. | 0.055 | 0.021 | 0.008 | 89. | 0.3 | 0.4 | 2.5 | 0.4 | 2. | <0.05 | 0.4 | <1. | <1. | <0.1 |
| S014 | NM257 | Private Production Well #17 | 8 | na | 6/19/1997 | 4. | 0.025 | 0.206 | <0.001 | 55. | 0.3 | 0.6 | 0.9 | 1.4 | 1. | 0.14 | 1.0 | 1. | 2. | 3.3 |
| S015 | NM006 | Windmill #01 | 8 | na | 8/24/1996 | 127. | 0.022 | 0.052 | 0.008 | 28. | 0.3 | 10 | nd | 2.4 | <1. | nd | 1.2 | 0.8 | nd | 1.0 |
| S030 | NM016 | Charles 4 | 8 | na | 6/22/1996 | 26. | 0.085 | 0.174 | 0.016 | nd | 0.2 | 0.6 | nd | 4. | <1. | nd | 1.0 | 1. | nd | 2.1 |
| S030 | NM017 | Charles 4 | 8 | na | 6/27/1996 | 5. | 0.063 | 0.158 | 0.014 | nd | 0.2 | 0.4 | nd | 4. | <1. | nd | 0.7 | 1. | nd | 1.8 |
| S030 | NM018 | Charles 4 | 8 | na | 6/27/1996 | 4. | 0.068 | 0.158 | 0.014 | nd | 0.1 | 0.4 | nd | 4. | <1. | nd | 0.7 | <1. | nd | 1.9 |
| S030 | NM019 | Charles 4 | 8 | na | 6/27/1996 | 4. | 0.077 | 0.156 | 0.015 | nd | 0.1 | 0.4 | nd | 4. | <1. | nd | 0.8 | <1. | nd | 1.9 |
| S030 | NM020 | Charles 4 | 8 | na | 6/27/1996 | 7. | 0.077 | 0.166 | 0.016 | nd | 0.1 | 0.3 | nd | 4. | <1. | nd | 0.9 | 1. | nd | 1.9 |
| S030 | NM021 | Charles 4 | 8 | na | 6/27/1996 | 4. | 0.079 | 0.167 | 0.017 | nd | 0.1 | 0.4 | nd | 4. | <1. | nd | 0.9 | 1. | nd | 2.0 |
| S030 | NM022 | Charles 4 | 8 | na | 6/27/1996 | 9. | 0.083 | 0.167 | 0.017 | nd | 0.2 | 0.5 | nd | 4. | <1. | nd | 0.9 | 1. | nd | 2.0 |
| S030 | NM023 | Charles 4 | 8 | na | 6/27/1996 | 8. | 0.088 | 0.168 | 0.017 | nd | 0.2 | 0.4 | nd | 4. | <1. | nd | 1.0 | 1. | nd | 2.0 |
| S030 | NM024 | Charles 4 | 8 | na | 6/27/1996 | 4. | 0.085 | 0.169 | 0.017 | nd | 0.1 | 0.3 | nd | 4. | <1. | nd | 1.0 | 1. | nd | 2.0 |
| S042 | NM031 | Domestic Well #03 | 8 | na | 8/14/1996 | 5. | 0.031 | 0.102 | 0.009 | 5. | <0.1 | 0.2 | nd | 9.3 | 7. | nd | 3.6 | 16. | nd | 2.2 |
| S055 | NM042 | Elena Gallegos | 8 | na | 6/25/1996 | 10. | 0.030 | 0.049 | 0.023 | nd | 1.0 | 14 | nd | 2. | <2. | nd | 1.0 | <2. | nd | 21. |
| S056 | NM043 | Embudito Spring | 8 | na | 7/2/1996 | 5. | 0.047 | 0.126 | 0.036 | nd | <0.2 | 2.0 | nd | 3. | <2. | nd | <1. | <2. | nd | 11. |
| S056 | NM213 | Embudito Spring | 8 | na | 3/21/1997 | 1. | 0.017 | 0.065 | 0.021 | 40. | 0.1 | 1.0 | 0.6 | 1.9 | <1. | 0.40 | 1.5 | 0.4 | <1. | 8.2 |
| S056 | NM214 | Embudito Spring | 8 | na | 3/21/1997 | 1. | 0.017 | 0.067 | 0.022 | 4. | 0.1 | 1.0 | 0.4 | 1.8 | <1. | <0.1 | 1.5 | 0.4 | <1. | 7.9 |
| S056 | NM227 | Embudito Spring | 8 | na | 4/29/1997 | 1. | 0.021 | 0.062 | 0.022 | 50. | 0.1 | 1.0 | 0.6 | 2.2 | <1. | 0.10 | 1.2 | 0.4 | <1. | 5.2 |
| S056 | NM239 | Embudito Spring | 8 | na | 5/27/1997 | 1. | 0.021 | 0.064 | 0.026 | 35. | 0.1 | 1.2 | 0.7 | 2.1 | <1. | 0.10 | 1.1 | 0.4 | <1. | 4.6 |
| S056 | NM364 | Embudito Spring | 8 | na | 7/17/1997 | 1. | 0.005 | 0.044 | 0.013 | 104. | 0.1 | 3.5 | 0.4 | nd | <1. | <0.1 | 0.3 | 0.3 | 1. | 3.2 |
| S071 | NM060 | Domestic Well #07 | 8 | na | 6/19/1996 | 4. | 0.022 | 0.071 | 0.011 | nd | 0.5 | 1.7 | nd | 1. | <1. | nd | 0.7 | <1. | nd | 5.6 |
| S083 | NM407 | Windmill #34 | 8 | na | 9/10/1997 | 3. | 0.097 | 0.078 | 0.027 | 557. | 1.1 | 1.7 | 3.9 | 8. | 3. | <0.1 | 5.9 | 7.7 | 3. | 4.1 |
| S095 | NM068 | Kirtland 1 | 8 | na | 6/25/1996 | 4. | 0.036 | 0.105 | 0.017 | nd | 0.1 | 0.6 | nd | 6. | <1. | nd | 1.8 | 1. | nd | 1.9 |
| S106 | NM295 | Domestic Well #23 | 8 | na | 6/26/1997 | 9. | 0.113 | 0.071 | 0.042 | 7. | 0.1 | 3.7 | 7.6 | 9.6 | 1 | <0.05 | 4.2 | 16. | 2. | 12. |
| S110 | NM078 | Love 1 | 8 | na | 6/22/1996 | 5. | 0.029 | 0.101 | 0.016 | nd | <0.1 | 0.6 | nd | 7. | <1. | nd | 1.7 | 1. | nd | 1.4 |
| S113 | NM080 | Domestic Well #11 | 8 | na | 8/15/1996 | 6. | 0.080 | 0.034 | 0.018 | 2. | <0.1 | 0.5 | nd | 36. | 13. | nd | 2.6 | 15. | nd | 3.6 |
| S114 | NM500 | Matheson D | 8 | na | 7/31/1998 | 5. | 0.024 | 0.090 | 0.019 | 7. | <0.05 | 0.1 | 0.7 | 1. | <1. | 0.09 | 5.8 | 1.9 | <1. | 0.8 |
| S115 | NM501 | Matheson M | 8 | na | 8/1/1998 | 4. | 0.026 | 0.061 | 0.017 | 6. | 0.13 | 0.3 | 0.7 | 4.6 | 2. | 0.05 | 6.5 | 1.9 | <1. | 4.0 |
| S116 | NM502 | Matheson S | 8 | na | 8/1/1998 | 4. | 0.021 | 0.077 | 0.013 | 5. | <0.05 | 0.2 | 0.3 | 3.1 | 2. | 0.05 | 1.7 | 0.8 | <1. | 2.3 |
| S117 | NM298 | Domestic Well #25 | 8 | na | 6/17/1997 | 3. | 0.022 | 0.057 | 0.007 | 12. | <0.1 | 0.9 | 0.1 | 1.4 | 4. | 0.10 | 2.0 | <1. | <1. | 7.5 |
| S118 | NM299 | Windmill #24 | 8 | na | 6/27/1997 | 5. | 0.103 | 0.072 | 0.020 | 754. | 0.9 | 5.9 | 4.1 | 3.9 | 3. | 0.08 | 1.4 | 1.1 | 5. | 4.5 |
| S119 | NM300 | Domestic Well #26 | 8 | 11 | 6/19/1997 | 4. | 0.064 | 0.045 | 0.052 | 21. | 0.3 | 2.0 | 4.1 | 1.8 | <1. | <0.05 | 4.6 | <1. | 2. | 6.1 |
| S122 | NM304 | Mesa Del Sol S | 8 | na | 6/29/1997 | 128. | 0.332 | 0.003 | 0.035 | 4. | 0.1 | 0.6 | 1.7 | 0.3 | <1. | 0.12 | 22. | 30. | <1. | 1.9 |
| S122 | NM505 | Mesa Del Sol S | 8 | na | 7/25/1998 | 6. | 0.040 | 0.053 | 0.042 | 4. | 0.07 | 0.2 | 6.3 | 14. | 2. | 0.10 | 6.9 | 8.8 | 2. | 7.2 |

**Table A4.** Summary of trace-element chemistry-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secon-dary hydro-chemical zone | Date | Al (µg/L) | B (mg/L) | Ba (mg/L) | Li (mg/L) | Zn (µg/L) | Pb (µg/L) | Cu (µg/L) | Rb (µg/L) | V (µg/L) | Cr (µg/L) | Co (µg/L) | Mo (µg/L) | As (µg/L) | Se (µg/L) | U (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S140 | NM306 | MRN 1 | 8 | na | 7/5/1997 | 4. | 0.043 | 0.081 | 0.037 | 29. | <0.1 | 2.6 | 3.9 | 6.8 | 4. | 0.09 | 4.2 | 1.6 | 2. | 4.7 |
| S141 | NM095 | National Utility 7 | 8 | na | 8/14/1996 | 4. | 0.044 | 0.067 | 0.003 | 3. | <0.1 | 0.6 | nd | 3.7 | <1. | nd | 0.7 | 0.7 | nd | 0.8 |
| S149 | NM312 | Nor Este D | 8 | na | 7/3/1997 | 10. | 0.405 | 0.056 | 0.185 | 5. | <0.1 | 0.4 | 9.9 | 35. | <1. | 0.09 | 8.6 | 54. | 1. | 2.0 |
| S150 | NM313 | Nor Este M | 8 | na | 7/2/1997 | 7. | 0.262 | 0.057 | 0.320 | 20. | 0.1 | 1.5 | 7.3 | 26. | <1. | 0.15 | 3.7 | 38. | 1. | 1.4 |
| S162 | NM317 | Stock Well #03 | 8 | na | 6/30/1997 | 5. | 0.017 | 0.031 | <0.001 | 22. | 0.2 | 0.4 | 0.1 | 7. | 3. | 0.60 | 0.4 | <1. | 1. | 0.6 |
| S163 | NM318 | PL 2 | 8 | na | 7/7/1997 | 9. | 0.033 | 0.075 | <0.001 | 32. | <0.1 | 1.8 | 1.2 | 6.3 | 3. | 0.10 | 3.2 | 1.1 | 1. | 2.7 |
| S164 | NM106 | Ponderosa 1 | 8 | na | 6/20/1996 | 4. | 0.126 | 0.199 | 0.053 | nd | 0.1 | 0.3 | nd | 2.7 | <1. | nd | 3.2 | 17. | nd | 7.0 |
| S165 | NM328 | Windmill #25 | 8 | na | 6/24/1997 | 3. | 0.104 | 0.015 | 0.015 | 102. | 5.5 | 5.7 | 5.0 | 18. | 6. | 0.09 | 3.7 | 3.1 | 2. | 8.1 |
| S168 | NM319 | Domestic Well #30 | 8 | na | 6/27/1997 | 9. | 0.039 | 0.044 | <0.001 | 8. | 0.3 | 1.0 | 0.7 | 44. | 19. | <0.05 | 2.1 | 11. | 2. | 1.2 |
| S170 | NM108 | Ridgecrest 3 | 8 | na | 6/22/1996 | 6. | 0.030 | 0.159 | 0.015 | nd | <0.1 | 0.7 | nd | 8. | 1. | nd | 1.2 | 2. | nd | 1.6 |
| S170 | NM412 | Ridgecrest 3 | 8 | na | 11/18/1997 | 6. | 0.037 | 0.145 | 0.015 | 2. | <0.1 | 0.5 | 1.7 | 7.8 | 2. | <0.1 | 1.2 | 2.7 | 2. | 1.7 |
| S195 | NM134 | Domestic Well #13 | 8 | na | 8/14/1996 | 4. | 0.038 | 0.068 | 0.01 | 3. | <0.1 | 0.4 | nd | 21. | 6. | nd | 2.9 | 3.8 | nd | 3.1 |
| S199 | NM138 | Windmill #08 | 8 | na | 8/23/1996 | 4. | 0.034 | 0.053 | 0.013 | 1,140. | 1.0 | 7.6 | nd | 3.9 | 4. | nd | 1.4 | 1.7 | nd | 16. |
| S209 | NM336 | Domestic Well #33 | 8 | na | 6/27/1997 | 4. | 0.118 | 0.061 | 0.029 | 13. | 0.2 | 1.1 | 3.6 | 4. | <1. | <0.05 | 5.9 | 13.7 | 3. | 13. |
| S212 | NM141 | Sandia Peak 1 | 8 | na | 6/26/1996 | 6. | 0.022 | 0.050 | 0.014 | nd | 0.8 | 0.7 | nd | 1. | <1. | nd | 0.8 | <1. | nd | 2.1 |
| S213 | NM142 | Sandia Peak 3 | 8 | na | 6/26/1996 | 5. | 0.029 | 0.065 | 0.016 | nd | 1.0 | 0.8 | nd | 1.3 | <1. | nd | 0.8 | <1. | nd | 4.4 |
| S224 | NM148 | Domestic Well #14 | 8 | na | 8/23/1996 | 3. | 0.029 | 0.088 | 0.011 | 165. | 1.3 | 0.5 | nd | 3.8 | <1. | nd | 2.3 | 12. | nd | 2.1 |
| S229 | NM515 | SH03 UNM | 8 | na | 7/28/1998 | 4. | 0.020 | 0.055 | 0.009 | 3. | 0.05 | 0.4 | 0.5 | 1.2 | <1. | 0.09 | 2.0 | 0.5 | 1. | 15. |
| S233 | NM153 | Domestic Well #16 | 8 | na | 8/23/1996 | 2. | 0.121 | 0.107 | 0.066 | 8. | 0.2 | 0.3 | nd | 6.7 | 2. | nd | 2.8 | 18. | nd | 4.3 |
| S239 | NM156 | Domestic Well #17 | 8 | na | 8/17/1996 | 3. | 0.052 | 0.064 | 0.023 | 6. | <0.1 | 0.8 | nd | 2.8 | <1. | nd | 3.1 | 2.4 | nd | 4.4 |
| S240 | NM157 | Domestic Well #18 | 8 | na | 6/19/1996 | 5. | 0.019 | 0.044 | 0.015 | nd | 2.0 | 1.0 | nd | 1.9 | <1. | nd | 0.5 | <1. | nd | 3.2 |
| S246 | NM343 | Windmill #32 | 8 | na | 6/24/1997 | 4. | 0.049 | 0.043 | <0.001 | 239. | 0.2 | 2.3 | 0.9 | 3.6 | 1 | 0.20 | 1.1 | <1. | 2. | 1.3 |
| S247 | NM161 | Domestic Well #19 | 8 | na | 8/15/1996 | 6. | 0.134 | 0.005 | 0.010 | <1. | <0.1 | 0.2 | nd | 35. | 13. | nd | 4.5 | 5.2 | nd | 6.7 |
| S248 | NM162 | Thomas 6 | 8 | na | 6/21/1996 | 4. | 0.103 | 0.176 | 0.024 | 2. | <0.1 | 0.3 | nd | 3. | <1. | nd | 3.7 | 6. | nd | 4.3 |
| S255 | NM523 | Tramway East | 8 | na | 7/30/1998 | 3. | 0.022 | 0.046 | 0.033 | 63. | 0.11 | 0.4 | 0.4 | 1.9 | <1. | <0.05 | 1.5 | 0.7 | 1. | 3.2 |
| S264 | NM174 | Walker 1 | 8 | na | 6/18/1996 | 3. | 0.040 | 0.093 | 0.041 | 1. | <0.1 | 0.3 | nd | 2.7 | 1. | nd | 1.4 | 19. | nd | 2.3 |
| S274 | NM177 | Domestic Well #20 | 8 | na | 8/15/1996 | 3. | 0.084 | 0.082 | 0.026 | 2. | <0.1 | 0.1 | nd | 8.2 | 5. | nd | 2.2 | 4.5 | nd | 3.7 |
| | | **Zone 9: Tijeras Fault Zone** | | | | | | | | | | | | | | | | | | |
| S041 | NM029 | Coyote Spring | 9 | na | 6/28/1996 | 122. | 1.23 | 0.104 | 2.52 | nd | <0.5 | 5.0 | nd | 2. | <2. | nd | <2. | <5. | nd | 6.6 |
| S072 | NM061 | Hubbell Spring | 9 | 8 | 8/23/1996 | 3. | 0.126 | 0.028 | 0.036 | 117. | <0.1 | 1.1 | nd | 14. | 1. | nd | 8.5 | 3.7 | nd | 6.4 |
| S098 | NM071 | KAFB-1902 | 9 | na | 6/28/1996 | 7. | 0.418 | 0.037 | 0.223 | nd | <0.5 | 44. | nd | <1. | <2. | nd | 16. | <2. | nd | 8.0 |
| S197 | NM136 | Windmill #06 | 9 | na | 8/23/1996 | 2. | 0.426 | 0.014 | 0.079 | 112. | <0.1 | 1.5 | nd | 7.8 | <1. | nd | 1.5 | 2.3 | nd | 2.7 |
| S227 | NM151 | SFR 3D | 9 | na | 8/24/1996 | 5. | 0.276 | 0.060 | 0.341 | 9. | 0.2 | 3.6 | nd | 5.8 | 2. | nd | 2.8 | 1.6 | nd | 19. |
| S228 | NM152 | SFR 3S | 9 | na | 8/24/1996 | 6. | 0.270 | 0.055 | 0.230 | 11. | 0.7 | 50. | nd | 6.8 | 2. | nd | 4.6 | 1.7 | nd | 15. |
| | | **Zone 10: Tijeras Arroyo** | | | | | | | | | | | | | | | | | | |
| S001 | NM001 | 4Hills-1 | 10 | 8 | 6/29/1996 | 5. | 0.082 | 0.046 | 0.027 | nd | <0.2 | 2.0 | nd | 1. | <2. | nd | 2.0 | <2. | nd | 7.8 |
| S002 | NM250 | Private Production Well #15 | 10 | 8 | 7/3/1997 | 4. | 0.054 | 0.050 | <0.001 | 2. | 0.1 | 0.8 | 0.5 | 1.8 | 1. | 0.09 | 1.2 | <1. | 3. | 4.5 |
| S058 | NM277 | Eubank 1 | 10 | 8 | 7/4/1997 | 5. | 0.041 | 0.043 | 0.013 | 7. | <0.1 | 2.8 | 0.3 | 3.9 | 4. | 0.11 | 2.0 | <1. | 2. | 3.7 |
| S096 | NM069 | Kirtland 11 | 10 | 8 | 6/25/1996 | 4. | 0.061 | 0.065 | 0.025 | nd | <0.1 | 1.0 | nd | 5. | <1. | nd | 1.9 | <1. | nd | 3.3 |
| S107 | NM075 | Lomas 1 | 10 | 8 | 6/22/1996 | <1. | 0.030 | 0.106 | 0.017 | nd | <0.1 | 0.3 | nd | 3. | <1. | nd | 0.4 | <1. | nd | 2.7 |
| S107 | NM410 | Lomas 1 | 10 | na | 11/18/1997 | 22. | 0.031 | 0.089 | 0.017 | 2. | <0.1 | 0.8 | 0.3 | 2.8 | <1. | <0.1 | 0.5 | <1. | 4. | 3.7 |
| | | **Zone 11: Northeastern** | | | | | | | | | | | | | | | | | | |
| S016 | NM258 | Windmill #15 | 11 | na | 6/18/1997 | <5. | 0.439 | 0.013 | 0.070 | 259. | 0.3 | 4.6 | 4.1 | 30. | 16. | <0.1 | 31. | 155. | 14. | 8.5 |
| S017 | NM259 | Windmill #16 | 11 | na | 6/18/1997 | 4. | 0.473 | 0.023 | <0.001 | 442. | <0.1 | 4.2 | 0.4 | 1.5 | 1. | 0.08 | 12. | 1.0 | 3. | 12. |
| S053 | NM276 | Private Production Well #18 | 11 | na | 6/25/1997 | <5. | 0.143 | 0.012 | 0.044 | 41. | <0.1 | 2.9 | 2.0 | 3.3 | 5. | 0.19 | 5.7 | 1.9 | 5. | 3.2 |
| S144 | NM097 | Private Production Well #06 | 11 | na | 8/28/1996 | 2. | 0.074 | 0.014 | 0.178 | 86. | 0.1 | 1.4 | nd | 6.1 | 3. | nd | 7.7 | 7.5 | nd | 14. |
| S204 | NM332 | Windmill #28 | 11 | na | 7/3/1997 | 4. | 0.060 | 0.036 | <0.001 | 263. | 0.2 | 4.5 | 1.1 | 3.0 | 1. | 0.08 | 9.4 | 2.0 | 3. | 2.9 |
| S207 | NM334 | Private Production Well #22 | 11 | na | 7/3/1997 | <5. | 0.117 | 0.010 | 0.040 | 22. | 0.8 | 3.7 | 2.2 | 3.8 | 12. | 0.22 | 4.7 | 2.3 | 5. | 4.2 |

**Table A4.** Summary of trace-element chemistry-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secon-dary hydro-chemical zone | Date | Al (µg/L) | B (mg/L) | Ba (mg/L) | Li (mg/L) | Zn (µg/L) | Pb (µg/L) | Cu (µg/L) | Rb (µg/L) | V (µg/L) | Cr (µg/L) | Co (µg/L) | Mo (µg/L) | As (µg/L) | Se (µg/L) | U (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S223 | NM338 | Windmill #29 | 11 | na | 6/25/1997 | 2. | 0.215 | 0.013 | 0.033 | 100. | <0.1 | 1.2 | 0.9 | 9.2 | <1. | 0.09 | 4.7 | 2.2 | 4. | 9.0 |
| | | **Zone 12: Central** | | | | | | | | | | | | | | | | | | |
| S011 | NM004 | Atris-1 | 12 | na | 6/22/1996 | 11. | 0.064 | 0.073 | 0.042 | nd | <0.1 | 0.8 | nd | <1. | <1. | nd | 4.4 | 5. | nd | 1.3 |
| S012 | NM005 | Atrisco 3 | 12 | 3 | 6/20/1996 | 5. | 0.149 | 0.460 | 0.064 | nd | <0.1 | 0.3 | nd | 19. | <1. | nd | 5.1 | 9. | nd | 4.7 |
| S025 | NM012 | Burton 2 | 12 | na | 6/19/1996 | 5. | 0.088 | 0.123 | 0.027 | nd | <0.1 | 0.3 | nd | 8. | <1. | nd | 3.4 | 4. | nd | 3.8 |
| S026 | NM013 | Burton 5 | 12 | na | 6/19/1996 | 5. | 0.085 | 0.140 | 0.036 | nd | <0.1 | 0.2 | nd | 8. | <1. | nd | 3.7 | 6. | nd | 2.8 |
| S033 | NM025 | Private Production Well #02 | 12 | na | 8/21/1996 | 4. | 0.098 | 0.147 | 0.017 | 3. | 0.5 | 1.0 | nd | 5.2 | 1. | nd | 2.7 | 3.5 | nd | 6.9 |
| S040 | NM028 | Coronado 1 | 12 | na | 6/18/1996 | 6. | 0.201 | 0.094 | 0.256 | nd | 0.1 | 1.1 | nd | 26. | 3. | nd | 4.4 | 27. | nd | 1.4 |
| S043 | NM267 | Del Sol D | 12 | na | 7/1/1997 | 7. | 0.286 | 0.108 | <0.001 | 6. | <0.1 | 0.2 | 7.0 | 28. | 8. | <0.05 | 5.8 | 38. | 2. | 4.2 |
| S043 | NM488 | Del Sol D | 12 | na | 7/21/1998 | 5. | 0.164 | 0.093 | 0.127 | 2. | <0.05 | 0.3 | 6.8 | 29. | 7. | <0.05 | 4.9 | 38. | 2. | 4.5 |
| S044 | NM268 | Del Sol M | 12 | na | 6/26/1997 | 7. | 0.304 | 0.116 | <0.001 | 3. | 0.1 | 2.6 | 6.6 | 4.4 | 2. | 0.23 | 7.2 | 9.6 | 1. | 12. |
| S044 | NM489 | Del Sol M | 12 | na | 7/21/1998 | 4. | 0.191 | 0.097 | 0.070 | 1. | <0.05 | <0.1 | 6.4 | 4.1 | 1. | 0.07 | 6.6 | 9.5 | 1. | 14. |
| S045 | NM269 | Del Sol S | 12 | na | 6/26/1997 | 6. | 0.059 | 0.220 | <0.001 | 4. | <0.1 | 1.3 | 5.6 | 4.3 | <1. | 0.16 | 2.9 | 3.3 | 12. | 1.8 |
| S045 | NM490 | Del Sol S | 12 | na | 7/21/1998 | 3. | 0.039 | 0.174 | 0.028 | 3. | <0.05 | 0.4 | 5.5 | 3.8 | <1. | 0.07 | 2.0 | 3.8 | 13. | 1.8 |
| S046 | NM032 | Duranes 1 | 12 | na | 6/20/1996 | 4. | 0.126 | 0.068 | 0.135 | nd | 0.1 | 0.5 | nd | 24. | <1. | nd | 2.2 | 16. | nd | 10. |
| S046 | NM033 | Duranes 1 | 12 | na | 6/29/1996 | 4. | 0.136 | 0.069 | 0.150 | nd | <0.1 | 0.5 | nd | 14. | <1. | nd | 2.3 | 11. | nd | 15. |
| S046 | NM034 | Duranes 1 | 12 | na | 6/29/1996 | 4. | 0.132 | 0.074 | 0.152 | nd | <0.1 | 1.4 | nd | 14. | <1. | nd | 2.3 | 11. | nd | 15. |
| S046 | NM035 | Duranes 1 | 12 | na | 6/29/1996 | 4. | 0.136 | 0.077 | 0.152 | nd | <0.1 | 0.6 | nd | 14. | <1. | nd | 2.2 | 11. | nd | 15. |
| S046 | NM036 | Duranes 1 | 12 | na | 6/29/1996 | 4. | 0.140 | 0.081 | 0.158 | nd | <0.1 | 0.5 | nd | 14. | <1. | nd | 2.1 | 11. | nd | 15. |
| S046 | NM037 | Duranes 1 | 12 | na | 6/29/1996 | 6. | 0.136 | 0.084 | 0.163 | nd | <0.1 | 0.5 | nd | 14. | <1. | nd | 2.1 | 11. | nd | 14. |
| S046 | NM038 | Duranes 1 | 12 | na | 6/29/1996 | 4. | 0.142 | 0.087 | 0.162 | nd | <0.1 | 4.8 | nd | 14. | <1. | nd | 2.1 | 11. | nd | 15. |
| S046 | NM039 | Duranes 1 | 12 | na | 6/29/1996 | 4. | 0.140 | 0.090 | 0.166 | nd | <0.1 | 0.5 | nd | 13. | <1. | nd | 2.1 | 11. | nd | 14. |
| S046 | NM040 | Duranes 1 | 12 | na | 6/29/1996 | 4. | 0.145 | 0.091 | 0.167 | nd | <0.1 | 0.4 | nd | 13. | 1. | nd | 2.0 | 11. | nd | 14. |
| S047 | NM270 | Duranes 7 | 12 | na | 6/26/1997 | 6. | 0.086 | 0.052 | 0.050 | 21. | 0.4 | 0.7 | 8.0 | 14. | 3. | 0.10 | 4.0 | 7.3 | <1. | 6.0 |
| S048 | NM271 | Duranes Yard 1 | 12 | na | 7/5/1997 | 5. | 0.069 | 0.062 | 0.034 | 6. | <0.1 | 0.4 | 7.3 | 5.1 | 2. | 0.46 | 5.6 | 4.6 | <1. | 4.3 |
| S049 | NM272 | Duranes Yard 2 | 12 | na | 7/5/1997 | 5. | 0.070 | 0.100 | 0.036 | 6. | <0.1 | 0.3 | 4.5 | 0.6 | 3. | 0.24 | 4.2 | 3.2 | <1. | 2.8 |
| S050 | NM273 | Duranes Yard 3 | 12 | na | 7/5/1997 | 5. | 0.063 | 0.108 | 0.032 | 6. | <0.1 | 11 | 4.6 | 0.9 | 3. | 0.13 | 4.0 | 4.5 | <1. | 3.9 |
| S051 | NM274 | Duranes Yard 4 | 12 | na | 7/5/1997 | 7. | 0.059 | 0.104 | 0.032 | 6. | 0.1 | 7.9 | 2.4 | 2.9 | 3. | 0.22 | 3.8 | 5.3 | <1. | 6.2 |
| S052 | NM275 | Duranes Yard 5 | 12 | na | 7/5/1997 | 6. | 0.063 | 0.084 | 0.028 | 10. | 0.1 | 5.8 | 2.1 | 1.8 | 3. | 0.14 | 4.2 | 5.5 | <1. | 1.6 |
| S060 | NM279 | Garfield D | 12 | 3 | 6/19/1997 | 8. | 0.261 | 0.040 | <0.001 | 2. | <0.1 | 0.1 | 4.4 | 37. | 2. | <0.05 | 3.0 | 51. | <1. | 3.6 |
| S061 | NM280 | Garfield M | 12 | na | 6/19/1997 | 5. | 0.171 | 0.069 | <0.001 | 18. | <0.1 | <0.1 | 5.9 | 12. | <1. | 0.07 | 5.0 | 22. | <1. | 2.9 |
| S062 | NM281 | Garfield S | 12 | na | 6/19/1997 | 4. | 0.107 | 0.041 | <0.001 | 7. | <0.1 | 0.4 | 8.2 | 0.2 | 1. | 0.45 | 4.9 | 4.7 | <1. | 14. |
| S062 | NM491 | Garfield S | 12 | na | 7/28/1998 | 4. | 0.09 | 0.040 | 0.065 | 3. | 0.07 | 1.1 | 7.9 | <0.1 | <1. | 0.43 | 4.8 | 4.9 | <1. | 12. |
| S064 | NM283 | Domestic Well #22 | 12 | na | 6/20/1997 | 5. | 0.052 | 0.073 | 0.033 | 16. | 0.5 | 0.5 | 11. | 7.6 | 4. | 0.12 | 4.0 | 4.5 | 2. | 4.1 |
| S068 | NM057 | Griegos 3 | 12 | na | 6/21/1996 | 4. | 0.089 | 0.058 | 0.074 | nd | <0.1 | 0.2 | nd | 14. | <1. | nd | 3.4 | 6. | nd | 4.1 |
| S075 | NM286 | Hunter Ridge Nest 1 Well 1 | 12 | 3 | 6/20/1997 | 6. | 0.378 | 0.043 | <0.001 | 5. | <0.1 | 0.0 | 5.1 | 17. | 4. | <0.05 | 15. | 5.9 | <1. | 8.5 |
| S076 | NM287 | Hunter Ridge Nest 1 Well 2 | 12 | na | 6/21/1997 | 4. | 0.056 | 0.069 | 0.030 | 10. | <0.1 | 0.3 | 7.1 | 7.4 | 8. | 0.22 | 4.4 | 4.0 | <1. | 4.4 |
| S077 | NM288 | Hunter Ridge Nest 1 Well 3 | 12 | na | 6/20/1997 | 6. | 0.101 | 0.043 | <0.001 | 6. | <0.1 | 0.3 | 7.3 | 6.2 | 2. | 0.09 | 8.3 | 3.6 | 2. | 3.9 |
| S078 | NM289 | Hunter Ridge Nest 2 Well 1 | 12 | na | 6/21/1997 | 4. | 0.080 | 0.040 | <0.001 | 9. | <0.1 | 0.2 | 12. | 3.7 | 2. | 0.22 | 9.0 | 2.7 | <1. | 2.8 |
| S079 | NM290 | Hunter Ridge Nest 2 Well 2 | 12 | na | 6/21/1997 | 5. | 0.085 | 0.031 | <0.001 | 4. | <0.1 | 0.1 | 10. | 4.5 | <1. | 0.21 | 8.5 | 2.8 | <1. | 2.0 |
| S080 | NM291 | Hunter Ridge Nest 2 Well 3 | 12 | na | 6/21/1997 | 5. | 0.087 | 0.034 | <0.001 | 3. | 0.1 | 0.3 | 10. | 5.1 | 2. | 0.05 | 4.3 | 3.1 | 2. | 2.4 |
| S081 | NM292 | Private Production Well #19 | 12 | na | 7/2/1997 | 4. | 0.079 | 0.060 | 0.049 | 11. | 0.1 | 2.8 | 7.9 | 10. | <1. | <0.05 | 5.1 | 4.6 | <1. | 4.0 |
| S084 | NM063 | Windmill #04 | 12 | na | 8/21/1996 | 3. | 0.089 | 0.045 | 0.049 | 377. | 2.7 | 0.8 | nd | 12. | 2. | nd | 4.6 | 3.5 | nd | 12. |
| S087 | NM493 | Isleta MD | 12 | 3 | 7/29/1998 | 8. | 0.142 | 0.028 | 0.045 | 1. | <0.05 | 0.2 | 5.1 | 41. | <1. | <0.05 | 7.0 | 43. | <1. | 8.9 |
| S088 | NM494 | Isleta MS | 12 | na | 7/29/1998 | 5. | 0.056 | 0.058 | 0.030 | 2. | <0.05 | 0.2 | 6.6 | 4.9 | <1. | 0.13 | 4.6 | 5.8 | <1. | 1.5 |
| S089 | NM495 | Isleta S | 12 | na | 7/29/1998 | 4. | 0.126 | 0.169 | 0.069 | 3. | <0.05 | 0.7 | 5.2 | <0.1 | <1. | 0.21 | 7.6 | 3.2 | <1. | 1.9 |
| S092 | NM066 | JMC-1 | 12 | na | 6/28/1996 | 11. | 0.094 | 0.078 | 0.044 | nd | 0.1 | 1.2 | nd | 5. | <1. | nd | 0.7 | 2. | nd | 11. |
| S097 | NM070 | Kirtland 14 | 12 | na | 6/25/1996 | 6. | 0.079 | 0.128 | 0.021 | nd | <0.1 | 0.5 | nd | 10 | <1. | nd | 2.3 | 4. | nd | 2.2 |

**Table A4.** Summary of trace-element chemistry-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secon-dary hydro-chemical zone | Date | Al (µg/L) | B (mg/L) | Ba (mg/L) | Li (mg/L) | Zn (µg/L) | Pb (µg/L) | Cu (µg/L) | Rb (µg/L) | V (µg/L) | Cr (µg/L) | Co (µg/L) | Mo (µg/L) | As (µg/L) | Se (µg/L) | U (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S100 | NM073 | LALF-9 | 12 | na | 6/29/1996 | 3. | 0.107 | 0.195 | 0.042 | nd | <0.2 | <1. | nd | <1. | <2. | nd | 4. | 2. | nd | 8.0 |
| S102 | NM074 | Leyendecker 1 | 12 | na | 6/21/1996 | 4. | 0.049 | 0.083 | 0.029 | nd | <0.1 | 0.3 | nd | 4. | <1. | nd | 4.1 | 5. | nd | 2.4 |
| S120 | NM301 | Mesa Del Sol D | 12 | na | 6/29/1997 | 7. | 0.040 | 0.042 | 0.035 | 15. | <0.1 | 1.0 | 5.9 | 15. | 2. | 0.08 | 16. | 11. | 3. | 21. |
| S120 | NM303 | Mesa Del Sol D | 12 | na | 6/28/1997 | 8. | 0.063 | 0.016 | 0.051 | 14. | <0.1 | 1.2 | 4.0 | 6.9 | 2. | 0.13 | 35. | 14. | 2. | 33. |
| S120 | NM503 | Mesa Del Sol D | 12 | na | 8/2/1998 | 51. | 0.351 | 0.002 | 0.039 | 2. | 0.06 | 0.3 | 1.3 | <0.1 | <1. | <0.05 | 9.9 | 45. | <1. | 0.2 |
| S121 | NM302 | Mesa Del Sol M | 12 | na | 6/28/1997 | 29. | 0.323 | 0.002 | 0.056 | 5. | <0.1 | 0.7 | 1.1 | 0.1 | <1. | <0.05 | 7.6 | 23. | <1. | 1.6 |
| S121 | NM504 | Mesa Del Sol M | 12 | na | 7/25/1998 | 20. | 0.349 | 0.002 | 0.069 | 1. | <0.05 | 0.2 | 0.9 | <0.1 | <1. | <0.05 | 4.4 | 27. | <1. | 0.6 |
| S123 | NM081 | MONT - 5A | 12 | na | 6/27/1996 | 6. | 0.072 | 0.090 | 0.027 | nd | <0.1 | 0.7 | nd | 6. | <1. | nd | 1.7 | 4. | nd | 5.1 |
| S124 | NM082 | Montaňo 2 D | 12 | na | 6/19/1996 | 6. | 0.067 | 0.088 | 0.051 | nd | <0.1 | 0.6 | nd | 7. | <1. | nd | 6.6 | 4. | nd | 6.0 |
| S125 | NM083 | Montaňo 2 M | 12 | na | 6/19/1996 | 5. | 0.086 | 0.141 | 0.056 | nd | <0.1 | 0.6 | nd | 5. | <1. | nd | 8.5 | 3. | nd | 10. |
| S126 | NM084 | Montaňo 2 S | 12 | na | 6/19/1996 | 8. | 0.081 | 0.062 | 0.057 | nd | <0.1 | 1.0 | nd | <1. | <1. | nd | 7.2 | 4. | nd | 0.4 |
| S127 | NM085 | Montaňo 4 D | 12 | na | 6/20/1996 | 5. | 0.062 | 0.132 | 0.033 | nd | <0.1 | 0.9 | nd | 6. | <1. | nd | 3.9 | 5. | nd | 6.4 |
| S128 | NM086 | Montaňo 4 M | 12 | na | 6/19/1996 | 6. | 0.140 | 0.060 | 0.067 | nd | <0.2 | 1.0 | nd | 3. | <2. | nd | 11. | 3. | nd | 19. |
| S130 | NM088 | Montaňo 5 D | 12 | na | 6/24/1996 | 10. | 0.063 | 0.065 | 0.044 | nd | <0.1 | 0.8 | nd | 6. | <1. | nd | 6.8 | 4. | nd | 2.3 |
| S131 | NM089 | Montaňo 5 M | 12 | na | 6/24/1996 | 7. | 0.055 | 0.085 | 0.031 | nd | <0.1 | 0.5 | nd | 0.5 | <1. | nd | 4.5 | 4. | nd | 5.5 |
| S132 | NM090 | Montaňo 5 S | 12 | na | 6/24/1996 | 12. | 0.048 | 0.074 | 0.023 | nd | <0.1 | 4.8 | nd | 4.5 | <1. | nd | 3.5 | 2.9 | nd | 1.9 |
| S133 | NM091 | Montaňo 6 D | 12 | na | 6/18/1996 | 6. | 0.120 | 0.093 | 0.110 | nd | <0.1 | 0.6 | nd | <1. | <1. | nd | 5.6 | 4.4 | nd | 4.2 |
| S134 | NM092 | Montaňo 6 MD | 12 | na | 6/18/1996 | 14. | 0.070 | 0.064 | 0.058 | nd | 0.1 | 0.9 | nd | 11. | <1. | nd | 1.8 | 6. | nd | 3.3 |
| S135 | NM093 | Montaňo 6 MS | 12 | na | 6/18/1996 | 15. | 0.044 | 0.066 | 0.040 | nd | <0.1 | 0.3 | nd | 9.6 | <1. | nd | 3.4 | 6. | nd | 2.3 |
| S136 | NM094 | Montaňo 6 S | 12 | na | 6/18/1996 | 7. | 0.068 | 0.071 | 0.040 | nd | <0.1 | 0.8 | nd | 4.8 | <1. | nd | 11 | 3.8 | nd | 5.4 |
| S137 | NM506 | Montesa M | 12 | na | 7/27/1998 | 4. | 0.090 | 0.098 | 0.087 | 3. | <0.05 | 0.2 | 7.6 | 10. | <1. | 0.07 | 4.0 | 16. | <1. | 2.1 |
| S138 | NM507 | Montesa S | 12 | na | 7/27/1998 | 5. | 0.054 | 0.080 | 0.014 | 9. | <0.05 | 0.4 | 6.5 | 7.3 | 1. | <0.05 | 5.1 | 2.8 | <1. | 1.6 |
| S139 | NM305 | Domestic Well #27 | 12 | na | 6/17/1997 | 5. | 0.086 | 0.056 | 0.035 | 26. | 0.3 | 0.5 | 12. | 12. | 5. | 0.08 | 2.7 | 6.1 | <1. | 7.5 |
| S142 | NM307 | Domestic Well #28 | 12 | na | 6/17/1997 | 3. | 0.049 | 0.083 | <0.001 | 42. | <0.1 | 0.2 | 11. | 7.4 | <1. | 0.08 | 4.4 | 3.7 | <1. | 2.4 |
| S146 | NM309 | NM Utilities 2 | 12 | na | 6/18/1997 | 3. | 0.064 | 0.062 | 0.042 | 9. | 0.4 | 0.7 | 9.1 | 18. | <1. | <0.05 | 2.6 | 11. | <1. | 3.2 |
| S151 | NM314 | Nor Este S | 12 | na | 7/2/1997 | 8. | 0.132 | 0.071 | 0.083 | 11. | <0.1 | 0.2 | 4.5 | 13. | <1. | 0.21 | 16. | 23. | <1. | 3.4 |
| S151 | NM508 | Nor Este S | 12 | na | 7/20/1998 | 16. | 0.118 | 0.084 | 0.100 | 2. | <0.05 | 0.2 | 5.3 | 11. | <1. | 0.18 | 17. | 22. | <1. | 5.0 |
| S153 | NM315 | Open Space | 12 | 10 | 6/17/1997 | 4. | 0.042 | 0.113 | <0.001 | 20. | 0.8 | 3.4 | 3.6 | 5.3 | 2. | 2.4 | 3.5 | 2.0 | <1. | 0.7 |
| S153 | NM411 | Open Space | 12 | na | 11/18/1997 | 3. | 0.043 | 0.108 | 0.010 | 20. | 1.3 | 6.7 | 3.5 | 5. | 2. | <0.1 | 3.5 | 2.2 | <1. | 0.7 |
| S154 | NM099 | ORLF-2 | 12 | na | 6/27/1996 | 4. | 0.066 | 0.066 | 0.048 | nd | <0.1 | 0.8 | nd | 5.3 | <1. | nd | 3.6 | 8. | nd | 3.2 |
| S155 | NM316 | Domestic Well #29 | 12 | na | 6/27/1997 | 4. | 0.047 | 0.062 | <0.001 | 4. | 0.1 | 0.9 | 4.0 | 9. | <1. | <0.05 | 3.0 | 4.5 | <1. | 1.9 |
| S156 | NM100 | Paseo 2D | 12 | na | 6/26/1996 | 23. | 0.063 | 0.084 | 0.033 | nd | <0.1 | 1.1 | nd | 2.7 | <1. | nd | 2.0 | 3.1 | nd | 2.1 |
| S157 | NM101 | Paseo 2MD | 12 | na | 6/26/1996 | 13. | 0.068 | 0.057 | 0.041 | nd | <0.1 | 0.5 | nd | <1. | <1. | nd | 4.7 | 3.8 | nd | 1.3 |
| S158 | NM102 | Paseo 2MS | 12 | na | 6/26/1996 | 6. | 0.094 | 0.063 | 0.058 | nd | <0.1 | 0.4 | nd | <1. | <1. | nd | 6.4 | 6.8 | nd | 0.2 |
| S159 | NM103 | Paseo 2S | 12 | na | 6/26/1996 | 6. | 0.098 | 0.217 | 0.065 | nd | <0.2 | 1.0 | nd | 2. | <2. | nd | 2.0 | 2. | nd | 10. |
| S160 | NM104 | Paseo 3D | 12 | na | 6/21/1996 | 4. | 0.050 | 0.071 | 0.030 | nd | <0.1 | 2.1 | nd | 2. | <1. | nd | 3.5 | 5. | nd | 1.6 |
| S161 | NM105 | Paseo 3M | 12 | na | 6/21/1996 | 6. | 0.101 | 0.067 | 0.061 | nd | <0.2 | 2.0 | nd | 2. | <2. | nd | 8. | <2. | nd | 7.6 |
| S171 | NM321 | Ridgecrest 4 | 12 | na | 6/26/1997 | 5. | 0.072 | 0.185 | <0.001 | 1. | <0.1 | 0.7 | 3.2 | 6.8 | 2. | 0.12 | 1.6 | 2.6 | 1. | 2.8 |
| S173 | NM323 | Rio Bravo 5 M | 12 | 3 | 7/4/1997 | 5. | 0.095 | 0.038 | 0.071 | 5. | <0.1 | 0.6 | 5.9 | 15. | <1. | <0.05 | 9.9 | 21. | <1. | 4.3 |
| S176 | NM111 | Rio Bravo 1 S | 12 | na | 6/17/1996 | 7. | 0.058 | 0.151 | 0.041 | nd | <0.2 | 1.0 | nd | <1. | <2. | nd | 7. | 7. | nd | 1.4 |
| S177 | NM112 | Rio Bravo 2 D | 12 | 3 | 6/25/1996 | 4. | 0.210 | 0.089 | 0.098 | nd | 0.2 | 0.3 | nd | 17. | <1. | nd | 4.2 | 23. | nd | 3.3 |
| S178 | NM113 | Rio Bravo 2 M | 12 | na | 6/25/1996 | 5. | 0.237 | 0.119 | 0.130 | nd | 0.2 | 0.6 | nd | 11. | <1. | nd | 2.1 | 10. | nd | 10. |
| S179 | NM114 | Rio Bravo 2 S | 12 | na | 6/25/1996 | 4. | 0.137 | 0.087 | 0.072 | nd | 0.2 | 8.7 | nd | 6.7 | <1. | nd | 11. | 9.5 | nd | 7.8 |
| S180 | NM115 | Rio Bravo 4 D | 12 | na | 6/25/1996 | 10. | 0.060 | 0.149 | 0.026 | nd | 0.2 | 0.2 | nd | 1. | <1. | nd | 2.3 | 7.4 | nd | 2.7 |
| S181 | NM116 | Rio Bravo 4 M | 12 | na | 6/25/1996 | 4. | 0.084 | 0.074 | 0.033 | nd | 0.1 | 0.7 | nd | 6.3 | <1. | nd | 1.0 | 4.7 | nd | 3.9 |
| S183 | NM126 | Rio Grande Utility 5 | 12 | 3 | 8/15/1996 | 4. | 0.131 | 0.081 | 0.039 | 2. | <0.1 | 0.2 | nd | 12. | 1. | nd | 5.8 | 15. | nd | 5.6 |
| S184 | NM127 | Rio Grande Utility 6 | 12 | na | 8/15/1996 | 4. | 0.059 | 0.091 | 0.026 | 2. | <0.1 | 0.1 | nd | 12. | <1. | nd | 3.2 | 6.8 | nd | 3.1 |
| S190 | NM325 | Rio Rancho 2 | 12 | na | 6/20/1997 | 3. | 0.052 | 0.086 | <0.001 | 2. | <0.1 | 0.9 | 8.3 | 5.2 | 1. | 0.08 | 3.6 | 5.3 | <1. | 2.5 |
| S203 | NM331 | Private Production Well #20 | 12 | na | 7/3/1997 | 14. | 0.064 | 0.150 | 0.018 | 23. | 0.3 | 2.2 | 1.9 | 3.2 | <1. | 0.07 | 3.5 | 2.9 | 2. | 6.3 |

**Table A4.** Summary of trace-element chemistry-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secon-dary hydro-chemical zone | Date | Al (µg/L) | B (mg/L) | Ba (mg/L) | Li (mg/L) | Zn (µg/L) | Pb (µg/L) | Cu (µg/L) | Rb (µg/L) | V (µg/L) | Cr (µg/L) | Co (µg/L) | Mo (µg/L) | As (µg/L) | Se (µg/L) | U (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S205 | NM333 | Private Production Well #21 | 12 | na | 7/3/1997 | 4. | 0.024 | 0.112 | <0.001 | 2. | <0.1 | 0.1 | 1.5 | 16. | <1. | 0.05 | 4.3 | 12. | <1. | 0.8 |
| S208 | NM140 | San Jose 2 | 12 | 3 | 6/20/1996 | 7. | 0.175 | 0.086 | 0.107 | nd | <0.1 | 0.4 | nd | 21. | 3. | nd | 4.6 | 21. | nd | 2.8 |
| S210 | NM511 | Sandia D | 12 | na | 7/30/1998 | 16. | 0.150 | 0.064 | 0.119 | 3. | <0.05 | 0.4 | 7.1 | 14. | 2. | 0.24 | 20 | 27. | 2. | 5.3 |
| S214 | NM513 | Sandia S | 12 | na | 7/30/1998 | 10. | 0.056 | 0.156 | 0.061 | 6. | <0.05 | 0.9 | 17. | 4.4 | <1. | 0.14 | 6.6 | 6.0 | 1. | 4.7 |
| S220 | NM147 | Santa Barbara 1 | 12 | na | 6/19/1996 | 6. | 0.061 | 0.102 | 0.047 | nd | <0.1 | 0.2 | nd | 8.2 | <1. | nd | 4.0 | 11. | nd | 2.4 |
| S220 | NM337 | Santa Barbara 1 | 12 | na | 6/26/1997 | 4. | 0.060 | 0.106 | <0.001 | 6. | <0.1 | 0.4 | 6.3 | 8.1 | <1. | <0.05 | 4.0 | 11. | <1. | 2.7 |
| S231 | NM517 | Sierra Vista M | 12 | 3 | 7/22/1998 | 7. | 0.105 | 0.035 | 0.080 | 3. | 0.07 | 0.2 | 4.6 | 29. | <1. | 0.08 | 5.1 | 23. | <1. | 3.7 |
| S232 | NM518 | Sierra Vista S | 12 | na | 7/22/1998 | 6. | 0.076 | 0.072 | 0.042 | 3. | 0.13 | 0.3 | 4.9 | 6.8 | <1. | 0.20 | 15. | 5.9 | 3. | 6.7 |
| S234 | NM339 | Sister Cities D | 12 | na | 6/30/1997 | 4. | 0.324 | 0.097 | 0.172 | 9. | <0.1 | 0.5 | 8.3 | 25. | 4. | 0.25 | 7.9 | 29. | 1. | 2.9 |
| S235 | NM340 | Sister Cities M | 12 | na | 6/27/1997 | 4. | 0.046 | 0.085 | <0.001 | 1. | <0.1 | 0.1 | 4.1 | 4.5 | <1. | 0.21 | 5.1 | 8.5 | <1. | 2.6 |
| S244 | NM158 | SWAB 3 - 760 | 12 | na | 7/1/1996 | 9. | 0.074 | 0.031 | 0.021 | 15. | 0.1 | 0.9 | nd | <1. | <1. | nd | 10. | 7. | nd | 1.0 |
| S245 | NM159 | SWAB 3 - 980 | 12 | na | 7/1/1996 | 4. | 0.068 | 0.061 | 0.020 | 12. | <0.1 | 0.7 | nd | <1. | <1. | nd | 10. | 5. | nd | 0.2 |
| S245 | NM160 | SWAB 3 - 980 | 12 | na | 7/1/1996 | 18. | 0.072 | 0.061 | 0.017 | 79. | 4.7 | 0.9 | nd | <1. | <1. | nd | 9.4 | 5. | nd | 0.3 |
| S253 | NM522 | Tome D | 12 | na | 8/6/1998 | 6. | 0.117 | 0.075 | 0.091 | 6. | <0.05 | <0.1 | 4.8 | 6.8 | <1. | <0.05 | 9.3 | 16. | 1. | 5.7 |
| S257 | NM344 | Domestic Well #34 | 12 | na | 6/17/1997 | 2. | 0.175 | 0.115 | 0.057 | 12. | <0.1 | 1.6 | 9.2 | 9.6 | 4. | 0.08 | 2.1 | 8.7 | 3. | 6.0 |
| S259 | NM171 | VGP-1 | 12 | na | 6/27/1996 | 5. | 0.142 | 0.071 | 0.071 | nd | <0.2 | <1. | nd | <1. | <2. | nd | 7. | 7. | nd | 5.3 |
| S261 | NM172 | Vol Andia 2 | 12 | na | 6/21/1996 | 5. | 0.047 | 0.090 | 0.022 | 3. | 0.6 | 0.4 | nd | 4.3 | <1. | nd | 3.3 | 6. | nd | 2.1 |
| S262 | NM173 | Vol Andia 5 | 12 | na | 6/18/1996 | 3. | 0.045 | 0.090 | 0.029 | 2. | <0.1 | 0.2 | nd | 5.7 | 1. | nd | 3.4 | 7. | nd | 2.9 |
| S265 | NM175 | Webster 1 | 12 | na | 6/18/1996 | 4. | 0.157 | 0.077 | 0.150 | 2. | <0.1 | 0.2 | nd | 22. | 2. | nd | 5.5 | 35. | nd | 2.3 |
| S267 | NM348 | West Bluff Nest 1 Well 2 | 12 | 3 | 6/23/1997 | <1. | 0.111 | 0.050 | 0.042 | 17. | <0.1 | 0.3 | 8.9 | 22. | <1. | <0.05 | 2.2 | 13. | <1. | 4.2 |
| S268 | NM349 | West Bluff Nest 1 Well 3 | 12 | na | 6/24/1997 | 2. | 0.080 | 0.055 | 0.028 | 9. | <0.1 | 0.1 | 8.6 | 12. | <1. | 0.22 | 2.9 | 6.8 | <1. | 4.0 |
| S269 | NM350 | West Bluff Nest 2 Well 1 | 12 | na | 6/24/1997 | 104. | 0.067 | 0.067 | 0.027 | 6. | <0.1 | 0.3 | 7.9 | 8.2 | <1. | 0.23 | 7.5 | 5.4 | <1. | 4.3 |
| S270 | NM351 | West Bluff Nest 2 Well 2 | 12 | na | 6/24/1997 | 8. | 0.058 | 0.063 | <0.001 | 4. | <0.1 | 0.4 | 8.3 | 7.8 | 1. | 0.07 | 7.5 | 4.7 | <1. | 4.3 |
| S271 | NM352 | West Bluff Nest 2 Well 3 | 12 | na | 6/24/1997 | 229. | 0.059 | 0.060 | <0.001 | 2. | <0.1 | 0.7 | 4.3 | 1.0 | 6. | 0.22 | 2.2 | 3.3 | <1. | 2.8 |
| S275 | NM178 | Yale 1 | 12 | na | 6/19/1996 | 3. | 0.08 | 0.111 | 0.035 | 15. | 0.1 | 0.2 | nd | 7.8 | 1. | nd | 4.5 | 7. | nd | 2.8 |
| SXXX | NM045 | Geoprobe #1 (45.3') | 12 | na | 7/1/1996 | 7. | 0.078 | 0.063 | 0.051 | nd | <0.1 | 0.3 | nd | <1. | <1. | nd | 9.5 | 8. | nd | 0.1 |
| SXXX | NM048 | Geoprobe #1 (30.5') | 12 | na | 7/1/1996 | 7. | 0.168 | 0.067 | 0.041 | nd | <0.1 | 0.4 | nd | <1. | <1. | nd | 5.4 | 8. | nd | 0.2 |
| SXXX | NM051 | Geoprobe #2 (40.5') | 12 | na | 7/1/1996 | 13. | 0.075 | 0.073 | 0.049 | nd | <0.1 | 0.2 | nd | <1. | <1. | nd | 6.4 | 7. | nd | 0.3 |
| | | **Zone 13: Discharge** | | | | | | | | | | | | | | | | | | |
| S143 | NM096 | Private Production Well #05 | 13 | na | 8/19/1996 | 4. | 0.560 | 0.021 | 0.326 | 16. | 0.1 | 0.7 | nd | 6.9 | 2. | nd | 11. | 12. | nd | 1.3 |
| S194 | NM327 | Domestic Well #32 | 13 | na | 6/30/1997 | <5. | 0.280 | 0.030 | 0.152 | 4. | <0.1 | 1.7 | 18. | 7.1 | 20. | <0.1 | 4.2 | 7.9 | 5. | 3.9 |
| S226 | NM150 | Domestic Well #15 | 13 | na | 8/19/1996 | 9. | 0.700 | 0.016 | 0.400 | 42. | <0.5 | 9.1 | nd | 11. | 10. | nd | 9.3 | 2.6 | nd | 5.2 |
| | | **No Zone: Exotic Water** | | | | | | | | | | | | | | | | | | |
| S009 | NM485 | Arroyo Salado Spring | E | E | 8/6/1998 | 326. | 3.33 | 0.035 | 2.87 | 170. | 4.2 | <10. | 300. | <10. | 2,200. | <5. | 4.1 | 13. | 23. | 24. |
| S023 | NM010 | Burn Site Well | E | E | 6/25/1996 | 9. | 0.113 | 0.074 | 0.048 | nd | 1.6 | 2.0 | nd | 2. | <2. | nd | 2.0 | <2. | nd | 5.7 |
| S028 | NM014 | Cerro Colorado Landfill MW | E | E | 8/12/1996 | 1. | 1.65 | 0.019 | 1.70 | 76. | <1. | 7.1 | nd | 36. | 14. | nd | 20. | 610. | nd | 5.5 |
| S038 | NM265 | Windmill #19 | E | E | 7/1/1997 | <5. | 1.09 | 0.005 | 0.458 | 16. | <1. | 6.2 | 2.9 | 2.2 | 33. | 0.68 | 6.5 | <10. | <10. | <1. |
| S054 | NM041 | Domestic Well #04 | E | E | 8/17/1996 | 33. | 5.00 | 0.046 | 5.70 | 14. | 0.9 | 5.6 | nd | 17. | 13. | nd | 0.7 | 33. | nd | 0.1 |
| S057 | NM044 | Embudo Spring | E | E | 7/2/1996 | 5. | 0.039 | 0.095 | 0.021 | nd | <0.2 | <1. | nd | <1. | <2. | nd | <1. | <2. | nd | 7.7 |
| S057 | NM215 | Embudo Spring | E | E | 3/21/1997 | 1. | 0.023 | 0.090 | 0.019 | 114. | 0.3 | 0.9 | 0.7 | 1.2 | <1. | 0.10 | 1.0 | 0.3 | 1. | 15. |
| S057 | NM228 | Embudo Spring | E | E | 4/29/1997 | 1. | 0.028 | 0.063 | 0.015 | 85. | 0.1 | 0.8 | 0.6 | 1.5 | <1. | 0.10 | 1.5 | 0.3 | <1. | 10. |
| S057 | NM241 | Embudo Spring | E | E | 5/27/1997 | 1. | 0.026 | 0.063 | 0.016 | 50. | 0.1 | 0.7 | 0.6 | 1.0 | <1. | 0.10 | 1.1 | 0.3 | <1. | 4.7 |
| S057 | NM242 | Embudo Spring | E | E | 5/27/1997 | 1. | 0.019 | 0.061 | 0.014 | 1. | 0.1 | 0.6 | 0.3 | 1.3 | <1. | 0.20 | 1.4 | 0.3 | <1. | 7.0 |
| S057 | NM365 | Embudo Spring | E | E | 7/17/1997 | 1. | 0.005 | 0.029 | 0.006 | 52. | 0.1 | 0.4 | 0.2 | nd | <1. | <0.1 | 0.4 | 0.2 | 1. | 3.9 |
| S063 | NM282 | Windmill #22 | E | E | 6/28/1997 | <5. | 0.088 | 0.017 | 0.076 | 194. | 0.2 | 2.0 | 9.5 | 0.7 | 8. | 0.66 | 8.0 | 1.1 | 3. | 19. |
| S067 | NM284 | Granite Hill | E | E | 7/4/1997 | 4. | 0.093 | 0.030 | <0.001 | 2. | <0.1 | 0.2 | 5.2 | 0.1 | 1. | 0.10 | 3.8 | <1. | 1. | 6.7 |
| S070 | NM059 | HERTF | E | E | 6/28/1996 | 7. | 0.081 | 0.054 | 0.037 | nd | 0.8 | 4.0 | nd | <1. | <2. | nd | 13. | <2. | nd | 9.1 |
| S091 | NM496 | Private Production Well #23 | E | E | 8/4/1998 | 6. | 0.471 | 0.368 | 0.469 | 7. | <0.05 | 0.4 | 12. | <0.1 | <1. | 0.10 | 9.0 | 20. | <1. | 0.2 |

**Table A4.** Summary of trace-element chemistry-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secon-dary hydro-chemical zone | Date | Al (µg/L) | B (mg/L) | Ba (mg/L) | Li (mg/L) | Zn (µg/L) | Pb (µg/L) | Cu (µg/L) | Rb (µg/L) | V (µg/L) | Cr (µg/L) | Co (µg/L) | Mo (µg/L) | As (µg/L) | Se (µg/L) | U (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S094 | NM293 | Stock Well #02 | E | E | 6/20/1997 | <5. | 0.213 | 0.003 | 0.103 | 17. | <0.1 | 1.9 | 1.6 | 2.0 | <2. | 0.14 | 2.6 | 1.4 | 11. | 15. |
| S099 | NM072 | LALF-1 | E | E | 6/29/1996 | 3. | 0.171 | 0.138 | 0.092 | nd | <0.2 | <1. | nd | <1. | <2. | nd | 8. | 8. | nd | 1.2 |
| S112 | NM296 | Domestic Well #24 | E | E | 6/21/1997 | 5. | 0.141 | 0.062 | 0.117 | 564. | 0.2 | 0.7 | 46. | 0.4 | 4. | 0.23 | 70. | 56. | <1. | 0.13 |
| S112 | NM297 | Domestic Well #24 | E | E | 6/21/1997 | <5. | 0.144 | 0.054 | 0.147 | 586. | 1.3 | 1.2 | 43. | 0.6 | 2. | <0.1 | 61. | 52. | 1. | 0.10 |
| S129 | NM087 | Montaño 4 S | E | E | 6/19/1996 | 3. | 0.131 | 0.044 | 0.132 | nd | <0.2 | 2.0 | nd | <1. | <2. | nd | 4.0 | 6. | nd | 77. |
| S152 | NM098 | Private Production Well #07 | E | E | 8/22/1996 | 5. | 0.470 | 0.051 | 0.133 | 63. | 0.8 | 4.3 | nd | 6.9 | 1. | nd | 0.3 | 5.9 | nd | 12. |
| S182 | NM117 | Rio Bravo 4 S | E | E | 6/25/1996 | 5. | 0.190 | 0.031 | 0.091 | nd | <0.2 | 1.0 | nd | 5. | <2. | nd | 6. | 2. | nd | 10. |
| S202 | NM330 | Windmill #27 | E | E | 7/2/1997 | 4. | 0.143 | 0.016 | 0.022 | 739. | <0.1 | 3.2 | 5.1 | 0.1 | <1. | 0.15 | 8.0 | <1. | 18. | 3.1 |
| S211 | NM512 | Sandia M | E | E | 7/30/1998 | 9. | 0.263 | 0.058 | 0.217 | 3. | <0.05 | 0.2 | 11. | 20. | 2. | 0.13 | 8.2 | 47. | 2. | 2.8 |
| S225 | NM149 | SBM-1 | E | E | 6/29/1996 | 7. | 0.222 | 0.042 | 0.081 | nd | <0.2 | 3.0 | nd | 3. | <2. | nd | nd | 3. | nd | 45. |
| S249 | NM163 | Private Production Well #09 | E | E | 6/26/1996 | 4. | 0.024 | 0.009 | 0.011 | 183. | 2.1 | 3.4 | nd | <1. | <1. | nd | 2.9 | 7. | nd | 74. |
| S249 | NM164 | Private Production Well #09 | E | E | 6/26/1996 | 5. | 0.021 | 0.008 | 0.011 | 201. | 2.0 | 3.3 | nd | <1. | <1. | nd | 2.9 | 6. | nd | 75. |
| S250 | NM165 | Private Production Well #10 | E | E | 6/26/1996 | 3. | 0.035 | 0.015 | 0.023 | 4. | 0.1 | 0.9 | nd | <1. | <1. | nd | 3.1 | 3. | nd | 32. |
| S251 | NM166 | Private Production Well #11 | E | E | 6/26/1996 | 7. | 0.024 | 0.031 | 0.021 | 10. | 1.4 | 1.5 | nd | 1. | <1. | nd | 2.0 | <1. | nd | 11. |
| S256 | NM169 | Tunnel Spring 1 | E | E | 6/18/1996 | 4. | <0.01 | 0.215 | 0.003 | nd | 1.7 | <1. | nd | <1. | <2. | nd | <1. | <2. | nd | 1.6 |
| S256 | NM170 | Tunnel Spring 2 | E | E | 6/18/1996 | 4. | <0.01 | 0.219 | 0.003 | nd | 1.7 | 4.0 | nd | <1. | <2. | nd | <1. | <2. | nd | 1.6 |
| S258 | NM524 | Vallecito Springs | E | E | 8/4/1998 | 3. | 0.167 | 0.062 | 0.164 | 165. | 0.20 | 0.4 | 33. | 0.2 | <1. | 0.12 | 7.6 | 23. | <1. | 0.3 |
| S273 | NM176 | Windmill #11 | E | E | 8/19/1996 | 9. | 0.060 | 0.220 | 0.034 | 68. | 0.2 | 5.7 | nd | <1. | <1. | nd | 2.3 | 1.9 | nd | 15. |
| S282 | NM529 | Windmill #44 | E | E | 7/29/1998 | <5. | 0.167 | 0.023 | 0.581 | 7,840. | 0.74 | 5.7 | 9.0 | 0.7 | <5. | 0.51 | 0.4 | 2.6 | 10. | 9.7 |
| SXXX | NM065 | Jemez Spring | E | E | 8/20/1996 | 10. | 7.17 | 0.280 | 8.80 | 12. | 0.2 | 1.7 | nd | 7.5 | 16. | nd | <1. | 550. | nd | 0.1 |
| SXXX | NM154 | Soda Dam Spring | E | E | 8/20/1996 | 23. | 14.20 | 0.404 | 14.2 | 50. | 0.4 | 1.4 | nd | 9.7 | 11. | nd | 1.0 | 1,500. | nd | 1.1 |

**Table A5.** Summary of dissolved gases (nitrogen, argon, oxygen, carbon dioxide, and methane)

[SXXX, no site number assigned; Hydrochemical Zone "E", exotic water, no primary or secondary zone assigned; $N_2$, nitrogen; Ar, argon; °C, degrees Celsius; mg/kg, milligrams per kilogram; cc STP/kg, cubic centimeters at standard temperature and pressure per kilogram of water; kg, kilogram; $O_2$, oxygen; $CO_2$, carbon dioxide; $CH_4$, methane; na, not applicable; nd, not determined; negative excess air indicates degassing]

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secondary hydro-chemical zone | Date | $N_2$ (mg/kg) | Ar (mg/kg) | Lab $O_2$ (mg/kg) | Field $O_2$ (mg/kg) | Lab $CO_2$ (mg/kg) | $CH_4$ (mg/kg) | Assigned recharge altitude (feet) | Excess $N_2$ (mg/kg) | Recom-mended recharge temp-erature (°C) | Recom-mended excess air (cc STP/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Zone 1: Northern Mountain Front** | | | | | | | | | | | | | |
| S027 | NM486 | CEPO 02 | 1 | na | 8/3/1998 | 14.12 | 0.5199 | 1.1 | 3.5 | 4.8 | <0.0001 | 6,500 | nd | 12.5 | 0.6 |
| S034 | NM027 | Private Production Well #04 | 1 | na | 8/28/1996 | 23.27 | 0.6858 | 4.3 | 5.7 | 5.4 | <0.0001 | 6,500 | nd | 11.1 | 9.5 |
| S035 | NM487 | Windmill #37 | 1 | na | 7/31/1998 | 16.19 | 0.5817 | 4.4 | 7.0 | 6.4 | <0.0001 | 6,500 | nd | 8.8 | 1.6 |
| S036 | NM026 | Private Production Well #03 | 1 | na | 8/28/1996 | 15.25 | 0.5730 | 1.8 | 6.2 | 12.2 | <0.0001 | 6,500 | nd | 7.9 | 0.3 |
| S065 | NM055 | Domestic Well #05 | 1 | na | 8/17/1996 | 14.57 | 0.5350 | 1.7 | 4.9 | 3.4 | <0.0001 | 6,500 | nd | 11.4 | 0.7 |
| S187 | NM131 | Rio Rancho 12 | 1 | na | 8/13/1996 | 15.88 | 0.5559 | <0.1 | 2.5 | 2.7 | <0.0001 | 6,500 | 1.0 | 9.3 | 0.4 |
| S206 | NM510 | Windmill #38 | 1 | 3 | 8/3/1998 | 11.71 | 0.4406 | 3.4 | 6.2 | 1.5 | <0.0001 | 6,500 | nd | 18.7 | - 0.3 |
| S216 | NM143 | Windmill #09 | 1 | na | 8/27/1996 | 13.94 | 0.5035 | 1.8 | 5.4 | 3.7 | <0.0001 | 6,500 | nd | 14.5 | 0.9 |
| S221 | NM530 | Windmill #45 | 1 | na | 8/20/1998 | 15.24 | 0.5371 | 1.5 | 5.5 | 42.5 | <0.0001 | 6,500 | nd | 12.7 | 1.8 |
| S222 | NM514 | Windmill #39 | 1 | 3 | 8/6/1998 | 12.44 | 0.4476 | 0.1 | 1.3 | 24.5 | 0.0110 | 6,500 | nd | 19.7 | 0.7 |
| S254 | NM168 | Private Production Well #12 | 1 | na | 8/28/1996 | 17.62 | 0.5296 | 4.4 | 6.8 | 8.8 | <0.0001 | 6,500 | 3.0 | 12.3 | 1.0 |
| S279 | NM527 | Windmill #42 | 1 | na | 7/28/1998 | 13.18 | 0.4831 | 1.7 | nd | 15.4 | <0.0001 | 6,500 | nd | 15.7 | 0.5 |
| S281 | NM528 | Windmill #43 | 1 | 3 | 7/28/1998 | 11.61 | 0.4303 | 2.1 | 2.6 | 2.7 | <0.0001 | 6,500 | nd | 20.3 | 0.0 |
| | | **Zone 2: Northwestern** | | | | | | | | | | | | | |
| S103 | NM497 | Lincoln D | 2 | na | 7/23/1998 | 14.02 | 0.4817 | 1.6 | 4.1 | 3.3 | <0.0001 | 5,000 | 0.5 | 19.4 | 1.0 |
| S104 | NM498 | Lincoln M | 2 | na | 7/23/1998 | 13.39 | 0.4855 | 3.9 | 6.5 | 2.0 | <0.0001 | 5,000 | nd | 18.3 | 0.6 |
| S105 | NM499 | Lincoln S | 2 | na | 7/23/1998 | 13.62 | 0.4801 | 4.4 | 6.7 | 2.8 | <0.0001 | 5,000 | 0.4 | 19.4 | 0.9 |
| S191 | NM326 | Rio Rancho 4 | 2 | 3 | 6/20/1997 | 13.05 | 0.4784 | 2.2 | 3.8 | 2.3 | <0.0001 | 5,000 | nd | 18.6 | 0.3 |
| S192 | NM128 | Rio Rancho 8 | 2 | 3 | 8/13/1996 | 13.91 | 0.4983 | 1.4 | 4.9 | 3.5 | <0.0001 | 5,000 | nd | 17.7 | 1.0 |
| S189 | NM133 | Rio Rancho 15 | 2 | na | 8/13/1996 | 16.07 | 0.4906 | 1.9 | 6.1 | 8.3 | <0.0001 | 6,500 | 2.5 | 15.6 | 0.8 |
| S278 | NM526 | Windmill #41 | 2 | na | 7/29/1998 | 11.59 | 0.4225 | 4.1 | 6.9 | 2.5 | <0.0001 | 5,000 | nd | 24.5 | 0.1 |
| S286 | NM184 | Private Production Well #13 | 2 | na | 8/26/1996 | 14.79 | 0.5358 | 2.1 | 7.9 | 7.8 | <0.0001 | 5,000 | nd | 14.1 | 0.9 |
| S287 | NM185 | Private Production Well #14 | 2 | na | 8/26/1996 | 15.08 | 0.5298 | 2.0 | 7.7 | 8.3 | <0.0001 | 5,000 | nd | 15.8 | 1.7 |
| | | **Zone 3: West Central** | | | | | | | | | | | | | |
| S003 | NM481 | 98th St. D | 3 | na | 8/4/1998 | 18.67 | 0.5406 | 0.1 | <0.1 | 1.6 | 0.0008 | 8,000 | 3.7 | 9.5 | 1.4 |
| S003 | NM251 | 98th St. D | 3 | na | 6/17/1997 | 17.93 | 0.5361 | <0.1 | 0.2 | 1.6 | <0.0001 | 8,000 | 3.1 | 9.6 | 1.2 |
| S004 | NM482 | 98th St. MD | 3 | na | 8/4/1998 | 17.14 | 0.5580 | 0.1 | <0.1 | 0.2 | 0.0006 | 8,000 | 1.8 | 8.0 | 1.3 |
| S004 | NM252 | 98th St. MD | 3 | na | 6/18/1997 | 17.21 | 0.5707 | <0.1 | 0.3 | 0.2 | <0.0001 | 8,000 | 1.5 | 7.0 | 1.3 |
| S005 | NM253 | 98th St. MS | 3 | na | 7/4/1997 | 16.63 | 0.5841 | <0.1 | 0.1 | 1.4 | 0.0029 | 8,000 | 0.7 | 5.8 | 1.1 |
| S005 | NM483 | 98th St. MS | 3 | na | 8/4/1998 | 16.71 | 0.5703 | 0.1 | 0.1 | 1.7 | 0.0035 | 8,000 | 1.0 | 7.1 | 1.3 |
| S006 | NM484 | 98th St. S | 3 | na | 8/5/1998 | 13.98 | 0.4806 | 1.5 | 0.3 | 0.1 | <0.0001 | 8,000 | 0.5 | 14.6 | 1.2 |
| S006 | NM254 | 98th St. S | 3 | na | 6/17/1997 | 13.74 | 0.4967 | 0.2 | 2.8 | 0.1 | 0.0006 | 8,000 | nd | 12.7 | 1.0 |
| S008 | NM003 | Private Production Well #01 | 3 | na | 8/12/1996 | 13.21 | 0.4735 | 4.7 | 4.0 | 0.7 | <0.0001 | 8,000 | nd | 15.0 | 1.1 |
| S010 | NM255 | Private Production Well #16 | 3 | na | 6/23/1997 | 12.21 | 0.4685 | 4.6 | 5.1 | 0.4 | <0.0001 | 8,000 | nd | 13.0 | - 0.5 |
| S018 | NM260 | Domestic Well #21 | 3 | na | 6/26/1997 | 14.71 | 0.4824 | 4.2 | 5.3 | 2.6 | <0.0001 | 8,000 | nd | 18.0 | 3.3 |
| S019 | NM007 | Belen 4 | 3 | 5 | 8/16/1996 | 13.05 | 0.4717 | 0.1 | 3.3 | 6.0 | <0.0001 | 8,000 | nd | 14.9 | 0.9 |
| S020 | NM008 | Belen 5 | 3 | 5 | 8/16/1996 | 12.25 | 0.4541 | <0.1 | 3.9 | 5.4 | <0.0001 | 8,000 | nd | 15.5 | 0.2 |
| S029 | NM015 | Cerro Colorado Lafill PW | 3 | 5 | 8/12/1996 | 16.71 | 0.5641 | <0.1 | 2.4 | 8.0 | <0.0001 | 8,000 | 1.2 | 7.4 | 1.2 |
| S037 | NM264 | College 2 | 3 | na | 6/19/1997 | 15.21 | 0.5476 | 2.8 | 5.0 | 0.3 | <0.0001 | 8,000 | nd | 8.9 | 1.4 |
| S066 | NM056 | Gonzales 1 | 3 | 12 | 6/20/1996 | 15.42 | 0.5382 | 0.2 | 3.0 | 1.8 | <0.0001 | 8,000 | 0.5 | 9.5 | 1.3 |
| S086 | NM492 | Isleta D | 3 | na | 7/29/1998 | 15.93 | 0.5295 | 0.1 | 0.1 | 0.1 | <0.0001 | 8,000 | 1.2 | 10.3 | 1.3 |
| S101 | NM294 | Leavitt 1 | 3 | na | 6/26/1997 | 13.32 | 0.4938 | 3.2 | 4.9 | 0.6 | <0.0001 | 8,000 | nd | 12.1 | 0.4 |
| S108 | NM076 | Los Lunas 3 | 3 | 12 | 8/14/1996 | 14.74 | 0.5354 | <0.1 | 0.3 | 1.4 | <0.0001 | 8,000 | nd | 9.5 | 1.1 |
| S109 | NM077 | Los Lunas 4 | 3 | 12 | 8/14/1996 | 14.82 | 0.5511 | <0.1 | 0.5 | 1.5 | <0.0001 | 8,000 | nd | 7.6 | 0.6 |
| S145 | NM308 | NM Utilities 1 | 3 | na | 6/18/1997 | 13.84 | 0.5084 | 2.2 | 5.0 | 3.6 | <0.0001 | 8,000 | nd | 11.2 | 0.7 |
| S147 | NM310 | NM Utilities 3 | 3 | na | 6/18/1997 | 14.16 | 0.5136 | 0.4 | 2.2 | 2.1 | <0.0001 | 8,000 | nd | 11.2 | 1.0 |
| S148 | NM311 | NM Utilities 4 | 3 | na | 6/18/1997 | 14.52 | 0.5253 | 2.4 | 3.8 | 2.4 | <0.0001 | 8,000 | nd | 10.4 | 1.1 |
| S166 | NM509 | Rabbit Hill | 3 | na | 8/4/1998 | 17.63 | 0.5955 | 0.9 | 3.6 | 16.5 | <0.0001 | 8,000 | 1.3 | 5.3 | 1.3 |
| S167 | NM107 | Domestic Well #12 | 3 | na | 8/14/1996 | 14.97 | 0.5083 | <0.1 | 0.9 | 0.7 | <0.0001 | 8,000 | 1.0 | 11.5 | 0.9 |
| S172 | NM322 | Rio Bravo 5 D | 3 | na | 7/4/1997 | 17.91 | 0.5713 | <0.1 | <0.1 | 0.1 | <0.0001 | 8,000 | 2.3 | 6.7 | 1.1 |
| S174 | NM109 | Rio Bravo 1 D | 3 | 12 | 6/17/1996 | 17.00 | 0.5515 | 0.1 | 0.1 | 0.5 | <0.0001 | 8,000 | 2.0 | 7.9 | 0.9 |
| S175 | NM110 | Rio Bravo 1 M | 3 | 12 | 6/17/1996 | 19.48 | 0.6080 | 0.8 | 0.1 | 0.6 | <0.0001 | 8,000 | 3.0 | 4.1 | 1.0 |
| S186 | NM130 | Rio Rancho 10 | 3 | na | 8/13/1996 | 15.29 | 0.5474 | 2.4 | 6.3 | 7.7 | <0.0001 | 8,000 | nd | 9.1 | 1.5 |
| S188 | NM132 | Rio Rancho 13 | 3 | na | 8/13/1996 | 15.71 | 0.5631 | 0.1 | 6.5 | 0.9 | <0.0001 | 8,000 | 0.5 | 6.9 | 0.7 |
| S193 | NM129 | Rio Rancho 9 | 3 | na | 8/13/1996 | 20.64 | 0.6188 | 1.0 | 7.3 | 2.5 | <0.0001 | 8,000 | 4.0 | 3.2 | 0.8 |
| S196 | NM135 | Windmill #05 | 3 | na | 8/21/1996 | 11.97 | 0.4269 | <0.1 | 3.0 | 4.3 | <0.0001 | 8,000 | nd | 19.7 | 0.8 |
| S200 | NM139 | Private Production Well #08 | 3 | na | 8/29/1996 | 15.83 | 0.5201 | <0.1 | 0.2 | 1.5 | <0.0001 | 8,000 | 1.5 | 10.7 | 1.0 |
| S218 | NM145 | Santa Ana Boundary M | 3 | na | 8/22/1996 | 16.25 | 0.5762 | 0.8 | 3.9 | 1.2 | <0.0001 | 8,000 | 0.5 | 6.4 | 1.1 |
| S219 | NM146 | Santa Ana Boundary S | 3 | na | 8/22/1996 | 16.49 | 0.5770 | 1.0 | 4.8 | 2.8 | <0.0001 | 8,000 | 1.0 | 5.8 | 0.6 |
| S230 | NM516 | Sierra Vista D | 3 | na | 7/22/1998 | 17.03 | 0.5374 | 0.1 | <0.1 | 0.4 | 0.0061 | 8,000 | 2.2 | 9.6 | 1.3 |
| S236 | NM155 | SAF (Soil Amement Facility) | 3 | na | 8/12/1996 | 11.76 | 0.4120 | 0.4 | 4.9 | 2.4 | <0.0001 | 8,000 | nd | 22.0 | 1.1 |
| S241 | NM519 | SWAB Test Hole 1 D | 3 | 1 | 8/5/1998 | 14.39 | 0.4695 | 0.1 | 0.9 | 3.5 | 0.1114 | 8,000 | 1.2 | 15.8 | 1.3 |
| S243 | NM521 | SWAB Test Hole 2 D | 3 | na | 8/7/1998 | 21.79 | 0.6116 | 0.1 | 4.0 | 1.3 | 0.0007 | 8,000 | nd | 16.5 | nd |
| S263 | NM346 | Volcano Cliff 1 | 3 | na | 6/19/1997 | 14.77 | 0.5412 | 1.4 | 3.9 | 3.3 | <0.0001 | 8,000 | nd | 8.8 | 0.9 |
| S266 | NM347 | West Bluff Nest 1 Well 1 | 3 | na | 6/23/1997 | 16.78 | 0.5332 | 0.0 | 0.1 | 0.3 | <0.0001 | 8,000 | 2.0 | 9.9 | 1.3 |
| S272 | NM353 | West Mesa 3 | 3 | na | 6/19/1997 | 13.73 | 0.5203 | 2.0 | 4.7 | 0.8 | <0.0001 | 8,000 | nd | 9.2 | 0.0 |
| S283 | NM181 | Zia Ball Park D | 3 | na | 8/26/1996 | 15.58 | 0.5502 | 1.1 | 5.3 | 3.6 | <0.0001 | 8,000 | 0.5 | 8.3 | 1.1 |
| S285 | NM183 | Zia Ball Park S | 3 | 2 | 8/26/1996 | 14.59 | 0.5297 | 0.4 | 4.5 | 4.6 | <0.0001 | 8,000 | nd | 9.9 | 1.1 |
| S288 | NM186 | Zia BMT D | 3 | na | 8/27/1996 | 18.43 | 0.6035 | <0.1 | 0.3 | 1.5 | 0.0472 | 8,000 | nd | 4.5 | 1.1 |

**Table A5.** Summary of dissolved gases (nitrogen, argon, neon, helium, oxygen, and carbon dioxide)-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secondary hydro-chemical zone | Date | $N_2$ (mg/kg) | Ar (mg/kg) | Lab $O_2$ (mg/kg) | Field $O_2$ (mg/kg) | Lab $CO_2$ (mg/kg) | $CH_4$ (mg/kg) | Assigned recharge altitude (feet) | Excess $N_2$ (mg/kg) | Recom-mended recharge temp-erature (ºC) | Recom-mended excess air (cc STP/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Zone 4: Western Boundary** | | | | | | | | | | | | | |
| S039 | NM266 | Windmill #20 | 4 | na | 6/21/1997 | 14.98 | 0.5019 | <0.1 | 3.4 | 33.1 | <0.0001 | 5,000 | 1.0 | 17.3 | 1.0 |
| S059 | NM278 | Windmill #21 | 4 | na | 6/23/1997 | 13.82 | 0.5191 | 4.7 | 7.4 | 9.4 | 0.0004 | 5,000 | nd | 14.2 | 0.0 |
| S074 | NM285 | Windmill #23 | 4 | na | 6/21/1997 | 12.26 | 0.4466 | 0.4 | 2.3 | 45.1 | <0.0001 | 5,000 | nd | 21.9 | 0.3 |
| | | **Zone 5: Rio Puerco** | | | | | | | | | | | | | |
| S069 | NM058 | Domestic Well #06 | 5 | na | 8/16/1996 | 35.65 | 0.8533 | 1.4 | 4.2 | 10.1 | <0.0001 | 5,000 | nd | 20.5 | nd |
| S111 | NM079 | Domestic Well #10 | 5 | na | 8/16/1996 | 17.12 | 0.5538 | 0.1 | <0.1 | 3.6 | <0.0001 | 5,000 | 1.8 | 12.8 | 1.1 |
| S185 | NM324 | Domestic Well #31 | 5 | na | 6/16/1997 | 23.73 | 0.7031 | 0.1 | 0.2 | 33.2 | 0.0034 | 5,000 | nd | 12.0 | nd |
| S198 | NM137 | Windmill #07 | 5 | na | 8/21/1996 | 20.27 | 0.6329 | 0.0 | 0.4 | 34.5 | <0.0001 | 5,000 | 3.0 | 7.0 | 1.1 |
| S237 | NM341 | Windmill #30 | 5 | 4 | 6/24/1997 | 12.64 | 0.4643 | 3.9 | 4.7 | 2.6 | <0.0001 | 5,000 | nd | 19.8 | 0.2 |
| S238 | NM342 | Windmill #31 | 5 | na | 6/24/1997 | 14.09 | 0.4965 | 1.2 | 4.1 | 20.8 | <0.0001 | 5,000 | nd | 18.5 | 1.4 |
| | | **Zone 7: Abo Arroyo** | | | | | | | | | | | | | |
| S021 | NM261 | Stock Well #01 | 7 | na | 6/23/1997 | 17.18 | 0.5793 | 4.1 | 5.6 | 15.4 | 0.0018 | 5,000 | nd | 13.7 | 3.3 |
| S024 | NM011 | Domestic Well #02 | 7 | 8 | 8/17/1996 | 13.57 | 0.4870 | 2.4 | 7.0 | 11.4 | <0.0001 | 5,000 | nd | 18.6 | 0.9 |
| S090 | NM064 | Domestic Well #08 | 7 | na | 8/19/1996 | 15.21 | 0.4628 | 4.8 | 6.8 | 6.1 | <0.0001 | 5,000 | nd | 29.2 | 4.7 |
| S093 | NM067 | Domestic Well #09 | 7 | 8 | 8/15/1996 | 13.40 | 0.4893 | 0.1 | 3.9 | 4.0 | <0.0001 | 5,000 | nd | 17.7 | 0.5 |
| | | **Zone 8: Eastern Mountain Front** | | | | | | | | | | | | | |
| S007 | NM002 | Domestic Well #01 | 8 | na | 6/21/1996 | 20.90 | 0.6622 | 2.9 | 9.2 | 18.3 | 0.0006 | 6,500 | nd | 8.8 | 6.4 |
| S014 | NM257 | Private Production Well #17 | 8 | na | 6/19/1997 | 14.21 | 0.5249 | 6.4 | 8.2 | 10.8 | <0.0001 | 6,500 | nd | 12.0 | 0.5 |
| S030 | NM020 | Charles 4 | 8 | na | 6/27/1996 | 13.75 | 0.4905 | 1.6 | 4.5 | 5.0 | <0.0001 | 6,500 | nd | 16.1 | 1.2 |
| S030 | NM018 | Charles 4 | 8 | na | 6/27/1996 | 13.61 | 0.5000 | 1.7 | 5.5 | 5.3 | <0.0001 | 6,500 | nd | 14.2 | 0.5 |
| S030 | NM021 | Charles 4 | 8 | na | 6/27/1996 | 13.81 | 0.4897 | 1.0 | 4.0 | 5.3 | <0.0001 | 6,500 | nd | 16.4 | 1.3 |
| S030 | NM023 | Charles 4 | 8 | na | 6/27/1996 | 13.89 | 0.5011 | 0.9 | 4.0 | 5.3 | <0.0001 | 6,500 | nd | 14.7 | 1.0 |
| S030 | NM019 | Charles 4 | 8 | na | 6/27/1996 | 13.43 | 0.4752 | 1.3 | 5.2 | 5.5 | <0.0001 | 6,500 | nd | 17.8 | 1.3 |
| S030 | NM022 | Charles 4 | 8 | na | 6/27/1996 | 13.96 | 0.5012 | 0.6 | 4.0 | 5.5 | <0.0001 | 6,500 | nd | 14.9 | 1.1 |
| S030 | NM017 | Charles 4 | 8 | na | 6/27/1996 | 13.59 | 0.4966 | 1.2 | 5.6 | 5.6 | <0.0001 | 6,500 | nd | 14.7 | 0.6 |
| S030 | NM024 | Charles 4 | 8 | na | 6/27/1996 | 13.93 | 0.5060 | 0.4 | 4.1 | 5.7 | <0.0001 | 6,500 | nd | 14.1 | 0.8 |
| S042 | NM031 | Domestic Well #03 | 8 | na | 8/14/1996 | 12.81 | 0.4715 | 0.0 | 4.2 | 4.5 | <0.0001 | 6,500 | nd | 16.6 | 0.3 |
| S055 | NM042 | Elena Gallegos | 8 | na | 6/25/1996 | 10.22 | 0.3742 | 3.4 | 6.2 | 12.8 | <0.0001 | 6,500 | nd | 27.3 | - 0.1 |
| S056 | NM043 | Embudito Spring | 8 | na | 7/2/1996 | 13.45 | 0.5198 | 0.3 | 3.4 | 25.0 | <0.0001 | 6,500 | nd | 10.8 | - 0.6 |
| S071 | NM060 | Domestic Well #07 | 8 | na | 6/19/1996 | 16.64 | 0.5356 | 3.6 | 8.7 | 14.9 | <0.0001 | 6,500 | nd | 16.8 | 4.3 |
| S095 | NM068 | Kirtland 1 | 8 | na | 6/25/1996 | 14.12 | 0.5037 | 2.3 | 7.2 | 8.0 | <0.0001 | 6,500 | nd | 15.0 | 1.3 |
| S106 | NM295 | Domestic Well #23 | 8 | na | 6/26/1997 | 15.25 | 0.5436 | <0.1 | 0.6 | 2.8 | <0.0001 | 6,500 | nd | 11.8 | 1.5 |
| S110 | NM078 | Love 1 | 8 | na | 6/22/1996 | 19.19 | 0.5763 | 1.8 | 5.7 | 6.5 | <0.0001 | 6,500 | nd | 17.3 | 7.0 |
| S113 | NM080 | Domestic Well #11 | 8 | na | 8/15/1996 | 14.77 | 0.5267 | 0.2 | 3.6 | 3.1 | <0.0001 | 6,500 | nd | 13.1 | 1.4 |
| S114 | NM500 | Matheson D | 8 | na | 7/31/1998 | 15.03 | 0.5133 | 0.1 | 1.3 | 4.0 | <0.0001 | 6,500 | nd | 15.9 | 2.4 |
| S115 | NM501 | Matheson M | 8 | na | 8/1/1998 | 13.40 | 0.4728 | 1.2 | 2.9 | 3.4 | <0.0001 | 6,500 | nd | 18.1 | 1.3 |
| S116 | NM502 | Matheson S | 8 | na | 8/1/1998 | 12.66 | 0.4632 | 3.9 | 5.5 | 6.4 | <0.0001 | 6,500 | nd | 17.6 | 0.4 |
| S117 | NM298 | Domestic Well #25 | 8 | na | 6/17/1997 | 18.38 | 0.6113 | 6.1 | 8.0 | 10.1 | <0.0001 | 6,500 | nd | 9.8 | 4.1 |
| S119 | NM300 | Domestic Well #26 | 8 | 11 | 6/19/1997 | 14.09 | 0.5170 | 4.9 | 5.8 | 26.4 | <0.0001 | 6,500 | nd | 12.8 | 0.6 |
| S122 | NM304 | Mesa Del Sol S | 8 | na | 6/29/1997 | 15.68 | 0.5232 | 0.1 | 0.4 | 0.1 | 0.0073 | 6,500 | 1.2 | 12.9 | 1.0 |
| S122 | NM505 | Mesa Del Sol S | 8 | na | 7/25/1998 | 14.07 | 0.4917 | 0.1 | 2.0 | 4.5 | 0.0028 | 6,500 | 0.3 | 16.0 | 1.2 |
| S140 | NM306 | MRN 1 | 8 | na | 7/5/1997 | 16.13 | 0.5685 | 3.4 | 5.6 | 10.2 | <0.0001 | 6,500 | nd | 10.4 | 2.0 |
| S141 | NM095 | National Utility 7 | 8 | na | 8/14/1996 | 13.89 | 0.4998 | 1.0 | 7.8 | 7.6 | <0.0001 | 6,500 | 0.5 | 14.9 | 1.0 |
| S149 | NM312 | Nor Este D | 8 | na | 7/3/1997 | 15.90 | 0.5707 | <0.1 | 0.2 | 0.9 | <0.0001 | 6,500 | nd | 9.6 | 1.5 |
| S150 | NM313 | Nor Este M | 8 | na | 7/2/1997 | 15.98 | 0.5836 | <0.1 | 0.3 | 1.5 | <0.0001 | 6,500 | nd | 8.1 | 1.1 |
| S162 | NM317 | Stock Well #03 | 8 | na | 6/30/1997 | 20.83 | 0.6456 | 7.6 | 7.2 | 1.8 | <0.0001 | 6,500 | nd | 10.9 | nd |
| S163 | NM318 | PL 2 | 8 | na | 7/7/1997 | 15.54 | 0.5717 | 3.1 | 5.2 | 7.4 | <0.0001 | 6,500 | nd | 8.7 | 0.8 |
| S164 | NM106 | Ponderosa 1 | 8 | na | 6/20/1996 | 15.68 | 0.5566 | 0.1 | 1.6 | 6.5 | 0.0002 | 6,500 | nd | 11.0 | 1.7 |
| S165 | NM328 | Windmill #25 | 8 | na | 6/24/1997 | 14.68 | 0.5566 | 1.2 | 1.8 | 0.6 | <0.0001 | 6,500 | nd | 8.7 | 0.0 |
| S168 | NM319 | Domestic Well #30 | 8 | na | 6/27/1997 | 12.86 | 0.4713 | 3.3 | 5.2 | 1.5 | <0.0001 | 6,500 | nd | 16.8 | 0.4 |
| S170 | NM108 | Ridgecrest 3 | 8 | na | 6/22/1996 | 14.07 | 0.4781 | 0.4 | 4.6 | 5.3 | <0.0001 | 6,500 | 0.6 | 17.4 | 1.2 |
| S195 | NM134 | Domestic Well #13 | 8 | na | 8/14/1996 | 13.51 | 0.4834 | <0.1 | 3.2 | 4.2 | <0.0001 | 6,500 | nd | 16.6 | 1.0 |
| S209 | NM336 | Domestic Well #33 | 8 | na | 6/27/1997 | 15.75 | 0.5447 | <0.1 | 0.2 | 1.9 | <0.0001 | 6,500 | nd | 12.9 | 2.4 |
| S212 | NM141 | Sandia Peak 1 | 8 | na | 6/26/1996 | 15.67 | 0.5443 | 3.3 | 7.6 | 9.9 | <0.0001 | 6,500 | nd | 12.8 | 2.2 |
| S213 | NM142 | Sandia Peak 3 | 8 | na | 6/26/1996 | 15.97 | 0.5272 | 3.8 | 7.8 | 11.7 | <0.0001 | 6,500 | nd | 16.3 | 3.5 |
| S224 | NM148 | Domestic Well #14 | 8 | na | 8/23/1996 | 13.14 | 0.4951 | 0.4 | 4.3 | 13.9 | <0.0001 | 6,500 | nd | 13.7 | - 0.1 |
| S229 | NM515 | SH03 UNM | 8 | na | 7/28/1998 | 15.90 | 0.5417 | 5.1 | 8.8 | 11.0 | <0.0001 | 6,500 | nd | 13.7 | 2.7 |
| S233 | NM153 | Domestic Well #16 | 8 | na | 8/23/1996 | 16.35 | 0.5595 | 0.1 | 1.9 | 18.7 | <0.0001 | 6,500 | nd | 12.2 | 2.8 |
| S239 | NM156 | Domestic Well #17 | 8 | na | 8/17/1996 | 16.17 | 0.5558 | <0.1 | 6.8 | 22.0 | <0.0001 | 6,500 | nd | 12.3 | 2.6 |
| S240 | NM157 | Domestic Well #18 | 8 | na | 6/19/1996 | 43.13 | 1.0214 | 12. | 8.0 | 7.2 | <0.0001 | 6,500 | nd | 11.5 | nd |
| S247 | NM161 | Domestic Well #19 | 8 | na | 8/15/1996 | 14.53 | 0.5454 | 0.0 | 5.8 | 3.1 | <0.0001 | 6,500 | nd | 9.9 | 0.2 |
| S248 | NM162 | Thomas 6 | 8 | na | 6/21/1996 | 26.93 | 0.7218 | 5.7 | 1.4 | 4.4 | <0.0001 | 6,500 | nd | 15.0 | 14.4 |
| S255 | NM523 | Tramway East | 8 | na | 7/30/1998 | 16.02 | 0.5391 | 3.1 | 5.6 | 5.3 | 0.0008 | 6,500 | nd | 14.5 | 3.1 |
| S264 | NM174 | Walker 1 | 8 | na | 6/18/1996 | 16.27 | 0.5569 | 0.2 | 2.5 | 5.2 | 0.0002 | 6,500 | nd | 12.4 | 2.8 |
| S274 | NM177 | Domestic Well #20 | 8 | na | 8/15/1996 | 12.94 | 0.4681 | <0.1 | 4.9 | 9.5 | <0.0001 | 6,500 | nd | 17.6 | 0.7 |
| | | **Zone 9: Tijeras Fault Zone** | | | | | | | | | | | | | |
| S041 | NM029 | Coyote Spring | 9 | na | 6/28/1996 | 16.97 | 0.4531 | 4.5 | 2.8 | 1,011.0 | 0.0004 | 6,500 | nd | nd | nd |
| S072 | NM061 | Hubbell Spring | 9 | 8 | 8/23/1996 | 13.45 | 0.5019 | 2.4 | 4.8 | 11.9 | <0.0001 | 6,500 | nd | 13.4 | 0.2 |
| S098 | NM071 | KAFB-1902 | 9 | na | 6/28/1996 | 18.43 | 0.5399 | 3.0 | 4.5 | 22.7 | <0.0001 | 6,500 | nd | 21.7 | 7.2 |
| S197 | NM136 | Windmill #06 | 9 | na | 8/23/1996 | 16.49 | 0.5459 | 0.1 | 0.3 | 2.0 | 0.0129 | 6,500 | 1.4 | 11.1 | 1.2 |
| S227 | NM151 | SFR 3D | 9 | na | 8/24/1996 | 11.90 | 0.4286 | <0.1 | 5.7 | 170.8 | <0.0001 | 6,500 | nd | 21.7 | 0.5 |
| S228 | NM152 | SFR 3S | 9 | na | 8/24/1996 | 13.55 | 0.4866 | 0.9 | 5.5 | 70.6 | <0.0001 | 6,500 | nd | 16.2 | 1.0 |
| | | **Zone 10: Tijeras Arroyo** | | | | | | | | | | | | | |
| S001 | NM001 | 4Hills-1 | 10 | 8 | 6/29/1996 | 16.16 | 0.5545 | 1.4 | 5.0 | 18.4 | <0.0001 | 6,500 | nd | 12.5 | 2.7 |

**Table A5.** Summary of dissolved gases (nitrogen, argon, neon, helium, oxygen, and carbon dioxide)-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secondary hydro-chemical zone | Date | $N_2$ (mg/kg) | Ar (mg/kg) | Lab $O_2$ (mg/kg) | Field $O_2$ (mg/kg) | Lab $CO_2$ (mg/kg) | $CH_4$ (mg/kg) | Assigned recharge altitude (feet) | Excess $N_2$ (mg/kg) | Recom-mended recharge temp-erature (ºC) | Recom-mended excess air (cc STP/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S002 | NM250 | Private Production Well #15 | 10 | 8 | 7/3/1997 | 44.51 | 1.0370 | 15. | 15. | 16.7 | <0.0001 | 6,500 | nd | 12.7 | nd |
| S058 | NM277 | Eubank 1 | 10 | 8 | 7/4/1997 | 13.39 | 0.5118 | 4.4 | 6.4 | 5.6 | <0.0001 | 6,500 | nd | 11.8 | - 0.4 |
| S096 | NM069 | Kirtland 11 | 10 | 8 | 6/25/1996 | 26.28 | 0.7264 | 4.6 | 7.0 | 12.0 | <0.0001 | 6,500 | nd | 12.6 | nd |
| | | **Zone 11: Northeastern** | | | | | | | | | | | | | |
| S053 | NM276 | Private Production Well #18 | 11 | na | 6/25/1997 | 14.79 | 0.5285 | 3.0 | 2.8 | 21.0 | <0.0001 | 5,000 | nd | 15.2 | 1.2 |
| S144 | NM097 | Private Production Well #06 | 11 | na | 8/28/1996 | 15.74 | 0.5520 | <0.1 | 0.2 | 15.2 | 0.0018 | 5,000 | 0.5 | 12.9 | 1.0 |
| S207 | NM334 | Private Production Well #22 | 11 | na | 7/3/1997 | 16.76 | 0.5749 | 5.0 | 6.7 | 13.9 | <0.0001 | 5,000 | nd | 13.3 | 2.7 |
| S223 | NM338 | Windmill #29 | 11 | na | 6/25/1997 | 15.25 | 0.5279 | 4.4 | 6.3 | 5.5 | <0.0001 | 5,000 | nd | 16.6 | 2.1 |
| | | **Zone 12: Central** | | | | | | | | | | | | | |
| S011 | NM004 | Atris-1 | 12 | na | 6/22/1996 | 14.98 | 0.5423 | 0.5 | 0.1 | 3.0 | 0.0018 | 5,000 | nd | 13.7 | 1.0 |
| S012 | NM005 | Atrisco 3 | 12 | 3 | 6/20/1996 | 14.98 | 0.5420 | 0.3 | 0.2 | 2.2 | 0.0020 | 5,000 | nd | 13.7 | 1.0 |
| S025 | NM012 | Burton 2 | 12 | na | 6/19/1996 | 23.67 | 0.6820 | 0.1 | 2.9 | 5.3 | <0.0001 | 5,000 | nd | 14.9 | 10.3 |
| S026 | NM013 | Burton 5 | 12 | na | 6/19/1996 | 23.09 | 0.6674 | 1.8 | 0.4 | 3.5 | <0.0001 | 5,000 | nd | 15.6 | 9.9 |
| S033 | NM025 | Private Production Well #02 | 12 | na | 8/21/1996 | 16.44 | 0.5306 | 0.2 | 0.8 | 16.0 | <0.0001 | 5,000 | 1.7 | 14.8 | 1.1 |
| S040 | NM028 | Coronado 1 | 12 | na | 6/18/1996 | 15.48 | 0.5552 | 0.1 | 0.7 | 2.9 | <0.0001 | 5,000 | nd | 13.0 | 1.3 |
| S043 | NM267 | Del Sol D | 12 | na | 7/1/1997 | 15.83 | 0.5763 | 0.2 | 0.5 | 2.2 | <0.0001 | 5,000 | nd | 11.0 | 1.0 |
| S043 | NM488 | Del Sol D | 12 | na | 7/21/1998 | 15.36 | 0.5520 | 0.1 | 0.5 | 2.3 | <0.0001 | 5,000 | nd | 13.2 | 1.2 |
| S044 | NM489 | Del Sol M | 12 | na | 7/21/1998 | 14.68 | 0.5289 | 0.1 | 0.5 | 4.9 | <0.0001 | 5,000 | nd | 14.9 | 1.0 |
| S044 | NM268 | Del Sol M | 12 | na | 6/26/1997 | 14.73 | 0.5436 | 0.1 | 0.6 | 5.2 | <0.0001 | 5,000 | nd | 12.8 | 0.5 |
| S045 | NM269 | Del Sol S | 12 | na | 6/26/1997 | 13.90 | 0.5123 | 1.5 | 2.9 | 3.4 | <0.0001 | 5,000 | nd | 15.4 | 0.4 |
| S045 | NM490 | Del Sol S | 12 | na | 7/21/1998 | 13.89 | 0.5032 | 0.8 | 3.3 | 3.9 | <0.0001 | 5,000 | nd | 16.8 | 0.7 |
| S046 | NM032 | Duranes 1 | 12 | na | 6/20/1996 | 16.48 | 0.5149 | 0.9 | <0.1 | 0.6 | 0.0005 | 5,000 | nd | 22.6 | 4.8 |
| S046 | NM039 | Duranes 1 | 12 | na | 6/29/1996 | 17.01 | 0.5169 | 0.2 | <0.1 | 11.0 | 0.0009 | 5,000 | nd | 24.0 | 5.6 |
| S046 | NM034 | Duranes 1 | 12 | na | 6/29/1996 | 16.88 | 0.5123 | 0.3 | 0.2 | 11.3 | 0.0009 | 5,000 | nd | 24.5 | 5.5 |
| S046 | NM036 | Duranes 1 | 12 | na | 6/29/1996 | 17.02 | 0.5302 | 0.1 | 0.1 | 11.3 | 0.0011 | 5,000 | nd | 21.5 | 5.1 |
| S046 | NM038 | Duranes 1 | 12 | na | 6/29/1996 | 18.08 | 0.5371 | 0.3 | 0.1 | 11.4 | 0.0010 | 5,000 | nd | 23.6 | 6.6 |
| S046 | NM035 | Duranes 1 | 12 | na | 6/29/1996 | 17.14 | 0.5318 | <0.1 | 0.1 | 11.5 | 0.0010 | 5,000 | nd | 21.5 | 5.2 |
| S046 | NM033 | Duranes 1 | 12 | na | 6/29/1996 | 17.86 | 0.5397 | 0.2 | 0.1 | 11.7 | 0.0009 | 5,000 | nd | 22.4 | 6.1 |
| S046 | NM037 | Duranes 1 | 12 | na | 6/29/1996 | 55.13 | 1.1753 | 11. | 0.1 | 12.1 | 0.0014 | 5,000 | nd | 22.4 | nd |
| S047 | NM270 | Duranes 7 | 12 | na | 6/26/1997 | 14.39 | 0.5354 | <0.1 | 0.2 | 2.9 | 0.0039 | 5,000 | nd | 13.2 | 0.3 |
| S048 | NM271 | Duranes Yard 1 | 12 | na | 7/5/1997 | 15.11 | 0.5653 | <0.1 | 0.1 | 3.1 | 0.0067 | 5,000 | nd | 10.8 | 0.2 |
| S049 | NM272 | Duranes Yard 2 | 12 | na | 7/5/1997 | 14.52 | 0.5614 | <0.1 | 0.1 | 2.8 | 0.0086 | 5,000 | nd | 10.0 | - 0.6 |
| S050 | NM273 | Duranes Yard 3 | 12 | na | 7/5/1997 | 13.73 | 0.5181 | <0.1 | 0.1 | 0.0 | <0.0001 | 5,000 | nd | 14.1 | - 0.2 |
| S051 | NM274 | Duranes Yard 4 | 12 | na | 7/5/1997 | 15.89 | 0.6013 | <0.1 | <0.1 | 4.8 | 0.0117 | 5,000 | nd | 8.0 | 0.1 |
| S052 | NM275 | Duranes Yard 5 | 12 | na | 7/5/1997 | 14.45 | 0.5618 | <0.1 | <0.1 | 4.6 | 0.0116 | 5,000 | nd | 9.8 | - 0.8 |
| S060 | NM279 | Garfield D | 12 | 3 | 6/19/1997 | 14.90 | 0.5429 | <0.1 | 0.2 | 1.7 | <0.0001 | 5,000 | nd | 13.4 | 0.8 |
| S061 | NM280 | Garfield M | 12 | na | 6/19/1997 | 15.24 | 0.5590 | <0.1 | 0.2 | 2.5 | 0.0041 | 5,000 | nd | 11.9 | 0.7 |
| S062 | NM491 | Garfield S | 12 | na | 7/28/1998 | 14.98 | 0.5222 | 0.1 | 0.1 | 31.3 | <0.0001 | 5,000 | 0.5 | 15.5 | 1.1 |
| S062 | NM281 | Garfield S | 12 | na | 6/19/1997 | 14.49 | 0.5306 | <0.1 | 0.3 | 36.1 | 0.0002 | 5,000 | nd | 14.1 | 0.6 |
| S064 | NM283 | Domestic Well #22 | 12 | na | 6/20/1997 | 15.79 | 0.5333 | 0.1 | 0.1 | 6.2 | <0.0001 | 5,000 | 1.0 | 14.5 | 1.0 |
| S068 | NM057 | Griegos 3 | 12 | na | 6/21/1996 | 15.43 | 0.5549 | <0.1 | 0.2 | 2.4 | 0.0010 | 5,000 | nd | 13.0 | 1.3 |
| S075 | NM286 | Hunter Ridge Nest 1 Well 1 | 12 | 3 | 6/20/1997 | 14.27 | 0.5349 | <0.1 | 0.2 | 2.2 | <0.0001 | 5,000 | nd | 13.0 | 0.1 |
| S076 | NM287 | Hunter Ridge Nest 1 Well 2 | 12 | na | 6/21/1997 | 15.50 | 0.5628 | <0.1 | 0.2 | 4.7 | <0.0001 | 5,000 | nd | 12.0 | 1.0 |
| S077 | NM288 | Hunter Ridge Nest 1 Well 3 | 12 | na | 6/20/1997 | 14.07 | 0.5183 | 0.6 | 3.1 | 8.0 | <0.0001 | 5,000 | nd | 14.9 | 0.4 |
| S078 | NM289 | Hunter Ridge Nest 2 Well 1 | 12 | na | 6/21/1997 | 15.13 | 0.5423 | <0.1 | 0.2 | 4.0 | 0.0049 | 5,000 | nd | 14.0 | 1.3 |
| S079 | NM290 | Hunter Ridge Nest 2 Well 2 | 12 | na | 6/21/1997 | 15.07 | 0.5304 | 0.1 | 0.1 | 5.1 | <0.0001 | 5,000 | nd | 15.7 | 1.7 |
| S080 | NM291 | Hunter Ridge Nest 2 Well 3 | 12 | na | 6/21/1997 | 25.14 | 0.6001 | 0.2 | 1.1 | 6.6 | <0.0001 | 5,000 | nd | nd | nd |
| S081 | NM292 | Private Production Well #19 | 12 | na | 7/2/1997 | 15.78 | 0.5739 | <0.1 | 0.3 | 4.2 | <0.0001 | 5,000 | nd | 11.2 | 1.1 |
| S084 | NM063 | Windmill #04 | 12 | na | 8/21/1996 | 14.11 | 0.5198 | <0.1 | 3.2 | 5.6 | <0.0001 | 5,000 | nd | 14.8 | 0.4 |
| S087 | NM493 | Isleta MD | 12 | 3 | 7/29/1998 | 14.62 | 0.5229 | 0.1 | <0.1 | 1.1 | 0.0007 | 5,000 | nd | 15.7 | 1.2 |
| S088 | NM494 | Isleta MS | 12 | na | 7/29/1998 | 14.66 | 0.5330 | 0.1 | <0.1 | 1.7 | 0.0049 | 5,000 | nd | 14.2 | 0.8 |
| S089 | NM495 | Isleta S | 12 | na | 7/29/1998 | 17.12 | 0.5341 | 0.1 | <0.1 | 13.0 | 0.0211 | 5,000 | 2.3 | 14.5 | 1.1 |
| S092 | NM066 | JMC-1 | 12 | na | 6/28/1996 | 10.54 | 0.3745 | 0.1 | <0.1 | 8.8 | 0.0002 | 5,000 | nd | nd | nd |
| S097 | NM070 | Kirtland 14 | 12 | na | 6/25/1996 | 14.61 | 0.5422 | <0.1 | 0.7 | 3.4 | <0.0001 | 5,000 | nd | 12.8 | 0.4 |
| S100 | NM073 | LALF-9 | 12 | na | 6/29/1996 | 17.49 | 0.5410 | 0.1 | 0.1 | 7.8 | 0.0052 | 5,000 | 2.5 | 13.9 | 1.1 |
| S102 | NM074 | Leyendecker 1 | 12 | na | 6/21/1996 | 15.14 | 0.5367 | 0.1 | 0.9 | 3.5 | 0.0014 | 5,000 | 0.3 | 14.1 | 1.0 |
| S120 | NM503 | Mesa Del Sol D | 12 | na | 8/2/1998 | 16.13 | 0.5334 | 0.1 | <0.1 | 0.1 | 0.0125 | 5,000 | 1.3 | 14.6 | 1.1 |
| S120 | NM303 | Mesa Del Sol D | 12 | na | 6/28/1997 | 19.85 | 0.5823 | 2.1 | 0.8 | 3.5 | <0.0001 | 5,000 | 3.9 | 10.4 | 1.0 |
| S120 | NM301 | Mesa Del Sol D | 12 | na | 6/29/1997 | 11.34 | 0.4304 | 0.4 | 3.3 | 4.3 | <0.0001 | 5,000 | nd | 22.0 | - 0.6 |
| S121 | NM504 | Mesa Del Sol M | 12 | na | 7/25/1998 | 16.90 | 0.5733 | 0.1 | <0.1 | 0.3 | 0.0047 | 5,000 | 1.1 | 11.3 | 1.1 |
| S121 | NM302 | Mesa Del Sol M | 12 | na | 6/28/1997 | 15.63 | 0.5678 | <0.1 | 0.1 | 0.4 | <0.0001 | 5,000 | nd | 11.6 | 1.1 |
| S123 | NM081 | MONT - 5A | 12 | na | 6/27/1996 | 15.56 | 0.5373 | 0.2 | <0.1 | 3.5 | 0.0001 | 5,000 | 1.0 | 13.3 | 0.5 |
| S124 | NM082 | Montaňo 2 D | 12 | na | 6/19/1996 | 17.46 | 0.6029 | <0.1 | 0.1 | 7.6 | 0.0281 | 5,000 | 1.0 | 8.9 | 1.0 |
| S125 | NM083 | Montaňo 2 M | 12 | na | 6/19/1996 | 18.63 | 0.5810 | 0.1 | <0.1 | 11.4 | 0.0243 | 5,000 | 3.0 | 9.9 | 0.5 |
| S126 | NM084 | Montaňo 2 S | 12 | na | 6/19/1996 | 16.71 | 0.5592 | <0.1 | <0.1 | 15.6 | 0.0016 | 5,000 | 1.5 | 11.8 | 0.7 |
| S127 | NM085 | Montaňo 4 D | 12 | na | 6/20/1996 | 18.64 | 0.5759 | 0.4 | 0.1 | 4.5 | 0.0024 | 5,000 | 3.0 | 10.6 | 0.7 |
| S128 | NM086 | Montaňo 4 M | 12 | na | 6/19/1996 | 19.07 | 0.5793 | 0.1 | 0.1 | 32.9 | 0.0132 | 5,000 | 3.0 | 11.1 | 1.3 |
| S130 | NM088 | Montaňo 5 D | 12 | na | 6/24/1996 | 14.46 | 0.5331 | 0.1 | 0.1 | 3.8 | 0.0181 | 5,000 | nd | 13.7 | 0.5 |
| S131 | NM089 | Montaňo 5 M | 12 | na | 6/24/1996 | 15.98 | 0.5844 | 0.1 | 0.1 | 3.3 | 0.0018 | 5,000 | 0.3 | 9.6 | 0.4 |
| S132 | NM090 | Montaňo 5 S | 12 | na | 6/24/1996 | 12.34 | 0.4286 | 0.1 | 0.1 | 4.3 | 0.0004 | 5,000 | 0.5 | 24.1 | 0.3 |
| S133 | NM091 | Montaňo 6 D | 12 | na | 6/18/1996 | 14.88 | 0.5240 | 0.1 | 0.1 | 2.9 | 0.0618 | 5,000 | 0.5 | 14.9 | 0.7 |
| S134 | NM092 | Montaňo 6 MD | 12 | na | 6/18/1996 | 14.91 | 0.5484 | <0.1 | 0.1 | 0.6 | <0.0001 | 5,000 | nd | 12.6 | 0.6 |
| S135 | NM093 | Montaňo 6 MS | 12 | na | 6/18/1996 | 15.71 | 0.5725 | <0.1 | 0.1 | 0.6 | 0.0002 | 5,000 | nd | 11.2 | 1.0 |
| S136 | NM094 | Montaňo 6 S | 12 | na | 6/18/1996 | 16.62 | 0.5566 | <0.1 | 0.1 | 2.7 | 0.0021 | 5,000 | 1.5 | 12.0 | 0.6 |
| S137 | NM506 | Montesa M | 12 | na | 7/27/1998 | 14.85 | 0.5306 | 0.1 | 5.5 | 2.4 | <0.0001 | 5,000 | nd | 15.1 | 1.3 |
| S138 | NM507 | Montesa S | 12 | na | 7/27/1998 | 24.61 | 0.6918 | 0.1 | 1.6 | 3.7 | <0.0001 | 5,000 | nd | 15.9 | nd |

**Table A5.** Summary of dissolved gases (nitrogen, argon, neon, helium, oxygen, and carbon dioxide)-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secondary hydro-chemical zone | Date | $N_2$ (mg/kg) | Ar (mg/kg) | Lab $O_2$ (mg/kg) | Field $O_2$ (mg/kg) | Lab $CO_2$ (mg/kg) | $CH_4$ (mg/kg) | Assigned recharge altitude (feet) | Excess $N_2$ (mg/kg) | Recom-mended recharge temp-erature (°C) | Recom-mended excess air (cc STP/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S139 | NM305 | Domestic Well #27 | 12 | na | 6/17/1997 | 14.51 | 0.5228 | 0.6 | 1.2 | 4.9 | <0.0001 | 5,000 | nd | 15.4 | 1.0 |
| S142 | NM307 | Domestic Well #28 | 12 | na | 6/17/1997 | 14.63 | 0.5249 | 0.1 | 1.0 | 3.9 | <0.0001 | 5,000 | nd | 15.4 | 1.1 |
| S146 | NM309 | NM Utilities 2 | 12 | na | 6/18/1997 | 14.99 | 0.5387 | 0.2 | 1.0 | 3.9 | <0.0001 | 5,000 | nd | 14.2 | 1.2 |
| S151 | NM508 | Nor Este S | 12 | na | 7/20/1998 | 13.48 | 0.5041 | 0.1 | 0.4 | 3.0 | <0.0001 | 5,000 | nd | 15.6 | 0.0 |
| S151 | NM314 | Nor Este S | 12 | na | 7/2/1997 | 14.74 | 0.5634 | <0.1 | 0.7 | 3.1 | <0.0001 | 5,000 | nd | 10.2 | - 0.3 |
| S154 | NM099 | ORLF-2 | 12 | na | 6/27/1996 | 14.70 | 0.5558 | -0.1 | <0.1 | 3.9 | <0.0001 | 5,000 | nd | 11.1 | - 0.1 |
| S155 | NM316 | Domestic Well #29 | 12 | na | 6/27/1997 | 14.51 | 0.5466 | <0.1 | 0.1 | 3.1 | <0.0001 | 5,000 | nd | 11.9 | 0.0 |
| S156 | NM100 | Paseo 2D | 12 | na | 6/26/1996 | 16.83 | 0.5626 | <0.1 | <0.1 | 2.1 | 0.1014 | 5,000 | 1.5 | 11.6 | 0.8 |
| S157 | NM101 | Paseo 2MD | 12 | na | 6/26/1996 | 15.22 | 0.5560 | 0.2 | <0.1 | 3.8 | 0.0028 | 5,000 | nd | 12.3 | 0.8 |
| S158 | NM102 | Paseo 2MS | 12 | na | 6/26/1996 | 16.64 | 0.5572 | 0.2 | <0.1 | 8.0 | 0.0024 | 5,000 | 1.5 | 11.9 | 0.6 |
| S159 | NM103 | Paseo 2S | 12 | na | 6/26/1996 | 19.52 | 0.5887 | 0.2 | <0.1 | 23.8 | 0.0005 | 5,000 | 3.5 | 9.8 | 0.8 |
| S160 | NM104 | Paseo 3D | 12 | na | 6/21/1996 | 15.10 | 0.5685 | 0.2 | 0.2 | 2.3 | 0.0017 | 5,000 | nd | 10.3 | 0.1 |
| S161 | NM105 | Paseo 3M | 12 | na | 6/21/1996 | 20.09 | 0.6278 | 0.9 | 0.1 | 41.0 | 0.0002 | 5,000 | 0.0 | 13.9 | 6.3 |
| S171 | NM321 | Ridgecrest 4 | 12 | na | 6/26/1997 | 14.42 | 0.5364 | 0.5 | 1.5 | 3.5 | <0.0001 | 5,000 | nd | 13.1 | 0.3 |
| S173 | NM323 | Rio Bravo 5 M | 12 | 3 | 7/4/1997 | 16.17 | 0.5802 | <0.1 | <0.1 | 1.7 | 0.0470 | 5,000 | 0.2 | 10.7 | 1.1 |
| S176 | NM111 | Rio Bravo 1 S | 12 | na | 6/17/1996 | 15.16 | 0.4973 | 0.1 | 0.1 | 11.9 | 0.0260 | 5,000 | 1.0 | 18.6 | 1.5 |
| S177 | NM112 | Rio Bravo 2 D | 12 | 3 | 6/25/1996 | 16.53 | 0.5816 | <0.1 | 0.1 | 2.4 | <0.0001 | 5,000 | 0.5 | 10.7 | 1.2 |
| S178 | NM113 | Rio Bravo 2 M | 12 | na | 6/25/1996 | 17.76 | 0.5592 | 0.1 | 0.1 | 6.9 | <0.0001 | 5,000 | 2.3 | 12.4 | 1.1 |
| S179 | NM114 | Rio Bravo 2 S | 12 | na | 6/25/1996 | 17.44 | 0.5476 | <0.1 | 0.1 | 7.5 | 0.0046 | 5,000 | 2.3 | 13.3 | 1.1 |
| S180 | NM115 | Rio Bravo 4 D | 12 | na | 6/25/1996 | 19.22 | 0.5493 | <0.1 | <0.1 | 3.4 | 0.0040 | 5,000 | 4.0 | 13.2 | 1.1 |
| S181 | NM116 | Rio Bravo 4 M | 12 | na | 6/25/1996 | 17.12 | 0.5003 | 0.1 | <0.1 | 5.3 | 0.0002 | 5,000 | 3.1 | 17.7 | 1.1 |
| S183 | NM126 | Rio Grae Utility 5 | 12 | 3 | 8/15/1996 | 15.29 | 0.5312 | <0.1 | 0.6 | 4.3 | <0.0001 | 5,000 | 0.5 | 14.8 | 1.1 |
| S184 | NM127 | Rio Grae Utility 6 | 12 | na | 8/15/1996 | 14.96 | 0.5512 | <0.1 | 0.1 | 3.1 | <0.0001 | 5,000 | nd | 12.3 | 0.6 |
| S190 | NM325 | Rio Rancho 2 | 12 | na | 6/20/1997 | 15.05 | 0.5244 | 0.6 | 1.6 | 4.6 | <0.0001 | 5,000 | 1.0 | 14.0 | 0.1 |
| S203 | NM331 | Private Production Well #20 | 12 | na | 7/3/1997 | 16.39 | 0.5595 | <0.1 | 1.1 | 9.1 | <0.0001 | 5,000 | 1.0 | 12.2 | 1.0 |
| S205 | NM333 | Private Production Well #21 | 12 | na | 7/3/1997 | 15.44 | 0.5565 | 0.1 | 0.1 | 8.2 | 0.0037 | 5,000 | nd | 12.7 | 1.2 |
| S208 | NM140 | San Jose 2 | 12 | 3 | 6/20/1996 | 15.92 | 0.5485 | 0.1 | 0.6 | 2.2 | <0.0001 | 5,000 | nd | 15.1 | 2.4 |
| S210 | NM511 | Sandia D | 12 | na | 7/30/1998 | 15.54 | 0.5473 | 0.1 | 1.1 | 3.9 | 0.0018 | 5,000 | 0.4 | 13.3 | 1.1 |
| S214 | NM513 | Sandia S | 12 | na | 7/30/1998 | 17.55 | 0.5574 | 0.1 | 0.1 | 0.6 | <0.0001 | 5,000 | 2.2 | 12.4 | 1.0 |
| S220 | NM147 | Santa Barbara 1 | 12 | na | 6/19/1996 | 25.49 | 0.7614 | 2.9 | 0.3 | 3.0 | 0.0003 | 5,000 | 0.0 | 8.4 | 10.1 |
| S231 | NM517 | Sierra Vista M | 12 | 3 | 7/22/1998 | 14.67 | 0.5336 | 0.1 | 0.1 | 0.9 | <0.0001 | 5,000 | nd | 14.2 | 0.8 |
| S232 | NM518 | Sierra Vista S | 12 | na | 7/22/1998 | 13.61 | 0.4893 | 1.0 | 4.6 | 6.9 | <0.0001 | 5,000 | nd | 18.4 | 0.9 |
| S234 | NM339 | Sister Cities D | 12 | na | 6/30/1997 | 14.71 | 0.5570 | 0.3 | 0.7 | 3.8 | <0.0001 | 5,000 | nd | 11.0 | - 0.1 |
| S235 | NM340 | Sister Cities M | 12 | na | 6/27/1997 | 14.61 | 0.5426 | <0.1 | 0.1 | 2.7 | 0.0039 | 5,000 | nd | 12.7 | 0.3 |
| S244 | NM158 | SWAB 3 - 760 | 12 | na | 7/1/1996 | 15.24 | 0.5370 | 0.2 | <0.1 | 0.4 | 4.8440 | 5,000 | nd | 15.1 | 1.7 |
| S245 | NM159 | SWAB 3 - 980 | 12 | na | 7/1/1996 | 15.37 | 0.5372 | <0.1 | <0.1 | 0.5 | 3.7693 | 5,000 | nd | 15.4 | 1.9 |
| S245 | NM160 | SWAB 3 - 980 | 12 | na | 7/1/1996 | 18.47 | 0.5879 | 0.1 | <0.1 | 0.5 | 4.2553 | 5,000 | nd | 15.8 | 5.2 |
| S253 | NM522 | Tome D | 12 | na | 8/6/1998 | 16.12 | 0.5506 | 0.1 | <0.1 | 2.1 | <0.0001 | 5,000 | 0.9 | 13.0 | 1.1 |
| S257 | NM344 | Domestic Well #34 | 12 | na | 6/17/1997 | 16.20 | 0.5700 | <0.1 | 0.1 | 14.8 | <0.0001 | 5,000 | 0.5 | 11.5 | 1.1 |
| S259 | NM171 | VGP-1 | 12 | na | 6/27/1996 | 19.39 | 0.6028 | 0.1 | <0.1 | 12.8 | 0.0008 | 5,000 | nd | 15.9 | 6.1 |
| S261 | NM172 | Vol Andia 2 | 12 | na | 6/21/1996 | 15.14 | 0.5565 | -0.2 | 0.6 | 3.0 | 0.0006 | 5,000 | nd | 12.0 | 0.7 |
| S262 | NM173 | Vol Andia 5 | 12 | na | 6/18/1996 | 15.32 | 0.5521 | 0.1 | 0.3 | 2.5 | 0.0008 | 5,000 | 0.5 | 11.9 | 0.3 |
| S265 | NM175 | Webster 1 | 12 | na | 6/18/1996 | 19.73 | 0.3999 | 7.2 | 1.1 | 0.2 | <0.0001 | 5,000 | nd | nd | nd |
| S267 | NM348 | West Bluff Nest 1 Well 2 | 12 | 3 | 6/23/1997 | 15.52 | 0.5619 | 0.1 | 0.2 | 2.6 | <0.0001 | 5,000 | nd | 12.2 | 1.1 |
| S268 | NM349 | West Bluff Nest 1 Well 3 | 12 | na | 6/24/1997 | 15.14 | 0.5717 | <0.1 | 0.2 | 3.1 | <0.0001 | 5,000 | nd | 10.0 | 0.0 |
| S269 | NM350 | West Bluff Nest 2 Well 1 | 12 | na | 6/24/1997 | 15.73 | 0.5604 | 0.2 | 0.1 | 3.1 | 0.0002 | 5,000 | nd | 12.9 | 1.5 |
| S270 | NM351 | West Bluff Nest 2 Well 2 | 12 | na | 6/24/1997 | 15.79 | 0.5773 | 0.1 | 0.2 | 3.7 | <0.0001 | 5,000 | nd | 10.7 | 0.9 |
| S271 | NM352 | West Bluff Nest 2 Well 3 | 12 | na | 6/24/1997 | 17.47 | 0.6344 | 0.1 | 1.4 | 7.6 | <0.0001 | 5,000 | nd | 7.3 | 1.4 |
| S275 | NM178 | Yale 1 | 12 | na | 6/19/1996 | 18.37 | 0.5891 | 0.1 | 1.6 | 3.8 | <0.0001 | 5,000 | 2.5 | 9.4 | 0.6 |
| SXXX | NM045 | Geoprobe #1 (45.3') | 12 | na | 7/1/1996 | 14.41 | 0.5276 | <0.1 | 0.1 | 2.5 | 0.0362 | 5,000 | nd | 14.4 | 0.6 |
| SXXX | NM049 | Geoprobe #1 (25') | 12 | na | 7/1/1996 | 17.52 | 0.6182 | -0.1 | 0.1 | 1.9 | 0.1460 | 5,000 | nd | 9.3 | 2.2 |
| SXXX | NM051 | Geoprobe #2 (40.5') | 12 | na | 7/1/1996 | 14.44 | 0.5387 | <0.1 | 0.1 | 2.5 | 0.0133 | 5,000 | nd | 12.8 | 0.2 |
| | | **Zone 13: Discharge** | | | | | | | | | | | | | |
| S143 | NM096 | Private Production Well #05 | 13 | na | 8/19/1996 | 17.59 | 0.5639 | <0.1 | 0.1 | 3.1 | 0.0014 | 5,000 | 2.0 | 12.1 | 1.1 |
| S194 | NM327 | Domestic Well #32 | 13 | na | 6/30/1997 | 14.38 | 0.5131 | 0.8 | 1.8 | 2.6 | <0.0001 | 5,000 | nd | 16.6 | 1.2 |
| S226 | NM150 | Domestic Well #15 | 13 | na | 8/19/1996 | 17.51 | 0.5682 | <0.1 | 0.1 | 5.5 | <0.0001 | 5,000 | 1.9 | 11.5 | 1.0 |
| | | **No Zone: Exotic Water** | | | | | | | | | | | | | |
| S009 | NM485 | Arroyo Salado Spring | E | E | 8/6/1998 | 10.72 | 0.4016 | 4.0 | 7.4 | 155.8 | <0.0001 | 5,000 | nd | nd | nd |
| S023 | NM010 | Burn Site Well | E | E | 6/25/1996 | 15.63 | 0.5332 | 0.7 | 3.6 | 25.3 | <0.0001 | 6,500 | nd | 14.4 | 2.6 |
| S038 | NM265 | Windmill #19 | E | E | 7/1/1997 | 21.41 | 0.6898 | <0.1 | 0.6 | 2.7 | 0.0086 | 5,000 | nd | 8.6 | nd |
| S054 | NM041 | Domestic Well #04 | E | E | 8/17/1996 | 2.985 | 0.1399 | <0.1 | 0.1 | 9.1 | 0.0183 | 6,500 | nd | nd | nd |
| S057 | NM044 | Embudo Spring | E | E | 7/2/1996 | 15.09 | 0.5519 | 0.1 | 0.1 | 52.1 | 0.0170 | 6,500 | nd | 10.3 | 0.9 |
| S063 | NM282 | Windmill #22 | E | E | 6/28/1997 | 16.35 | 0.5387 | 3.6 | 3.6 | 12.7 | <0.0001 | 5,000 | nd | 17.9 | 3.5 |
| S067 | NM284 | Granite Hill | E | E | 7/4/1997 | 23.20 | 0.6255 | 0.1 | 0.1 | 16.5 | 0.0002 | 6,500 | nd | nd | nd |
| S070 | NM059 | HERTF | E | E | 6/28/1996 | 14.99 | 0.5165 | 1.9 | 3.0 | 13.2 | <0.0001 | 6,500 | nd | 15.3 | 2.2 |
| S091 | NM496 | Private Production Well #23 | E | E | 8/4/1998 | 16.28 | 0.5482 | 0.1 | nd | 15.1 | 0.0327 | 5,000 | 1.1 | 13.3 | 1.1 |
| S094 | NM293 | Stock Well #02 | E | E | 6/20/1997 | 21.91 | 0.6057 | 4.6 | 5.2 | 20.0 | <0.0001 | 5,000 | nd | 23.0 | nd |
| S099 | NM072 | LALF-1 | E | E | 6/29/1996 | 17.44 | 0.5178 | 0.1 | 0.0 | 33.2 | 0.0015 | 5,000 | 3.0 | 16.0 | 1.1 |
| S112 | NM296 | Domestic Well #24 | E | E | 6/21/1997 | 14.25 | 0.4924 | <0.1 | nd | 13.9 | 0.0686 | 6,500 | nd | 17.2 | 2.0 |
| S129 | NM087 | Montaňo 4 S | E | E | 6/19/1996 | 15.83 | 0.5348 | 0.2 | 0.2 | 44.4 | 0.0016 | 5,000 | 1.0 | 14.4 | 1.1 |
| S152 | NM098 | Private Production Well #07 | E | E | 8/22/1996 | 16.66 | 0.5606 | 0.1 | 1.8 | 26.3 | <0.0001 | 6,500 | 1.5 | 9.3 | 0.7 |
| S182 | NM117 | Rio Bravo 4 S | E | E | 6/25/1996 | 18.59 | 0.5459 | 1.1 | 0.0 | 32.0 | 0.0105 | 5,000 | 3.5 | 13.4 | 1.0 |
| S211 | NM512 | Sandia M | E | E | 7/30/1998 | 15.80 | 0.5542 | 0.1 | 0.8 | 2.1 | <0.0001 | 6,500 | 0.6 | 10.2 | 1.0 |
| S225 | NM149 | SBM-1 | E | E | 6/29/1996 | 15.26 | 0.5149 | 0.1 | 0.0 | 91.4 | 0.0006 | 5,000 | 1.0 | 15.9 | 0.9 |
| S249 | NM164 | Private Production Well #09 | E | E | 6/26/1996 | 13.65 | 0.4874 | 5.2 | nd | 9.8 | <0.0001 | 6,500 | nd | 16.3 | 1.1 |
| S249 | NM163 | Private Production Well #09 | E | E | 6/26/1996 | 35.29 | 0.8637 | 12. | 5.3 | 10.7 | 0.0002 | 6,500 | nd | 15.2 | nd |

**Table A5.** Summary of dissolved gases (nitrogen, argon, neon, helium, oxygen, and carbon dioxide)-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secondary hydro-chemical zone | Date | $N_2$ (mg/kg) | Ar (mg/kg) | Lab $O_2$ (mg/kg) | Field $O_2$ (mg/kg) | Lab $CO_2$ (mg/kg) | $CH_4$ (mg/kg) | Assigned recharge altitude (feet) | Excess $N_2$ (mg/kg) | Recom-mended recharge temp-erature (°C) | Recom-mended excess air (cc STP/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S250 | NM165 | Private Production Well #10 | E | E | 6/26/1996 | 18.06 | 0.5517 | -0.1 | 0.1 | 9.6 | 0.0001 | 6,500 | nd | 18.2 | 6.1 |
| S251 | NM166 | Private Production Well #11 | E | E | 6/26/1996 | 14.67 | 0.5013 | 5.1 | 6.0 | 14.6 | <0.0001 | 6,500 | nd | 16.9 | 2.3 |
| S282 | NM529 | Windmill #44 | E | E | 7/29/1998 | 13.74 | 0.4757 | 2.2 | 3.8 | 11.7 | <0.0001 | 5,000 | nd | 21.2 | 1.6 |
| SXXX | NM154 | Soda Dam Spring | E | E | 8/20/1996 | 3.888 | 0.1454 | <0.1 | 2.0 | 429.7 | 0.0037 | 8,000 | nd | nd | nd |
| SXXX | NM065 | Jemez Spring | E | E | 8/20/1996 | 1.164 | 0.0368 | <0.1 | nd | 436.3 | 0.0250 | 8,000 | nd | nd | nd |

**Table A6.** Sensitivity analysis for recharge temperatures calculated from dissolved gases

[SXXX, no site number assigned; Hydrochemical Zone "E", exotic water, no primary or secondary zone assigned; $N_2$, nitrogen; Ar, argon; Alt., altitude; ºC, degrees Celsius; mg/kg, milligrams per kilogram; cc STP/kg, cubic centimeters at standard temperature and pressure per kilogram of water; na, not applicable; nd, not determined; negative excess air indicates degassing]

| | | | | | | | | | Assuming no excess $N_2$ | | | | | | | Assuming calculated excess $N_2$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Alt. 5,000 feet | | Alt. 6,500 feet | | Alt. 8,000 feet | | | Alt. 5,000 feet | | Alt. 6,500 feet | | Alt. 8,000 feet | |
| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Second-ary hydro-chemical zone | Date | $N_2$ (mg/kg) | Ar (mg/kg) | Assigned recharge altitude (feet) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Calcu-lated excess $N_2$ (mg/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) |
| | | **Zone 1: Northern Mountain Front** | | | | | | | | | | | | | | | | | | | |
| S027 | NM486 | CEPO 02 | 1 | na | 8/3/1998 | 14.07 | 0.5213 | 6,500 | 14.5 | 0.3 | 12.1 | 0.4 | 9.9 | 0.5 | nd | 14.5 | 0.3 | 12.1 | 0.4 | 9.9 | 0.5 |
| S027 | NM486 | CEPO 02 | 1 | na | 8/3/1998 | 14.16 | 0.5185 | 6,500 | 15.1 | 0.6 | 12.8 | 0.7 | 10.5 | 0.8 | nd | 15.1 | 0.6 | 12.8 | 0.7 | 10.5 | 0.8 |
| S034 | NM027 | Private Production Well #04 | 1 | na | 8/28/1996 | 23.27 | 0.6858 | 6,500 | 13.4 | 9.4 | 11.1 | 9.5 | 8.8 | 9.6 | nd | 13.4 | 9.4 | 11.1 | 9.5 | 8.8 | 9.6 |
| S035 | NM487 | Windmill #37 | 1 | na | 7/31/1998 | 16.17 | 0.5819 | 6,500 | 11.0 | 1.4 | 8.8 | 1.5 | 6.6 | 1.6 | nd | 11.0 | 1.4 | 8.8 | 1.5 | 6.6 | 1.6 |
| S035 | NM487 | Windmill #37 | 1 | na | 7/31/1998 | 16.21 | 0.5816 | 6,500 | 11.1 | 1.5 | 8.9 | 1.6 | 6.7 | 1.7 | nd | 11.1 | 1.5 | 8.9 | 1.6 | 6.7 | 1.7 |
| S036 | NM026 | Private Production Well #03 | 1 | na | 8/28/1996 | 15.25 | 0.5730 | 6,500 | 10.1 | 0.2 | 7.9 | 0.3 | 5.8 | 0.4 | nd | 10.1 | 0.2 | 7.9 | 0.3 | 5.8 | 0.4 |
| S065 | NM055 | Domestic Well #05 | 1 | na | 8/17/1996 | 14.57 | 0.5350 | 6,500 | 13.7 | 0.6 | 11.4 | 0.7 | 9.2 | 0.8 | nd | 13.7 | 0.6 | 11.4 | 0.7 | 9.2 | 0.8 |
| S187 | NM131 | Rio Rancho 12 | 1 | na | 8/13/1996 | 15.88 | 0.5559 | 6,500 | 13.9 | 2.0 | 11.6 | 2.1 | 9.3 | 2.2 | 1.0 | 11.5 | 0.2 | 9.3 | 0.4 | 7.1 | 0.5 |
| S206 | NM510 | Windmill #38 | 1 | 3 | 8/3/1998 | 11.69 | 0.4400 | 6,500 | 21.3 | -0.4 | 18.8 | -0.3 | 16.3 | -0.2 | nd | 21.3 | -0.4 | 18.8 | -0.3 | 16.3 | -0.2 |
| S206 | NM510 | Windmill #38 | 1 | 3 | 8/3/1998 | 11.73 | 0.4413 | 6,500 | 21.2 | -0.4 | 18.7 | -0.3 | 16.2 | -0.2 | nd | 21.2 | -0.4 | 18.7 | -0.3 | 16.2 | -0.2 |
| S216 | NM143 | Windmill #09 | 1 | na | 8/27/1996 | 13.94 | 0.5035 | 6,500 | 16.9 | 0.8 | 14.5 | 0.9 | 12.2 | 1.1 | nd | 16.9 | 0.8 | 14.5 | 0.9 | 12.2 | 1.1 |
| S221 | NM530 | Windmill #45 | 1 | na | 8/20/1998 | 15.20 | 0.5363 | 6,500 | 15.1 | 1.6 | 12.8 | 1.8 | 10.5 | 1.9 | nd | 15.1 | 1.6 | 12.8 | 1.8 | 10.5 | 1.9 |
| S221 | NM530 | Windmill #45 | 1 | na | 8/20/1998 | 15.27 | 0.5379 | 6,500 | 15.1 | 1.7 | 12.7 | 1.8 | 10.4 | 1.9 | nd | 15.1 | 1.7 | 12.7 | 1.8 | 10.4 | 1.9 |
| S222 | NM514 | Windmill #39 | 1 | 3 | 8/6/1998 | 12.44 | 0.4476 | 6,500 | 22.3 | 0.5 | 19.7 | 0.7 | 17.2 | 0.8 | nd | 22.3 | 0.5 | 19.7 | 0.7 | 17.2 | 0.8 |
| S254 | NM168 | Private Production Well #12 | 1 | na | 8/28/1996 | 17.62 | 0.5296 | 6,500 | 23.6 | 6.1 | 21.0 | 6.2 | 18.4 | 6.4 | 3.0 | 14.6 | 0.9 | 12.3 | 1.0 | 10.0 | 1.1 |
| S279 | NM527 | Windmill #42 | 1 | na | 7/28/1998 | 13.15 | 0.4818 | 6,500 | 18.3 | 0.4 | 15.8 | 0.5 | 13.5 | 0.6 | nd | 18.3 | 0.4 | 15.8 | 0.5 | 13.5 | 0.6 |
| S279 | NM527 | Windmill #42 | 1 | na | 7/28/1998 | 13.21 | 0.4843 | 6,500 | 18.0 | 0.4 | 15.6 | 0.5 | 13.2 | 0.6 | nd | 18.0 | 0.4 | 15.6 | 0.5 | 13.2 | 0.6 |
| S281 | NM528 | Windmill #43 | 1 | 3 | 7/28/1998 | 11.55 | 0.4318 | 6,500 | 22.4 | -0.3 | 19.9 | -0.2 | 17.4 | -0.1 | nd | 22.4 | -0.3 | 19.9 | -0.2 | 17.4 | -0.1 |
| S281 | NM528 | Windmill #43 | 1 | 3 | 7/28/1998 | 11.68 | 0.4289 | 6,500 | 23.4 | 0.0 | 20.8 | 0.1 | 18.3 | 0.3 | nd | 23.4 | 0.0 | 20.8 | 0.1 | 18.3 | 0.3 |
| | | **Zone 2: Northwestern** | | | | | | | | | | | | | | | | | | | |
| S103 | NM497 | Lincoln D | 2 | na | 7/23/1998 | 14.02 | 0.4817 | 5,000 | 21.0 | 1.9 | 18.4 | 2.0 | 16.0 | 2.1 | 0.5 | 19.4 | 1.0 | 16.9 | 1.1 | 14.5 | 1.3 |
| S104 | NM498 | Lincoln M | 2 | na | 7/23/1998 | 13.36 | 0.4846 | 5,000 | 18.4 | 0.6 | 16.0 | 0.7 | 13.6 | 0.9 | nd | 18.4 | 0.6 | 16.0 | 0.7 | 13.6 | 0.9 |
| S104 | NM498 | Lincoln M | 2 | na | 7/23/1998 | 13.41 | 0.4864 | 5,000 | 18.2 | 0.6 | 15.8 | 0.7 | 13.4 | 0.9 | nd | 18.2 | 0.6 | 15.8 | 0.7 | 13.4 | 0.9 |
| S105 | NM499 | Lincoln S | 2 | na | 7/23/1998 | 13.16 | 0.4751 | 5,000 | 19.5 | 0.7 | 17.0 | 0.8 | 14.6 | 0.9 | nd | 19.5 | 0.7 | 17.0 | 0.8 | 14.6 | 0.9 |
| S105 | NM499 | Lincoln S | 2 | na | 7/23/1998 | 14.09 | 0.4851 | 5,000 | 20.5 | 1.8 | 18.0 | 2.0 | 15.6 | 2.1 | 0.4 | 19.3 | 1.2 | 16.8 | 1.3 | 14.4 | 1.4 |
| S191 | NM326 | Rio Rancho 4 | 2 | 3 | 6/20/1997 | 13.05 | 0.4784 | 5,000 | 18.6 | 0.3 | 16.1 | 0.4 | 13.7 | 0.6 | nd | 18.6 | 0.3 | 16.1 | 0.4 | 13.7 | 0.6 |
| S192 | NM128 | Rio Rancho 8 | 2 | 3 | 8/13/1996 | 13.91 | 0.4983 | 5,000 | 17.7 | 1.0 | 15.3 | 1.1 | 12.9 | 1.2 | nd | 17.7 | 1.0 | 15.3 | 1.1 | 12.9 | 1.2 |
| S189 | NM133 | Rio Rancho 15 | 2 | na | 8/13/1996 | 16.07 | 0.4906 | 6,500 | 26.2 | 5.0 | 23.5 | 5.2 | 20.9 | 5.3 | 2.5 | 18.0 | 0.7 | 15.6 | 0.8 | 13.2 | 1.0 |
| S278 | NM526 | Windmill #41 | 2 | na | 7/29/1998 | 11.58 | 0.4228 | 5,000 | 24.3 | 0.1 | 21.7 | 0.2 | 19.2 | 0.3 | nd | 24.3 | 0.1 | 21.7 | 0.2 | 19.2 | 0.3 |
| S278 | NM526 | Windmill #41 | 2 | na | 7/29/1998 | 11.61 | 0.4221 | 5,000 | 24.6 | 0.2 | 22.0 | 0.3 | 19.4 | 0.4 | nd | 24.6 | 0.2 | 22.0 | 0.3 | 19.4 | 0.4 |
| S286 | NM184 | Private Production Well #13 | 2 | na | 8/26/1996 | 14.79 | 0.5358 | 5,000 | 14.1 | 0.9 | 11.8 | 1.1 | 9.6 | 1.2 | nd | 14.1 | 0.9 | 11.8 | 1.1 | 9.6 | 1.2 |
| S287 | NM185 | Private Production Well #14 | 2 | na | 8/26/1996 | 15.08 | 0.5298 | 5,000 | 15.8 | 1.7 | 13.4 | 1.8 | 11.1 | 1.9 | nd | 15.8 | 1.7 | 13.4 | 1.8 | 11.1 | 1.9 |
| | | **Zone 3: West Central** | | | | | | | | | | | | | | | | | | | |
| S003 | NM251 | 98th St. D | 3 | na | 6/17/1997 | 17.93 | 0.5361 | 8,000 | 23.3 | 6.4 | 20.7 | 6.5 | 18.2 | 6.7 | 3.1 | 14.2 | 1.0 | 11.9 | 1.1 | 9.6 | 1.2 |
| S003 | NM481 | 98th St. D | 3 | na | 8/4/1998 | 18.66 | 0.5412 | 8,000 | 24.8 | 7.4 | 22.2 | 7.6 | 19.7 | 7.7 | 3.6 | 14.0 | 1.2 | 11.7 | 1.3 | 9.5 | 1.4 |
| S003 | NM481 | 98th St. D | 3 | na | 8/4/1998 | 18.69 | 0.5400 | 8,000 | 25.2 | 7.5 | 22.5 | 7.7 | 20.0 | 7.8 | 3.7 | 14.0 | 1.1 | 11.7 | 1.2 | 9.4 | 1.3 |
| S004 | NM482 | 98th St. MD | 3 | na | 8/4/1998 | 17.10 | 0.5578 | 8,000 | 16.8 | 4.0 | 14.4 | 4.2 | 12.1 | 4.3 | 1.7 | 12.5 | 1.1 | 10.2 | 1.2 | 8.0 | 1.3 |
| S004 | NM482 | 98th St. MD | 3 | na | 8/4/1998 | 17.18 | 0.5581 | 8,000 | 17.0 | 4.2 | 14.6 | 4.3 | 12.3 | 4.4 | 1.8 | 12.4 | 1.0 | 10.1 | 1.1 | 7.9 | 1.3 |
| S004 | NM252 | 98th St. MD | 3 | na | 6/18/1997 | 17.21 | 0.5707 | 8,000 | 15.1 | 3.7 | 12.7 | 3.8 | 10.5 | 3.9 | 1.5 | 11.4 | 1.1 | 9.2 | 1.2 | 7.0 | 1.3 |
| S005 | NM253 | 98th St. MS | 3 | na | 7/4/1997 | 16.63 | 0.5841 | 8,000 | 11.7 | 2.1 | 9.5 | 2.2 | 7.3 | 2.3 | 0.7 | 10.1 | 0.9 | 7.9 | 1.0 | 5.8 | 1.1 |
| S005 | NM483 | 98th St. MS | 3 | na | 8/4/1998 | 16.65 | 0.5673 | 8,000 | 14.2 | 2.9 | 11.8 | 3.0 | 9.6 | 3.1 | 1.0 | 11.7 | 1.1 | 9.5 | 1.2 | 7.3 | 1.3 |
| S005 | NM483 | 98th St. MS | 3 | na | 8/4/1998 | 16.77 | 0.5732 | 8,000 | 13.6 | 2.8 | 11.3 | 2.9 | 9.1 | 3.0 | 1.0 | 11.2 | 1.1 | 9.0 | 1.2 | 6.8 | 1.3 |

**Table A6.** Sensitivity analysis for recharge temperatures calculated from dissolved gases-- Continued

| | | | | | | | | | Assuming no excess $N_2$ | | | | | | | Assuming calculated excess $N_2$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Alt. 5,000 feet | | Alt. 6,500 feet | | Alt. 8,000 feet | | | Alt. 5,000 feet | | Alt. 6,500 feet | | Alt. 8,000 feet | |
| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Second-ary hydro-chemical zone | Date | $N_2$ (mg/kg) | Ar (mg/kg) | Assigned recharge altitude (feet) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Calcu-lated excess $N_2$ (mg/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) |
| S006 | NM254 | 98th St. S | 3 | na | 6/17/1997 | 13.74 | 0.4967 | 8,000 | 17.5 | 0.8 | 15.1 | 0.9 | 12.7 | 1.0 | nd | 17.5 | 0.8 | 15.1 | 0.9 | 12.7 | 1.0 |
| S006 | NM484 | 98th St. S | 3 | na | 8/5/1998 | 13.94 | 0.4794 | 8,000 | 21.1 | 1.8 | 18.6 | 2.0 | 16.2 | 2.1 | 0.5 | 19.6 | 1.0 | 17.1 | 1.1 | 14.7 | 1.2 |
| S006 | NM484 | 98th St. S | 3 | na | 8/5/1998 | 14.01 | 0.4819 | 8,000 | 20.9 | 1.8 | 18.4 | 2.0 | 15.9 | 2.1 | 0.5 | 19.3 | 1.0 | 16.9 | 1.1 | 14.5 | 1.2 |
| S008 | NM003 | Private Production Well #01 | 3 | na | 8/12/1996 | 13.21 | 0.4735 | 8,000 | 19.9 | 0.8 | 17.4 | 0.9 | 15.0 | 1.1 | nd | 19.9 | 0.8 | 17.4 | 0.9 | 15.0 | 1.1 |
| S010 | NM255 | Private Production Well #16 | 3 | na | 6/23/1997 | 12.21 | 0.4685 | 8,000 | 17.8 | - 0.7 | 15.4 | - 0.6 | 13.0 | - 0.5 | nd | 17.8 | - 0.7 | 15.4 | - 0.6 | 13.0 | - 0.5 |
| S018 | NM260 | Domestic Well #21 | 3 | na | 6/26/1997 | 14.71 | 0.4824 | 8,000 | 23.1 | 3.0 | 20.5 | 3.2 | 18.0 | 3.3 | nd | 23.1 | 3.0 | 20.5 | 3.2 | 18.0 | 3.3 |
| S019 | NM007 | Belen 4 | 3 | 5 | 8/16/1996 | 13.05 | 0.4717 | 8,000 | 19.7 | 0.6 | 17.3 | 0.7 | 14.9 | 0.9 | nd | 19.7 | 0.6 | 17.3 | 0.7 | 14.9 | 0.9 |
| S020 | NM008 | Belen 5 | 3 | 5 | 8/16/1996 | 12.25 | 0.4541 | 8,000 | 20.5 | 0.0 | 18.0 | 0.1 | 15.5 | 0.2 | nd | 20.5 | 0.0 | 18.0 | 0.1 | 15.5 | 0.2 |
| S029 | NM015 | Cerro Colorado Landfill PW | 3 | 5 | 8/12/1996 | 16.71 | 0.5641 | 8,000 | 14.8 | 3.1 | 12.5 | 3.2 | 10.2 | 3.3 | 1.2 | 11.9 | 1.0 | 9.6 | 1.1 | 7.4 | 1.2 |
| S037 | NM264 | College 2 | 3 | na | 6/19/1997 | 15.21 | 0.5476 | 8,000 | 13.5 | 1.2 | 11.2 | 1.3 | 8.9 | 1.4 | nd | 13.5 | 1.2 | 11.2 | 1.3 | 8.9 | 1.4 |
| S066 | NM056 | Gonzales 1 | 3 | 12 | 6/20/1996 | 15.42 | 0.5382 | 8,000 | 15.4 | 1.9 | 13.0 | 2.1 | 10.7 | 2.2 | 0.5 | 14.1 | 1.1 | 11.8 | 1.2 | 9.5 | 1.3 |
| S086 | NM492 | Isleta D | 3 | na | 7/29/1998 | 15.82 | 0.5254 | 8,000 | 18.6 | 3.2 | 16.2 | 3.3 | 13.8 | 3.4 | 1.2 | 15.3 | 1.1 | 12.9 | 1.2 | 10.6 | 1.3 |
| S086 | NM492 | Isleta D | 3 | na | 7/29/1998 | 16.04 | 0.5335 | 8,000 | 17.9 | 3.2 | 15.5 | 3.4 | 13.1 | 3.5 | 1.2 | 14.6 | 1.1 | 12.3 | 1.3 | 10.0 | 1.4 |
| S101 | NM294 | Leavitt 1 | 3 | na | 6/26/1997 | 13.32 | 0.4938 | 8,000 | 16.8 | 0.2 | 14.4 | 0.3 | 12.1 | 0.4 | nd | 16.8 | 0.2 | 14.4 | 0.3 | 12.1 | 0.4 |
| S108 | NM076 | Los Lunas 3 | 3 | 12 | 8/14/1996 | 14.74 | 0.5354 | 8,000 | 14.1 | 0.9 | 11.7 | 1.0 | 9.5 | 1.1 | nd | 14.1 | 0.9 | 11.7 | 1.0 | 9.5 | 1.1 |
| S109 | NM077 | Los Lunas 4 | 3 | 12 | 8/14/1996 | 14.82 | 0.5511 | 8,000 | 12.0 | 0.4 | 9.8 | 0.5 | 7.6 | 0.6 | nd | 12.0 | 0.4 | 9.8 | 0.5 | 7.6 | 0.6 |
| S145 | NM308 | NM Utilities 1 | 3 | na | 6/18/1997 | 13.84 | 0.5084 | 8,000 | 15.9 | 0.4 | 13.5 | 0.6 | 11.2 | 0.7 | nd | 15.9 | 0.4 | 13.5 | 0.6 | 11.2 | 0.7 |
| S147 | NM310 | NM Utilities 3 | 3 | na | 6/18/1997 | 14.16 | 0.5136 | 8,000 | 15.9 | 0.8 | 13.5 | 0.9 | 11.2 | 1.0 | nd | 15.9 | 0.8 | 13.5 | 0.9 | 11.2 | 1.0 |
| S148 | NM311 | NM Utilities 4 | 3 | na | 6/18/1997 | 14.52 | 0.5253 | 8,000 | 15.0 | 0.9 | 12.7 | 1.0 | 10.4 | 1.1 | nd | 15.0 | 0.9 | 12.7 | 1.0 | 10.4 | 1.1 |
| S166 | NM509 | Rabbit Hill | 3 | na | 8/4/1998 | 17.48 | 0.5920 | 8,000 | 12.6 | 3.3 | 10.4 | 3.4 | 8.2 | 3.5 | 1.3 | 9.7 | 1.0 | 7.5 | 1.1 | 5.4 | 1.2 |
| S166 | NM509 | Rabbit Hill | 3 | na | 8/4/1998 | 17.79 | 0.5991 | 8,000 | 12.4 | 3.5 | 10.1 | 3.6 | 7.9 | 3.7 | 1.3 | 9.5 | 1.2 | 7.3 | 1.3 | 5.2 | 1.4 |
| S167 | NM107 | Domestic Well #12 | 3 | na | 8/14/1996 | 14.97 | 0.5083 | 8,000 | 19.1 | 2.4 | 16.6 | 2.5 | 14.2 | 2.7 | 1.0 | 16.2 | 0.7 | 13.8 | 0.8 | 11.5 | 0.9 |
| S172 | NM322 | Rio Bravo 5 D | 3 | na | 7/4/1997 | 17.91 | 0.5713 | 8,000 | 16.9 | 4.9 | 14.5 | 5.0 | 12.2 | 5.1 | 2.3 | 11.1 | 0.9 | 8.9 | 1.0 | 6.7 | 1.1 |
| S174 | NM109 | Rio Bravo 1 D | 3 | 12 | 6/17/1996 | 17.00 | 0.5515 | 8,000 | 17.6 | 4.1 | 15.2 | 4.3 | 12.8 | 4.4 | 2.0 | 12.4 | 0.6 | 10.1 | 0.8 | 7.9 | 0.9 |
| S175 | NM110 | Rio Bravo 1 M | 3 | 12 | 6/17/1996 | 19.48 | 0.6080 | 8,000 | 15.3 | 6.1 | 13.0 | 6.2 | 10.7 | 6.3 | 3.0 | 8.4 | 0.8 | 6.2 | 0.9 | 4.1 | 1.0 |
| S186 | NM130 | Rio Rancho 10 | 3 | na | 8/13/1996 | 15.29 | 0.5474 | 8,000 | 13.7 | 1.3 | 11.4 | 1.4 | 9.1 | 1.5 | nd | 13.7 | 1.3 | 11.4 | 1.4 | 9.1 | 1.5 |
| S188 | NM132 | Rio Rancho 13 | 3 | na | 8/13/1996 | 15.71 | 0.5631 | 8,000 | 12.5 | 1.4 | 10.2 | 1.5 | 8.0 | 1.6 | 0.5 | 11.3 | 0.5 | 9.1 | 0.6 | 6.9 | 0.7 |
| S193 | NM129 | Rio Rancho 9 | 3 | na | 8/13/1996 | 20.64 | 0.6188 | 8,000 | 16.8 | 7.7 | 14.4 | 7.8 | 12.0 | 7.9 | 4.0 | 7.4 | 0.6 | 5.3 | 0.7 | 3.2 | 0.8 |
| S196 | NM135 | Windmill #05 | 3 | na | 8/21/1996 | 11.97 | 0.4269 | 8,000 | 24.9 | 0.6 | 22.2 | 0.7 | 19.7 | 0.8 | nd | 24.9 | 0.6 | 22.2 | 0.7 | 19.7 | 0.8 |
| S200 | NM139 | Private Production Well #08 | 3 | na | 8/29/1996 | 15.83 | 0.5201 | 8,000 | 19.6 | 3.4 | 17.1 | 3.5 | 14.7 | 3.7 | 1.5 | 15.3 | 0.8 | 13.0 | 0.9 | 10.7 | 1.0 |
| S218 | NM145 | Santa Ana Boundary M | 3 | na | 8/22/1996 | 16.25 | 0.5762 | 8,000 | 11.9 | 1.8 | 9.7 | 1.9 | 7.5 | 2.0 | 0.5 | 10.8 | 0.9 | 8.6 | 1.0 | 6.4 | 1.1 |
| S219 | NM146 | Santa Ana Boundary S | 3 | na | 8/22/1996 | 16.49 | 0.5770 | 8,000 | 12.4 | 2.2 | 10.1 | 2.3 | 7.9 | 2.4 | 1.0 | 10.1 | 0.4 | 7.9 | 0.5 | 5.8 | 0.6 |
| S230 | NM516 | Sierra Vista D | 3 | na | 7/22/1998 | 17.03 | 0.5365 | 8,000 | 20.3 | 4.8 | 17.8 | 4.9 | 15.4 | 5.1 | 2.2 | 14.1 | 1.0 | 11.8 | 1.1 | 9.6 | 1.2 |
| S230 | NM516 | Sierra Vista D | 3 | na | 7/22/1998 | 17.04 | 0.5384 | 8,000 | 20.0 | 4.8 | 17.5 | 4.9 | 15.1 | 5.0 | 2.1 | 14.1 | 1.1 | 11.8 | 1.2 | 9.6 | 1.3 |
| S236 | NM155 | SAF (Soil Amendment Facility) | 3 | na | 8/12/1996 | 11.76 | 0.4120 | 8,000 | 27.3 | 0.8 | 24.6 | 1.0 | 22.0 | 1.1 | nd | 27.3 | 0.8 | 24.6 | 1.0 | 22.0 | 1.1 |
| S241 | NM519 | SWAB Test Hole 1 D | 3 | 1 | 8/5/1998 | 14.36 | 0.4702 | 8,000 | 24.3 | 2.9 | 21.7 | 3.1 | 19.2 | 3.2 | 1.1 | 20.7 | 1.0 | 18.2 | 1.2 | 15.7 | 1.3 |
| S241 | NM519 | SWAB Test Hole 1 D | 3 | 1 | 8/5/1998 | 14.42 | 0.4689 | 8,000 | 24.8 | 3.1 | 22.2 | 3.2 | 19.7 | 3.4 | 1.2 | 20.8 | 1.0 | 18.3 | 1.2 | 15.8 | 1.3 |
| S243 | NM521 | SWAB Test Hole 2 D | 3 | na | 8/7/1998 | 19.10 | 0.5535 | 8,000 | 23.9 | 7.7 | 21.3 | 7.8 | 18.7 | 8.0 | nd | 23.9 | 7.7 | 21.3 | 7.8 | 18.7 | 8.0 |
| S243 | NM521 | SWAB Test Hole 2 D | 3 | na | 8/7/1998 | 24.47 | 0.6697 | 8,000 | 19.2 | 12.2 | 16.7 | 12.3 | 14.3 | 12.4 | nd | 19.2 | 12.2 | 16.7 | 12.3 | 14.3 | 12.4 |
| S263 | NM346 | Volcano Cliff 1 | 3 | na | 6/19/1997 | 14.77 | 0.5412 | 8,000 | 13.3 | 0.7 | 11.0 | 0.8 | 8.8 | 0.9 | nd | 13.3 | 0.7 | 11.0 | 0.8 | 8.8 | 0.9 |
| S266 | NM347 | West Bluff Nest 1 Well 1 | 3 | na | 6/23/1997 | 16.78 | 0.5332 | 8,000 | 20.1 | 4.5 | 17.6 | 4.6 | 15.2 | 4.8 | 2.0 | 14.5 | 1.0 | 12.2 | 1.2 | 9.9 | 1.3 |
| S272 | NM353 | West Mesa 3 | 3 | na | 6/19/1997 | 13.73 | 0.5203 | 8,000 | 13.8 | - 0.2 | 11.5 | - 0.1 | 9.2 | 0.0 | nd | 13.8 | - 0.2 | 11.5 | - 0.1 | 9.2 | 0.0 |
| S283 | NM181 | Zia Ball Park D | 3 | na | 8/26/1996 | 15.58 | 0.5502 | 8,000 | 14.0 | 1.7 | 11.7 | 1.8 | 9.4 | 1.9 | 0.5 | 12.8 | 0.8 | 10.5 | 1.0 | 8.3 | 1.1 |
| S285 | NM183 | Zia Ball Park S | 3 | 2 | 8/26/1996 | 14.59 | 0.5297 | 8,000 | 14.5 | 0.9 | 12.2 | 1.0 | 9.9 | 1.1 | nd | 14.5 | 0.9 | 12.2 | 1.0 | 9.9 | 1.1 |
| S288 | NM186 | Zia BMT D | 3 | na | 8/27/1996 | 18.43 | 0.6035 | 8,000 | 13.3 | 4.4 | 11.0 | 4.5 | 8.8 | 4.6 | 2.0 | 8.8 | 0.9 | 6.6 | 1.0 | 4.5 | 1.1 |
| | | **Zone 4: Western Boundary** | | | | | | | | | | | | | | | | | | | |
| S039 | NM266 | Windmill #20 | 4 | na | 6/21/1997 | 14.98 | 0.5019 | 5,000 | 20.2 | 2.7 | 17.7 | 2.8 | 15.3 | 2.9 | 1.0 | 17.3 | 1.0 | 14.9 | 1.1 | 12.5 | 1.2 |
| S059 | NM278 | Windmill #21 | 4 | na | 6/23/1997 | 13.82 | 0.5191 | 5,000 | 14.2 | 0.0 | 11.8 | 0.1 | 9.6 | 0.2 | nd | 14.2 | 0.0 | 11.8 | 0.1 | 9.6 | 0.2 |

**Table A6.** Sensitivity analysis for recharge temperatures calculated from dissolved gases-- Continued

| | | | | | | | | | Assuming no excess $N_2$ | | | | | | | Assuming calculated excess $N_2$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Alt. 5,000 feet | | Alt. 6,500 feet | | Alt. 8,000 feet | | | Alt. 5,000 feet | | Alt. 6,500 feet | | Alt. 8,000 feet | |
| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Second-ary hydro-chemical zone | Date | $N_2$ (mg/kg) | Ar (mg/kg) | Assigned recharge altitude (feet) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Calcu-lated excess $N_2$ (mg/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) |
| S074 | NM285 | Windmill #23 | 4 | na | 6/21/1997 | 12.26 | 0.4466 | 5,000 | 21.9 | 0.3 | 19.3 | 0.4 | 16.9 | 0.5 | nd | 21.9 | 0.3 | 19.3 | 0.4 | 16.9 | 0.5 |
| | | **Zone 5: Rio Puerco** | | | | | | | | | | | | | | | | | | | |
| S069 | NM058 | Domestic Well #06 | 5 | na | 8/16/1996 | 35.65 | 0.8533 | 5,000 | 20.5 | 23.9 | 18.0 | 24.1 | 15.5 | 24.2 | nd | 20.5 | 23.9 | 18.0 | 24.1 | 15.5 | 24.2 |
| S111 | NM079 | Domestic Well #10 | 5 | na | 8/16/1996 | 17.12 | 0.5538 | 5,000 | 17.5 | 4.2 | 15.1 | 4.4 | 12.8 | 4.5 | 1.8 | 12.8 | 1.1 | 10.5 | 1.2 | 8.3 | 1.3 |
| S185 | NM324 | Domestic Well #31 | 5 | na | 6/16/1997 | 23.73 | 0.7031 | 5,000 | 12.0 | 9.5 | 9.8 | 9.6 | 7.6 | 9.7 | nd | 12.0 | 9.5 | 9.8 | 9.6 | 7.6 | 9.7 |
| S198 | NM137 | Windmill #07 | 5 | na | 8/21/1996 | 20.27 | 0.6329 | 5,000 | 13.6 | 6.4 | 11.3 | 6.5 | 9.1 | 6.6 | 3.0 | 7.0 | 1.1 | 4.9 | 1.2 | 2.9 | 1.3 |
| S237 | NM341 | Windmill #30 | 5 | 4 | 6/24/1997 | 12.64 | 0.4643 | 5,000 | 19.8 | 0.2 | 17.3 | 0.3 | 14.9 | 0.4 | nd | 19.8 | 0.2 | 17.3 | 0.3 | 14.9 | 0.4 |
| S238 | NM342 | Windmill #31 | 5 | na | 6/24/1997 | 14.09 | 0.4965 | 5,000 | 18.5 | 1.4 | 16.1 | 1.5 | 13.7 | 1.6 | nd | 18.5 | 1.4 | 16.1 | 1.5 | 13.7 | 1.6 |
| | | **Zone 7: Abo Arroyo** | | | | | | | | | | | | | | | | | | | |
| S021 | NM261 | Stock Well #01 | 7 | na | 6/23/1997 | 17.18 | 0.5793 | 5,000 | 13.7 | 3.3 | 11.4 | 3.4 | 9.2 | 3.5 | nd | 13.7 | 3.3 | 11.4 | 3.4 | 9.2 | 3.5 |
| S024 | NM011 | Domestic Well #02 | 7 | 8 | 8/17/1996 | 13.57 | 0.4870 | 5,000 | 18.6 | 0.9 | 16.2 | 1.0 | 13.8 | 1.1 | nd | 18.6 | 0.9 | 16.2 | 1.0 | 13.8 | 1.1 |
| S090 | NM064 | Domestic Well #08 | 7 | na | 8/19/1996 | 15.21 | 0.4628 | 5,000 | 29.2 | 4.7 | 26.4 | 4.8 | 23.8 | 5.0 | nd | 29.2 | 4.7 | 26.4 | 4.8 | 23.8 | 5.0 |
| S093 | NM067 | Domestic Well #09 | 7 | 8 | 8/15/1996 | 13.40 | 0.4893 | 5,000 | 17.7 | 0.5 | 15.3 | 0.6 | 12.9 | 0.7 | nd | 17.7 | 0.5 | 15.3 | 0.6 | 12.9 | 0.7 |
| | | **Zone 8: Eastern Mountain Front** | | | | | | | | | | | | | | | | | | | |
| S007 | NM002 | Domestic Well #01 | 8 | na | 6/21/1996 | 20.90 | 0.6622 | 6,500 | 11.0 | 6.3 | 8.8 | 6.4 | 6.6 | 6.5 | nd | 11.0 | 6.3 | 8.8 | 6.4 | 6.6 | 6.5 |
| S014 | NM257 | Private Production Well #17 | 8 | na | 6/19/1997 | 14.21 | 0.5249 | 6,500 | 14.3 | 0.4 | 12.0 | 0.5 | 9.7 | 0.6 | nd | 14.3 | 0.4 | 12.0 | 0.5 | 9.7 | 0.6 |
| S030 | NM019 | Charles 4 | 8 | na | 6/27/1996 | 13.43 | 0.4752 | 6,500 | 20.3 | 1.1 | 17.8 | 1.3 | 15.4 | 1.4 | nd | 20.3 | 1.1 | 17.8 | 1.3 | 15.4 | 1.4 |
| S030 | NM017 | Charles 4 | 8 | na | 6/27/1996 | 13.59 | 0.4966 | 6,500 | 17.1 | 0.5 | 14.7 | 0.6 | 12.3 | 0.7 | nd | 17.1 | 0.5 | 14.7 | 0.6 | 12.3 | 0.7 |
| S030 | NM018 | Charles 4 | 8 | na | 6/27/1996 | 13.61 | 0.5000 | 6,500 | 16.6 | 0.4 | 14.2 | 0.5 | 11.8 | 0.6 | nd | 16.6 | 0.4 | 14.2 | 0.5 | 11.8 | 0.6 |
| S030 | NM020 | Charles 4 | 8 | na | 6/27/1996 | 13.75 | 0.4905 | 6,500 | 18.5 | 1.0 | 16.1 | 1.2 | 13.7 | 1.3 | nd | 18.5 | 1.0 | 16.1 | 1.2 | 13.7 | 1.3 |
| S030 | NM021 | Charles 4 | 8 | na | 6/27/1996 | 13.81 | 0.4897 | 6,500 | 18.9 | 1.2 | 16.4 | 1.3 | 14.0 | 1.4 | nd | 18.9 | 1.2 | 16.4 | 1.3 | 14.0 | 1.4 |
| S030 | NM023 | Charles 4 | 8 | na | 6/27/1996 | 13.89 | 0.5011 | 6,500 | 17.2 | 0.8 | 14.7 | 1.0 | 12.4 | 1.1 | nd | 17.2 | 0.8 | 14.7 | 1.0 | 12.4 | 1.1 |
| S030 | NM024 | Charles 4 | 8 | na | 6/27/1996 | 13.93 | 0.5060 | 6,500 | 16.5 | 0.7 | 14.1 | 0.8 | 11.8 | 0.9 | nd | 16.5 | 0.7 | 14.1 | 0.8 | 11.8 | 0.9 |
| S030 | NM022 | Charles 4 | 8 | na | 6/27/1996 | 13.96 | 0.5012 | 6,500 | 17.3 | 0.9 | 14.9 | 1.1 | 12.6 | 1.2 | nd | 17.3 | 0.9 | 14.9 | 1.1 | 12.6 | 1.2 |
| S042 | NM031 | Domestic Well #03 | 8 | na | 8/14/1996 | 12.81 | 0.4715 | 6,500 | 19.1 | 0.2 | 16.6 | 0.3 | 14.2 | 0.4 | nd | 19.1 | 0.2 | 16.6 | 0.3 | 14.2 | 0.4 |
| S055 | NM042 | Elena Gallegos | 8 | na | 6/25/1996 | 10.22 | 0.3742 | 6,500 | 30.0 | - 0.3 | 27.3 | - 0.1 | 24.6 | 0.0 | nd | 30.0 | - 0.3 | 27.3 | - 0.1 | 24.6 | 0.0 |
| S056 | NM043 | Embudito Spring | 8 | na | 7/2/1996 | 13.45 | 0.5198 | 6,500 | 13.1 | - 0.7 | 10.8 | - 0.6 | 8.6 | - 0.5 | nd | 13.1 | - 0.7 | 10.8 | - 0.6 | 8.6 | - 0.5 |
| S071 | NM060 | Domestic Well #07 | 8 | na | 6/19/1996 | 16.64 | 0.5356 | 6,500 | 19.3 | 4.2 | 16.8 | 4.3 | 14.4 | 4.4 | nd | 19.3 | 4.2 | 16.8 | 4.3 | 14.4 | 4.4 |
| S095 | NM068 | Kirtland 1 | 8 | na | 6/25/1996 | 14.12 | 0.5037 | 6,500 | 17.4 | 1.1 | 15.0 | 1.3 | 12.6 | 1.4 | nd | 17.4 | 1.1 | 15.0 | 1.3 | 12.6 | 1.4 |
| S106 | NM295 | Domestic Well #23 | 8 | na | 6/26/1997 | 15.25 | 0.5436 | 6,500 | 14.1 | 1.4 | 11.8 | 1.5 | 9.6 | 1.6 | nd | 14.1 | 1.4 | 11.8 | 1.5 | 9.6 | 1.6 |
| S110 | NM078 | Love 1 | 8 | na | 6/22/1996 | 19.19 | 0.5763 | 6,500 | 19.8 | 6.9 | 17.3 | 7.0 | 14.9 | 7.1 | nd | 19.8 | 6.9 | 17.3 | 7.0 | 14.9 | 7.1 |
| S113 | NM080 | Domestic Well #11 | 8 | na | 8/15/1996 | 14.77 | 0.5267 | 6,500 | 15.5 | 1.3 | 13.1 | 1.4 | 10.8 | 1.5 | nd | 15.5 | 1.3 | 13.1 | 1.4 | 10.8 | 1.5 |
| S114 | NM500 | Matheson D | 8 | na | 7/31/1998 | 14.63 | 0.5066 | 6,500 | 18.3 | 1.9 | 15.9 | 2.0 | 13.5 | 2.1 | nd | 18.3 | 1.9 | 15.9 | 2.0 | 13.5 | 2.1 |
| S114 | NM500 | Matheson D | 8 | na | 7/31/1998 | 15.43 | 0.5201 | 6,500 | 18.4 | 2.7 | 15.9 | 2.8 | 13.6 | 3.0 | nd | 18.4 | 2.7 | 15.9 | 2.8 | 13.6 | 3.0 |
| S115 | NM501 | Matheson M | 8 | na | 8/1/1998 | 13.40 | 0.4728 | 6,500 | 20.6 | 1.2 | 18.1 | 1.3 | 15.7 | 1.4 | nd | 20.6 | 1.2 | 18.1 | 1.3 | 15.7 | 1.4 |
| S116 | NM502 | Matheson S | 8 | na | 8/1/1998 | 12.66 | 0.4632 | 6,500 | 20.1 | 0.3 | 17.6 | 0.4 | 15.2 | 0.5 | nd | 20.1 | 0.3 | 17.6 | 0.4 | 15.2 | 0.5 |
| S117 | NM298 | Domestic Well #25 | 8 | na | 6/17/1997 | 18.38 | 0.6113 | 6,500 | 12.1 | 4.0 | 9.8 | 4.1 | 7.7 | 4.2 | nd | 12.1 | 4.0 | 9.8 | 4.1 | 7.7 | 4.2 |
| S119 | NM300 | Domestic Well #26 | 8 | 11 | 6/19/1997 | 14.09 | 0.5170 | 6,500 | 15.2 | 0.5 | 12.8 | 0.6 | 10.6 | 0.8 | nd | 15.2 | 0.5 | 12.8 | 0.6 | 10.6 | 0.8 |
| S122 | NM505 | Mesa Del Sol S | 8 | na | 7/25/1998 | 14.03 | 0.4906 | 6,500 | 19.4 | 1.5 | 16.9 | 1.7 | 14.5 | 1.8 | 0.3 | 18.5 | 1.0 | 16.0 | 1.1 | 13.7 | 1.2 |
| S122 | NM505 | Mesa Del Sol S | 8 | na | 7/25/1998 | 14.11 | 0.4927 | 6,500 | 19.2 | 1.6 | 16.8 | 1.7 | 14.4 | 1.8 | 0.3 | 18.3 | 1.1 | 15.9 | 1.2 | 13.5 | 1.3 |
| S122 | NM304 | Mesa Del Sol S | 8 | na | 6/29/1997 | 15.68 | 0.5232 | 6,500 | 18.6 | 3.0 | 16.1 | 3.1 | 13.7 | 3.3 | 1.2 | 15.2 | 0.9 | 12.9 | 1.0 | 10.6 | 1.2 |
| S140 | NM306 | MRN 1 | 8 | na | 7/5/1997 | 16.13 | 0.5685 | 6,500 | 12.7 | 1.9 | 10.4 | 2.0 | 8.2 | 2.1 | nd | 12.7 | 1.9 | 10.4 | 2.0 | 8.2 | 2.1 |
| S141 | NM095 | National Utility 7 | 8 | na | 8/14/1996 | 13.89 | 0.4998 | 6,500 | 17.4 | 0.9 | 14.9 | 1.0 | 12.6 | 1.1 | nd | 17.4 | 0.9 | 14.9 | 1.0 | 12.6 | 1.1 |
| S149 | NM312 | Nor Este D | 8 | na | 7/3/1997 | 15.90 | 0.5707 | 6,500 | 11.9 | 1.4 | 9.6 | 1.5 | 7.4 | 1.6 | nd | 11.9 | 1.4 | 9.6 | 1.5 | 7.4 | 1.6 |
| S150 | NM313 | Nor Este M | 8 | na | 7/2/1997 | 15.98 | 0.5836 | 6,500 | 10.3 | 1.0 | 8.1 | 1.1 | 6.0 | 1.2 | nd | 10.3 | 1.0 | 8.1 | 1.1 | 6.0 | 1.2 |
| S162 | NM317 | Stock Well #03 | 8 | na | 6/30/1997 | 20.83 | 0.6456 | 6,500 | 13.2 | 6.9 | 10.9 | 7.0 | 8.6 | 7.1 | nd | 13.2 | 6.9 | 10.9 | 7.0 | 8.6 | 7.1 |

**Table A6.** Sensitivity analysis for recharge temperatures calculated from dissolved gases-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Second-ary hydro-chemical zone | Date | $N_2$ (mg/kg) | Ar (mg/kg) | Assigned recharge altitude (feet) | Assuming no excess $N_2$: Alt. 5,000 feet: Recharge temp-erature (ºC) | Assuming no excess $N_2$: Alt. 5,000 feet: Excess air (cc STP/kg) | Assuming no excess $N_2$: Alt. 6,500 feet: Recharge temp-erature (ºC) | Assuming no excess $N_2$: Alt. 6,500 feet: Excess air (cc STP/kg) | Assuming no excess $N_2$: Alt. 8,000 feet: Recharge temp-erature (ºC) | Assuming no excess $N_2$: Alt. 8,000 feet: Excess air (cc STP/kg) | Calcu-lated excess $N_2$ (mg/kg) | Assuming calculated excess $N_2$: Alt. 5,000 feet: Recharge temp-erature (ºC) | Assuming calculated excess $N_2$: Alt. 5,000 feet: Excess air (cc STP/kg) | Assuming calculated excess $N_2$: Alt. 6,500 feet: Recharge temp-erature (ºC) | Assuming calculated excess $N_2$: Alt. 6,500 feet: Excess air (cc STP/kg) | Assuming calculated excess $N_2$: Alt. 8,000 feet: Recharge temp-erature (ºC) | Assuming calculated excess $N_2$: Alt. 8,000 feet: Excess air (cc STP/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S163 | NM318 | PL 2 | 8 | na | 7/7/1997 | 15.54 | 0.5717 | 6,500 | 10.9 | 0.7 | 8.7 | 0.8 | 6.5 | 0.9 | nd | 10.9 | 0.7 | 8.7 | 0.8 | 6.5 | 0.9 |
| S164 | NM106 | Ponderosa 1 | 8 | na | 6/20/1996 | 15.68 | 0.5566 | 6,500 | 13.3 | 1.6 | 11.0 | 1.7 | 8.8 | 1.8 | nd | 13.3 | 1.6 | 11.0 | 1.7 | 8.8 | 1.8 |
| S165 | NM328 | Windmill #25 | 8 | na | 6/24/1997 | 14.68 | 0.5566 | 6,500 | 11.0 | - 0.1 | 8.7 | 0.0 | 6.6 | 0.1 | nd | 11.0 | - 0.1 | 8.7 | 0.0 | 6.6 | 0.1 |
| S168 | NM319 | Domestic Well #30 | 8 | na | 6/27/1997 | 12.86 | 0.4713 | 6,500 | 19.2 | 0.3 | 16.8 | 0.4 | 14.4 | 0.5 | nd | 19.2 | 0.3 | 16.8 | 0.4 | 14.4 | 0.5 |
| S170 | NM108 | Ridgecrest 3 | 8 | na | 6/22/1996 | 14.07 | 0.4781 | 6,500 | 21.8 | 2.1 | 19.2 | 2.2 | 16.8 | 2.4 | 0.6 | 19.9 | 1.1 | 17.4 | 1.2 | 15.0 | 1.3 |
| S195 | NM134 | Domestic Well #13 | 8 | na | 8/14/1996 | 13.51 | 0.4834 | 6,500 | 19.1 | 0.9 | 16.6 | 1.0 | 14.2 | 1.2 | nd | 19.1 | 0.9 | 16.6 | 1.0 | 14.2 | 1.2 |
| S209 | NM336 | Domestic Well #33 | 8 | na | 6/27/1997 | 15.75 | 0.5447 | 6,500 | 15.3 | 2.2 | 12.9 | 2.4 | 10.6 | 2.5 | nd | 15.3 | 2.2 | 12.9 | 2.4 | 10.6 | 2.5 |
| S212 | NM141 | Sandia Peak 1 | 8 | na | 6/26/1996 | 15.67 | 0.5443 | 6,500 | 15.1 | 2.1 | 12.8 | 2.2 | 10.5 | 2.4 | nd | 15.1 | 2.1 | 12.8 | 2.2 | 10.5 | 2.4 |
| S213 | NM142 | Sandia Peak 3 | 8 | na | 6/26/1996 | 15.97 | 0.5272 | 6,500 | 18.7 | 3.4 | 16.3 | 3.5 | 13.9 | 3.6 | nd | 18.7 | 3.4 | 16.3 | 3.5 | 13.9 | 3.6 |
| S224 | NM148 | Domestic Well #14 | 8 | na | 8/23/1996 | 13.14 | 0.4951 | 6,500 | 16.1 | - 0.2 | 13.7 | - 0.1 | 11.4 | 0.0 | nd | 16.1 | - 0.2 | 13.7 | - 0.1 | 11.4 | 0.0 |
| S229 | NM515 | SH03 UNM | 8 | na | 7/28/1998 | 15.78 | 0.5376 | 6,500 | 16.5 | 2.6 | 14.1 | 2.7 | 11.8 | 2.8 | nd | 16.5 | 2.6 | 14.1 | 2.7 | 11.8 | 2.8 |
| S229 | NM515 | SH03 UNM | 8 | na | 7/28/1998 | 16.02 | 0.5459 | 6,500 | 15.8 | 2.7 | 13.4 | 2.8 | 11.1 | 2.9 | nd | 15.8 | 2.7 | 13.4 | 2.8 | 11.1 | 2.9 |
| S233 | NM153 | Domestic Well #16 | 8 | na | 8/23/1996 | 16.35 | 0.5595 | 6,500 | 14.6 | 2.7 | 12.2 | 2.8 | 10.0 | 2.9 | nd | 14.6 | 2.7 | 12.2 | 2.8 | 10.0 | 2.9 |
| S239 | NM156 | Domestic Well #17 | 8 | na | 8/17/1996 | 16.17 | 0.5558 | 6,500 | 14.7 | 2.5 | 12.3 | 2.6 | 10.1 | 2.7 | nd | 14.7 | 2.5 | 12.3 | 2.6 | 10.1 | 2.7 |
| S247 | NM161 | Domestic Well #19 | 8 | na | 8/15/1996 | 14.53 | 0.5454 | 6,500 | 12.1 | 0.1 | 9.9 | 0.2 | 7.7 | 0.3 | nd | 12.1 | 0.1 | 9.9 | 0.2 | 7.7 | 0.3 |
| S248 | NM162 | Thomas 6 | 8 | na | 6/21/1996 | 26.93 | 0.7218 | 6,500 | 17.4 | 14.3 | 15.0 | 14.4 | 12.7 | 14.5 | nd | 17.4 | 14.3 | 15.0 | 14.4 | 12.7 | 14.5 |
| S255 | NM523 | Tramway East | 8 | na | 7/30/1998 | 15.92 | 0.5375 | 6,500 | 16.9 | 2.8 | 14.5 | 3.0 | 12.1 | 3.1 | nd | 16.9 | 2.8 | 14.5 | 3.0 | 12.1 | 3.1 |
| S255 | NM523 | Tramway East | 8 | na | 7/30/1998 | 16.11 | 0.5407 | 6,500 | 16.9 | 3.0 | 14.5 | 3.2 | 12.2 | 3.3 | nd | 16.9 | 3.0 | 14.5 | 3.2 | 12.2 | 3.3 |
| S264 | NM174 | Walker 1 | 8 | na | 6/18/1996 | 16.27 | 0.5569 | 6,500 | 14.8 | 2.6 | 12.4 | 2.8 | 10.1 | 2.9 | nd | 14.8 | 2.6 | 12.4 | 2.8 | 10.1 | 2.9 |
| S274 | NM177 | Domestic Well #20 | 8 | na | 8/15/1996 | 12.94 | 0.4681 | 6,500 | 20.1 | 0.6 | 17.6 | 0.7 | 15.1 | 0.8 | nd | 20.1 | 0.6 | 17.6 | 0.7 | 15.1 | 0.8 |
| | | **Zone 9: Tijeras Fault Zone** | | | | | | | | | | | | | | | | | | | |
| S041 | NM030 | Coyote Spring | 9 | na | 7/1/1996 | 5.403 | 0.2260 | 6,500 | 49.6 | - 2.5 | 46.6 | - 2.4 | 43.7 | - 2.2 | nd | 49.6 | - 2.5 | 46.6 | - 2.4 | 43.7 | - 2.2 |
| S041 | NM030 | Coyote Spring | 9 | na | 7/1/1996 | 5.905 | 0.2521 | 6,500 | 43.7 | - 2.7 | 40.7 | - 2.6 | 37.8 | - 2.4 | nd | 43.7 | - 2.7 | 40.7 | - 2.6 | 37.8 | - 2.4 |
| S041 | NM030 | Coyote Spring | 9 | na | 7/1/1996 | 6.308 | 0.2404 | 6,500 | 50.0 | - 1.6 | 47.0 | - 1.4 | 44.0 | - 1.3 | nd | 50.0 | - 1.6 | 47.0 | - 1.4 | 44.0 | - 1.3 |
| S041 | NM029 | Coyote Spring | 9 | na | 6/28/1996 | 16.97 | 0.4531 | 6,500 | 39.9 | 8.1 | 36.9 | 8.3 | 34.1 | 8.4 | nd | 39.9 | 8.1 | 36.9 | 8.3 | 34.1 | 8.4 |
| S072 | NM061 | Hubbell Spring | 9 | 8 | 8/23/1996 | 13.45 | 0.5019 | 6,500 | 15.8 | 0.0 | 13.4 | 0.2 | 11.1 | 0.3 | nd | 15.8 | 0.0 | 13.4 | 0.2 | 11.1 | 0.3 |
| S098 | NM071 | KAFB-1902 | 9 | na | 6/28/1996 | 18.43 | 0.5399 | 6,500 | 24.3 | 7.1 | 21.7 | 7.2 | 19.1 | 7.4 | nd | 24.3 | 7.1 | 21.7 | 7.2 | 19.1 | 7.4 |
| S197 | NM136 | Windmill #06 | 9 | na | 8/23/1996 | 16.49 | 0.5459 | 6,500 | 17.1 | 3.5 | 14.7 | 3.6 | 12.3 | 3.7 | 1.4 | 13.4 | 1.0 | 11.1 | 1.2 | 8.9 | 1.3 |
| S227 | NM151 | SFR 3D | 9 | na | 8/24/1996 | 11.90 | 0.4286 | 6,500 | 24.3 | 0.4 | 21.7 | 0.5 | 19.1 | 0.7 | nd | 24.3 | 0.4 | 21.7 | 0.5 | 19.1 | 0.7 |
| S228 | NM152 | SFR 3S | 9 | na | 8/24/1996 | 13.55 | 0.4866 | 6,500 | 18.6 | 0.9 | 16.2 | 1.0 | 13.8 | 1.1 | nd | 18.6 | 0.9 | 16.2 | 1.0 | 13.8 | 1.1 |
| | | **Zone 10: Tijeras Arroyo** | | | | | | | | | | | | | | | | | | | |
| S001 | NM001 | 4Hills-1 | 10 | 8 | 6/29/1996 | 16.16 | 0.5545 | 6,500 | 14.8 | 2.6 | 12.5 | 2.7 | 10.2 | 2.8 | nd | 14.8 | 2.6 | 12.5 | 2.7 | 10.2 | 2.8 |
| S058 | NM277 | Eubank 1 | 10 | 8 | 7/4/1997 | 13.39 | 0.5118 | 6,500 | 14.1 | - 0.5 | 11.8 | - 0.4 | 9.6 | - 0.3 | nd | 14.1 | - 0.5 | 11.8 | - 0.4 | 9.6 | - 0.3 |
| S096 | NM069 | Kirtland 11 | 10 | 8 | 6/25/1996 | 26.28 | 0.7264 | 6,500 | 14.9 | 12.9 | 12.6 | 13.1 | 10.3 | 13.2 | nd | 14.9 | 12.9 | 12.6 | 13.1 | 10.3 | 13.2 |
| | | **Zone 11: Northeastern** | | | | | | | | | | | | | | | | | | | |
| S053 | NM276 | Private Production Well #18 | 11 | na | 6/25/1997 | 14.79 | 0.5285 | 5,000 | 15.2 | 1.2 | 12.9 | 1.4 | 10.6 | 1.5 | nd | 15.2 | 1.2 | 12.9 | 1.4 | 10.6 | 1.5 |
| S144 | NM097 | Private Production Well #06 | 11 | na | 8/28/1996 | 15.74 | 0.5520 | 5,000 | 14.1 | 1.9 | 11.8 | 2.0 | 9.6 | 2.1 | 0.5 | 12.9 | 1.0 | 10.6 | 1.2 | 8.4 | 1.3 |
| S207 | NM334 | Private Production Well #22 | 11 | na | 7/3/1997 | 16.76 | 0.5749 | 5,000 | 13.3 | 2.7 | 11.0 | 2.9 | 8.8 | 3.0 | nd | 13.3 | 2.7 | 11.0 | 2.9 | 8.8 | 3.0 |
| S223 | NM338 | Windmill #29 | 11 | na | 6/25/1997 | 15.25 | 0.5279 | 5,000 | 16.6 | 2.1 | 14.2 | 2.2 | 11.9 | 2.3 | nd | 16.6 | 2.1 | 14.2 | 2.2 | 11.9 | 2.3 |
| | | **Zone 12: Central** | | | | | | | | | | | | | | | | | | | |
| S011 | NM004 | Atris-1 | 12 | na | 6/22/1996 | 14.98 | 0.5423 | 5,000 | 13.7 | 1.0 | 11.4 | 1.1 | 9.1 | 1.2 | nd | 13.7 | 1.0 | 11.4 | 1.1 | 9.1 | 1.2 |
| S012 | NM005 | Atrisco 3 | 12 | 3 | 6/20/1996 | 14.98 | 0.5420 | 5,000 | 13.7 | 1.0 | 11.4 | 1.1 | 9.2 | 1.2 | nd | 13.7 | 1.0 | 11.4 | 1.1 | 9.2 | 1.2 |
| S025 | NM012 | Burton 2 | 12 | na | 6/19/1996 | 23.67 | 0.6820 | 5,000 | 14.9 | 10.3 | 12.6 | 10.4 | 10.3 | 10.5 | nd | 14.9 | 10.3 | 12.6 | 10.4 | 10.3 | 10.5 |
| S026 | NM013 | Burton 5 | 12 | na | 6/19/1996 | 23.09 | 0.6674 | 5,000 | 15.6 | 9.9 | 13.3 | 10.0 | 11.0 | 10.1 | nd | 15.6 | 9.9 | 13.3 | 10.0 | 11.0 | 10.1 |
| S033 | NM025 | Private Production Well #02 | 12 | na | 8/21/1996 | 16.44 | 0.5306 | 5,000 | 19.6 | 4.0 | 17.1 | 4.2 | 14.7 | 4.3 | 1.7 | 14.8 | 1.1 | 12.5 | 1.2 | 10.2 | 1.3 |
| S040 | NM028 | Coronado 1 | 12 | na | 6/18/1996 | 15.48 | 0.5552 | 5,000 | 13.0 | 1.3 | 10.7 | 1.4 | 8.5 | 1.5 | nd | 13.0 | 1.3 | 10.7 | 1.4 | 8.5 | 1.5 |

**Table A6.** Sensitivity analysis for recharge temperatures calculated from dissolved gases-- Continued

| | | | | | | | | | Assuming no excess $N_2$ | | | | | | | Assuming calculated excess $N_2$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Alt. 5,000 feet | | Alt. 6,500 feet | | Alt. 8,000 feet | | | Alt. 5,000 feet | | Alt. 6,500 feet | | Alt. 8,000 feet | |
| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Second-ary hydro-chemical zone | Date | $N_2$ (mg/kg) | Ar (mg/kg) | Assigned recharge altitude (feet) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Calcu-lated excess $N_2$ (mg/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) |
| S043 | NM488 | Del Sol D | 12 | na | 7/21/1998 | 15.33 | 0.5515 | 5,000 | 13.2 | 1.2 | 10.9 | 1.3 | 8.7 | 1.4 | nd | 13.2 | 1.2 | 10.9 | 1.3 | 8.7 | 1.4 |
| S043 | NM488 | Del Sol D | 12 | na | 7/21/1998 | 15.39 | 0.5525 | 5,000 | 13.2 | 1.3 | 10.9 | 1.4 | 8.7 | 1.5 | nd | 13.2 | 1.3 | 10.9 | 1.4 | 8.7 | 1.5 |
| S043 | NM267 | Del Sol D | 12 | na | 7/1/1997 | 15.83 | 0.5763 | 5,000 | 11.0 | 1.0 | 8.7 | 1.2 | 6.6 | 1.3 | nd | 11.0 | 1.0 | 8.7 | 1.2 | 6.6 | 1.3 |
| S044 | NM489 | Del Sol M | 12 | na | 7/21/1998 | 14.28 | 0.5213 | 5,000 | 15.0 | 0.7 | 12.7 | 0.8 | 10.4 | 0.9 | nd | 15.0 | 0.7 | 12.7 | 0.8 | 10.4 | 0.9 |
| S044 | NM268 | Del Sol M | 12 | na | 6/26/1997 | 14.73 | 0.5436 | 5,000 | 12.8 | 0.5 | 10.6 | 0.6 | 8.3 | 0.7 | nd | 12.8 | 0.5 | 10.6 | 0.6 | 8.3 | 0.7 |
| S044 | NM489 | Del Sol M | 12 | na | 7/21/1998 | 15.08 | 0.5365 | 5,000 | 14.8 | 1.4 | 12.4 | 1.5 | 10.2 | 1.6 | nd | 14.8 | 1.4 | 12.4 | 1.5 | 10.2 | 1.6 |
| S045 | NM490 | Del Sol S | 12 | na | 7/21/1998 | 13.86 | 0.5039 | 5,000 | 16.6 | 0.7 | 14.2 | 0.8 | 11.9 | 0.9 | nd | 16.6 | 0.7 | 14.2 | 0.8 | 11.9 | 0.9 |
| S045 | NM269 | Del Sol S | 12 | na | 6/26/1997 | 13.90 | 0.5123 | 5,000 | 15.4 | 0.4 | 13.0 | 0.5 | 10.7 | 0.6 | nd | 15.4 | 0.4 | 13.0 | 0.5 | 10.7 | 0.6 |
| S045 | NM490 | Del Sol S | 12 | na | 7/21/1998 | 13.91 | 0.5025 | 5,000 | 17.0 | 0.8 | 14.6 | 0.9 | 12.3 | 1.1 | nd | 17.0 | 0.8 | 14.6 | 0.9 | 12.3 | 1.1 |
| S046 | NM032 | Duranes 1 | 12 | na | 6/20/1996 | 16.48 | 0.5149 | 5,000 | 22.6 | 4.8 | 20.0 | 4.9 | 17.6 | 5.0 | nd | 22.6 | 4.8 | 20.0 | 4.9 | 17.6 | 5.0 |
| S046 | NM034 | Duranes 1 | 12 | na | 6/29/1996 | 16.88 | 0.5123 | 5,000 | 24.5 | 5.5 | 21.9 | 5.7 | 19.3 | 5.8 | nd | 24.5 | 5.5 | 21.9 | 5.7 | 19.3 | 5.8 |
| S046 | NM039 | Duranes 1 | 12 | na | 6/29/1996 | 17.01 | 0.5169 | 5,000 | 24.0 | 5.6 | 21.4 | 5.7 | 18.9 | 5.9 | nd | 24.0 | 5.6 | 21.4 | 5.7 | 18.9 | 5.9 |
| S046 | NM036 | Duranes 1 | 12 | na | 6/29/1996 | 17.02 | 0.5302 | 5,000 | 21.5 | 5.1 | 18.9 | 5.2 | 16.5 | 5.3 | nd | 21.5 | 5.1 | 18.9 | 5.2 | 16.5 | 5.3 |
| S046 | NM035 | Duranes 1 | 12 | na | 6/29/1996 | 17.14 | 0.5318 | 5,000 | 21.5 | 5.2 | 19.0 | 5.3 | 16.5 | 5.5 | nd | 21.5 | 5.2 | 19.0 | 5.3 | 16.5 | 5.5 |
| S046 | NM033 | Duranes 1 | 12 | na | 6/29/1996 | 17.86 | 0.5397 | 5,000 | 22.4 | 6.1 | 19.8 | 6.2 | 17.3 | 6.4 | nd | 22.4 | 6.1 | 19.8 | 6.2 | 17.3 | 6.4 |
| S046 | NM038 | Duranes 1 | 12 | na | 6/29/1996 | 18.08 | 0.5371 | 5,000 | 23.6 | 6.6 | 21.0 | 6.7 | 18.5 | 6.9 | nd | 23.6 | 6.6 | 21.0 | 6.7 | 18.5 | 6.9 |
| S047 | NM270 | Duranes 7 | 12 | na | 6/26/1997 | 14.39 | 0.5354 | 5,000 | 13.2 | 0.3 | 10.9 | 0.4 | 8.7 | 0.5 | nd | 13.2 | 0.3 | 10.9 | 0.4 | 8.7 | 0.5 |
| S048 | NM271 | Duranes Yard 1 | 12 | na | 7/5/1997 | 15.11 | 0.5653 | 5,000 | 10.8 | 0.2 | 8.6 | 0.4 | 6.4 | 0.5 | nd | 10.8 | 0.2 | 8.6 | 0.4 | 6.4 | 0.5 |
| S049 | NM272 | Duranes Yard 2 | 12 | na | 7/5/1997 | 14.52 | 0.5614 | 5,000 | 10.0 | - 0.6 | 7.8 | - 0.5 | 5.7 | - 0.4 | nd | 10.0 | - 0.6 | 7.8 | - 0.5 | 5.7 | - 0.4 |
| S050 | NM273 | Duranes Yard 3 | 12 | na | 7/5/1997 | 13.73 | 0.5181 | 5,000 | 14.1 | - 0.2 | 11.8 | 0.0 | 9.5 | 0.1 | nd | 14.1 | - 0.2 | 11.8 | 0.0 | 9.5 | 0.1 |
| S051 | NM274 | Duranes Yard 4 | 12 | na | 7/5/1997 | 15.89 | 0.6013 | 5,000 | 8.0 | 0.1 | 5.8 | 0.2 | 3.7 | 0.3 | nd | 8.0 | 0.1 | 5.8 | 0.2 | 3.7 | 0.3 |
| S052 | NM275 | Duranes Yard 5 | 12 | na | 7/5/1997 | 14.45 | 0.5618 | 5,000 | 9.8 | - 0.8 | 7.6 | - 0.6 | 5.5 | - 0.6 | nd | 9.8 | - 0.8 | 7.6 | - 0.6 | 5.5 | - 0.6 |
| S060 | NM279 | Garfield D | 12 | 3 | 6/19/1997 | 14.90 | 0.5429 | 5,000 | 13.4 | 0.8 | 11.1 | 1.0 | 8.9 | 1.1 | nd | 13.4 | 0.8 | 11.1 | 1.0 | 8.9 | 1.1 |
| S061 | NM280 | Garfield M | 12 | na | 6/19/1997 | 15.24 | 0.5590 | 5,000 | 11.9 | 0.7 | 9.7 | 0.9 | 7.5 | 1.0 | nd | 11.9 | 0.7 | 9.7 | 0.9 | 7.5 | 1.0 |
| S062 | NM281 | Garfield S | 12 | na | 6/19/1997 | 14.49 | 0.5306 | 5,000 | 14.1 | 0.6 | 11.8 | 0.7 | 9.6 | 0.9 | nd | 14.1 | 0.6 | 11.8 | 0.7 | 9.6 | 0.9 |
| S062 | NM491 | Garfield S | 12 | na | 7/28/1998 | 14.96 | 0.5202 | 5,000 | 17.0 | 1.9 | 14.6 | 2.0 | 12.3 | 2.1 | 0.5 | 15.7 | 1.0 | 13.3 | 1.1 | 11.0 | 1.3 |
| S062 | NM491 | Garfield S | 12 | na | 7/28/1998 | 15.01 | 0.5241 | 5,000 | 16.5 | 1.8 | 14.1 | 1.9 | 11.8 | 2.0 | 0.4 | 15.4 | 1.1 | 13.1 | 1.2 | 10.8 | 1.3 |
| S064 | NM283 | Domestic Well #22 | 12 | na | 6/20/1997 | 15.79 | 0.5333 | 5,000 | 17.2 | 2.8 | 14.8 | 2.9 | 12.4 | 3.0 | 1.0 | 14.5 | 1.0 | 12.2 | 1.2 | 9.9 | 1.3 |
| S068 | NM057 | Griegos 3 | 12 | na | 6/21/1996 | 15.43 | 0.5549 | 5,000 | 13.0 | 1.3 | 10.7 | 1.4 | 8.5 | 1.5 | nd | 13.0 | 1.3 | 10.7 | 1.4 | 8.5 | 1.5 |
| S075 | NM286 | Hunter Ridge Nest 1 Well 1 | 12 | 3 | 6/20/1997 | 14.27 | 0.5349 | 5,000 | 13.0 | 0.1 | 10.7 | 0.2 | 8.5 | 0.3 | nd | 13.0 | 0.1 | 10.7 | 0.2 | 8.5 | 0.3 |
| S076 | NM287 | Hunter Ridge Nest 1 Well 2 | 12 | na | 6/21/1997 | 15.50 | 0.5628 | 5,000 | 12.0 | 1.0 | 9.8 | 1.2 | 7.6 | 1.3 | nd | 12.0 | 1.0 | 9.8 | 1.2 | 7.6 | 1.3 |
| S077 | NM288 | Hunter Ridge Nest 1 Well 3 | 12 | na | 6/20/1997 | 14.07 | 0.5183 | 5,000 | 14.9 | 0.4 | 12.6 | 0.5 | 10.3 | 0.7 | nd | 14.9 | 0.4 | 12.6 | 0.5 | 10.3 | 0.7 |
| S078 | NM289 | Hunter Ridge Nest 2 Well 1 | 12 | na | 6/21/1997 | 15.13 | 0.5423 | 5,000 | 14.0 | 1.3 | 11.7 | 1.4 | 9.5 | 1.5 | nd | 14.0 | 1.3 | 11.7 | 1.4 | 9.5 | 1.5 |
| S079 | NM290 | Hunter Ridge Nest 2 Well 2 | 12 | na | 6/21/1997 | 15.07 | 0.5304 | 5,000 | 15.7 | 1.7 | 13.3 | 1.8 | 11.0 | 1.9 | nd | 15.7 | 1.7 | 13.3 | 1.8 | 11.0 | 1.9 |
| S080 | NM291 | Hunter Ridge Nest 2 Well 3 | 12 | na | 6/21/1997 | 25.14 | 0.6001 | 5,000 | 37.6 | 16.2 | 34.7 | 16.3 | 31.9 | 16.5 | nd | 37.6 | 16.2 | 34.7 | 16.3 | 31.9 | 16.5 |
| S081 | NM292 | Private Production Well #19 | 12 | na | 7/2/1997 | 15.78 | 0.5739 | 5,000 | 11.2 | 1.1 | 8.9 | 1.2 | 6.8 | 1.3 | nd | 11.2 | 1.1 | 8.9 | 1.2 | 6.8 | 1.3 |
| S084 | NM063 | Windmill #04 | 12 | na | 8/21/1996 | 14.11 | 0.5198 | 5,000 | 14.8 | 0.4 | 12.4 | 0.5 | 10.2 | 0.7 | nd | 14.8 | 0.4 | 12.4 | 0.5 | 10.2 | 0.7 |
| S087 | NM493 | Isleta MD | 12 | 3 | 7/29/1998 | 14.59 | 0.5211 | 5,000 | 15.9 | 1.2 | 13.5 | 1.3 | 11.2 | 1.5 | nd | 15.9 | 1.2 | 13.5 | 1.3 | 11.2 | 1.5 |
| S087 | NM493 | Isleta MD | 12 | 3 | 7/29/1998 | 14.65 | 0.5247 | 5,000 | 15.5 | 1.2 | 13.1 | 1.3 | 10.8 | 1.4 | nd | 15.5 | 1.2 | 13.1 | 1.3 | 10.8 | 1.4 |
| S088 | NM494 | Isleta MS | 12 | na | 7/29/1998 | 14.65 | 0.5336 | 5,000 | 14.1 | 0.8 | 11.8 | 0.9 | 9.5 | 1.0 | nd | 14.1 | 0.8 | 11.8 | 0.9 | 9.5 | 1.0 |
| S088 | NM494 | Isleta MS | 12 | na | 7/29/1998 | 14.67 | 0.5325 | 5,000 | 14.3 | 0.9 | 12.0 | 1.0 | 9.7 | 1.1 | nd | 14.3 | 0.9 | 12.0 | 1.0 | 9.7 | 1.1 |
| S089 | NM495 | Isleta S | 12 | na | 7/29/1998 | 17.09 | 0.5338 | 5,000 | 21.0 | 5.0 | 18.5 | 5.2 | 16.0 | 5.3 | 2.3 | 14.4 | 1.0 | 12.1 | 1.1 | 9.8 | 1.2 |
| S089 | NM495 | Isleta S | 12 | na | 7/29/1998 | 17.16 | 0.5344 | 5,000 | 21.1 | 5.1 | 18.6 | 5.3 | 16.1 | 5.4 | 2.3 | 14.5 | 1.1 | 12.2 | 1.2 | 9.9 | 1.4 |
| S092 | NM066 | JMC-1 | 12 | na | 6/28/1996 | 10.54 | 0.3745 | 5,000 | 31.3 | 0.3 | 28.5 | 0.4 | 25.8 | 0.5 | nd | 31.3 | 0.3 | 28.5 | 0.4 | 25.8 | 0.5 |
| S097 | NM070 | Kirtland 14 | 12 | na | 6/25/1996 | 14.61 | 0.5422 | 5,000 | 12.8 | 0.4 | 10.5 | 0.5 | 8.3 | 0.6 | nd | 12.8 | 0.4 | 10.5 | 0.5 | 8.3 | 0.6 |
| S100 | NM073 | LALF-9 | 12 | na | 6/29/1996 | 17.49 | 0.5410 | 5,000 | 20.9 | 5.4 | 18.4 | 5.6 | 16.0 | 5.7 | 2.5 | 13.9 | 1.1 | 11.6 | 1.2 | 9.3 | 1.3 |
| S102 | NM074 | Leyendecker 1 | 12 | na | 6/21/1996 | 15.14 | 0.5367 | 5,000 | 14.9 | 1.5 | 12.6 | 1.6 | 10.3 | 1.7 | 0.3 | 14.1 | 1.0 | 11.8 | 1.1 | 9.6 | 1.2 |
| S120 | NM301 | Mesa Del Sol D | 12 | na | 6/29/1997 | 11.34 | 0.4304 | 5,000 | 22.0 | - 0.6 | 19.4 | - 0.5 | 17.0 | - 0.4 | nd | 22.0 | - 0.6 | 19.4 | - 0.5 | 17.0 | - 0.4 |

**Table A6.** Sensitivity analysis for recharge temperatures calculated from dissolved gases-- Continued

| | | | | | | | | | Assuming no excess $N_2$ | | | | | | | Assuming calculated excess $N_2$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Alt. 5,000 feet | | Alt. 6,500 feet | | Alt. 8,000 feet | | | Alt. 5,000 feet | | Alt. 6,500 feet | | Alt. 8,000 feet | |
| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Second-ary hydro-chemical zone | Date | $N_2$ (mg/kg) | Ar (mg/kg) | Assigned recharge altitude (feet) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Calcu-lated excess $N_2$ (mg/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) |
| S120 | NM503 | Mesa Del Sol D | 12 | na | 8/2/1998 | 16.10 | 0.5325 | 5,000 | 18.2 | 3.4 | 15.8 | 3.5 | 13.4 | 3.6 | 1.3 | 14.7 | 1.1 | 12.3 | 1.2 | 10.1 | 1.3 |
| S120 | NM503 | Mesa Del Sol D | 12 | na | 8/2/1998 | 16.16 | 0.5344 | 5,000 | 18.1 | 3.4 | 15.6 | 3.5 | 13.3 | 3.6 | 1.3 | 14.5 | 1.1 | 12.2 | 1.2 | 9.9 | 1.4 |
| S120 | NM303 | Mesa Del Sol D | 12 | na | 6/28/1997 | 19.85 | 0.5823 | 5,000 | 20.7 | 7.8 | 18.2 | 7.9 | 15.8 | 8.0 | 3.9 | 10.4 | 1.0 | 8.2 | 1.1 | 6.1 | 1.2 |
| S121 | NM302 | Mesa Del Sol M | 12 | na | 6/28/1997 | 15.63 | 0.5678 | 5,000 | 11.6 | 1.1 | 9.4 | 1.2 | 7.2 | 1.3 | nd | 11.6 | 1.1 | 9.4 | 1.2 | 7.2 | 1.3 |
| S121 | NM504 | Mesa Del Sol M | 12 | na | 7/25/1998 | 16.90 | 0.5721 | 5,000 | 14.1 | 3.1 | 11.8 | 3.2 | 9.5 | 3.3 | 1.1 | 11.4 | 1.2 | 9.2 | 1.3 | 7.0 | 1.4 |
| S121 | NM504 | Mesa Del Sol M | 12 | na | 7/25/1998 | 16.90 | 0.5744 | 5,000 | 13.8 | 3.0 | 11.4 | 3.1 | 9.2 | 3.2 | 1.1 | 11.1 | 1.1 | 8.9 | 1.2 | 6.7 | 1.3 |
| S123 | NM081 | MONT - 5A | 12 | na | 6/27/1996 | 15.56 | 0.5373 | 5,000 | 15.9 | 2.2 | 13.5 | 2.3 | 11.2 | 2.5 | 1.0 | 13.3 | 0.5 | 11.0 | 0.6 | 8.8 | 0.7 |
| S124 | NM082 | Montaño 2 D | 12 | na | 6/19/1996 | 17.46 | 0.6029 | 5,000 | 11.1 | 2.8 | 8.9 | 2.9 | 6.7 | 3.0 | 1.0 | 8.9 | 1.0 | 6.8 | 1.1 | 4.7 | 1.2 |
| S125 | NM083 | Montaño 2 M | 12 | na | 6/19/1996 | 18.63 | 0.5810 | 5,000 | 17.3 | 5.7 | 14.9 | 5.9 | 12.5 | 6.0 | 3.0 | 9.9 | 0.5 | 7.7 | 0.6 | 5.6 | 0.7 |
| S126 | NM084 | Montaño 2 S | 12 | na | 6/19/1996 | 16.71 | 0.5592 | 5,000 | 15.6 | 3.3 | 13.2 | 3.4 | 10.9 | 3.5 | 1.5 | 11.8 | 0.7 | 9.6 | 0.8 | 7.4 | 0.9 |
| S127 | NM085 | Montaño 4 D | 12 | na | 6/20/1996 | 18.64 | 0.5759 | 5,000 | 18.2 | 6.0 | 15.8 | 6.1 | 13.4 | 6.2 | 3.0 | 10.6 | 0.7 | 8.4 | 0.8 | 6.2 | 0.9 |
| S128 | NM086 | Montaño 4 M | 12 | na | 6/19/1996 | 19.07 | 0.5793 | 5,000 | 18.9 | 6.6 | 16.4 | 6.7 | 14.0 | 6.8 | 3.0 | 11.1 | 1.3 | 8.9 | 1.4 | 6.7 | 1.5 |
| S130 | NM088 | Montaño 5 D | 12 | na | 6/24/1996 | 14.46 | 0.5331 | 5,000 | 13.7 | 0.5 | 11.4 | 0.6 | 9.2 | 0.7 | nd | 13.7 | 0.5 | 11.4 | 0.6 | 9.2 | 0.7 |
| S131 | NM089 | Montaño 5 M | 12 | na | 6/24/1996 | 15.98 | 0.5844 | 5,000 | 10.2 | 1.0 | 8.0 | 1.1 | 5.9 | 1.2 | 0.3 | 9.6 | 0.4 | 7.4 | 0.5 | 5.3 | 0.6 |
| S132 | NM090 | Montaño 5 S | 12 | na | 6/24/1996 | 12.34 | 0.4286 | 5,000 | 25.9 | 1.2 | 23.2 | 1.3 | 20.6 | 1.4 | 0.5 | 24.1 | 0.3 | 21.5 | 0.4 | 18.9 | 0.6 |
| S133 | NM091 | Montaño 6 D | 12 | na | 6/18/1996 | 14.88 | 0.5240 | 5,000 | 16.2 | 1.6 | 13.8 | 1.7 | 11.5 | 1.8 | 0.5 | 14.9 | 0.7 | 12.5 | 0.9 | 10.3 | 1.0 |
| S134 | NM092 | Montaño 6 MD | 12 | na | 6/18/1996 | 14.91 | 0.5484 | 5,000 | 12.6 | 0.6 | 10.3 | 0.7 | 8.1 | 0.8 | nd | 12.6 | 0.6 | 10.3 | 0.7 | 8.1 | 0.8 |
| S135 | NM093 | Montaño 6 MS | 12 | na | 6/18/1996 | 15.71 | 0.5725 | 5,000 | 11.2 | 1.0 | 8.9 | 1.1 | 6.8 | 1.2 | nd | 11.2 | 1.0 | 8.9 | 1.1 | 6.8 | 1.2 |
| S136 | NM094 | Montaño 6 S | 12 | na | 6/18/1996 | 16.62 | 0.5566 | 5,000 | 15.7 | 3.3 | 13.4 | 3.4 | 11.1 | 3.5 | 1.5 | 12.0 | 0.6 | 9.7 | 0.7 | 7.5 | 0.9 |
| S137 | NM506 | Montesa M | 12 | na | 7/27/1998 | 14.82 | 0.5301 | 5,000 | 15.1 | 1.2 | 12.7 | 1.4 | 10.5 | 1.5 | nd | 15.1 | 1.2 | 12.7 | 1.4 | 10.5 | 1.5 |
| S137 | NM506 | Montesa M | 12 | na | 7/27/1998 | 14.88 | 0.5312 | 5,000 | 15.1 | 1.3 | 12.7 | 1.4 | 10.5 | 1.5 | nd | 15.1 | 1.3 | 12.7 | 1.4 | 10.5 | 1.5 |
| S138 | NM507 | Montesa S | 12 | na | 7/27/1998 | 24.59 | 0.6924 | 5,000 | 15.8 | 11.4 | 13.4 | 11.5 | 11.1 | 11.7 | nd | 15.8 | 11.4 | 13.4 | 11.5 | 11.1 | 11.7 |
| S138 | NM507 | Montesa S | 12 | na | 7/27/1998 | 24.63 | 0.6912 | 5,000 | 16.0 | 11.5 | 13.7 | 11.7 | 11.4 | 11.8 | nd | 16.0 | 11.5 | 13.7 | 11.7 | 11.4 | 11.8 |
| S139 | NM305 | Domestic Well #27 | 12 | na | 6/17/1997 | 14.51 | 0.5228 | 5,000 | 15.4 | 1.0 | 13.0 | 1.1 | 10.7 | 1.2 | nd | 15.4 | 1.0 | 13.0 | 1.1 | 10.7 | 1.2 |
| S142 | NM307 | Domestic Well #28 | 12 | na | 6/17/1997 | 14.63 | 0.5249 | 5,000 | 15.4 | 1.1 | 13.0 | 1.2 | 10.7 | 1.3 | nd | 15.4 | 1.1 | 13.0 | 1.2 | 10.7 | 1.3 |
| S146 | NM309 | NM Utilities 2 | 12 | na | 6/18/1997 | 14.99 | 0.5387 | 5,000 | 14.2 | 1.2 | 11.9 | 1.3 | 9.6 | 1.4 | nd | 14.2 | 1.2 | 11.9 | 1.3 | 9.6 | 1.4 |
| S151 | NM508 | Nor Este S | 12 | na | 7/20/1998 | 13.42 | 0.5033 | 5,000 | 15.5 | - 0.1 | 13.2 | 0.0 | 10.9 | 0.2 | nd | 15.5 | - 0.1 | 13.2 | 0.0 | 10.9 | 0.2 |
| S151 | NM508 | Nor Este S | 12 | na | 7/20/1998 | 13.54 | 0.5049 | 5,000 | 15.6 | 0.1 | 13.2 | 0.2 | 10.9 | 0.3 | nd | 15.6 | 0.1 | 13.2 | 0.2 | 10.9 | 0.3 |
| S151 | NM314 | Nor Este S | 12 | na | 7/2/1997 | 14.74 | 0.5634 | 5,000 | 10.2 | - 0.3 | 8.0 | - 0.2 | 5.9 | - 0.1 | nd | 10.2 | - 0.3 | 8.0 | - 0.2 | 5.9 | - 0.1 |
| S154 | NM099 | ORLF-2 | 12 | na | 6/27/1996 | 14.70 | 0.5558 | 5,000 | 11.1 | - 0.1 | 8.9 | 0.0 | 6.7 | 0.1 | nd | 11.1 | - 0.1 | 8.9 | 0.0 | 6.7 | 0.1 |
| S155 | NM316 | Domestic Well #29 | 12 | na | 6/27/1997 | 14.51 | 0.5466 | 5,000 | 11.9 | 0.0 | 9.7 | 0.1 | 7.5 | 0.2 | nd | 11.9 | 0.0 | 9.7 | 0.1 | 7.5 | 0.2 |
| S156 | NM100 | Paseo 2D | 12 | na | 6/26/1996 | 16.83 | 0.5626 | 5,000 | 15.4 | 3.4 | 13.0 | 3.5 | 10.7 | 3.6 | 1.5 | 11.6 | 0.8 | 9.4 | 0.9 | 7.2 | 1.0 |
| S157 | NM101 | Paseo 2MD | 12 | na | 6/26/1996 | 15.22 | 0.5560 | 5,000 | 12.3 | 0.8 | 10.0 | 1.0 | 7.8 | 1.1 | nd | 12.3 | 0.8 | 10.0 | 1.0 | 7.8 | 1.1 |
| S158 | NM102 | Paseo 2MS | 12 | na | 6/26/1996 | 16.64 | 0.5572 | 5,000 | 15.7 | 3.3 | 13.3 | 3.4 | 11.0 | 3.5 | 1.5 | 11.9 | 0.6 | 9.7 | 0.8 | 7.5 | 0.9 |
| S159 | NM103 | Paseo 2S | 12 | na | 6/26/1996 | 19.52 | 0.5887 | 5,000 | 18.6 | 7.0 | 16.1 | 7.1 | 13.7 | 7.2 | 3.5 | 9.8 | 0.8 | 7.6 | 0.9 | 5.4 | 1.0 |
| S160 | NM104 | Paseo 3D | 12 | na | 6/21/1996 | 15.10 | 0.5685 | 5,000 | 10.3 | 0.1 | 8.1 | 0.2 | 6.0 | 0.3 | nd | 10.3 | 0.1 | 8.1 | 0.2 | 6.0 | 0.3 |
| S161 | NM105 | Paseo 3M | 12 | na | 6/21/1996 | 20.09 | 0.6278 | 5,000 | 13.9 | 6.3 | 11.6 | 6.4 | 9.3 | 6.5 | 0.0 | 13.9 | 6.3 | 11.6 | 6.4 | 9.3 | 6.5 |
| S171 | NM321 | Ridgecrest 4 | 12 | na | 6/26/1997 | 14.42 | 0.5364 | 5,000 | 13.1 | 0.3 | 10.8 | 0.4 | 8.6 | 0.5 | nd | 13.1 | 0.3 | 10.8 | 0.4 | 8.6 | 0.5 |
| S173 | NM323 | Rio Bravo 5 M | 12 | 3 | 7/4/1997 | 16.17 | 0.5802 | 5,000 | 11.2 | 1.5 | 9.0 | 1.6 | 6.8 | 1.7 | 0.2 | 10.7 | 1.1 | 8.5 | 1.2 | 6.4 | 1.3 |
| S176 | NM111 | Rio Bravo 1 S | 12 | na | 6/17/1996 | 15.16 | 0.4973 | 5,000 | 21.7 | 3.2 | 19.1 | 3.3 | 16.7 | 3.5 | 1.0 | 18.6 | 1.5 | 16.1 | 1.6 | 13.7 | 1.7 |
| S177 | NM112 | Rio Bravo 2 D | 12 | 3 | 6/25/1996 | 16.53 | 0.5816 | 5,000 | 11.8 | 2.0 | 9.6 | 2.1 | 7.4 | 2.2 | 0.5 | 10.7 | 1.2 | 8.5 | 1.3 | 6.3 | 1.4 |
| S178 | NM113 | Rio Bravo 2 M | 12 | na | 6/25/1996 | 17.76 | 0.5592 | 5,000 | 18.5 | 5.1 | 16.1 | 5.3 | 13.7 | 5.4 | 2.3 | 12.4 | 1.1 | 10.2 | 1.2 | 8.0 | 1.3 |
| S179 | NM114 | Rio Bravo 2 S | 12 | na | 6/25/1996 | 17.44 | 0.5476 | 5,000 | 19.6 | 5.1 | 17.1 | 5.2 | 14.7 | 5.3 | 2.3 | 13.3 | 1.1 | 11.0 | 1.2 | 8.8 | 1.3 |
| S180 | NM115 | Rio Bravo 4 D | 12 | na | 6/25/1996 | 19.22 | 0.5493 | 5,000 | 25.1 | 8.1 | 22.5 | 8.2 | 19.9 | 8.3 | 4.0 | 13.2 | 1.1 | 10.9 | 1.2 | 8.7 | 1.3 |
| S181 | NM116 | Rio Bravo 4 M | 12 | na | 6/25/1996 | 17.12 | 0.5003 | 5,000 | 28.0 | 6.5 | 25.3 | 6.6 | 22.7 | 6.7 | 3.1 | 17.7 | 1.1 | 15.2 | 1.2 | 12.9 | 1.3 |
| S183 | NM126 | Rio Grande Utility 5 | 12 | 3 | 8/15/1996 | 15.29 | 0.5312 | 5,000 | 16.2 | 2.0 | 13.8 | 2.1 | 11.5 | 2.2 | 0.5 | 14.8 | 1.1 | 12.5 | 1.3 | 10.2 | 1.4 |
| S184 | NM127 | Rio Grande Utility 6 | 12 | na | 8/15/1996 | 14.96 | 0.5512 | 5,000 | 12.3 | 0.6 | 10.1 | 0.7 | 7.9 | 0.8 | nd | 12.3 | 0.6 | 10.1 | 0.7 | 7.9 | 0.8 |
| S190 | NM325 | Rio Rancho 2 | 12 | na | 6/20/1997 | 15.05 | 0.5244 | 5,000 | 16.6 | 1.9 | 14.2 | 2.0 | 11.9 | 2.1 | 1.0 | 14.0 | 0.1 | 11.6 | 0.2 | 9.4 | 0.4 |

**Table A6.** Sensitivity analysis for recharge temperatures calculated from dissolved gases-- Continued

| | | | | | | | | | Assuming no excess $N_2$ | | | | | | | Assuming calculated excess $N_2$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Alt. 5,000 feet | | Alt. 6,500 feet | | Alt. 8,000 feet | | | Alt. 5,000 feet | | Alt. 6,500 feet | | Alt. 8,000 feet | |
| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Second-ary hydro-chemical zone | Date | $N_2$ (mg/kg) | Ar (mg/kg) | Assigned recharge altitude (feet) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Calcu-lated excess $N_2$ (mg/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) |
| S203 | NM331 | Private Production Well #20 | 12 | na | 7/3/1997 | 16.39 | 0.5595 | 5,000 | 14.7 | 2.7 | 12.3 | 2.9 | 10.1 | 3.0 | 1.0 | 12.2 | 1.0 | 9.9 | 1.1 | 7.7 | 1.2 |
| S205 | NM333 | Private Production Well #21 | 12 | na | 7/3/1997 | 15.44 | 0.5565 | 5,000 | 12.7 | 1.2 | 10.5 | 1.3 | 8.3 | 1.4 | nd | 12.7 | 1.2 | 10.5 | 1.3 | 8.3 | 1.4 |
| S208 | NM140 | San Jose 2 | 12 | 3 | 6/20/1996 | 15.92 | 0.5485 | 5,000 | 15.1 | 2.4 | 12.8 | 2.5 | 10.5 | 2.6 | nd | 15.1 | 2.4 | 12.8 | 2.5 | 10.5 | 2.6 |
| S210 | NM511 | Sandia D | 12 | na | 7/30/1998 | 15.49 | 0.5470 | 5,000 | 14.3 | 1.7 | 11.9 | 1.8 | 9.7 | 1.9 | 0.4 | 13.3 | 1.0 | 11.0 | 1.1 | 8.7 | 1.2 |
| S210 | NM511 | Sandia D | 12 | na | 7/30/1998 | 15.59 | 0.5476 | 5,000 | 14.4 | 1.8 | 12.1 | 2.0 | 9.8 | 2.1 | 0.4 | 13.4 | 1.1 | 11.1 | 1.3 | 8.9 | 1.4 |
| S214 | NM513 | Sandia S | 12 | na | 7/30/1998 | 17.31 | 0.5517 | 5,000 | 18.5 | 4.7 | 16.0 | 4.8 | 13.6 | 4.9 | 2.1 | 12.9 | 1.0 | 10.6 | 1.1 | 8.4 | 1.2 |
| S214 | NM513 | Sandia S | 12 | na | 7/30/1998 | 17.80 | 0.5631 | 5,000 | 17.9 | 5.0 | 15.5 | 5.2 | 13.2 | 5.3 | 2.3 | 12.0 | 1.0 | 9.7 | 1.1 | 7.5 | 1.2 |
| S220 | NM147 | Santa Barbara 1 | 12 | na | 6/19/1996 | 25.49 | 0.7614 | 5,000 | 8.4 | 10.1 | 6.2 | 10.2 | 4.1 | 10.3 | 0.0 | 8.4 | 10.1 | 6.2 | 10.2 | 4.1 | 10.3 |
| S231 | NM517 | Sierra Vista M | 12 | 3 | 7/22/1998 | 14.66 | 0.5348 | 5,000 | 14.0 | 0.8 | 11.6 | 0.9 | 9.4 | 1.0 | nd | 14.0 | 0.8 | 11.6 | 0.9 | 9.4 | 1.0 |
| S231 | NM517 | Sierra Vista M | 12 | 3 | 7/22/1998 | 14.68 | 0.5323 | 5,000 | 14.4 | 0.9 | 12.1 | 1.0 | 9.8 | 1.1 | nd | 14.4 | 0.9 | 12.1 | 1.0 | 9.8 | 1.1 |
| S232 | NM518 | Sierra Vista S | 12 | na | 7/22/1998 | 13.61 | 0.4892 | 5,000 | 18.4 | 0.9 | 15.9 | 1.0 | 13.5 | 1.1 | nd | 18.4 | 0.9 | 15.9 | 1.0 | 13.5 | 1.1 |
| S232 | NM518 | Sierra Vista S | 12 | na | 7/22/1998 | 13.61 | 0.4894 | 5,000 | 18.3 | 0.9 | 15.9 | 1.0 | 13.5 | 1.1 | nd | 18.3 | 0.9 | 15.9 | 1.0 | 13.5 | 1.1 |
| S234 | NM339 | Sister Cities D | 12 | na | 6/30/1997 | 14.71 | 0.5570 | 5,000 | 11.0 | - 0.1 | 8.8 | 0.0 | 6.6 | 0.1 | nd | 11.0 | - 0.1 | 8.8 | 0.0 | 6.6 | 0.1 |
| S235 | NM340 | Sister Cities M | 12 | na | 6/27/1997 | 14.61 | 0.5426 | 5,000 | 12.7 | 0.3 | 10.4 | 0.4 | 8.2 | 0.6 | nd | 12.7 | 0.3 | 10.4 | 0.4 | 8.2 | 0.6 |
| S244 | NM158 | SWAB 3 - 760 | 12 | na | 7/1/1996 | 15.13 | 0.5291 | 5,000 | 16.0 | 1.8 | 13.7 | 1.9 | 11.4 | 2.0 | nd | 16.0 | 1.8 | 13.7 | 1.9 | 11.4 | 2.0 |
| S244 | NM158 | SWAB 3 - 760 | 12 | na | 7/1/1996 | 15.36 | 0.5448 | 5,000 | 14.2 | 1.6 | 11.9 | 1.7 | 9.7 | 1.8 | nd | 14.2 | 1.6 | 11.9 | 1.7 | 9.7 | 1.8 |
| S245 | NM159 | SWAB 3 - 980 | 12 | na | 7/1/1996 | 15.37 | 0.5372 | 5,000 | 15.4 | 1.9 | 13.1 | 2.0 | 10.8 | 2.1 | nd | 15.4 | 1.9 | 13.1 | 2.0 | 10.8 | 2.1 |
| S245 | NM160 | SWAB 3 - 980 | 12 | na | 7/1/1996 | 15.48 | 0.5409 | 5,000 | 15.2 | 1.9 | 12.8 | 2.1 | 10.5 | 2.2 | nd | 15.2 | 1.9 | 12.8 | 2.1 | 10.5 | 2.2 |
| S245 | NM160 | SWAB 3 - 980 | 12 | na | 7/1/1996 | 21.45 | 0.6348 | 5,000 | 16.4 | 8.4 | 14.0 | 8.5 | 11.7 | 8.6 | nd | 16.4 | 8.4 | 14.0 | 8.5 | 11.7 | 8.6 |
| S253 | NM522 | Tome D | 12 | na | 8/6/1998 | 16.11 | 0.5505 | 5,000 | 15.3 | 2.6 | 13.0 | 2.7 | 10.7 | 2.9 | 0.9 | 13.0 | 1.1 | 10.8 | 1.2 | 8.5 | 1.3 |
| S253 | NM522 | Tome D | 12 | na | 8/6/1998 | 16.13 | 0.5507 | 5,000 | 15.3 | 2.6 | 13.0 | 2.8 | 10.7 | 2.9 | 0.9 | 13.1 | 1.1 | 10.8 | 1.2 | 8.5 | 1.3 |
| S257 | NM344 | Domestic Well #34 | 12 | na | 6/17/1997 | 16.20 | 0.5700 | 5,000 | 12.7 | 2.0 | 10.4 | 2.1 | 8.2 | 2.2 | 0.5 | 11.5 | 1.1 | 9.3 | 1.2 | 7.1 | 1.3 |
| S259 | NM171 | VGP-1 | 12 | na | 6/27/1996 | 19.39 | 0.6028 | 5,000 | 15.9 | 6.1 | 13.5 | 6.3 | 11.2 | 6.4 | nd | 15.9 | 6.1 | 13.5 | 6.3 | 11.2 | 6.4 |
| S261 | NM172 | Vol Andia 2 | 12 | na | 6/21/1996 | 15.14 | 0.5565 | 5,000 | 12.0 | 0.7 | 9.8 | 0.8 | 7.6 | 0.9 | nd | 12.0 | 0.7 | 9.8 | 0.8 | 7.6 | 0.9 |
| S262 | NM173 | Vol Andia 5 | 12 | na | 6/18/1996 | 15.32 | 0.5521 | 5,000 | 13.1 | 1.2 | 10.8 | 1.3 | 8.6 | 1.4 | 0.5 | 11.9 | 0.3 | 9.6 | 0.4 | 7.4 | 0.5 |
| S265 | NM175 | Webster 1 | 12 | na | 6/18/1996 | 19.73 | 0.3999 | 5,000 | 75.4 | 15.5 | 73.1 | 15.6 | 70.8 | 15.7 | nd | 75.4 | 15.5 | 73.1 | 15.6 | 70.8 | 15.7 |
| S267 | NM348 | West Bluff Nest 1 Well 2 | 12 | 3 | 6/23/1997 | 15.52 | 0.5619 | 5,000 | 12.2 | 1.1 | 9.9 | 1.2 | 7.7 | 1.3 | nd | 12.2 | 1.1 | 9.9 | 1.2 | 7.7 | 1.3 |
| S268 | NM349 | West Bluff Nest 1 Well 3 | 12 | na | 6/24/1997 | 15.14 | 0.5717 | 5,000 | 10.0 | 0.0 | 7.8 | 0.1 | 5.7 | 0.2 | nd | 10.0 | 0.0 | 7.8 | 0.1 | 5.7 | 0.2 |
| S269 | NM350 | West Bluff Nest 2 Well 1 | 12 | na | 6/24/1997 | 15.73 | 0.5604 | 5,000 | 12.9 | 1.5 | 10.6 | 1.7 | 8.4 | 1.8 | nd | 12.9 | 1.5 | 10.6 | 1.7 | 8.4 | 1.8 |
| S270 | NM351 | West Bluff Nest 2 Well 2 | 12 | na | 6/24/1997 | 15.79 | 0.5773 | 5,000 | 10.7 | 0.9 | 8.5 | 1.0 | 6.4 | 1.1 | nd | 10.7 | 0.9 | 8.5 | 1.0 | 6.4 | 1.1 |
| S271 | NM352 | West Bluff Nest 2 Well 3 | 12 | na | 6/24/1997 | 17.47 | 0.6344 | 5,000 | 7.3 | 1.4 | 5.1 | 1.5 | 3.1 | 1.6 | nd | 7.3 | 1.4 | 5.1 | 1.5 | 3.1 | 1.6 |
| S275 | NM178 | Yale 1 | 12 | na | 6/19/1996 | 18.37 | 0.5891 | 5,000 | 15.3 | 4.9 | 13.0 | 5.1 | 10.7 | 5.2 | 2.5 | 9.4 | 0.6 | 7.2 | 0.7 | 5.1 | 0.8 |
| SXXX | NM045 | Geoprobe #1 (45.3') | 12 | na | 7/1/1996 | 14.41 | 0.5276 | 5,000 | 14.4 | 0.6 | 12.1 | 0.7 | 9.8 | 0.9 | nd | 14.4 | 0.6 | 12.1 | 0.7 | 9.8 | 0.9 |
| SXXX | NM049 | Geoprobe #1 (25') | 12 | na | 7/1/1996 | 17.52 | 0.6182 | 5,000 | 9.3 | 2.2 | 7.1 | 2.3 | 5.0 | 2.4 | nd | 9.3 | 2.2 | 7.1 | 2.3 | 5.0 | 2.4 |
| SXXX | NM051 | Geoprobe #2 (40.5') | 12 | na | 7/1/1996 | 14.44 | 0.5387 | 5,000 | 12.8 | 0.2 | 10.6 | 0.3 | 8.3 | 0.4 | nd | 12.8 | 0.2 | 10.6 | 0.3 | 8.34 | 0.4 |
| | | **Zone 13: Discharge** | | | | | | | | | | | | | | | | | | | |
| S143 | NM096 | Private Production Well #05 | 13 | na | 8/19/1996 | 17.59 | 0.5639 | 5,000 | 17.2 | 4.6 | 14.8 | 4.8 | 12.5 | 4.9 | 2.0 | 12.1 | 1.1 | 9.8 | 1.3 | 7.6 | 1.4 |
| S194 | NM327 | Domestic Well #32 | 13 | na | 6/30/1997 | 14.38 | 0.5131 | 5,000 | 16.6 | 1.2 | 14.2 | 1.3 | 11.8 | 1.4 | nd | 16.6 | 1.2 | 14.2 | 1.3 | 11.8 | 1.4 |
| S226 | NM150 | Domestic Well #15 | 13 | na | 8/19/1996 | 17.51 | 0.5682 | 5,000 | 16.3 | 4.3 | 13.9 | 4.4 | 11.6 | 4.6 | 1.9 | 11.5 | 1.0 | 9.3 | 1.1 | 7.1 | 1.2 |
| | | **No Zone: Exotic Water** | | | | | | | | | | | | | | | | | | | |
| S009 | NM485 | Arroyo Salado Spring | E | E | 8/6/1998 | 10.72 | 0.4016 | 5,000 | 25.7 | - 0.5 | 23.1 | - 0.4 | 20.5 | - 0.3 | nd | 25.7 | - 0.5 | 23.1 | - 0.4 | 20.5 | - 0.3 |
| S023 | NM010 | Burn Site Well | E | E | 6/25/1996 | 15.63 | 0.5332 | 6,500 | 16.8 | 2.5 | 14.4 | 2.6 | 12.0 | 2.8 | nd | 16.8 | 2.5 | 14.4 | 2.6 | 12.0 | 2.8 |
| S028 | NM014 | Cerro Colorado Landfill MW | E | E | 8/12/1996 | 8.100 | 0.3299 | 5,000 | 32.0 | - 2.1 | 29.2 | - 2.0 | 26.5 | - 1.8 | nd | 32.0 | - 2.1 | 29.2 | - 2.0 | 26.5 | - 1.8 |
| S038 | NM265 | Windmill #19 | E | E | 7/1/1997 | 21.41 | 0.6898 | 5,000 | 8.6 | 6.0 | 6.5 | 6.1 | 4.4 | 6.2 | nd | 8.6 | 6.0 | 6.5 | 6.1 | 4.4 | 6.2 |
| S054 | NM041 | Domestic Well #04 | E | E | 8/17/1996 | 2.985 | 0.1399 | 6,500 | 66.1 | - 3.0 | 63.4 | - 2.9 | 60.8 | - 2.8 | nd | 66.1 | - 3.0 | 63.4 | - 2.9 | 60.8 | - 2.8 |
| S057 | NM044 | Embudo Spring | E | E | 7/2/1996 | 15.09 | 0.5519 | 6,500 | 12.6 | 0.8 | 10.3 | 0.9 | 8.1 | 1.0 | nd | 12.6 | 0.8 | 10.3 | 0.9 | 8.1 | 1.0 |
| S063 | NM282 | Windmill #22 | E | E | 6/28/1997 | 16.35 | 0.5387 | 5,000 | 17.9 | 3.5 | 15.4 | 3.7 | 13.1 | 3.8 | nd | 17.9 | 3.5 | 15.4 | 3.7 | 13.1 | 3.8 |

**Table A6.** Sensitivity analysis for recharge temperatures calculated from dissolved gases-- Continued

| | | | | | | | | | Assuming no excess $N_2$ | | | | | | | Assuming calculated excess $N_2$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Alt. 5,000 feet | | Alt. 6,500 feet | | Alt. 8,000 feet | | | Alt. 5,000 feet | | Alt. 6,500 feet | | Alt. 8,000 feet | |
| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Second-ary hydro-chemical zone | Date | $N_2$ (mg/kg) | Ar (mg/kg) | Assigned recharge altitude (feet) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Calcu-lated excess $N_2$ (mg/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) | Recharge temp-erature (ºC) | Excess air (cc STP/kg) |
| S067 | NM284 | Granite Hill | E | E | 7/4/1997 | 23.20 | 0.6255 | 6,500 | 23.4 | 11.8 | 20.8 | 12.0 | 18.3 | 12.1 | nd | 23.4 | 11.8 | 20.8 | 12.0 | 18.3 | 12.1 |
| S070 | NM059 | HERTF | E | E | 6/28/1996 | 14.99 | 0.5165 | 6,500 | 17.7 | 2.1 | 15.3 | 2.2 | 12.9 | 2.3 | nd | 17.7 | 2.1 | 15.3 | 2.2 | 12.9 | 2.3 |
| S091 | NM496 | Private Production Well #23 | E | E | 8/4/1998 | 16.28 | 0.5482 | 5,000 | 16.1 | 3.0 | 13.8 | 3.1 | 11.4 | 3.3 | 1.1 | 13.3 | 1.1 | 11.0 | 1.2 | 8.8 | 1.3 |
| S094 | NM293 | Stock Well #02 | E | E | 6/20/1997 | 21.91 | 0.6057 | 5,000 | 23.0 | 10.4 | 20.4 | 10.5 | 17.9 | 10.7 | nd | 23.0 | 10.4 | 20.4 | 10.5 | 17.9 | 10.7 |
| S099 | NM072 | LALF-1 | E | E | 6/29/1996 | 17.44 | 0.5178 | 5,000 | 25.4 | 6.3 | 22.7 | 6.4 | 20.2 | 6.6 | 3.0 | 16.0 | 1.1 | 13.6 | 1.2 | 11.3 | 1.3 |
| S112 | NM296 | Domestic Well #24 | E | E | 6/21/1997 | 14.25 | 0.4924 | 6,500 | 19.7 | 1.8 | 17.2 | 2.0 | 14.8 | 2.1 | nd | 19.7 | 1.8 | 17.2 | 2.0 | 14.8 | 2.1 |
| S129 | NM087 | Montaňo 4 S | E | E | 6/19/1996 | 15.83 | 0.5348 | 5,000 | 17.1 | 2.8 | 14.7 | 2.9 | 12.3 | 3.0 | 1.0 | 14.4 | 1.1 | 12.1 | 1.2 | 9.8 | 1.3 |
| S152 | NM098 | Private Production Well #07 | E | E | 8/22/1996 | 16.66 | 0.5606 | 6,500 | 15.2 | 3.2 | 12.9 | 3.3 | 10.6 | 3.4 | 1.5 | 11.5 | 0.5 | 9.3 | 0.7 | 7.1 | 0.8 |
| S182 | NM117 | Rio Bravo 4 S | E | E | 6/25/1996 | 18.59 | 0.5459 | 5,000 | 23.6 | 7.1 | 21.0 | 7.3 | 18.5 | 7.4 | 3.5 | 13.4 | 1.0 | 11.1 | 1.1 | 8.9 | 1.3 |
| S211 | NM512 | Sandia M | E | E | 7/30/1998 | 15.67 | 0.5509 | 6,500 | 14.1 | 1.8 | 11.8 | 2.0 | 9.6 | 2.1 | 0.6 | 12.6 | 0.8 | 10.4 | 0.9 | 8.2 | 1.0 |
| S211 | NM512 | Sandia M | E | E | 7/30/1998 | 15.94 | 0.5575 | 6,500 | 13.8 | 2.0 | 11.5 | 2.1 | 9.3 | 2.2 | 0.6 | 12.4 | 1.0 | 10.1 | 1.1 | 7.9 | 1.2 |
| S225 | NM149 | SBM-1 | E | E | 6/29/1996 | 15.26 | 0.5149 | 5,000 | 18.8 | 2.6 | 16.3 | 2.8 | 13.9 | 2.9 | 1.0 | 15.9 | 0.9 | 13.6 | 1.0 | 11.3 | 1.1 |
| S249 | NM164 | Private Production Well #09 | E | E | 6/26/1996 | 13.65 | 0.4874 | 6,500 | 18.8 | 1.0 | 16.3 | 1.1 | 13.9 | 1.2 | nd | 18.8 | 1.0 | 16.3 | 1.1 | 13.9 | 1.2 |
| S249 | NM163 | Private Production Well #09 | E | E | 6/26/1996 | 35.29 | 0.8637 | 6,500 | 17.6 | 22.9 | 15.2 | 23.0 | 12.8 | 23.1 | nd | 17.6 | 22.9 | 15.2 | 23.0 | 12.8 | 23.1 |
| S250 | NM165 | Private Production Well #10 | E | E | 6/26/1996 | 18.06 | 0.5517 | 6,500 | 20.7 | 6.0 | 18.2 | 6.1 | 15.8 | 6.2 | nd | 20.7 | 6.0 | 18.2 | 6.1 | 15.8 | 6.2 |
| S251 | NM166 | Private Production Well #11 | E | E | 6/26/1996 | 14.67 | 0.5013 | 6,500 | 19.4 | 2.2 | 16.9 | 2.3 | 14.5 | 2.4 | nd | 19.4 | 2.2 | 16.9 | 2.3 | 14.5 | 2.4 |
| S282 | NM529 | Windmill #44 | E | E | 7/29/1998 | 13.74 | 0.4757 | 5,000 | 21.2 | 1.6 | 18.6 | 1.8 | 16.2 | 1.9 | nd | 21.2 | 1.6 | 18.6 | 1.8 | 16.2 | 1.9 |
| SXXX | NM065 | Jemez Spring | E | E | 8/20/1996 | 1.164 | 0.0368 | 8,000 | 90.2 | - 0.3 | 88.5 | - 0.2 | 86.9 | - 0.2 | nd | 90.2 | - 0.3 | 88.5 | - 0.2 | 86.9 | - 0.2 |
| SXXX | NM154 | Soda Dam Spring | E | E | 8/20/1996 | 3.888 | 0.1454 | 8,000 | 69.7 | - 1.6 | 67.2 | - 1.5 | 64.7 | - 1.4 | nd | 69.7 | - 1.6 | 67.2 | - 1.5 | 64.7 | - 1.4 |

## **Table A7.** Summary of chlorofluorocarbon concentrations in water from wells and springs

[SXXX, no site number assigned; Hydrochemical Zone "E", exotic water, no primary or secondary zone assigned; CFC-11, trichlorofluoromethane ($CFCl_3$); CFC-12, dichlorodifluoromethane ($CF_2Cl_2$); CFC-113, trichlorotrifluoroethane ($C_2F_3Cl_3$); pg/kg, picograms per kilogram; pptv, parts per trillion by volume; na, not applicable; Modern concentrations of CFC-11, CFC-12, and CFC-113 assumed to be 271, 532, and 84.5 pptv, respectively, in calculation of Percent modern CFC.]

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secondary hydro-chemical zone | Date | CFC-11 (pg/kg) | CFC-12 (pg/kg) | CFC-113 (pg/kg) | Calculated atmospheric partial pressure of CFC-11 (pptv) | Calculated atmospheric partial pressure of CFC-12 (pptv) | Calculated atmospheric partial pressure of CFC-113 (pptv) | Percent modern CFC-11 | Percent modern CFC-12 | Percent modern CFC-113 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Zone 1: Northern Mountain Front** | | | | | | | | | | | | |
| S027 | NM486 | CEPO 02 | 1 | na | 8/3/1998 | 3.2 | 1.6 | 3.9 | 1.7 | 3.5 | 4.9 | 0.6 | 0.7 | 5.8 |
| S034 | NM027 | Private Production Well #04 | 1 | na | 8/28/1996 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S036 | NM026 | Private Production Well #03 | 1 | na | 8/28/1996 | 0.3 | 0.8 | 0.0 | 0.1 | 1.8 | 0.0 | 0.1 | 0.3 | 0.0 |
| S065 | NM055 | Domestic Well #05 | 1 | na | 8/17/1996 | 8.5 | 5.6 | 0.0 | 4.3 | 12.2 | 0.0 | 1.6 | 2.3 | 0.0 |
| S187 | NM131 | Rio Rancho 12 | 1 | na | 8/13/1996 | 8.4 | 6.3 | 2.4 | 4.3 | 13.8 | 3.0 | 1.6 | 2.6 | 3.5 |
| S216 | NM143 | Windmill #09 | 1 | na | 8/27/1996 | 23.4 | 16.8 | 5.9 | 12.1 | 37.1 | 7.4 | 4.5 | 7.0 | 8.8 |
| S254 | NM168 | Private Production Well #12 | 1 | na | 8/28/1996 | 0.3 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| | | **Zone 2: Northwestern** | | | | | | | | | | | | |
| S103 | NM497 | Lincoln D | 2 | na | 7/23/1998 | 18.7 | 3.3 | 2.4 | 9.7 | 7.4 | 3.1 | 3.6 | 1.4 | 3.7 |
| S104 | NM498 | Lincoln M | 2 | na | 7/23/1998 | 119.6 | 0.2 | 0.0 | 62.2 | 0.5 | 0.0 | 22.9 | 0.1 | 0.0 |
| S105 | NM499 | Lincoln S | 2 | na | 7/23/1998 | 10.5 | 4.4 | 2.1 | 5.5 | 9.8 | 2.8 | 2.0 | 1.8 | 3.3 |
| S191 | NM326 | Rio Rancho 4 | 2 | 3 | 6/20/1997 | 186.4 | 108.2 | 34.1 | 94.6 | 236. | 41.8 | 34.9 | 44.3 | 49.4 |
| S192 | NM128 | Rio Rancho 8 | 2 | 3 | 8/13/1996 | 0.4 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| S189 | NM133 | Rio Rancho 15 | 2 | na | 8/13/1996 | 0.3 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S286 | NM184 | Private Production Well #13 | 2 | na | 8/26/1996 | 5.8 | 5.2 | 0.0 | 3.0 | 11.4 | 0.0 | 1.1 | 2.1 | 0.0 |
| S287 | NM185 | Private Production Well #14 | 2 | na | 8/26/1996 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | **Zone 3: West Central** | | | | | | | | | | | | |
| S003 | NM481 | 98th St. D | 3 | na | 8/4/1998 | 8.0 | 15.5 | 0.0 | 4.1 | 34.6 | 0.0 | 1.5 | 6.5 | 0.0 |
| S003 | NM251 | 98th St. D | 3 | na | 6/17/1997 | 10.7 | 2.8 | 0.0 | 27.4 | 13.8 | 0.0 | 10.1 | 2.6 | 0.0 |
| S004 | NM482 | 98th St. MD | 3 | na | 8/4/1998 | 31.7 | 29.1 | 0.0 | 16.5 | 64.8 | 0.0 | 6.1 | 12.2 | 0.0 |
| S004 | NM252 | 98th St. MD | 3 | na | 6/18/1997 | 153. | 0.6 | 0.0 | 80.2 | 1.5 | 0.0 | 29.6 | 0.3 | 0.0 |
| S005 | NM483 | 98th St. MS | 3 | na | 8/4/1998 | 4.5 | 20.7 | 0.0 | 2.4 | 47.2 | 0.0 | 0.9 | 8.9 | 0.0 |
| S005 | NM253 | 98th St. MS | 3 | na | 7/4/1997 | 18.6 | 4.2 | 0.0 | 9.4 | 9.1 | 0.0 | 3.5 | 1.7 | 0.0 |
| S006 | NM484 | 98th St. S | 3 | na | 8/5/1998 | 53.8 | 31.3 | 31.3 | 28.0 | 69.7 | 39.4 | 10.3 | 13.1 | 46.6 |
| S006 | NM254 | 98th St. S | 3 | na | 6/17/1997 | 241. | 74.0 | 109. | 122. | 161. | 133. | 45.1 | 30.3 | 157.6 |
| S008 | NM003 | Private Production Well #01 | 3 | na | 8/12/1996 | 0.3 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| S010 | NM255 | Private Production Well #16 | 3 | na | 6/23/1997 | 453. | 72,872. | 51.5 | 230. | 158,647. | 63.2 | 84.8 | 29,821. | 74.8 |
| S018 | NM260 | Domestic Well #21 | 3 | na | 6/26/1997 | 36.5 | 32.3 | 5.2 | 18.5 | 70.2 | 6.4 | 6.8 | 13.2 | 7.6 |
| S019 | NM007 | Belen 4 | 3 | 5 | 8/16/1996 | 64.9 | 45.4 | 0.0 | 32.9 | 98.8 | 0.0 | 12.2 | 18.6 | 0.0 |
| S020 | NM008 | Belen 5 | 3 | 5 | 8/16/1996 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S029 | NM015 | Cerro Colorado Landfill PW | 3 | 5 | 8/12/1996 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S037 | NM264 | College 2 | 3 | na | 6/19/1997 | 0.5 | 1.1 | 0.0 | 0.2 | 2.3 | 0.0 | 0.1 | 0.4 | 0.0 |
| S066 | NM056 | Gonzales 1 | 3 | 12 | 6/20/1996 | 7.3 | 6.6 | 0.0 | 3.7 | 14.3 | 0.0 | 1.4 | 2.7 | 0.0 |
| S086 | NM492 | Isleta D | 3 | na | 7/29/1998 | 59.1 | 6.9 | 0.0 | 30.8 | 15.5 | 0.0 | 11.4 | 2.9 | 0.0 |
| S101 | NM294 | Leavitt 1 | 3 | na | 6/26/1997 | 5.7 | 6.0 | 0.0 | 2.9 | 13.1 | 0.0 | 1.1 | 2.5 | 0.0 |
| S108 | NM076 | Los Lunas 3 | 3 | 12 | 8/14/1996 | 0.5 | 1.0 | 0.0 | 0.3 | 2.2 | 0.0 | 0.1 | 0.4 | 0.0 |
| S109 | NM077 | Los Lunas 4 | 3 | 12 | 8/14/1996 | 0.2 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S145 | NM308 | NM Utilities 1 | 3 | na | 6/18/1997 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S147 | NM310 | NM Utilities 3 | 3 | na | 6/18/1997 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S148 | NM311 | NM Utilities 4 | 3 | na | 6/18/1997 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S166 | NM509 | Rabbit Hill | 3 | na | 8/4/1998 | 7.8 | 2.3 | 8.1 | 4.1 | 5.1 | 10.1 | 1.5 | 1.0 | 12.0 |
| S167 | NM107 | Domestic Well #12 | 3 | na | 8/14/1996 | 0.8 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| S172 | NM322 | Rio Bravo 5 D | 3 | na | 7/4/1997 | 7.3 | 0.0 | 26.6 | 3.8 | 0.0 | 33.5 | 1.4 | 0.0 | 39.7 |
| S174 | NM109 | Rio Bravo 1 D | 3 | 12 | 6/17/1996 | 0.9 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 |
| S175 | NM110 | Rio Bravo 1 M | 3 | 12 | 6/17/1996 | 5.3 | 2.4 | 0.0 | 2.7 | 5.2 | 0.0 | 1.0 | 1.0 | 0.0 |
| S186 | NM130 | Rio Rancho 10 | 3 | na | 8/13/1996 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S188 | NM132 | Rio Rancho 13 | 3 | na | 8/13/1996 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S193 | NM129 | Rio Rancho 9 | 3 | na | 8/13/1996 | 16.0 | 25.7 | 5.2 | 8.1 | 55.9 | 6.4 | 3.0 | 10.5 | 7.6 |
| S196 | NM135 | Windmill #05 | 3 | na | 8/21/1996 | 127. | 93.6 | 25.1 | 64.2 | 204. | 30.8 | 23.7 | 38.3 | 36.4 |
| S200 | NM139 | Private Production Well #08 | 3 | na | 8/29/1996 | 0.0 | 0.8 | 0.0 | 0.0 | 1.8 | 0.0 | 0.0 | 0.3 | 0.0 |
| S217 | NM144 | Santa Ana Boundary D | 3 | na | 8/22/1996 | 0.9 | 0.9 | 9.6 | 0.5 | 2.0 | 12.5 | 0.2 | 0.4 | 14.8 |
| S218 | NM145 | Santa Ana Boundary M | 3 | na | 8/22/1996 | 13.6 | 5.7 | 203. | 6.9 | 12.4 | 249. | 2.6 | 2.3 | 294.2 |
| S219 | NM146 | Santa Ana Boundary S | 3 | na | 8/22/1996 | 2.1 | 3.6 | 0.0 | 1.1 | 8.1 | 0.0 | 0.4 | 1.5 | 0.0 |
| S230 | NM516 | Sierra Vista D | 3 | na | 7/22/1998 | 37.3 | 0.0 | 0.0 | 19.2 | 0.0 | 0.0 | 7.1 | 0.0 | 0.0 |
| S236 | NM155 | SAF (Soil Amendment Facility) | 3 | na | 8/12/1996 | 137. | 77.4 | 24.0 | 69.7 | 169. | 29.5 | 25.7 | 31.7 | 34.9 |
| S263 | NM346 | Volcano Cliff 1 | 3 | na | 6/19/1997 | 1.2 | 2.7 | 0.0 | 0.6 | 5.9 | 0.0 | 0.2 | 1.1 | 0.0 |
| S266 | NM347 | West Bluff Nest 1 Well 1 | 3 | na | 6/23/1997 | 7.8 | 0.4 | 19.1 | 4.0 | 0.9 | 24.3 | 1.5 | 0.2 | 28.8 |
| S272 | NM353 | West Mesa 3 | 3 | na | 6/19/1997 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S283 | NM181 | Zia Ball Park D | 3 | na | 8/26/1996 | 0.9 | 0.3 | 331. | 0.5 | 0.8 | 426. | 0.2 | 0.1 | 503.8 |
| S284 | NM182 | Zia Ball Park M | 3 | na | 8/26/1996 | 8.3 | 0.9 | 360. | 4.2 | 1.9 | 442. | 1.5 | 0.4 | 523.3 |
| S285 | NM183 | Zia Ball Park S | 3 | 2 | 8/26/1996 | 5.2 | 1.3 | 39.1 | 2.6 | 2.8 | 48.0 | 1.0 | 0.5 | 56.8 |
| | | **Zone 4: Western Boundary** | | | | | | | | | | | | |
| S059 | NM278 | Windmill #21 | 4 | na | 6/23/1997 | 18.2 | 13.8 | 0.0 | 9.2 | 30.1 | 0.0 | 3.4 | 5.7 | 0.0 |
| | | **Zone 5: Rio Puerco** | | | | | | | | | | | | |
| S069 | NM058 | Domestic Well #06 | 5 | na | 8/16/1996 | 20.1 | 52.2 | 11.7 | 10.5 | 116.6 | 14.8 | 3.9 | 21.9 | 17.6 |
| S082 | NM409 | Windmill #36 | 5 | na | 9/10/1997 | 95.5 | 42.0 | 6.5 | 48.5 | 91.4 | 8.0 | 17.9 | 17.2 | 9.4 |
| S085 | NM408 | Windmill #35 | 5 | na | 9/10/1997 | 212. | 98.5 | 18.5 | 107. | 215. | 22.7 | 39.6 | 40.3 | 26.9 |
| S111 | NM079 | Domestic Well #10 | 5 | na | 8/16/1996 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S185 | NM324 | Domestic Well #31 | 5 | na | 6/16/1997 | 5.4 | 12.2 | 0.0 | 2.8 | 27.2 | 0.0 | 1.0 | 5.1 | 0.0 |
| S198 | NM137 | Windmill #07 | 5 | na | 8/21/1996 | 73.1 | 43.8 | 8.1 | 37.1 | 95.5 | 10.0 | 13.7 | 17.9 | 11.8 |
| | | **Zone 7: Abo Arroyo** | | | | | | | | | | | | |
| S021 | NM261 | Stock Well #01 | 7 | na | 6/23/1997 | 605. | 221. | 27.3 | 307. | 482. | 33.5 | 113.3 | 90.6 | 39.7 |
| S024 | NM011 | Domestic Well #02 | 7 | 8 | 8/17/1996 | 2.7 | 1.7 | 0.0 | 1.4 | 19.3 | 0.0 | 0.5 | 3.6 | 0.0 |
| S090 | NM064 | Domestic Well #08 | 7 | na | 8/19/1996 | 6.6 | 3.1 | 0.0 | 3.3 | 6.7 | 0.0 | 1.2 | 1.3 | 0.0 |
| S093 | NM067 | Domestic Well #09 | 7 | 8 | 8/15/1996 | 1.4 | 0.9 | 0.0 | 0.7 | 1.9 | 0.0 | 0.3 | 0.4 | 0.0 |
| S007 | NM002 | Domestic Well #01 | 8 | na | 6/21/1996 | 695.5 | 327.0 | 96.1 | 361. | 726. | 121. | 133.0 | 136.4 | 143.4 |

**Table A7.** Summary of chlorofluorocarbon concentrations in water from wells and springs-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secondary hydro-chemical zone | Date | CFC-11 (pg/kg) | CFC-12 (pg/kg) | CFC-113 (pg/kg) | Calculated atmospheric partial pressure of CFC-11 (pptv) | Calculated atmospheric partial pressure of CFC-12 (pptv) | Calculated atmospheric partial pressure of CFC-113 (pptv) | Percent modern CFC-11 | Percent modern CFC-12 | Percent modern CFC-113 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Zone 8: Eastern Mountain Front** | | | | | | | | | | | | |
| S030 | NM023 | Charles 4 | 8 | na | 6/27/1996 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S030 | NM024 | Charles 4 | 8 | na | 6/27/1996 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S030 | NM022 | Charles 4 | 8 | na | 6/27/1996 | 0.5 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| S030 | NM024 | Charles 4 | 8 | na | 6/27/1996 | 0.7 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| S030 | NM016 | Charles 4 | 8 | na | 6/22/1996 | 0.7 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| S030 | NM021 | Charles 4 | 8 | na | 6/27/1996 | 0.8 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 |
| S030 | NM018 | Charles 4 | 8 | na | 6/27/1996 | 1.1 | 1.1 | 0.0 | 0.6 | 2.7 | 0.0 | 0.2 | 0.5 | 0.0 |
| S030 | NM020 | Charles 4 | 8 | na | 6/27/1996 | 1.3 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 |
| S030 | NM019 | Charles 4 | 8 | na | 6/27/1996 | 1.5 | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 |
| S030 | NM017 | Charles 4 | 8 | na | 6/27/1996 | 1.8 | 0.0 | 0.0 | 0.9 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 |
| S042 | NM031 | Domestic Well #03 | 8 | na | 8/14/1996 | 0.4 | 0.0 | 0.0 | 0.2 | 12.6 | 0.0 | 0.1 | 2.4 | 0.0 |
| S055 | NM042 | Elena Gallegos | 8 | na | 6/25/1996 | 428. | 207. | 54.5 | 217. | 452. | 66.8 | 80.1 | 84.9 | 79.1 |
| S056 | NM043 | Embudito Spring | 8 | na | 7/2/1996 | 432. | 220. | 66.0 | 224. | 488. | 82.9 | 82.5 | 91.7 | 98.1 |
| S056 | NM227 | Embudito Spring | 8 | na | 4/29/1997 | 523. | 287. | 72.9 | 244. | 584. | 82.3 | 90.2 | 109.7 | 97.4 |
| S056 | NM227 | Embudito Spring | 8 | na | 4/29/1997 | 620. | 324. | 86.2 | 268. | 614. | 89.4 | 98.9 | 115.4 | 105.9 |
| S056 | NM214 | Embudito Spring | 8 | na | 3/21/1997 | 638. | 401. | 88.6 | 243. | 679. | 80.1 | 89.8 | 127.7 | 94.8 |
| S056 | NM213 | Embudito Spring | 8 | na | 3/21/1997 | 738. | 419. | 123. | 261. | 664. | 102. | 96.2 | 124.8 | 120.4 |
| S071 | NM060 | Domestic Well #07 | 8 | na | 6/19/1996 | 0.5 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| S083 | NM407 | Windmill #34 | 8 | na | 9/10/1997 | 58.6 | 16.8 | 3.8 | 29.7 | 36.6 | 4.7 | 11.0 | 6.9 | 5.5 |
| S095 | NM068 | Kirtland 1 | 8 | na | 6/25/1996 | 191. | 11.9 | 3.8 | 96.8 | 26.0 | 4.7 | 35.7 | 4.9 | 5.5 |
| S106 | NM295 | Domestic Well #23 | 8 | na | 6/26/1997 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S110 | NM078 | Love 1 | 8 | na | 6/22/1996 | 34.0 | 10.1 | 55.6 | 17.2 | 22.0 | 68.3 | 6.4 | 4.1 | 80.8 |
| S113 | NM080 | Domestic Well #11 | 8 | na | 8/15/1996 | 1.9 | 1.4 | 0.0 | 0.9 | 3.0 | 0.0 | 0.3 | 0.6 | 0.0 |
| S114 | NM500 | Matheson D | 8 | na | 7/31/1998 | 247. | 50.2 | 14.1 | 126. | 109. | 18.4 | 46.3 | 20.5 | 21.8 |
| S115 | NM501 | Matheson M | 8 | na | 8/1/1998 | 127. | 43.4 | 27.8 | 64.5 | 94.4 | 34.1 | 23.8 | 17.7 | 40.3 |
| S116 | NM502 | Matheson S | 8 | na | 8/1/1998 | 15.5 | 5.0 | 1.1 | 8.0 | 11.1 | 1.4 | 3.0 | 2.1 | 1.7 |
| S117 | NM298 | Domestic Well #25 | 8 | na | 6/17/1997 | 4.2 | 13.2 | 0.0 | 2.2 | 29.4 | 0.0 | 0.8 | 5.5 | 0.0 |
| S119 | NM300 | Domestic Well #26 | 8 | 11 | 6/19/1997 | 5,591. | 551. | 29.8 | 2,837. | 1,200. | 36.5 | 1,046.9 | 225.5 | 43.2 |
| S122 | NM304 | Mesa Del Sol S | 8 | na | 6/29/1997 | 0.3 | 17.8 | 0.0 | 0.2 | 38.6 | 0.0 | 0.1 | 7.3 | 0.0 |
| S122 | NM505 | Mesa Del Sol S | 8 | na | 7/25/1998 | 18.9 | 12.1 | 3.1 | 9.8 | 27.1 | 4.0 | 3.6 | 5.1 | 4.7 |
| S140 | NM306 | MRN 1 | 8 | na | 7/5/1997 | 114. | 0.0 | 0.0 | 57.8 | 0.0 | 0.0 | 21.3 | 0.0 | 0.0 |
| S141 | NM095 | National Utility 7 | 8 | na | 8/14/1996 | 69.1 | 785. | 7.5 | 35.0 | 1,709. | 9.2 | 12.9 | 321.3 | 10.9 |
| S149 | NM312 | Nor Este D | 8 | na | 7/3/1997 | 9.6 | 0.0 | 0.0 | 5.0 | 0.0 | 0.0 | 1.8 | 0.0 | 0.0 |
| S150 | NM313 | Nor Este M | 8 | na | 7/2/1997 | 4.6 | 0.0 | 0.0 | 2.4 | 0.0 | 0.0 | 0.9 | 0.0 | 0.0 |
| S162 | NM317 | Stock Well #03 | 8 | na | 6/30/1997 | 1.9 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 |
| S163 | NM318 | PL 2 | 8 | na | 7/7/1997 | 5.9 | 0.0 | 0.0 | 3.0 | 0.0 | 0.0 | 1.1 | 0.0 | 0.0 |
| S164 | NM106 | Ponderosa 1 | 8 | na | 6/20/1996 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S168 | NM319 | Domestic Well #30 | 8 | na | 6/27/1997 | 7.3 | 9.2 | 22.1 | 3.7 | 20.3 | 27.8 | 1.4 | 3.8 | 33.0 |
| S170 | NM108 | Ridgecrest 3 | 8 | na | 6/22/1996 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S195 | NM134 | Domestic Well #13 | 8 | na | 8/14/1996 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S209 | NM336 | Domestic Well #33 | 8 | na | 6/27/1997 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S212 | NM141 | Sandia Peak 1 | 8 | na | 6/26/1996 | 0.3 | 3.1 | 0.0 | 0.1 | 6.8 | 0.0 | 0.1 | 1.3 | 0.0 |
| S213 | NM142 | Sandia Peak 3 | 8 | na | 6/26/1996 | 1.9 | 13.2 | 1.4 | 0.9 | 28.7 | 1.7 | 0.3 | 5.4 | 2.0 |
| S224 | NM148 | Domestic Well #14 | 8 | na | 8/23/1996 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S229 | NM515 | SH03 UNM | 8 | na | 7/28/1998 | 67.6 | 3.5 | 0.0 | 35.1 | 7.8 | 0.0 | 12.9 | 1.5 | 0.0 |
| S233 | NM153 | Domestic Well #16 | 8 | na | 8/23/1996 | 0.0 | 0.8 | 0.0 | 0.0 | 1.8 | 0.0 | 0.0 | 0.3 | 0.0 |
| S239 | NM156 | Domestic Well #17 | 8 | na | 8/17/1996 | 1.9 | 10,691. | 3.2 | 1.0 | 23,276. | 3.9 | 0.4 | 4,375. | 4.6 |
| S240 | NM157 | Domestic Well #18 | 8 | na | 6/19/1996 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S247 | NM161 | Domestic Well #19 | 8 | na | 8/15/1996 | 0.1 | 1.3 | 0.0 | 0.1 | 2.8 | 0.0 | 0.0 | 0.5 | 0.0 |
| S248 | NM162 | Thomas 6 | 8 | na | 6/21/1996 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S255 | NM523 | Tramway East | 8 | na | 7/30/1998 | 18.8 | 4.3 | 0.0 | 6.5 | 9.6 | 1.4 | 2.4 | 1.8 | 1.6 |
| S264 | NM174 | Walker 1 | 8 | na | 6/18/1996 | 1.1 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 |
| S274 | NM177 | Domestic Well #20 | 8 | na | 8/15/1996 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | **Zone 9: Tijeras Fault Zone** | | | | | | | | | | | | |
| S041 | NM029 | Coyote Spring | 9 | na | 6/28/1996 | 145. | 91.6 | 18.4 | 75.4 | 203. | 22.8 | 27.8 | 38.1 | 27.0 |
| S072 | NM061 | Hubbell Spring | 9 | 8 | 8/23/1996 | 99.8 | 77.9 | 14.9 | 50.6 | 170. | 18.3 | 18.7 | 31.9 | 21.7 |
| S098 | NM071 | KAFB-1902 | 9 | na | 6/28/1996 | 444. | 1,626. | 90.4 | 225. | 3,540. | 111. | 83.1 | 665.5 | 131.2 |
| S197 | NM136 | Windmill #06 | 9 | na | 8/23/1996 | 18.6 | 30.5 | 5.6 | 9.4 | 66.5 | 6.9 | 3.5 | 12.5 | 8.2 |
| S227 | NM151 | SFR 3D | 9 | na | 8/24/1996 | 17.7 | 4.4 | 0.0 | 9.0 | 9.6 | 0.0 | 3.3 | 1.8 | 0.0 |
| S228 | NM152 | SFR 3S | 9 | na | 8/24/1996 | 42.3 | 9.6 | 113. | 21.5 | 20.9 | 138. | 7.9 | 3.9 | 163.4 |
| | | **Zone 10: Tijeras Arroyo** | | | | | | | | | | | | |
| S001 | NM001 | 4Hills-1 | 10 | 8 | 6/29/1996 | 887. | 364. | 81.0 | 450. | 793. | 99.4 | 166.0 | 149.0 | 117.6 |
| S002 | NM250 | Private Production Well #15 | 10 | 8 | 7/3/1997 | 879. | 785. | 329. | 459. | 1,751. | 420. | 169.3 | 329.0 | 496.7 |
| S058 | NM277 | Eubank 1 | 10 | 8 | 7/4/1997 | 288. | 185. | 54.9 | 146. | 404. | 67.3 | 53.9 | 75.9 | 79.7 |
| S096 | NM069 | Kirtland 11 | 10 | 8 | 6/25/1996 | 55.2 | 184. | 563. | 28.0 | 400. | 690. | 10.3 | 75.2 | 8.2 |
| | | **Zone 11: Northeastern** | | | | | | | | | | | | |
| S144 | NM097 | Private Production Well #06 | 11 | na | 8/28/1996 | 3.2 | 1.4 | 0.0 | 1.6 | 3.0 | 0.0 | 0.6 | 0.6 | 0.0 |
| S207 | NM334 | Private Production Well #22 | 11 | na | 7/3/1997 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | | **Zone 12: Central** | | | | | | | | | | | | |
| S011 | NM004 | Atris-1 | 12 | na | 6/22/1996 | 1.2 | 82.1 | 0.0 | 0.6 | 179. | 0.0 | 0.2 | 33.6 | 0.0 |
| S012 | NM005 | Atrisco 3 | 12 | 3 | 6/20/1996 | 0.6 | 9.9 | 0.0 | 0.3 | 22.6 | 0.0 | 0.1 | 4.3 | 0.0 |
| S025 | NM012 | Burton 2 | 12 | na | 6/19/1996 | 31.6 | 47.2 | 14.9 | 16.0 | 103. | 18.2 | 5.9 | 19.3 | 21.6 |
| S026 | NM013 | Burton 5 | 12 | na | 6/19/1996 | 1.3 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 |
| S033 | NM025 | Private Production Well #02 | 12 | na | 8/21/1996 | 29.2 | 28.6 | 1.9 | 14.8 | 62.3 | 2.3 | 5.5 | 11.7 | 2.7 |
| S040 | NM028 | Coronado 1 | 12 | na | 6/18/1996 | 52.6 | 332. | 0.0 | 26.7 | 722. | 0.0 | 9.8 | 135.7 | 0.0 |
| S043 | NM488 | Del Sol D | 12 | na | 7/21/1998 | 2.8 | 0.2 | 0.0 | 1.4 | 0.4 | 0.0 | 0.5 | 0.1 | 0.0 |
| S043 | NM267 | Del Sol D | 12 | na | 7/1/1997 | 8.0 | 1.2 | 0.0 | 4.2 | 2.7 | 0.0 | 1.5 | 0.5 | 0.0 |
| S044 | NM268 | Del Sol M | 12 | na | 6/26/1997 | 3.9 | 0.0 | 0.0 | 2.0 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 |
| S044 | NM489 | Del Sol M | 12 | na | 7/21/1998 | 3.9 | 0.0 | 0.0 | 2.0 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 |
| S045 | NM269 | Del Sol S | 12 | na | 6/26/1997 | 28.0 | 19.5 | 0.0 | 14.2 | 42.4 | 0.0 | 5.2 | 8.0 | 0.0 |
| S045 | NM490 | Del Sol S | 12 | na | 7/21/1998 | 28.7 | 16.2 | 0.0 | 15.0 | 36.1 | 0.0 | 5.5 | 6.8 | 0.0 |

**Table A7.** Summary of chlorofluorocarbon concentrations in water from wells and springs-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secondary hydro-chemical zone | Date | CFC-11 (pg/kg) | CFC-12 (pg/kg) | CFC-113 (pg/kg) | Calculated atmospheric partial pressure of CFC-11 (pptv) | Calculated atmospheric partial pressure of CFC-12 (pptv) | Calculated atmospheric partial pressure of CFC-113 (pptv) | Percent modern CFC-11 | Percent modern CFC-12 | Percent modern CFC-113 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S046 | NM033 | Duranes 1 | 12 | na | 6/29/1996 | 0.0 | 179. | 0.0 | 0.0 | 391. | 0.0 | 0.0 | 73.4 | 0.0 |
| S046 | NM035 | Duranes 1 | 12 | na | 6/29/1996 | 0.0 | 165. | 0.0 | 0.0 | 386. | 0.0 | 0.0 | 72.6 | 0.0 |
| S046 | NM036 | Duranes 1 | 12 | na | 6/29/1996 | 0.0 | 163. | 0.0 | 0.0 | 381. | 0.0 | 0.0 | 71.6 | 0.0 |
| S046 | NM037 | Duranes 1 | 12 | na | 6/29/1996 | 0.0 | 173. | 0.0 | 0.0 | 402. | 0.0 | 0.0 | 75.7 | 0.0 |
| S046 | NM038 | Duranes 1 | 12 | na | 6/29/1996 | 0.0 | 176. | 0.0 | 0.0 | 411. | 0.0 | 0.0 | 77.3 | 0.0 |
| S046 | NM039 | Duranes 1 | 12 | na | 6/29/1996 | 0.0 | 180. | 0.0 | 0.0 | 421. | 0.0 | 0.0 | 79.1 | 0.0 |
| S046 | NM040 | Duranes 1 | 12 | na | 6/29/1996 | 0.0 | 183. | 0.0 | 0.0 | 399. | 0.0 | 0.0 | 75.0 | 0.0 |
| S046 | NM034 | Duranes 1 | 12 | na | 6/29/1996 | 0.4 | 160. | 0.0 | 0.2 | 373. | 0.0 | 0.1 | 70.2 | 0.0 |
| S046 | NM032 | Duranes 1 | 12 | na | 6/20/1996 | 0.5 | 77.9 | 0.0 | 0.2 | 170. | 0.0 | 0.1 | 31.9 | 0.0 |
| S047 | NM270 | Duranes 7 | 12 | na | 6/26/1997 | 0.1 | 32.8 | 0.0 | 0.0 | 71.4 | 0.0 | 0.0 | 13.4 | 0.0 |
| S048 | NM271 | Duranes Yard 1 | 12 | na | 7/5/1997 | 4.2 | 5.2 | 0.0 | 1.8 | 9.9 | 0.0 | 0.7 | 1.9 | 0.0 |
| S049 | NM272 | Duranes Yard 2 | 12 | na | 7/5/1997 | 25.1 | 15.7 | 15.3 | 10.6 | 28.9 | 15.3 | 3.9 | 5.4 | 18.1 |
| S050 | NM273 | Duranes Yard 3 | 12 | na | 7/5/1997 | 28.6 | 67.2 | 67.8 | 15.0 | 150. | 86.1 | 5.5 | 28.3 | 101.9 |
| S051 | NM274 | Duranes Yard 4 | 12 | na | 7/5/1997 | 2.5 | 136. | 0.0 | 0.9 | 226. | 0.0 | 0.3 | 42.5 | 0.0 |
| S052 | NM275 | Duranes Yard 5 | 12 | na | 7/5/1997 | 5.0 | 197. | 27.9 | 2.1 | 359. | 27.5 | 0.8 | 67.4 | 32.5 |
| S060 | NM279 | Garfield D | 12 | 3 | 6/19/1997 | 2.4 | 0.0 | 11.3 | 1.2 | 0.0 | 13.9 | 0.5 | 0.0 | 16.5 |
| S061 | NM280 | Garfield M | 12 | na | 6/19/1997 | 2.1 | 0.0 | 0.0 | 1.1 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 |
| S062 | NM281 | Garfield S | 12 | na | 6/19/1997 | 15.5 | 861. | 43.0 | 7.9 | 1,875. | 52.7 | 2.9 | 352.4 | 62.4 |
| S062 | NM491 | Garfield S | 12 | na | 7/28/1998 | 22.9 | 964. | 20.3 | 11.9 | 2,148. | 26.1 | 4.4 | 403.8 | 30.9 |
| S064 | NM283 | Domestic Well #22 | 12 | na | 6/20/1997 | 5.6 | 10.4 | 0.0 | 2.9 | 22.7 | 0.0 | 1.1 | 4.3 | 0.0 |
| S068 | NM057 | Griegos 3 | 12 | na | 6/21/1996 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S075 | NM286 | Hunter Ridge Nest 1 Well 1 | 12 | 3 | 6/20/1997 | 4.9 | 0.0 | 28.4 | 2.5 | 0.0 | 35.6 | 0.9 | 0.0 | 42.2 |
| S076 | NM287 | Hunter Ridge Nest 1 Well 2 | 12 | na | 6/21/1997 | 9.9 | 0.3 | 7.8 | 5.2 | 0.6 | 9.8 | 1.9 | 0.1 | 11.6 |
| S077 | NM288 | Hunter Ridge Nest 1 Well 3 | 12 | na | 6/20/1997 | 63.6 | 36.0 | 107. | 33.8 | 82.9 | 136. | 12.5 | 15.6 | 160.8 |
| S078 | NM289 | Hunter Ridge Nest 2 Well 1 | 12 | na | 6/21/1997 | 7.7 | 1.6 | 0.0 | 3.9 | 3.5 | 0.0 | 1.4 | 0.7 | 0.0 |
| S079 | NM290 | Hunter Ridge Nest 2 Well 2 | 12 | na | 6/21/1997 | 4.9 | 0.0 | 0.0 | 2.6 | 0.0 | 0.0 | 0.9 | 0.0 | 0.0 |
| S080 | NM291 | Hunter Ridge Nest 2 Well 3 | 12 | na | 6/21/1997 | 6.1 | 3.1 | 10.4 | 3.2 | 7.0 | 12.9 | 1.2 | 1.3 | 15.2 |
| S081 | NM292 | Private Production Well #19 | 12 | na | 7/2/1997 | 1.1 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 |
| S084 | NM063 | Windmill #04 | 12 | na | 8/21/1996 | 65.8 | 38.7 | 6.6 | 33.4 | 84.4 | 8.1 | 12.3 | 15.9 | 9.6 |
| S087 | NM493 | Isleta MD | 12 | 3 | 7/29/1998 | 4.6 | 3.8 | 0.0 | 2.4 | 8.7 | 0.0 | 0.9 | 1.6 | 0.0 |
| S088 | NM494 | Isleta MS | 12 | na | 7/29/1998 | 3.4 | 4.3 | 0.0 | 1.7 | 9.7 | 0.0 | 0.6 | 1.8 | 0.0 |
| S089 | NM495 | Isleta S | 12 | na | 7/29/1998 | 0.6 | 17.7 | 0.0 | 0.3 | 39.6 | 0.0 | 0.1 | 7.4 | 0.0 |
| S092 | NM066 | JMC-1 | 12 | na | 6/28/1996 | 202. | 279. | 31.8 | 103. | 608. | 39.0 | 37.9 | 114.3 | 46.2 |
| S097 | NM070 | Kirtland 14 | 12 | na | 6/25/1996 | 1.6 | 27.5 | 0.0 | 0.8 | 60.0 | 0.0 | 0.3 | 11.3 | 0.0 |
| S100 | NM073 | LALF-9 | 12 | na | 6/29/1996 | 5,521. | 45,228. | 31,499. | 2,801. | 98,464. | 38,638. | 1,034. | 18,508. | 45,725. |
| S102 | NM074 | Leyendecker 1 | 12 | na | 6/21/1996 | 28.0 | 125.8 | 0.0 | 14.2 | 274. | 0.0 | 5.2 | 51.5 | 0.0 |
| S120 | NM503 | Mesa Del Sol D | 12 | na | 8/2/1998 | 22.3 | 0.5 | 0.0 | 11.3 | 1.1 | 0.0 | 4.2 | 0.2 | 0.0 |
| S120 | NM303 | Mesa Del Sol D | 12 | na | 6/28/1997 | 85.4 | 108.6 | 90.5 | 43.3 | 236. | 111. | 16.0 | 44.4 | 131.4 |
| S120 | NM301 | Mesa Del Sol D | 12 | na | 6/29/1997 | 112. | 88.9 | 25.7 | 56.6 | 194. | 31.5 | 20.9 | 36.4 | 37.3 |
| S121 | NM302 | Mesa Del Sol M | 12 | na | 6/28/1997 | 0.0 | 6.5 | 0.0 | 0.0 | 14.2 | 0.0 | 0.0 | 2.7 | 0.0 |
| S121 | NM504 | Mesa Del Sol M | 12 | na | 7/25/1998 | 5.9 | 1.6 | 0.0 | 3.0 | 3.5 | 0.0 | 1.1 | 0.7 | 0.0 |
| S123 | NM081 | MONT - 5A | 12 | na | 6/27/1996 | 3.4 | 79.0 | 0.0 | 1.7 | 172. | 0.0 | 0.6 | 32.3 | 0.0 |
| S124 | NM082 | Montaňo 2 D | 12 | na | 6/19/1996 | 0.7 | 53.9 | 0.0 | 0.3 | 117. | 0.0 | 0.1 | 22.1 | 0.0 |
| S125 | NM083 | Montaňo 2 M | 12 | na | 6/19/1996 | 0.4 | 37.2 | 0.0 | 0.2 | 83.2 | 0.0 | 0.1 | 15.6 | 0.0 |
| S126 | NM084 | Montaňo 2 S | 12 | na | 6/19/1996 | 0.8 | 214.1 | 0.0 | 0.4 | 466. | 0.0 | 0.2 | 87.6 | 0.0 |
| S127 | NM085 | Montaňo 4 D | 12 | na | 6/20/1996 | 0.0 | 8.9 | 0.0 | 0.0 | 19.4 | 0.0 | 0.0 | 3.6 | 0.0 |
| S128 | NM086 | Montaňo 4 M | 12 | na | 6/19/1996 | 0.0 | 56.1 | 0.0 | 0.0 | 122. | 0.0 | 0.0 | 23.0 | 0.0 |
| S130 | NM088 | Montaňo 5 D | 12 | na | 6/24/1996 | 0.3 | 4.4 | 0.0 | 0.2 | 9.7 | 0.0 | 0.1 | 1.8 | 0.0 |
| S131 | NM089 | Montaňo 5 M | 12 | na | 6/24/1996 | 14.7 | 200. | 11.1 | 7.5 | 435. | 13.6 | 2.8 | 81.7 | 16.1 |
| S132 | NM090 | Montaňo 5 S | 12 | na | 6/24/1996 | 74.0 | 177. | 61.3 | 37.6 | 385. | 75.2 | 13.9 | 72.3 | 89.0 |
| S133 | NM091 | Montaňo 6 D | 12 | na | 6/18/1996 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S133 | NM091 | Montaňo 6 D | 12 | na | 6/18/1996 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S134 | NM092 | Montaňo 6 MD | 12 | na | 6/18/1996 | 1.5 | 0.3 | 194. | 0.7 | 0.7 | 238. | 0.3 | 0.1 | 282.0 |
| S135 | NM093 | Montaňo 6 MS | 12 | na | 6/18/1996 | 1.6 | 0.0 | 106. | 0.8 | 0.0 | 130. | 0.3 | 0.0 | 153.5 |
| S136 | NM094 | Montaňo 6 S | 12 | na | 6/18/1996 | 1.0 | 266.8 | 0.0 | 0.5 | 581. | 0.0 | 0.2 | 109.2 | 0.0 |
| S137 | NM506 | Montesa M | 12 | na | 7/27/1998 | 36.0 | 1.7 | 1.3 | 18.5 | 3.8 | 1.7 | 6.8 | 0.7 | 2.0 |
| S138 | NM507 | Montesa S | 12 | na | 7/27/1998 | 69.1 | 52.6 | 0.0 | 35.8 | 117. | 0.0 | 13.2 | 22.1 | 0.0 |
| S139 | NM305 | Domestic Well #27 | 12 | na | 6/17/1997 | 99.3 | 0.0 | 0.0 | 50.4 | 0.0 | 0.0 | 18.6 | 0.0 | 0.0 |
| S142 | NM307 | Domestic Well #28 | 12 | na | 6/17/1997 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S146 | NM309 | NM Utilities 2 | 12 | na | 6/18/1997 | 2.7 | 0.0 | 0.0 | 1.4 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 |
| S151 | NM508 | Nor Este S | 12 | na | 7/20/1998 | 65.2 | 6.2 | 0.0 | 75.0 | 14.8 | 0.0 | 27.7 | 2.8 | 0.0 |
| S151 | NM314 | Nor Este S | 12 | na | 7/2/1997 | 272. | 207. | 48.9 | 108. | 429. | 48.6 | 39.9 | 80.6 | 57.6 |
| S153 | NM411 | Open Space | 12 | na | 11/18/1997 | 447. | 37.5 | 25.3 | 227. | 81.6 | 31.1 | 83.8 | 15.3 | 36.8 |
| S154 | NM099 | ORLF-2 | 12 | na | 6/27/1996 | 53.1 | 117.6 | 5.1 | 26.9 | 256. | 6.2 | 9.9 | 48.1 | 7.4 |
| S155 | NM316 | Domestic Well #29 | 12 | na | 6/27/1997 | 0.2 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S156 | NM100 | Paseo 2D | 12 | na | 6/26/1996 | 3.0 | 2.8 | 69.8 | 1.5 | 6.2 | 85.6 | 0.6 | 1.2 | 101.3 |
| S157 | NM101 | Paseo 2MD | 12 | na | 6/26/1996 | 0.4 | 41.6 | 7.6 | 0.2 | 90.6 | 9.3 | 0.1 | 17.0 | 11.1 |
| S158 | NM102 | Paseo 2MS | 12 | na | 6/26/1996 | 0.1 | 453. | 1.2 | 0.1 | 1,021. | 1.5 | 0.0 | 192.0 | 1.8 |
| S159 | NM103 | Paseo 2S | 12 | na | 6/26/1996 | 71.0 | 2,068. | 6.1 | 36.7 | 4,581. | 7.9 | 13.5 | 861.1 | 9.3 |
| S160 | NM104 | Paseo 3D | 12 | na | 6/21/1996 | 8.2 | 26.8 | 170. | 4.2 | 58.3 | 209. | 1.5 | 11.0 | 247.2 |
| S161 | NM105 | Paseo 3M | 12 | na | 6/21/1996 | 11.2 | 2,205. | 10.8 | 5.7 | 4,801. | 13.2 | 2.1 | 902.5 | 15.6 |
| S171 | NM321 | Ridgecrest 4 | 12 | na | 6/26/1997 | 0.1 | 20.9 | 0.0 | 0.0 | 46.8 | 0.0 | 0.0 | 8.8 | 0.0 |
| S173 | NM323 | Rio Bravo 5 M | 12 | 3 | 7/4/1997 | 0.6 | 1,713. | 0.0 | 0.3 | 3,821. | 0.0 | 0.1 | 718.2 | 0.0 |
| S176 | NM111 | Rio Bravo 1 S | 12 | na | 6/17/1996 | 2.0 | 69.1 | 0.0 | 1.0 | 150. | 0.0 | 0.4 | 28.3 | 0.0 |
| S177 | NM112 | Rio Bravo 2 D | 12 | 3 | 6/25/1996 | 0.4 | 33.0 | 0.0 | 0.2 | 71.7 | 0.0 | 0.1 | 13.5 | 0.0 |
| S178 | NM113 | Rio Bravo 2 M | 12 | na | 6/25/1996 | 0.0 | 4.8 | 0.0 | 0.0 | 10.9 | 0.0 | 0.0 | 2.0 | 0.0 |
| S179 | NM114 | Rio Bravo 2 S | 12 | na | 6/25/1996 | 1.3 | 8.1 | 13.2 | 0.7 | 17.7 | 16.2 | 0.3 | 3.3 | 19.2 |
| S180 | NM115 | Rio Bravo 4 D | 12 | na | 6/25/1996 | 1.6 | 0.6 | 0.0 | 0.8 | 1.4 | 0.0 | 0.3 | 0.3 | 0.0 |
| S181 | NM116 | Rio Bravo 4 M | 12 | na | 6/25/1996 | 5.1 | 37.6 | 0.0 | 2.6 | 81.9 | 0.0 | 1.0 | 15.4 | 0.0 |
| S183 | NM126 | Rio Grande Utility 5 | 12 | 3 | 8/15/1996 | 1.0 | 0.5 | 0.0 | 0.5 | 1.1 | 0.0 | 0.2 | 0.2 | 0.0 |
| S184 | NM127 | Rio Grande Utility 6 | 12 | na | 8/15/1996 | 0.9 | 0.0 | 5.9 | 0.5 | 0.0 | 7.2 | 0.2 | 0.0 | 8.5 |
| S190 | NM325 | Rio Rancho 2 | 12 | na | 6/20/1997 | 26.6 | 1.3 | 0.0 | 13.4 | 2.8 | 0.0 | 4.9 | 0.5 | 0.0 |
| S203 | NM331 | Private Production Well #20 | 12 | na | 7/3/1997 | 53.0 | 129. | 7.0 | 26.9 | 281. | 8.6 | 9.9 | 52.9 | 10.2 |
| S205 | NM333 | Private Production Well #21 | 12 | na | 7/3/1997 | 0.4 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| S208 | NM140 | San Jose 2 | 12 | 3 | 6/20/1996 | 0.0 | 14.5 | 0.0 | 0.0 | 31.6 | 0.0 | 0.0 | 5.9 | 0.0 |

**Table A7.** Summary of chlorofluorocarbon concentrations in water from wells and springs-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secondary hydro-chemical zone | Date | CFC-11 (pg/kg) | CFC-12 (pg/kg) | CFC-113 (pg/kg) | Calculated atmospheric partial pressure of CFC-11 (pptv) | Calculated atmospheric partial pressure of CFC-12 (pptv) | Calculated atmospheric partial pressure of CFC-113 (pptv) | Percent modern CFC-11 | Percent modern CFC-12 | Percent modern CFC-113 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S210 | NM511 | Sandia D | 12 | na | 7/30/1998 | 29.0 | 18.0 | 9.0 | 14.7 | 39.1 | 6.7 | 5.4 | 7.4 | 7.9 |
| S214 | NM513 | Sandia S | 12 | na | 7/30/1998 | 39.4 | 21.0 | 4.4 | 20.0 | 45.7 | 6.0 | 7.4 | 8.6 | 7.1 |
| S220 | NM147 | Santa Barbara 1 | 12 | na | 6/19/1996 | 533. | 1,284.6 | 6.0 | 271. | 2,797. | 7.4 | 99.9 | 525.7 | 8.7 |
| S231 | NM517 | Sierra Vista M | 12 | 3 | 7/22/1998 | 43.7 | 0.6 | 13.3 | 22.6 | 1.4 | 16.9 | 8.4 | 0.3 | 20.1 |
| S232 | NM518 | Sierra Vista S | 12 | na | 7/22/1998 | 20.1 | 27.6 | 8.5 | 10.5 | 61.5 | 10.6 | 3.9 | 11.6 | 12.5 |
| S234 | NM339 | Sister Cities D | 12 | na | 6/30/1997 | 9.0 | 2.8 | 0.0 | 4.7 | 6.3 | 0.0 | 1.7 | 1.2 | 0.0 |
| S235 | NM340 | Sister Cities M | 12 | na | 6/27/1997 | 3.2 | 0.5 | 0.0 | 1.6 | 1.0 | 0.0 | 0.6 | 0.2 | 0.0 |
| S244 | NM158 | SWAB 3 - 760 | 12 | na | 7/1/1996 | 66.2 | 66.3 | 40.6 | 34.4 | 147. | 51.7 | 12.7 | 27.6 | 61.1 |
| S245 | NM159 | SWAB 3 - 980 | 12 | na | 7/1/1996 | 0.0 | 55.7 | 0.0 | 3.1 | 104. | 0.0 | 1.2 | 19.5 | 0.0 |
| S245 | NM160 | SWAB 3 - 980 | 12 | na | 7/1/1996 | 0.0 | 23.2 | 0.0 | 0.0 | 50.6 | 0.0 | 0.0 | 9.5 | 0.0 |
| S253 | NM522 | Tome D | 12 | na | 8/6/1998 | 33.3 | 7.3 | 31.8 | 14.2 | 16.4 | 40.2 | 5.2 | 3.1 | 47.6 |
| S257 | NM344 | Domestic Well #34 | 12 | na | 6/17/1997 | 0.2 | 19.3 | 0.0 | 0.1 | 43.2 | 0.0 | 0.0 | 8.1 | 0.0 |
| S259 | NM171 | VGP-1 | 12 | na | 6/27/1996 | 0.2 | 28.6 | 0.0 | 0.1 | 62.3 | 0.0 | 0.0 | 11.7 | 0.0 |
| S261 | NM172 | Vol Andia 2 | 12 | na | 6/21/1996 | 19.1 | 16.0 | 0.0 | 9.7 | 34.9 | 0.0 | 3.6 | 6.6 | 0.0 |
| S262 | NM173 | Vol Andia 5 | 12 | na | 6/18/1996 | 2,310. | 1,942. | 169. | 1,172. | 4,227. | 208. | 432.5 | 794.5 | 246.0 |
| S265 | NM175 | Webster 1 | 12 | na | 6/18/1996 | 0.7 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| S267 | NM348 | West Bluff Nest 1 Well 2 | 12 | 3 | 6/23/1997 | 5.7 | 5.9 | 11.4 | 3.0 | 13.6 | 14.5 | 1.1 | 2.6 | 17.1 |
| S268 | NM349 | West Bluff Nest 1 Well 3 | 12 | na | 6/24/1997 | 6.1 | 0.5 | 8.1 | 3.2 | 1.3 | 15.7 | 1.2 | 0.2 | 18.6 |
| S269 | NM350 | West Bluff Nest 2 Well 1 | 12 | na | 6/24/1997 | 8.0 | 3.7 | 6.1 | 4.2 | 8.1 | 11.9 | 1.6 | 1.5 | 14.0 |
| S270 | NM351 | West Bluff Nest 2 Well 2 | 12 | na | 6/24/1997 | 5.9 | 3.7 | 5.8 | 3.0 | 8.1 | 7.2 | 1.1 | 1.5 | 8.5 |
| S271 | NM352 | West Bluff Nest 2 Well 3 | 12 | na | 6/24/1997 | 63.2 | 261. | 21.2 | 32.0 | 568. | 26.0 | 11.8 | 106.8 | 30.8 |
| S275 | NM178 | Yale 1 | 12 | na | 6/19/1996 | 543. | 161. | 14.2 | 275. | 351. | 17.5 | 101.6 | 65.9 | 20.7 |
| SXXX | NM045 | Geoprobe #1 (45.3') | 12 | na | 7/1/1996 | 0.9 | 2,633. | 0.0 | 0.5 | 5,733. | 0.0 | 0.2 | 1,078. | 0.0 |
| SXXX | NM046 | Geoprobe #1 (40.8') | 12 | na | 7/1/1996 | 2.1 | 2,734. | 0.0 | 1.1 | 5,952. | 0.0 | 0.4 | 1,119. | 0.0 |
| SXXX | NM047 | Geoprobe #1 (35.8') | 12 | na | 7/1/1996 | 1.0 | 2,587. | 0.0 | 0.5 | 5,633. | 0.0 | 0.2 | 1,059. | 0.0 |
| SXXX | NM048 | Geoprobe #1 (30.5') | 12 | na | 7/1/1996 | 1.6 | 831. | 0.0 | 0.8 | 1,810. | 0.0 | 0.3 | 340.3 | 0.0 |
| SXXX | NM049 | Geoprobe #1 (25') | 12 | na | 7/1/1996 | 1.3 | 33.8 | 0.0 | 0.6 | 73.6 | 0.0 | 0.2 | 13.8 | 0.0 |
| SXXX | NM050 | Geoprobe #1 (20.2') | 12 | na | 7/1/1996 | 2.1 | 25.7 | 0.0 | 1.1 | 56.0 | 0.0 | 0.4 | 10.5 | 0.0 |
| SXXX | NM051 | Geoprobe #2 (40.5') | 12 | na | 7/1/1996 | 6.7 | 9.1 | 27.9 | 3.4 | 19.9 | 34.2 | 1.3 | 3.7 | 40.4 |
| SXXX | NM052 | Geoprobe #2 (35.3') | 12 | na | 7/1/1996 | 1.5 | 5.8 | 21.9 | 0.8 | 12.5 | 26.8 | 0.3 | 2.4 | 31.8 |
| SXXX | NM053 | Geoprobe #2 (30.2') | 12 | na | 7/1/1996 | 2.7 | 17.1 | 29.4 | 1.4 | 37.3 | 36.1 | 0.5 | 7.0 | 42.7 |
| SXXX | NM054 | Geoprobe #2 (23.4') | 12 | na | 7/1/1996 | 3.2 | 4.9 | 35.2 | 1.6 | 10.6 | 43.1 | 0.6 | 2.0 | 51.0 |
| | | **Zone 13: Discharge** | | | | | | | | | | | | |
| S143 | NM096 | Private Production Well #05 | 13 | na | 8/19/1996 | 1.6 | 0.8 | 0.0 | 0.8 | 1.7 | 0.0 | 0.3 | 0.3 | 0.0 |
| S194 | NM327 | Domestic Well #32 | 13 | na | 6/30/1997 | 6.4 | 6.1 | 0.0 | 3.3 | 13.7 | 0.0 | 1.2 | 2.6 | 0.0 |
| S226 | NM150 | Domestic Well #15 | 13 | na | 8/19/1996 | 2.0 | 2.0 | 0.0 | 1.0 | 4.3 | 0.0 | 0.4 | 0.8 | 0.0 |
| | | **No Zone: Exotic Water** | | | | | | | | | | | | |
| S023 | NM010 | Burn Site Well | E | E | 6/25/1996 | 963. | 68,205. | 72.4 | 488. | 148,488. | 88.8 | 180.3 | 27,911. | 105.1 |
| S028 | NM014 | Cerro Colorado Landfill MW | E | E | 8/12/1996 | 32.7 | 37.0 | 623. | 16.6 | 81.5 | 764. | 6.1 | 15.3 | 904.4 |
| S054 | NM041 | Domestic Well #04 | E | E | 8/17/1996 | 0.6 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| S057 | NM044 | Embudo Spring | E | E | 7/2/1996 | 6.7 | 218.5 | 21.0 | 3.4 | 487. | 26.2 | 1.3 | 91.6 | 31.0 |
| S057 | NM241 | Embudo Spring | E | E | 5/27/1997 | 466. | 288. | 59.6 | 235. | 625. | 73.2 | 86.5 | 117.5 | 86.6 |
| S057 | NM241 | Embudo Spring | E | E | 5/27/1997 | 537. | 269. | 74.4 | 262. | 568. | 88.2 | 96.7 | 106.7 | 104.3 |
| S057 | NM215 | Embudo Spring | E | E | 3/21/1997 | 575. | 309. | 90.2 | 234. | 555. | 87.3 | 86.4 | 104.3 | 103.4 |
| S067 | NM284 | Granite Hill | E | E | 7/4/1997 | 4.4 | 51.9 | 14.6 | 2.3 | 115. | 18.2 | 0.8 | 21.7 | 21.6 |
| S070 | NM059 | HERTF | E | E | 6/28/1996 | 6,747. | 1,013. | 486. | 3,423. | 2,206. | 596. | 1,263.2 | 414.8 | 705.5 |
| S091 | NM496 | Private Production Well #23 | E | E | 8/4/1998 | 0.0 | 32.7 | 0.0 | 0.0 | 73.1 | 0.0 | 0.0 | 13.7 | 0.0 |
| S094 | NM293 | Stock Well #02 | E | E | 6/20/1997 | 319. | 173. | 36.8 | 162. | 376. | 45.1 | 59.8 | 70.6 | 53.4 |
| S099 | NM072 | LALF-1 | E | E | 6/29/1996 | 8,586. | 77,577. | 58,391. | 4,356. | 168,891. | 71,625. | 1,607.7 | 31,746. | 84,763. |
| S112 | NM297 | Domestic Well #24 | E | E | 6/21/1997 | 0.0 | 4.9 | 0.0 | 0.0 | 10.7 | 0.0 | 0.0 | 2.0 | 0.0 |
| S129 | NM087 | Montaño 4 S | E | E | 6/19/1996 | 73.3 | 809. | 13.7 | 37.9 | 1,795. | 17.2 | 14.0 | 337.5 | 20.4 |
| S152 | NM098 | Private Production Well #07 | E | E | 8/22/1996 | 25.5 | 17.6 | 7.0 | 13.0 | 38.3 | 8.6 | 4.8 | 7.2 | 10.2 |
| S182 | NM117 | Rio Bravo 4 S | E | E | 6/25/1996 | 1.5 | 21.6 | 0.0 | 0.8 | 47.0 | 0.0 | 0.3 | 8.8 | 0.0 |
| S211 | NM512 | Sandia M | E | E | 7/30/1998 | 26.8 | 3.6 | 2.3 | 13.6 | 7.9 | 5.6 | 5.0 | 1.5 | 6.6 |
| S225 | NM149 | SBM-1 | E | E | 6/29/1996 | 12.2 | 71.5 | 12.4 | 6.3 | 158. | 58.4 | 2.3 | 29.8 | 69.1 |
| S249 | NM163 | Private Production Well #09 | E | E | 6/26/1996 | 2,378. | 886.0 | 47.6 | 1,206. | 1,928. | 58.3 | 445.2 | 362.6 | 69.1 |
| S250 | NM165 | Private Production Well #10 | E | E | 6/26/1996 | 105. | 137. | 1.0 | 53.4 | 299. | 1.3 | 19.7 | 56.2 | 1.5 |
| S251 | NM166 | Private Production Well #11 | E | E | 6/26/1996 | 365. | 1,093. | 47.7 | 185. | 2,381. | 58.5 | 68.3 | 447.6 | 69.2 |
| S256 | NM170 | Tunnel Spring 2 | E | E | 6/18/1996 | 446. | 217. | 54.0 | 226. | 473. | 66.2 | 83.5 | 89.0 | 78.3 |
| S256 | NM169 | Tunnel Spring 1 | E | E | 6/18/1996 | 460. | 240. | 58.6 | 233. | 523. | 71.8 | 86.0 | 98.3 | 85.0 |
| SXXX | NM065 | Jemez Spring | E | E | 8/20/1996 | 22.1 | 4.2 | 9.5 | 11.2 | 9.1 | 11.7 | 4.1 | 1.7 | 13.8 |
| SXXX | NM154 | Soda Dam Spring | E | E | 8/20/1996 | 75.2 | 33.0 | 9.5 | 38.2 | 71.9 | 11.7 | 14.1 | 13.5 | 13.9 |

**Table A8.** Summary of sulfur hexafluoride and helium concentrations in water samples from wells and springs

[SXXX, no site number assigned; Hydrochemical Zone "E", exotic water, no primary or secondary zone assigned; $SF_6$, sulfur hexafluoride; He, helium; fMol/kg, femtomoles per kilogram; GC, gas chromotography; MS, mass spectrometry; ccSTP/g, cubic centimeters at standard temperature and pressure per gram; LDEO, Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY; na, not available; nd, not determined]

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Second-ary hydro-chemical zone | Date | $SF_6$ (fMol/kg) | USGS He by GC (ccSTP/g x$10^8$) | LDEO He by MS (ccSTP/g x$10^8$) | Replicate 1 LDEO He by MS (ccSTP/g x$10^8$) | Replicate 2 LDEO He by MS (ccSTP/g x$10^8$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Zone 1: Northern Mountain Front** | | | | | | | | |
| S027 | NM486 | CEPO 02 | 1 | na | 8/3/1998 | 0.408 | 405. | | | |
| S034 | NM027 | Private Production Well #04 | 1 | na | 8/28/1996 | 0.015 | nd | | | |
| S034 | NM027 | Private Production Well #04 | 1 | na | 8/28/1996 | 0.141 | nd | | | |
| S035 | NM487 | Windmill #37 | 1 | na | 7/31/1998 | 0.552 | 7.5 | | | |
| S036 | NM026 | Private Production Well #03 | 1 | na | 8/28/1996 | 0.143 | nd | | | |
| S065 | NM055 | Domestic Well #05 | 1 | na | 8/17/1996 | 1.279 | nd | | | |
| S206 | NM510 | Windmill #38 | 1 | 3 | 8/3/1998 | 0.798 | 6.3 | | | |
| S221 | NM530 | Windmill #45 | 1 | na | 8/20/1998 | 0.685 | 190. | | | |
| S279 | NM527 | Windmill #42 | 1 | na | 7/28/1998 | nd | 6.0 | | | |
| S281 | NM528 | Windmill #43 | 1 | 3 | 7/28/1998 | nd | 5.6 | | | |
| | | **Zone 2: Northwestern** | | | | | | | | |
| S103 | NM497 | Lincoln D | 2 | na | 7/23/1998 | 5.414 | 18.5 | | | |
| S104 | NM498 | Lincoln M | 2 | na | 7/23/1998 | 1.683 | 6.8 | | | |
| S105 | NM499 | Lincoln S | 2 | na | 7/23/1998 | 1.706 | 5.8 | 4.9 | | |
| S191 | NM326 | Rio Rancho 4 | 2 | 3 | 6/20/1997 | 2.596 | 8.5 | | | |
| S192 | NM128 | Rio Rancho 8 | 2 | 3 | 8/13/1996 | 1.251 | nd | | | |
| S189 | NM133 | Rio Rancho 15 | 2 | na | 8/13/1996 | 1.265 | nd | | | |
| S278 | NM526 | Windmill #41 | 2 | na | 7/29/1998 | 0.351 | 8.9 | | | |
| S286 | NM184 | Private Production Well #13 | 2 | na | 8/26/1996 | 3.300 | nd | | | |
| S287 | NM185 | Private Production Well #14 | 2 | na | 8/26/1996 | 3.170 | nd | | | |
| | | **Zone 3: West Central** | | | | | | | | |
| S003 | NM481 | 98th St. D | 3 | na | 8/4/1998 | 0.299 | 3,418. | | | |
| S003 | NM251 | 98th St. D | 3 | na | 6/17/1997 | 1.306 | 2,728. | | | |
| S004 | NM482 | 98th St. MD | 3 | na | 8/4/1998 | 2.815 | 422. | | | |
| S004 | NM252 | 98th St. MD | 3 | na | 6/18/1997 | 7.010 | 297. | | | |
| S005 | NM483 | 98th St. MS | 3 | na | 8/4/1998 | 0.685 | 21.0 | | | |
| S005 | NM253 | 98th St. MS | 3 | na | 7/4/1997 | 1.362 | 29.7 | | | |
| S006 | NM484 | 98th St. S | 3 | na | 8/5/1998 | 2.051 | 23.6 | 9.7 | | |
| S006 | NM254 | 98th St. S | 3 | na | 6/17/1997 | 5.324 | 10.8 | | | |
| S008 | NM003 | Private Production Well #01 | 3 | na | 8/12/1996 | 2.822 | nd | | | |
| S010 | NM255 | Private Production Well #16 | 3 | na | 6/23/1997 | nd | 13.6 | | | |
| S018 | NM260 | Domestic Well #21 | 3 | na | 6/26/1997 | 1.576 | 11.8 | | | |
| S019 | NM007 | Belen 4 | 3 | 5 | 8/16/1996 | 1.676 | nd | | | |
| S020 | NM008 | Belen 5 | 3 | 5 | 8/16/1996 | 2.774 | nd | | | |
| S029 | NM015 | Cerro Colorado Landfill PW | 3 | 5 | 8/12/1996 | 1.455 | nd | | | |
| S037 | NM264 | College 2 | 3 | na | 6/19/1997 | 2.862 | 11.1 | | | |
| S066 | NM056 | Gonzales 1 | 3 | 12 | 6/20/1996 | 2.041 | nd | 50.4 | | |
| S086 | NM492 | Isleta D | 3 | na | 7/29/1998 | 2.005 | 1,047. | | | |
| S101 | NM294 | Leavitt 1 | 3 | na | 6/26/1997 | 1.781 | nd | | | |
| S108 | NM076 | Los Lunas 3 | 3 | 12 | 8/14/1996 | 1.339 | nd | | | |
| S109 | NM077 | Los Lunas 4 | 3 | 12 | 8/14/1996 | 2.513 | nd | | | |
| S145 | NM308 | NM Utilities 1 | 3 | na | 6/18/1997 | 0.590 | 8.2 | | | |
| S147 | NM310 | NM Utilities 3 | 3 | na | 6/18/1997 | 2.490 | 13.7 | | | |
| S148 | NM311 | NM Utilities 4 | 3 | na | 6/18/1997 | 3.434 | 11.1 | | | |
| S166 | NM509 | Rabbit Hill | 3 | na | 8/4/1998 | 5.420 | 253. | | | |
| S167 | NM107 | Domestic Well #12 | 3 | na | 8/14/1996 | 1.469 | nd | | | |
| S172 | NM322 | Rio Bravo 5 D | 3 | na | 7/4/1997 | 0.222 | 809. | | | |
| S174 | NM109 | Rio Bravo 1 D | 3 | 12 | 6/17/1996 | 1.618 | nd | 687.5 | | |
| S175 | NM110 | Rio Bravo 1 M | 3 | 12 | 6/17/1996 | 1.657 | nd | 488.9 | | |
| S186 | NM130 | Rio Rancho 10 | 3 | na | 8/13/1996 | 1.160 | nd | | | |
| S188 | NM132 | Rio Rancho 13 | 3 | na | 8/13/1996 | 0.620 | nd | | | |
| S196 | NM135 | Windmill #05 | 3 | na | 8/21/1996 | 0.282 | nd | | | |

**Table A8.** Summary of sulfur hexafluoride and helium concentrations in water samples from wells and springs-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Second-ary hydro-chemical zone | Date | $SF_6$ (fMol/kg) | USGS He by GC (ccSTP/g x$10^8$) | LDEO He by MS (ccSTP/g x$10^8$) | Replicate 1 LDEO He by MS (ccSTP/g x$10^8$) | Replicate 2 LDEO He by MS (ccSTP/g x$10^8$) |
|---|---|---|---|---|---|---|---|---|---|---|
| S200 | NM139 | Private Production Well #08 | 3 | na | 8/29/1996 | 2.884 | nd | | | |
| S217 | NM144 | Santa Ana Boundary D | 3 | na | 8/22/1996 | 92.67 | nd | | | |
| S218 | NM145 | Santa Ana Boundary M | 3 | na | 8/22/1996 | 7.532 | nd | | | |
| S219 | NM146 | Santa Ana Boundary S | 3 | na | 8/22/1996 | 1.324 | nd | | | |
| S230 | NM516 | Sierra Vista D | 3 | na | 7/22/1998 | 0.503 | 892. | | | |
| S236 | NM155 | SAF (Soil Amendment Facility) | 3 | na | 8/12/1996 | 1.519 | nd | | | |
| S241 | NM519 | SWAB Test Hole 1 D | 3 | 1 | 8/5/1998 | nd | 2,412. | | | |
| S243 | NM521 | SWAB Test Hole 2 D | 3 | na | 8/7/1998 | 1.223 | nd | | | |
| S263 | NM346 | Volcano Cliff 1 | 3 | na | 6/19/1997 | 2.506 | 15.6 | | | |
| S266 | NM347 | West Bluff Nest 1 Well 1 | 3 | na | 6/23/1997 | 2.366 | 835. | | | |
| S272 | NM353 | West Mesa 3 | 3 | na | 6/19/1997 | 2.424 | nd | | | |
| S283 | NM181 | Zia Ball Park D | 3 | na | 8/26/1996 | 2.525 | nd | | | |
| S284 | NM182 | Zia Ball Park M | 3 | na | 8/26/1996 | 0.222 | nd | | | |
| S285 | NM183 | Zia Ball Park S | 3 | 2 | 8/26/1996 | 1.578 | nd | | | |
| | | **Zone 4: Western Boundary** | | | | | | | | |
| S039 | NM266 | Windmill #20 | 4 | na | 6/21/1997 | 1.433 | 14.3 | | | |
| S059 | NM278 | Windmill #21 | 4 | na | 6/23/1997 | 1.809 | 13.8 | | | |
| S074 | NM285 | Windmill #23 | 4 | na | 6/21/1997 | 1.450 | nd | | | |
| S169 | NM320 | Rest Area | 4 | na | 6/30/1997 | 3.351 | nd | | | |
| | | **Zone 5: Rio Puerco** | | | | | | | | |
| S069 | NM058 | Domestic Well #06 | 5 | na | 8/16/1996 | 1.832 | nd | | | |
| S085 | NM408 | Windmill #35 | 5 | na | 9/10/1997 | 0.485 | nd | | | |
| S185 | NM324 | Domestic Well #31 | 5 | na | 6/16/1997 | nd | 2,285. | | | |
| S198 | NM137 | Windmill #07 | 5 | na | 8/21/1996 | 25.21 | nd | | | |
| S237 | NM341 | Windmill #30 | 5 | 4 | 6/24/1997 | 0.322 | 73.9 | | | |
| | | **Zone 7: Abo Arroyo** | | | | | | | | |
| S021 | NM261 | Stock Well #01 | 7 | na | 6/23/1997 | 0.990 | 5.7 | 6.2 | | |
| S024 | NM011 | Domestic Well #02 | 7 | 8 | 8/17/1996 | 1.836 | nd | | | |
| S090 | NM064 | Domestic Well #08 | 7 | na | 8/19/1996 | 1.073 | nd | | | |
| S093 | NM067 | Domestic Well #09 | 7 | 8 | 8/15/1996 | 2.620 | nd | | | |
| | | **Zone 8: Eastern Mountain Front** | | | | | | | | |
| S007 | NM002 | Domestic Well #01 | 8 | na | 6/21/1996 | 2.650 | nd | 9.4 | | |
| S013 | NM256 | Windmill #14 | 8 | na | 6/24/1997 | 0.408 | nd | | | |
| S014 | NM257 | Private Production Well #17 | 8 | na | 6/19/1997 | 0.385 | 5.6 | | | |
| S030 | NM024 | Charles 4 | 8 | na | 6/27/1996 | 2.008 | nd | 66.8 | | |
| S030 | NM021 | Charles 4 | 8 | na | 6/27/1996 | 2.018 | nd | 176.8 | | |
| S030 | NM020 | Charles 4 | 8 | na | 6/27/1996 | 2.032 | nd | | | |
| S030 | NM023 | Charles 4 | 8 | na | 6/27/1996 | 2.132 | nd | 139.0 | 176.8 | 66.8 |
| S030 | NM019 | Charles 4 | 8 | na | 6/27/1996 | 2.171 | nd | | | |
| S030 | NM016 | Charles 4 | 8 | na | 6/22/1996 | 3.840 | nd | | | |
| S042 | NM031 | Domestic Well #03 | 8 | na | 8/14/1996 | 5.414 | nd | | | |
| S055 | NM042 | Elena Gallegos | 8 | na | 6/25/1996 | 73.02 | nd | 8.1 | | |
| S056 | NM043 | Embudito Spring | 8 | na | 7/2/1996 | 1.242 | nd | | | |
| S071 | NM060 | Domestic Well #07 | 8 | na | 6/19/1996 | 0.590 | nd | 5.6 | | |
| S095 | NM068 | Kirtland 1 | 8 | na | 6/25/1996 | 6.667 | nd | | | |
| S106 | NM295 | Domestic Well #23 | 8 | na | 6/26/1997 | 7.368 | 404. | 331.1 | | |
| S110 | NM078 | Love 1 | 8 | na | 6/22/1996 | 20.45 | nd | | | |
| S113 | NM080 | Domestic Well #11 | 8 | na | 8/15/1996 | 1.875 | nd | | | |
| S114 | NM500 | Matheson D | 8 | na | 7/31/1998 | 61.49 | 434. | | | |
| S115 | NM501 | Matheson M | 8 | na | 8/1/1998 | 20.53 | 20.2 | | | |
| S116 | NM502 | Matheson S | 8 | na | 8/1/1998 | 2.801 | 5.7 | 6.8 | | |
| S117 | NM298 | Domestic Well #25 | 8 | na | 6/17/1997 | nd | 7.3 | 6.4 | | |
| S118 | NM299 | Windmill #24 | 8 | na | 6/27/1997 | 0.844 | nd | | | |
| S119 | NM300 | Domestic Well #26 | 8 | 11 | 6/19/1997 | 1.226 | 34.6 | | | |
| S122 | NM304 | Mesa Del Sol S | 8 | na | 6/29/1997 | 15.09 | 655. | | | |
| S122 | NM505 | Mesa Del Sol S | 8 | na | 7/25/1998 | 17.40 | 147. | 183.7 | | |

**Table A8.** Summary of sulfur hexafluoride and helium concentrations in water samples from wells and springs-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Second-ary hydro-chemical zone | Date | $SF_6$ (fMol/kg) | USGS He by GC (ccSTP/g x$10^8$) | LDEO He by MS (ccSTP/g x$10^8$) | Replicate 1 LDEO He by MS (ccSTP/g x$10^8$) | Replicate 2 LDEO He by MS (ccSTP/g x$10^8$) |
|---|---|---|---|---|---|---|---|---|---|---|
| S140 | NM306 | MRN 1 | 8 | na | 7/5/1997 | 9.550 | 28.7 | | | |
| S141 | NM095 | National Utility 7 | 8 | na | 8/14/1996 | 1.326 | nd | | | |
| S149 | NM312 | Nor Este D | 8 | na | 7/3/1997 | 6.057 | 1,307. | | | |
| S150 | NM313 | Nor Este M | 8 | na | 7/2/1997 | 4.385 | 609. | | | |
| S162 | NM317 | Stock Well #03 | 8 | na | 6/30/1997 | 2.195 | 10.0 | | | |
| S163 | NM318 | PL 2 | 8 | na | 7/7/1997 | nd | 37.3 | | | |
| S164 | NM106 | Ponderosa 1 | 8 | na | 6/20/1996 | 20.37 | nd | 1,164. | | |
| S165 | NM328 | Windmill #25 | 8 | na | 6/24/1997 | 1.762 | 17.8 | | | |
| S168 | NM319 | Domestic Well #30 | 8 | na | 6/27/1997 | 2.298 | 5.7 | | | |
| S170 | NM108 | Ridgecrest 3 | 8 | na | 6/22/1996 | 9.660 | 267. | 133.0 | | |
| S195 | NM134 | Domestic Well #13 | 8 | na | 8/14/1996 | 5.028 | nd | | | |
| S209 | NM336 | Domestic Well #33 | 8 | na | 6/27/1997 | 4.890 | 949. | | | |
| S212 | NM141 | Sandia Peak 1 | 8 | na | 6/26/1996 | 59.39 | nd | 6.2 | | |
| S213 | NM142 | Sandia Peak 3 | 8 | na | 6/26/1996 | 5.228 | nd | 5.7 | | |
| S224 | NM148 | Domestic Well #14 | 8 | na | 8/23/1996 | 0.342 | nd | | | |
| S229 | NM515 | SH03 UNM | 8 | na | 7/28/1998 | 0.205 | 5.8 | 4.9 | | |
| S233 | NM153 | Domestic Well #16 | 8 | na | 8/23/1996 | 0.437 | nd | | | |
| S239 | NM156 | Domestic Well #17 | 8 | na | 8/17/1996 | 1.145 | nd | | | |
| S240 | NM157 | Domestic Well #18 | 8 | na | 6/19/1996 | 74.90 | nd | | | |
| S247 | NM161 | Domestic Well #19 | 8 | na | 8/15/1996 | 1.782 | nd | | | |
| S248 | NM162 | Thomas 6 | 8 | na | 6/21/1996 | 2.307 | nd | | | |
| S255 | NM523 | Tramway East | 8 | na | 7/30/1998 | 196.8 | 32.4 | | | |
| S264 | NM174 | Walker 1 | 8 | na | 6/18/1996 | 79.25 | nd | 749.5 | | |
| S274 | NM177 | Domestic Well #20 | 8 | na | 8/15/1996 | 4.422 | nd | | | |
| | | **Zone 9: Tijeras Fault Zone** | | | | | | | | |
| S041 | NM029 | Coyote Spring | 9 | na | 6/28/1996 | 0.023 | nd | | | |
| S072 | NM061 | Hubbell Spring | 9 | 8 | 8/23/1996 | 0.223 | nd | | | |
| S098 | NM071 | KAFB-1902 | 9 | na | 6/28/1996 | 0.084 | nd | | | |
| S197 | NM136 | Windmill #06 | 9 | na | 8/23/1996 | 0.694 | nd | | | |
| S227 | NM151 | SFR 3D | 9 | na | 8/24/1996 | 42.07 | nd | | | |
| S228 | NM152 | SFR 3S | 9 | na | 8/24/1996 | 51.00 | nd | | | |
| | | **Zone 10: Tijeras Arroyo** | | | | | | | | |
| S001 | NM001 | 4Hills-1 | 10 | 8 | 6/29/1996 | 107.7 | nd | 5.7 | 5.6 | |
| S058 | NM277 | Eubank 1 | 10 | 8 | 7/4/1997 | 6.614 | 5.2 | 4.2 | | |
| S096 | NM069 | Kirtland 11 | 10 | 8 | 6/25/1996 | 18.98 | nd | 22.1 | | |
| S107 | NM075 | Lomas 1 | 10 | 8 | 6/22/1996 | 5.486 | nd | | | |
| | | **Zone 11: Northeastern** | | | | | | | | |
| S016 | NM258 | Windmill #15 | 11 | na | 6/18/1997 | 1.479 | nd | | | |
| S017 | NM259 | Windmill #16 | 11 | na | 6/18/1997 | 0.388 | nd | | | |
| S053 | NM276 | Private Production Well #18 | 11 | na | 6/25/1997 | nd | 29.4 | | | |
| S144 | NM097 | Private Production Well #06 | 11 | na | 8/28/1996 | 3.931 | nd | | | |
| S207 | NM334 | Private Production Well #22 | 11 | na | 7/3/1997 | 0.799 | 14.2 | | | |
| S223 | NM338 | Windmill #29 | 11 | na | 6/25/1997 | 1.032 | 9.7 | | | |
| | | **Zone 12: Central** | | | | | | | | |
| S011 | NM004 | Atris-1 | 12 | na | 6/22/1996 | 1.896 | nd | 3.9 | | |
| S012 | NM005 | Atrisco 3 | 12 | 3 | 6/20/1996 | 2.562 | nd | 74.2 | | |
| S025 | NM012 | Burton 2 | 12 | na | 6/19/1996 | 16.92 | nd | 27.6 | | |
| S026 | NM013 | Burton 5 | 12 | na | 6/19/1996 | 2.053 | nd | 82.5 | | |
| S040 | NM028 | Coronado 1 | 12 | na | 6/18/1996 | 2.601 | nd | | | |
| S043 | NM488 | Del Sol D | 12 | na | 7/21/1998 | 4.243 | 758. | | | |
| S043 | NM267 | Del Sol D | 12 | na | 7/1/1997 | 7.461 | nd | | | |
| S044 | NM268 | Del Sol M | 12 | na | 6/26/1997 | 5.379 | nd | | | |
| S044 | NM489 | Del Sol M | 12 | na | 7/21/1998 | nd | 54.9 | | | |
| S045 | NM269 | Del Sol S | 12 | na | 6/26/1997 | 1.928 | nd | | | |
| S045 | NM490 | Del Sol S | 12 | na | 7/21/1998 | 2.516 | 5.8 | | | |
| S046 | NM032 | Duranes 1 | 12 | na | 6/20/1996 | 2.667 | nd | 9.2 | | |

**Table A8.** Summary of sulfur hexafluoride and helium concentrations in water samples from wells and springs-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Second-ary hydro-chemical zone | Date | $SF_6$ (fMol/kg) | USGS He by GC (ccSTP/g x$10^8$) | LDEO He by MS (ccSTP/g x$10^8$) | Replicate 1 LDEO He by MS (ccSTP/g x$10^8$) | Replicate 2 LDEO He by MS (ccSTP/g x$10^8$) |
|---|---|---|---|---|---|---|---|---|---|---|
| S046 | NM033 | Duranes 1 | 12 | na | 6/29/1996 | 3.452 | nd | | | |
| S046 | NM035 | Duranes 1 | 12 | na | 6/29/1996 | 3.452 | nd | 4.7 | 4.6 | |
| S046 | NM034 | Duranes 1 | 12 | na | 6/29/1996 | 3.578 | nd | 4.6 | | |
| S046 | NM036 | Duranes 1 | 12 | na | 6/29/1996 | 3.691 | nd | | | |
| S046 | NM037 | Duranes 1 | 12 | na | 6/29/1996 | 3.716 | nd | | | |
| S046 | NM039 | Duranes 1 | 12 | na | 6/29/1996 | 3.766 | nd | | | |
| S046 | NM040 | Duranes 1 | 12 | na | 6/29/1996 | 3.816 | nd | | | |
| S046 | NM038 | Duranes 1 | 12 | na | 6/29/1996 | 3.829 | nd | | | |
| S047 | NM270 | Duranes 7 | 12 | na | 6/26/1997 | 1.912 | 5.9 | 8.5 | | |
| S048 | NM271 | Duranes Yard 1 | 12 | na | 7/5/1997 | 2.088 | nd | 4.0 | | |
| S049 | NM272 | Duranes Yard 2 | 12 | na | 7/5/1997 | nd | nd | 4.0 | 4.0 | |
| S050 | NM273 | Duranes Yard 3 | 12 | na | 7/5/1997 | nd | 5.1 | 3.9 | | |
| S051 | NM274 | Duranes Yard 4 | 12 | na | 7/5/1997 | 2.848 | 5.7 | 4.1 | | |
| S052 | NM275 | Duranes Yard 5 | 12 | na | 7/5/1997 | 2.404 | 3.6 | 4.0 | | |
| S060 | NM279 | Garfield D | 12 | 3 | 6/19/1997 | 3.092 | 10.8 | | | |
| S061 | NM280 | Garfield M | 12 | na | 6/19/1997 | 2.368 | 6.6 | | | |
| S062 | NM491 | Garfield S | 12 | na | 7/28/1998 | 5.950 | 5.4 | 4.4 | | |
| S062 | NM281 | Garfield S | 12 | na | 6/19/1997 | 6.178 | 5.9 | 4.2 | | |
| S064 | NM283 | Domestic Well #22 | 12 | na | 6/20/1997 | 3.714 | 5.6 | | | |
| S068 | NM057 | Griegos 3 | 12 | na | 6/21/1996 | 0.816 | nd | 8.1 | | |
| S075 | NM286 | Hunter Ridge Nest 1 Well 1 | 12 | 3 | 6/20/1997 | 4.245 | 6.0 | | | |
| S076 | NM287 | Hunter Ridge Nest 1 Well 2 | 12 | na | 6/21/1997 | 3.238 | 6.5 | | | |
| S077 | NM288 | Hunter Ridge Nest 1 Well 3 | 12 | na | 6/20/1997 | 2.577 | 6.5 | | | |
| S078 | NM289 | Hunter Ridge Nest 2 Well 1 | 12 | na | 6/21/1997 | 3.393 | 5.9 | 6.1 | | |
| S079 | NM290 | Hunter Ridge Nest 2 Well 2 | 12 | na | 6/21/1997 | 2.381 | 7.1 | 4.3 | | |
| S080 | NM291 | Hunter Ridge Nest 2 Well 3 | 12 | na | 6/21/1997 | 7.823 | 12.7 | 12.5 | | |
| S081 | NM292 | Private Production Well #19 | 12 | na | 7/2/1997 | 2.459 | 15.0 | | | |
| S084 | NM063 | Windmill #04 | 12 | na | 8/21/1996 | 1.117 | nd | | | |
| S087 | NM493 | Isleta MD | 12 | 3 | 7/29/1998 | 7.011 | 20.3 | | | |
| S088 | NM494 | Isleta MS | 12 | na | 7/29/1998 | 2.387 | 6.5 | | | |
| S089 | NM495 | Isleta S | 12 | na | 7/29/1998 | 1.579 | 5.7 | 4.3 | | |
| S092 | NM066 | JMC-1 | 12 | na | 6/28/1996 | 203.4 | nd | 4.3 | | |
| S097 | NM070 | Kirtland 14 | 12 | na | 6/25/1996 | 1.980 | nd | 95.0 | | |
| S100 | NM073 | LALF-9 | 12 | na | 6/29/1996 | 1.992 | nd | 4.4 | | |
| S102 | NM074 | Leyendecker 1 | 12 | na | 6/21/1996 | 0.929 | nd | 5.1 | | |
| S120 | NM503 | Mesa Del Sol D | 12 | na | 8/2/1998 | 2.486 | 675. | | | |
| S120 | NM301 | Mesa Del Sol D | 12 | na | 6/29/1997 | 14.65 | 191. | | | |
| S121 | NM504 | Mesa Del Sol M | 12 | na | 7/25/1998 | 1.912 | 398. | | | |
| S121 | NM302 | Mesa Del Sol M | 12 | na | 6/28/1997 | 5.108 | 381. | | | |
| S123 | NM081 | MONT - 5A | 12 | na | 6/27/1996 | nd | nd | 4.6 | | |
| S124 | NM082 | Montaňo 2 D | 12 | na | 6/19/1996 | 1.286 | nd | 4.7 | | |
| S125 | NM083 | Montaňo 2 M | 12 | na | 6/19/1996 | 1.212 | nd | 4.6 | | |
| S126 | NM084 | Montaňo 2 S | 12 | na | 6/19/1996 | 3.657 | nd | 4.3 | | |
| S127 | NM085 | Montaňo 4 D | 12 | na | 6/20/1996 | 1.391 | nd | 4.6 | | |
| S128 | NM086 | Montaňo 4 M | 12 | na | 6/19/1996 | 1.632 | nd | 4.9 | | |
| S130 | NM088 | Montaňo 5 D | 12 | na | 6/24/1996 | 1.406 | nd | 3.9 | | |
| S131 | NM089 | Montaňo 5 M | 12 | na | 6/24/1996 | 14.54 | nd | 4.0 | | |
| S132 | NM090 | Montaňo 5 S | 12 | na | 6/24/1996 | 1.028 | nd | 3.7 | | |
| S133 | NM091 | Montaňo 6 D | 12 | na | 6/18/1996 | 1.731 | nd | 6.3 | | |
| S134 | NM092 | Montaňo 6 MD | 12 | na | 6/18/1996 | 1.453 | nd | 5.3 | | |
| S135 | NM093 | Montaňo 6 MS | 12 | na | 6/18/1996 | 0.481 | nd | 4.1 | | |
| S136 | NM094 | Montaňo 6 S | 12 | na | 6/18/1996 | 1.449 | nd | 4.2 | | |
| S137 | NM506 | Montesa M | 12 | na | 7/27/1998 | 1.222 | 149. | | | |
| S138 | NM507 | Montesa S | 12 | na | 7/27/1998 | 7.024 | 31.9 | 29.4 | | |
| S139 | NM305 | Domestic Well #27 | 12 | na | 6/17/1997 | nd | 7.5 | | | |
| S142 | NM307 | Domestic Well #28 | 12 | na | 6/17/1997 | nd | 5.5 | | | |
| S146 | NM309 | NM Utilities 2 | 12 | na | 6/18/1997 | 2.393 | 4.8 | | | |
| S151 | NM508 | Nor Este S | 12 | na | 7/20/1998 | 5.679 | 202. | 31.4 | | |

**Table A8.** Summary of sulfur hexafluoride and helium concentrations in water samples from wells and springs-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Second-ary hydro-chemical zone | Date | $SF_6$ (fMol/kg) | USGS He by GC (ccSTP/g x$10^8$) | LDEO He by MS (ccSTP/g x$10^8$) | Replicate 1 LDEO He by MS (ccSTP/g x$10^8$) | Replicate 2 LDEO He by MS (ccSTP/g x$10^8$) |
|---|---|---|---|---|---|---|---|---|---|---|
| S151 | NM314 | Nor Este S | 12 | na | 7/2/1997 | 14.28 | 28.1 | | | |
| S153 | NM411 | Open Space | 12 | na | 11/18/1997 | nd | nd | 5.4 | | |
| S154 | NM099 | ORLF-2 | 12 | na | 6/27/1996 | 2.009 | nd | 4.0 | | |
| S155 | NM316 | Domestic Well #29 | 12 | na | 6/27/1997 | 1.126 | 5.6 | 4.4 | 4.2 | |
| S156 | NM100 | Paseo 2D | 12 | na | 6/26/1996 | 0.536 | nd | 3.9 | | |
| S157 | NM101 | Paseo 2MD | 12 | na | 6/26/1996 | 11.17 | nd | 4.2 | | |
| S158 | NM102 | Paseo 2MS | 12 | na | 6/26/1996 | 3.240 | nd | 4.1 | | |
| S159 | NM103 | Paseo 2S | 12 | na | 6/26/1996 | 3.018 | nd | 5.1 | | |
| S160 | NM104 | Paseo 3D | 12 | na | 6/21/1996 | 1.026 | nd | 4.1 | | |
| S171 | NM321 | Ridgecrest 4 | 12 | na | 6/26/1997 | 3.481 | nd | | | |
| S173 | NM323 | Rio Bravo 5 M | 12 | 3 | 7/4/1997 | 3.603 | 6.2 | 4.5 | | |
| S176 | NM111 | Rio Bravo 1 S | 12 | na | 6/17/1996 | 2.299 | nd | 4.4 | | |
| S177 | NM112 | Rio Bravo 2 D | 12 | 3 | 6/25/1996 | 2.035 | nd | 61.6 | | |
| S178 | NM113 | Rio Bravo 2 M | 12 | na | 6/25/1996 | 3.089 | nd | 120.6 | | |
| S179 | NM114 | Rio Bravo 2 S | 12 | na | 6/25/1996 | 2.484 | nd | 21.5 | | |
| S180 | NM115 | Rio Bravo 4 D | 12 | na | 6/25/1996 | 2.776 | nd | 80.6 | | |
| S181 | NM116 | Rio Bravo 4 M | 12 | na | 6/25/1996 | 3.069 | nd | 24.7 | | |
| S183 | NM126 | Rio Grande Utility 5 | 12 | 3 | 8/15/1996 | 3.189 | nd | | | |
| S184 | NM127 | Rio Grande Utility 6 | 12 | na | 8/15/1996 | 1.756 | nd | | | |
| S190 | NM325 | Rio Rancho 2 | 12 | na | 6/20/1997 | 2.036 | 5.3 | | | |
| S203 | NM331 | Private Production Well #20 | 12 | na | 7/3/1997 | 2.007 | 52.3 | | | |
| S205 | NM333 | Private Production Well #21 | 12 | na | 7/3/1997 | 2.667 | 39.7 | | | |
| S208 | NM140 | San Jose 2 | 12 | 3 | 6/20/1996 | 3.177 | nd | 121.0 | | |
| S210 | NM511 | Sandia D | 12 | na | 7/30/1998 | 13.15 | 733. | | | |
| S214 | NM513 | Sandia S | 12 | na | 7/30/1998 | 2.981 | 172. | 209.3 | | |
| S220 | NM147 | Santa Barbara 1 | 12 | na | 6/19/1996 | 1.142 | nd | 6.1 | | |
| S231 | NM517 | Sierra Vista M | 12 | 3 | 7/22/1998 | 3.761 | 8.9 | | | |
| S232 | NM518 | Sierra Vista S | 12 | na | 7/22/1998 | 6.420 | 6.7 | 4.9 | | |
| S234 | NM339 | Sister Cities D | 12 | na | 6/30/1997 | 4.942 | 44.6 | | | |
| S235 | NM340 | Sister Cities M | 12 | na | 6/27/1997 | 1.467 | 5.3 | | | |
| S244 | NM158 | SWAB 3 - 760 | 12 | na | 7/1/1996 | 12.49 | nd | | | |
| S245 | NM159 | SWAB 3 - 980 | 12 | na | 7/1/1996 | 19.99 | nd | 4.3 | 4.0 | |
| S245 | NM160 | SWAB 3 - 980 | 12 | na | 7/1/1996 | 27.83 | nd | | | |
| S253 | NM522 | Tome D | 12 | na | 8/6/1998 | nd | 1,130. | | | |
| S257 | NM344 | Domestic Well #34 | 12 | na | 6/17/1997 | nd | 136. | 98.2 | | |
| S259 | NM171 | VGP-1 | 12 | na | 6/27/1996 | 4.105 | nd | 5.2 | | |
| S261 | NM172 | Volandia 2 | 12 | na | 6/21/1996 | 0.891 | nd | | | |
| S262 | NM173 | Volandia 5 | 12 | na | 6/18/1996 | 1.319 | nd | 4.6 | | |
| S265 | NM175 | Webster 1 | 12 | na | 6/18/1996 | 1.440 | nd | | | |
| S267 | NM348 | West Bluff Nest 1 Well 2 | 12 | 3 | 6/23/1997 | 3.248 | 8.1 | | | |
| S268 | NM349 | West Bluff Nest 1 Well 3 | 12 | na | 6/24/1997 | 3.352 | 7.2 | | | |
| S269 | NM350 | West Bluff Nest 2 Well 1 | 12 | na | 6/24/1997 | 3.912 | 6.9 | 5.0 | | |
| S270 | NM351 | West Bluff Nest 2 Well 2 | 12 | na | 6/24/1997 | 3.508 | 6.4 | 4.5 | | |
| S271 | NM352 | West Bluff Nest 2 Well 3 | 12 | na | 6/24/1997 | 3.393 | 5.2 | 4.9 | 4.9 | |
| S275 | NM178 | Yale 1 | 12 | na | 6/19/1996 | 5.923 | nd | 22.1 | | |
| SXXX | NM045 | Geoprobe #1 (45.3') | 12 | na | 7/1/1996 | 1.545 | nd | | | |
| SXXX | NM051 | Geoprobe #2 (40.5') | 12 | na | 7/1/1996 | 2.010 | nd | | | |
| | | **Zone 13: Discharge** | | | | | | | | |
| S143 | NM096 | Private Production Well #05 | 13 | na | 8/19/1996 | 0.264 | nd | | | |
| S194 | NM327 | Domestic Well #32 | 13 | na | 6/30/1997 | 8.017 | 6,917. | | | |
| S226 | NM150 | Domestic Well #15 | 13 | na | 8/19/1996 | 0.409 | nd | | | |
| | | **No Zone: Exotic Water** | | | | | | | | |
| S023 | NM010 | Burn Site Well | E | E | 6/25/1996 | 0.771 | nd | 8.7 | | |
| S028 | NM014 | Cerro Colorado Landfill MW | E | E | 8/12/1996 | 1.482 | nd | | | |
| S038 | NM265 | Windmill #19 | E | E | 7/1/1997 | 0.359 | 12,234. | | | |
| S054 | NM041 | Domestic Well #04 | E | E | 8/17/1996 | 1.766 | nd | | | |
| S057 | NM044 | Embudo Spring | E | E | 7/2/1996 | 1.617 | nd | | | |

**Table A8.** Summary of sulfur hexafluoride and helium concentrations in water samples from wells and springs-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Second-ary hydro-chemical zone | Date | $SF_6$ (fMol/kg) | USGS He by GC (ccSTP/g x$10^8$) | LDEO He by MS (ccSTP/g x$10^8$) | Replicate 1 LDEO He by MS (ccSTP/g x$10^8$) | Replicate 2 LDEO He by MS (ccSTP/g x$10^8$) |
|---|---|---|---|---|---|---|---|---|---|---|
| S063 | NM282 | Windmill #22 | E | E | 6/28/1997 | 1.704 | nd | | | |
| S067 | NM284 | Granite Hill | E | E | 7/4/1997 | 210.9 | 301. | | | |
| S070 | NM059 | HERTF | E | E | 6/28/1996 | 753.2 | nd | 10.9 | | |
| S091 | NM496 | Private Production Well #23 | E | E | 8/4/1998 | 3.349 | 44.3 | 38.6 | | |
| S094 | NM293 | Stock Well #02 | E | E | 6/20/1997 | 2.428 | 10.1 | | | |
| S099 | NM072 | LALF-1 | E | E | 6/29/1996 | 5.283 | nd | 3.9 | 3.8 | |
| S112 | NM297 | Domestic Well #24 | E | E | 6/21/1997 | 0.935 | 487. | | | |
| S129 | NM087 | Montaňo 4 S | E | E | 6/19/1996 | 3.415 | nd | 4.2 | | |
| S152 | NM098 | Private Production Well #07 | E | E | 8/22/1996 | 0.693 | nd | | | |
| S182 | NM117 | Rio Bravo 4 S | E | E | 6/25/1996 | 7.463 | nd | | | |
| S202 | NM330 | Windmill #27 | E | E | 7/2/1997 | 0.764 | nd | | | |
| S211 | NM512 | Sandia M | E | E | 7/30/1998 | 1.977 | 1,534. | | | |
| S225 | NM149 | SBM-1 | E | E | 6/29/1996 | 9.374 | nd | 4.0 | | |
| S249 | NM164 | Private Production Well #09 | E | E | 6/26/1996 | 168.1 | nd | | | |
| S249 | NM163 | Private Production Well #09 | E | E | 6/26/1996 | 182.6 | nd | 6.3 | | |
| S250 | NM165 | Private Production Well #10 | E | E | 6/26/1996 | 287.9 | nd | 36.8 | | |
| S251 | NM166 | Private Production Well #11 | E | E | 6/26/1996 | 80.60 | nd | 5.4 | | |
| S256 | NM169 | Tunnel Spring 1 | E | E | 6/18/1996 | 11.93 | nd | 4.0 | | |
| S282 | NM529 | Windmill #44 | E | E | 7/29/1998 | 1.073 | 139. | | | |
| SXXX | NM154 | Soda Dam Spring | E | E | 8/20/1996 | 0.000 | nd | | | |
| SXXX | NM065 | Jemez Spring | E | E | 8/20/1996 | 0.342 | nd | | | |
| SXXX | NM065 | Jemez Spring | E | E | 8/20/1996 | 0.689 | nd | | | |

**Table A9.** Summary of stable hydrogen, oxygen, and sulfur isotopic data from wells and springs

[SXXX, no site number assigned; Hydrochemical Zone "E", exotic water, no primary or secondary zone assigned; $\delta^{2}H$, hydrogen-2; $\delta^{18}O$, oxygen-18; $SO_4^{2-}$, sulfate; $\delta^{34}S$, sulfur-34; $\delta=((R_{sample}/R_{standard})-1)x1000$, where R is an isotope ratio; per mil, parts per thousand; mg/L, milligrams per liter; na, not applicable; nd, not determined]

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secondary hydro-chemical zone | Date | $\delta^{2}H$ (per mil) | $\delta^{18}O$ (per mil) | $^{2}H$ excess (per mil) | $SO_4^{2-}$ (mg/L) | $\delta^{34}S$ (per mil) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Zone 1: Northern Mountain Front** | | | | | | | | |
| S027 | NM486 | CEPO 02 | 1 | na | 8/3/1998 | -68.4 | - 9.60 | 8.4 | 16.5 | nd |
| S034 | NM027 | Private Production Well #04 | 1 | na | 8/28/1996 | -74.4 | -10.1 | 6.4 | 14.1 | nd |
| S035 | NM487 | Windmill #37 | 1 | na | 7/31/1998 | -80.4 | -11.3 | 9.8 | 17.8 | nd |
| S036 | NM026 | Private Production Well #03 | 1 | na | 8/28/1996 | -72.3 | - 9.62 | 4.7 | 17.6 | nd |
| S065 | NM055 | Domestic Well #05 | 1 | na | 8/17/1996 | -72.8 | - 9.72 | 5.0 | 20.9 | nd |
| S187 | NM131 | Rio Rancho 12 | 1 | na | 8/13/1996 | -89.1 | -11.8 | 5.7 | 56.1 | nd |
| S206 | NM510 | Windmill #38 | 1 | 3 | 8/3/1998 | -82.3 | -11.3 | 7.9 | 38.1 | nd |
| S216 | NM143 | Windmill #09 | 1 | na | 8/27/1996 | -74.0 | - 9.60 | 2.9 | 52.1 | nd |
| S221 | NM530 | Windmill #45 | 1 | na | 8/20/1998 | -72.1 | -10.1 | 9.1 | 29.1 | nd |
| S222 | NM514 | Windmill #39 | 1 | 3 | 8/6/1998 | -78.5 | -11.2 | 11.1 | 84.7 | nd |
| S254 | NM168 | Private Production Well #12 | 1 | na | 8/28/1996 | -76.8 | -10.6 | 7.6 | 7.3 | nd |
| S277 | NM525 | Windmill #40 | 1 | na | 7/28/1998 | -81.7 | -11.2 | 7.9 | 28.5 | nd |
| S279 | NM527 | Windmill #42 | 1 | na | 7/28/1998 | -84.1 | -11.6 | 8.6 | 11.1 | nd |
| S281 | NM528 | Windmill #43 | 1 | 3 | 7/28/1998 | -88.0 | -12.1 | 8.4 | 9.3 | nd |
| | | **Zone 2: Northwestern** | | | | | | | | |
| S103 | NM497 | Lincoln D | 2 | na | 7/23/1998 | -67.3 | -8.88 | 3.8 | 42.5 | 0.6 |
| S104 | NM498 | Lincoln M | 2 | na | 7/23/1998 | -56.5 | -7.52 | 3.7 | 28.7 | 0.9 |
| S105 | NM499 | Lincoln S | 2 | na | 7/23/1998 | -56.6 | -7.59 | 4.2 | 17.2 | 0.9 |
| S191 | NM326 | Rio Rancho 4 | 2 | 3 | 6/20/1997 | -87.0 | -11.5 | 5.0 | 58.4 | nd |
| S192 | NM128 | Rio Rancho 8 | 2 | 3 | 8/13/1996 | -88.1 | -11.7 | 5.7 | 66.2 | nd |
| S189 | NM133 | Rio Rancho 15 | 2 | na | 8/13/1996 | -81.6 | -10.7 | 3.8 | 100. | 8.8 |
| S276 | NM179 | Windmill #12 | 2 | na | 8/27/1996 | -64.9 | -9.02 | 7.3 | 10.4 | nd |
| S278 | NM526 | Windmill #41 | 2 | na | 7/29/1998 | -61.1 | -7.99 | 2.8 | 60.6 | nd |
| S280 | NM180 | Windmill #13 | 2 | na | 8/27/1996 | -57.8 | -7.41 | 1.5 | 28.6 | nd |
| S286 | NM184 | Private Production Well #13 | 2 | na | 8/26/1996 | -59.0 | -8.43 | 8.4 | 24.7 | nd |
| S287 | NM185 | Private Production Well #14 | 2 | na | 8/26/1996 | -64.7 | -8.73 | 5.1 | 40.4 | nd |
| | | **Zone 3: West Central** | | | | | | | | |
| S003 | NM251 | 98th St. D | 3 | na | 6/17/1997 | -92.2 | -12.0 | 3.9 | 252. | 3.5 |
| S003 | NM481 | 98th St. D | 3 | na | 8/4/1998 | -91.6 | -11.9 | 3.9 | 243. | 2.8 |
| S004 | NM252 | 98th St. MD | 3 | na | 6/18/1997 | -110. | -14.6 | 5.9 | 90.3 | - 1.5 |
| S004 | NM482 | 98th St. MD | 3 | na | 8/4/1998 | -110. | -14.5 | 6.1 | 87.8 | - 1.5 |
| S005 | NM253 | 98th St. MS | 3 | na | 7/4/1997 | -111. | -14.6 | 5.2 | 97.5 | - 2.5 |
| S005 | NM483 | 98th St. MS | 3 | na | 8/4/1998 | -110. | -14.6 | 6.6 | 95.7 | - 2.3 |
| S006 | NM254 | 98th St. S | 3 | na | 6/17/1997 | -92.7 | -12.2 | 4.9 | 83.1 | - 2.2 |
| S006 | NM484 | 98th St. S | 3 | na | 8/5/1998 | -92.6 | -12.1 | 4.2 | 66.2 | - 1.9 |
| S008 | NM003 | Private Production Well #01 | 3 | na | 8/12/1996 | -99.4 | -12.6 | 1.5 | 96.5 | nd |
| S010 | NM255 | Private Production Well #16 | 3 | na | 6/23/1997 | -87.4 | -11.3 | 3.0 | 114. | nd |
| S018 | NM260 | Domestic Well #21 | 3 | na | 6/26/1997 | -100. | -13.0 | 4.1 | 145. | nd |
| S019 | NM007 | Belen 4 | 3 | 5 | 8/16/1996 | -91.0 | -11.8 | 3.6 | 193. | nd |
| S020 | NM008 | Belen 5 | 3 | 5 | 8/16/1996 | -92.1 | -12.0 | 3.7 | 171. | nd |
| S029 | NM015 | Cerro Colorado Landfill PW | 3 | 5 | 8/12/1996 | -88.0 | -11.1 | 0.6 | 260. | nd |
| S037 | NM264 | College 2 | 3 | na | 6/19/1997 | -109. | -14.4 | 5.9 | 62.4 | nd |
| S066 | NM056 | Gonzales 1 | 3 | 12 | 6/20/1996 | -100. | -13.2 | 5.6 | 78.8 | nd |
| S086 | NM492 | Isleta D | 3 | na | 7/29/1998 | -97.6 | -13.0 | 6.1 | 115. | 0.2 |
| S101 | NM294 | Leavitt 1 | 3 | na | 6/26/1997 | -94.7 | -12.4 | 4.9 | 70.5 | nd |
| S108 | NM076 | Los Lunas 3 | 3 | 12 | 8/14/1996 | -97.8 | -12.9 | 5.6 | 71.8 | nd |
| S109 | NM077 | Los Lunas 4 | 3 | 12 | 8/14/1996 | -98.5 | -13.2 | 6.9 | 56.9 | nd |
| S145 | NM308 | NM Utilities 1 | 3 | na | 6/18/1997 | -87.3 | -11.5 | 5.1 | 38.7 | nd |
| S147 | NM310 | NM Utilities 3 | 3 | na | 6/18/1997 | -96.4 | -12.9 | 6.6 | 67.8 | nd |
| S148 | NM311 | NM Utilities 4 | 3 | na | 6/18/1997 | -94.7 | -12.7 | 6.5 | 53.0 | nd |
| S166 | NM509 | Rabbit Hill | 3 | na | 8/4/1998 | -84.6 | -11.4 | 6.5 | 90.9 | nd |
| S167 | NM107 | Domestic Well #12 | 3 | na | 8/14/1996 | -104. | -13.7 | 5.1 | 144. | - 4.5 |

**Table A9.** Summary of stable hydrogen, oxygen, and sulfur isotopic data from wells and springs-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secondary hydro-chemical zone | Date | $\delta^2H$ (per mil) | $\delta^{18}O$ (per mil) | $^2H$ excess (per mil) | $SO_4^{2-}$ (mg/L) | $\delta^{34}S$ (per mil) |
|---|---|---|---|---|---|---|---|---|---|---|
| S172 | NM322 | Rio Bravo 5 D | 3 | na | 7/4/1997 | -92.4 | -12.3 | 6.1 | 141. | nd |
| S174 | NM109 | Rio Bravo 1 D | 3 | 12 | 6/17/1996 | -92.8 | -12.4 | 6.2 | 167. | - 2.3 |
| S175 | NM110 | Rio Bravo 1 M | 3 | 12 | 6/17/1996 | -97.7 | -12.7 | 3.8 | 152. | 2.1 |
| S186 | NM130 | Rio Rancho 10 | 3 | na | 8/13/1996 | -103. | -13.4 | 4.8 | 94.8 | nd |
| S188 | NM132 | Rio Rancho 13 | 3 | na | 8/13/1996 | -118. | -15.6 | 6.3 | 75.2 | - 3.1 |
| S193 | NM129 | Rio Rancho 9 | 3 | na | 8/13/1996 | -105. | -13.8 | 5.0 | 47.8 | nd |
| S196 | NM135 | Windmill #05 | 3 | na | 8/21/1996 | -99.5 | -13.0 | 4.3 | 97.4 | nd |
| S200 | NM139 | Private Production Well #08 | 3 | na | 8/29/1996 | -91.3 | -11.8 | 3.3 | 186. | nd |
| S217 | NM144 | Santa Ana Boundary D | 3 | na | 8/22/1996 | -101. | -13.4 | 6.2 | 41.1 | nd |
| S218 | NM145 | Santa Ana Boundary M | 3 | na | 8/22/1996 | -102. | -13.6 | 7.3 | 29.7 | nd |
| S219 | NM146 | Santa Ana Boundary S | 3 | na | 8/22/1996 | -101. | -13.2 | 4.8 | 36.3 | nd |
| S230 | NM516 | Sierra Vista D | 3 | na | 7/22/1998 | -95.4 | -12.6 | 5.2 | 183. | 0.7 |
| S236 | NM155 | SAF (Soil Amendment Facility) | 3 | na | 8/12/1996 | -97.1 | -12.5 | 2.8 | 209. | - 9.5 |
| S241 | NM519 | SWAB Test Hole 1 D | 3 | 1 | 8/5/1998 | -89.5 | -11.6 | 3.0 | 259. | - 2.5 |
| S242 | NM520 | SWAB Test Hole 1 S | 3 | 1 | 8/1/1998 | -81.7 | -10.5 | 1.9 | 119. | - 8.5 |
| S243 | NM521 | SWAB Test Hole 2 D | 3 | na | 8/7/1998 | -73.6 | -9.99 | 6.3 | 33.9 | nd |
| S263 | NM346 | Volcano Cliff 1 | 3 | na | 6/19/1997 | -96.4 | -12.7 | 5.1 | 50.8 | nd |
| S266 | NM347 | West Bluff Nest 1 Well 1 | 3 | na | 6/23/1997 | -94.1 | -12.1 | 2.9 | 169. | nd |
| S272 | NM353 | West Mesa 3 | 3 | na | 6/19/1997 | -92.5 | -12.2 | 5.2 | 53.4 | nd |
| S283 | NM181 | Zia Ball Park D | 3 | na | 8/26/1996 | -99.9 | -13.4 | 6.9 | 66.0 | nd |
| S284 | NM182 | Zia Ball Park M | 3 | na | 8/26/1996 | -100. | -13.2 | 5.4 | 61.8 | nd |
| S285 | NM183 | Zia Ball Park S | 3 | 2 | 8/26/1996 | -91.9 | -12.1 | 5.1 | 208. | nd |
| S288 | NM186 | Zia BMT D | 3 | na | 8/27/1996 | -105. | -14.1 | 8.3 | 133. | 14.3 |
| | | **Zone 4: Western Boundary** | | | | | | | | |
| S031 | NM263 | Windmill #18 | 4 | na | 6/24/1997 | -64.0 | -9.12 | 8.9 | 554. | nd |
| S039 | NM266 | Windmill #20 | 4 | na | 6/21/1997 | -79.5 | -10.8 | 6.9 | 919. | nd |
| S059 | NM278 | Windmill #21 | 4 | na | 6/23/1997 | -72.9 | -9.50 | 3.1 | 793. | nd |
| S074 | NM285 | Windmill #23 | 4 | na | 6/21/1997 | -53.5 | -8.12 | 11.5 | 583. | nd |
| S169 | NM320 | Rest Area | 4 | na | 6/30/1997 | -52.9 | -7.56 | 7.6 | 571. | nd |
| S201 | NM329 | Windmill #26 | 4 | na | 7/2/1997 | -81.4 | -11.3 | 9.3 | 936. | 9.4 |
| S252 | NM167 | Windmill #10 | 4 | na | 8/29/1996 | -56.5 | -7.84 | 6.2 | 414. | nd |
| S260 | NM345 | Windmill #33 | 4 | na | 6/25/1997 | -64.8 | -9.12 | 8.2 | 672. | nd |
| | | **Zone 5: Rio Puerco** | | | | | | | | |
| S032 | NM262 | Windmill #17 | 5 | na | 6/24/1997 | -64.0 | -8.65 | 5.3 | 903. | nd |
| S069 | NM058 | Domestic Well #06 | 5 | na | 8/16/1996 | -68.2 | -8.95 | 3.5 | 490. | nd |
| S073 | NM062 | Windmill #03 | 5 | na | 8/16/1996 | -60.6 | -7.74 | 1.3 | 1,060. | - 2.1 |
| S082 | NM409 | Windmill #36 | 5 | na | 9/10/1997 | -59.8 | -8.21 | 5.9 | 1,180. | nd |
| S085 | NM408 | Windmill #35 | 5 | na | 9/10/1997 | -72.4 | -9.56 | 4.1 | 543. | nd |
| S111 | NM079 | Domestic Well #10 | 5 | na | 8/16/1996 | -60.0 | -7.81 | 2.5 | 702. | - 4.4 |
| S185 | NM324 | Domestic Well #31 | 5 | na | 6/16/1997 | -73.5 | -9.75 | 4.5 | 1,107. | nd |
| S198 | NM137 | Windmill #07 | 5 | na | 8/21/1996 | -61.6 | -7.59 | - 0.8 | 2,130. | - 0.1 |
| S215 | NM335 | Sandoval Spring | 5 | 4 | 7/1/1997 | -59.2 | -8.51 | 8.9 | 291. | nd |
| S237 | NM341 | Windmill #30 | 5 | 4 | 6/24/1997 | -63.5 | -8.73 | 6.3 | 490. | nd |
| S238 | NM342 | Windmill #31 | 5 | na | 6/24/1997 | -59.4 | -7.66 | 1.9 | 1,303. | nd |
| | | **Zone 6: Southwestern Mountain Front** | | | | | | | | |
| S022 | NM009 | Windmill #02 | 6 | na | 8/19/1996 | -53.5 | -7.74 | 8.4 | 70.9 | nd |
| | | **Zone 7: Abo Arroyo** | | | | | | | | |
| S021 | NM261 | Stock Well #01 | 7 | na | 6/23/1997 | -58.5 | -8.23 | 7.3 | 687. | nd |
| S024 | NM011 | Domestic Well #02 | 7 | 8 | 8/17/1996 | -66.7 | -9.28 | 7.5 | 264. | nd |
| S090 | NM064 | Domestic Well #08 | 7 | na | 8/19/1996 | -63.6 | -8.82 | 7.0 | 311. | nd |
| S093 | NM067 | Domestic Well #09 | 7 | 8 | 8/15/1996 | -75.8 | -10.7 | 9.8 | 78.0 | nd |
| | | **Zone 8: Eastern Mountain Front** | | | | | | | | |
| S007 | NM002 | Domestic Well #01 | 8 | na | 6/21/1996 | -87.2 | -11.9 | 8.2 | 42.3 | 4.3 |
| S013 | NM256 | Windmill #14 | 8 | na | 6/24/1997 | -74.5 | -10.4 | 8.7 | 10.7 | nd |
| S014 | NM257 | Private Production Well #17 | 8 | na | 6/19/1997 | -84.1 | -11.8 | 10.4 | 58.4 | nd |
| S015 | NM006 | Windmill #01 | 8 | na | 8/24/1996 | -79.7 | -11.4 | 11.3 | 26.8 | nd |
| S030 | NM016 | Charles 4 | 8 | na | 6/22/1996 | -88.9 | -12.2 | 8.8 | 27.4 | 3.0 |

**Table A9.** Summary of stable hydrogen, oxygen, and sulfur isotopic data from wells and springs-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secondary hydro-chemical zone | Date | $\delta^2H$ (per mil) | $\delta^{18}O$ (per mil) | $^2H$ excess (per mil) | $SO_4^{2-}$ (mg/L) | $\delta^{34}S$ (per mil) |
|---|---|---|---|---|---|---|---|---|---|---|
| S030 | NM017 | Charles 4 | 8 | na | 6/27/1996 | -88.0 | -12.2 | 9.4 | 26.7 | nd |
| S030 | NM018 | Charles 4 | 8 | na | 6/27/1996 | -89.6 | -12.1 | 7.4 | 26.7 | nd |
| S030 | NM019 | Charles 4 | 8 | na | 6/27/1996 | -87.4 | -12.1 | 9.3 | 26.7 | nd |
| S030 | NM020 | Charles 4 | 8 | na | 6/27/1996 | -90.7 | -12.1 | 6.3 | 26.7 | nd |
| S030 | NM021 | Charles 4 | 8 | na | 6/27/1996 | -88.4 | -12.2 | 9.0 | 26.7 | nd |
| S030 | NM022 | Charles 4 | 8 | na | 6/27/1996 | -89.6 | -12.2 | 8.2 | 25.6 | nd |
| S030 | NM023 | Charles 4 | 8 | na | 6/27/1996 | -91.2 | -12.2 | 6.6 | 27.0 | nd |
| S030 | NM024 | Charles 4 | 8 | na | 6/27/1996 | -89.1 | -12.2 | 8.5 | 26.7 | nd |
| S042 | NM031 | Domestic Well #03 | 8 | na | 8/14/1996 | -71.1 | -10.1 | 10.1 | 20.1 | nd |
| S055 | NM042 | Elena Gallegos | 8 | na | 6/25/1996 | -84.1 | -11.4 | 7.5 | 43.9 | 2.6 |
| S056 | NM043 | Embudito Spring | 8 | na | 7/2/1996 | -38.5 | -5.50 | 5.5 | 98.6 | 4.8 |
| S056 | NM213 | Embudito Spring | 8 | na | 3/21/1997 | -82.0 | -11.5 | 10.3 | 57.4 | nd |
| S056 | NM214 | Embudito Spring | 8 | na | 3/21/1997 | -82.3 | -11.4 | 9.2 | 57.4 | nd |
| S056 | NM227 | Embudito Spring | 8 | na | 4/29/1997 | -85.9 | -11.9 | 9.0 | 43.7 | nd |
| S056 | NM239 | Embudito Spring | 8 | na | 5/27/1997 | -82.4 | -11.4 | 9.0 | 44.8 | nd |
| S056 | NM364 | Embudito Spring | 8 | na | 7/17/1997 | -77.9 | -10.9 | 9.2 | nd | nd |
| S071 | NM060 | Domestic Well #07 | 8 | na | 6/19/1996 | -84.3 | -11.6 | 8.6 | 20.2 | 3.5 |
| S083 | NM407 | Windmill #34 | 8 | na | 9/10/1997 | -75.0 | -10.2 | 6.3 | 55.0 | nd |
| S095 | NM068 | Kirtland 1 | 8 | na | 6/25/1996 | -79.5 | -11.0 | 8.4 | 52.8 | 0.0 |
| S106 | NM295 | Domestic Well #23 | 8 | na | 6/26/1997 | -85.7 | -11.8 | 8.6 | 49.4 | nd |
| S110 | NM078 | Love 1 | 8 | na | 6/22/1996 | -80.2 | -11.2 | 9.6 | 24.3 | nd |
| S113 | NM080 | Domestic Well #11 | 8 | na | 8/15/1996 | -76.0 | -11.0 | 11.7 | 34.7 | nd |
| S114 | NM500 | Matheson D | 8 | na | 7/31/1998 | -78.9 | -11.2 | 10.5 | 19.5 | 3.6 |
| S115 | NM501 | Matheson M | 8 | na | 8/1/1998 | -79.6 | -11.4 | 11.5 | 19.6 | 3.0 |
| S116 | NM502 | Matheson S | 8 | na | 8/1/1998 | -80.8 | -11.6 | 11.9 | 17.6 | 3.9 |
| S117 | NM298 | Domestic Well #25 | 8 | na | 6/17/1997 | -83.6 | -11.8 | 11.0 | 27.9 | nd |
| S118 | NM299 | Windmill #24 | 8 | na | 6/27/1997 | -61.7 | -9.02 | 10.5 | 55.0 | nd |
| S119 | NM300 | Domestic Well #26 | 8 | 11 | 6/19/1997 | -83.7 | -11.7 | 10.1 | 92.6 | - 0.3 |
| S122 | NM304 | Mesa Del Sol S | 8 | na | 6/29/1997 | -97.7 | -13.1 | 6.9 | 66.0 | - 0.2 |
| S122 | NM505 | Mesa Del Sol S | 8 | na | 7/25/1998 | -86.8 | -12.0 | 9.2 | 26.1 | 2.3 |
| S140 | NM306 | MRN 1 | 8 | na | 7/5/1997 | -73.7 | -10.4 | 9.6 | 70.2 | nd |
| S141 | NM095 | National Utility 7 | 8 | na | 8/14/1996 | -79.9 | -11.5 | 12.4 | 12.1 | nd |
| S149 | NM312 | Nor Este D | 8 | na | 7/3/1997 | -87.1 | -11.9 | 8.2 | 66.4 | 9.4 |
| S150 | NM313 | Nor Este M | 8 | na | 7/2/1997 | -80.8 | -10.8 | 5.9 | 44.1 | 9.3 |
| S162 | NM317 | Stock Well #03 | 8 | na | 6/30/1997 | -74.9 | -10.7 | 10.8 | 13.2 | 6.8 |
| S163 | NM318 | PL 2 | 8 | na | 7/7/1997 | -75.5 | -10.6 | 9.2 | 55.6 | nd |
| S164 | NM106 | Ponderosa 1 | 8 | na | 6/20/1996 | -89.3 | -12.1 | 7.4 | 33.8 | nd |
| S165 | NM328 | Windmill #25 | 8 | na | 6/24/1997 | -87.3 | -12.3 | 10.7 | 52.6 | nd |
| S168 | NM319 | Domestic Well #30 | 8 | na | 6/27/1997 | -69.9 | -10.2 | 11.6 | 29.5 | nd |
| S170 | NM108 | Ridgecrest 3 | 8 | na | 6/22/1996 | -85.9 | -11.7 | 7.8 | 22.1 | 2.2 |
| S170 | NM412 | Ridgecrest 3 | 8 | na | 11/18/1997 | nd | nd | nd | 23.7 | 2.5 |
| S195 | NM134 | Domestic Well #13 | 8 | na | 8/14/1996 | -72.0 | -10.2 | 9.8 | 30.8 | nd |
| S199 | NM138 | Windmill #08 | 8 | na | 8/23/1996 | -78.3 | -10.5 | 5.9 | 80.7 | nd |
| S209 | NM336 | Domestic Well #33 | 8 | na | 6/27/1997 | -81.8 | -11.4 | 9.8 | 51.0 | nd |
| S212 | NM141 | Sandia Peak 1 | 8 | na | 6/26/1996 | -83.0 | -11.6 | 9.9 | 14.3 | nd |
| S213 | NM142 | Sandia Peak 3 | 8 | na | 6/26/1996 | -81.2 | -11.2 | 8.1 | 30.4 | 3.6 |
| S224 | NM148 | Domestic Well #14 | 8 | na | 8/23/1996 | -81.8 | -11.5 | 10.5 | 31.3 | nd |
| S229 | NM515 | SH03 UNM | 8 | na | 7/28/1998 | -83.0 | -11.6 | 9.7 | 31.2 | nd |
| S233 | NM153 | Domestic Well #16 | 8 | na | 8/23/1996 | -89.9 | -12.6 | 10.6 | 42.6 | nd |
| S239 | NM156 | Domestic Well #17 | 8 | na | 8/17/1996 | -83.5 | -12.0 | 12.6 | 35.9 | nd |
| S240 | NM157 | Domestic Well #18 | 8 | na | 6/19/1996 | -80.4 | -11.4 | 11.1 | 14.3 | nd |
| S246 | NM343 | Windmill #32 | 8 | na | 6/24/1997 | -72.4 | -10.3 | 10.2 | 70.8 | nd |
| S247 | NM161 | Domestic Well #19 | 8 | na | 8/15/1996 | -90.5 | -12.4 | 9.0 | 35.7 | nd |
| S248 | NM162 | Thomas 6 | 8 | na | 6/21/1996 | -89.0 | -12.3 | 9.2 | 31.1 | 2.8 |
| S255 | NM523 | Tramway East | 8 | na | 7/30/1998 | -80.6 | -11.4 | 10.4 | 16.8 | nd |
| S264 | NM174 | Walker 1 | 8 | na | 6/18/1996 | -84.1 | -11.9 | 10.8 | 24.6 | nd |
| S274 | NM177 | Domestic Well #20 | 8 | na | 8/15/1996 | -72.7 | -10.1 | 8.0 | 43.6 | nd |
| | | **Zone 9: Tijeras Fault Zone** | | | | | | | | |
| S041 | NM029 | Coyote Spring | 9 | na | 6/28/1996 | -82.5 | -11.4 | 8.5 | 140. | 7.0 |

**Table A9.** Summary of stable hydrogen, oxygen, and sulfur isotopic data from wells and springs-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secondary hydro-chemical zone | Date | $\delta^2H$ (per mil) | $\delta^{18}O$ (per mil) | $^2H$ excess (per mil) | $SO_4^{2-}$ (mg/L) | $\delta^{34}S$ (per mil) |
|---|---|---|---|---|---|---|---|---|---|---|
| S072 | NM061 | Hubbell Spring | 9 | 8 | 8/23/1996 | -72.7 | -9.97 | 7.1 | 211. | nd |
| S098 | NM071 | KAFB-1902 | 9 | na | 6/28/1996 | -59.8 | -6.31 | - 9.3 | 292. | 2.1 |
| S197 | NM136 | Windmill #06 | 9 | na | 8/23/1996 | -93.0 | -12.3 | 5.5 | 326. | nd |
| S227 | NM151 | SFR 3D | 9 | na | 8/24/1996 | -74.3 | -10.3 | 8.1 | 92.6 | nd |
| S228 | NM152 | SFR 3S | 9 | na | 8/24/1996 | -74.2 | -10.2 | 7.6 | 90.2 | nd |
| | | **Zone 10: Tijeras Arroyo** | | | | | | | | |
| S001 | NM001 | 4Hills-1 | 10 | 8 | 6/29/1996 | -74.0 | -9.65 | 3.2 | 287. | 0.9 |
| S002 | NM250 | Private Production Well #15 | 10 | 8 | 7/3/1997 | -75.7 | -10.3 | 7.1 | 130. | nd |
| S058 | NM277 | Eubank 1 | 10 | 8 | 7/4/1997 | -76.7 | -10.6 | 7.9 | 85.1 | nd |
| S096 | NM069 | Kirtland 11 | 10 | 8 | 6/25/1996 | -73.7 | -10.2 | 7.8 | 83.1 | nd |
| S107 | NM075 | Lomas 1 | 10 | 8 | 6/22/1996 | -76.2 | -10.5 | 7.7 | 94.3 | nd |
| S107 | NM410 | Lomas 1 | 10 | na | 11/18/1997 | nd | nd | nd | 95.0 | nd |
| | | **Zone 11: Northeastern** | | | | | | | | |
| S016 | NM258 | Windmill #15 | 11 | na | 6/18/1997 | -75.1 | -9.72 | 2.6 | 284. | nd |
| S017 | NM259 | Windmill #16 | 11 | na | 6/18/1997 | -61.5 | -8.38 | 5.5 | 97.9 | nd |
| S053 | NM276 | Private Production Well #18 | 11 | na | 6/25/1997 | -74.7 | -10.2 | 6.9 | 540. | nd |
| S144 | NM097 | Private Production Well #06 | 11 | na | 8/28/1996 | -72.7 | -10.2 | 8.8 | 476. | - 4.7 |
| S204 | NM332 | Windmill #28 | 11 | na | 7/3/1997 | -67.8 | -9.49 | 8.1 | 104. | nd |
| S207 | NM334 | Private Production Well #22 | 11 | na | 7/3/1997 | -68.6 | -9.74 | 9.4 | 877. | nd |
| S223 | NM338 | Windmill #29 | 11 | na | 6/25/1997 | -66.9 | -9.01 | 5.2 | 399. | nd |
| | | **Zone 12: Central** | | | | | | | | |
| S011 | NM004 | Atris-1 | 12 | na | 6/22/1996 | -94.0 | -12.5 | 5.9 | 63.6 | - 4.1 |
| S012 | NM005 | Atrisco 3 | 12 | 3 | 6/20/1996 | -93.6 | -12.6 | 7.5 | 80.7 | nd |
| S025 | NM012 | Burton 2 | 12 | na | 6/19/1996 | -96.4 | -13.1 | 8.4 | 38.7 | nd |
| S026 | NM013 | Burton 5 | 12 | na | 6/19/1996 | -96.0 | -13.1 | 9.1 | 28.7 | nd |
| S033 | NM025 | Private Production Well #02 | 12 | na | 8/21/1996 | -90.0 | -11.9 | 5.1 | 149. | - 0.8 |
| S040 | NM028 | Coronado 1 | 12 | na | 6/18/1996 | -94.7 | -12.6 | 6.1 | 44.3 | 5.1 |
| S043 | NM267 | Del Sol D | 12 | na | 7/1/1997 | -102. | -13.8 | 7.8 | 45.4 | 2.4 |
| S043 | NM488 | Del Sol D | 12 | na | 7/21/1998 | -102. | -13.9 | 9.1 | 41.7 | nd |
| S044 | NM268 | Del Sol M | 12 | na | 6/26/1997 | -93.7 | -12.8 | 8.5 | 46.3 | 3.5 |
| S044 | NM489 | Del Sol M | 12 | na | 7/21/1998 | -95.6 | -12.8 | 6.5 | 42.6 | nd |
| S045 | NM269 | Del Sol S | 12 | na | 6/26/1997 | -93.8 | -12.8 | 8.9 | 98.8 | - 1.3 |
| S045 | NM490 | Del Sol S | 12 | na | 7/21/1998 | -95.3 | -12.7 | 6.0 | 109. | nd |
| S046 | NM032 | Duranes 1 | 12 | na | 6/20/1996 | -93.5 | -12.4 | 5.6 | 117. | nd |
| S046 | NM033 | Duranes 1 | 12 | na | 6/29/1996 | -92.0 | -12.3 | 6.6 | 156. | nd |
| S046 | NM034 | Duranes 1 | 12 | na | 6/29/1996 | -92.8 | -12.4 | 6.3 | 159. | nd |
| S046 | NM035 | Duranes 1 | 12 | na | 6/29/1996 | -92.3 | -12.5 | 7.7 | 156. | nd |
| S046 | NM036 | Duranes 1 | 12 | na | 6/29/1996 | -92.4 | -12.4 | 6.5 | 156. | nd |
| S046 | NM037 | Duranes 1 | 12 | na | 6/29/1996 | -91.8 | -12.3 | 6.5 | 157. | nd |
| S046 | NM038 | Duranes 1 | 12 | na | 6/29/1996 | -92.3 | -12.4 | 6.8 | 159. | nd |
| S046 | NM039 | Duranes 1 | 12 | na | 6/29/1996 | -94.2 | -12.3 | 4.4 | 159. | nd |
| S046 | NM040 | Duranes 1 | 12 | na | 6/29/1996 | -95.1 | -12.3 | 3.0 | 159. | nd |
| S047 | NM270 | Duranes 7 | 12 | na | 6/26/1997 | -93.4 | -12.7 | 8.4 | 66.5 | nd |
| S048 | NM271 | Duranes Yard 1 | 12 | na | 7/5/1997 | -95.2 | -12.8 | 7.1 | 62.2 | - 1.9 |
| S049 | NM272 | Duranes Yard 2 | 12 | na | 7/5/1997 | -93.4 | -12.6 | 7.3 | 60.8 | - 0.9 |
| S050 | NM273 | Duranes Yard 3 | 12 | na | 7/5/1997 | -85.1 | -11.2 | 4.4 | 70.7 | - 2.8 |
| S051 | NM274 | Duranes Yard 4 | 12 | na | 7/5/1997 | -91.1 | -12.0 | 4.6 | 67.9 | - 2.2 |
| S052 | NM275 | Duranes Yard 5 | 12 | na | 7/5/1997 | -90.6 | -12.2 | 6.9 | 62.7 | - 1.6 |
| S060 | NM279 | Garfield D | 12 | 3 | 6/19/1997 | -94.5 | -13.0 | 9.5 | 60.8 | 1.2 |
| S061 | NM280 | Garfield M | 12 | na | 6/19/1997 | -93.7 | -12.9 | 9.1 | 43.1 | 2.9 |
| S062 | NM281 | Garfield S | 12 | na | 6/19/1997 | -89.1 | -11.9 | 5.9 | 224. | -22.3 |
| S062 | NM491 | Garfield S | 12 | na | 7/28/1998 | -91.4 | -12.3 | 7.1 | 208. | nd |
| S064 | NM283 | Domestic Well #22 | 12 | na | 6/20/1997 | -95.3 | -12.9 | 7.8 | 81.6 | 0.9 |
| S068 | NM057 | Griegos 3 | 12 | na | 6/21/1996 | -96.0 | -12.9 | 7.1 | 69.7 | nd |
| S075 | NM286 | Hunter Ridge Nest 1 Well 1 | 12 | 3 | 6/20/1997 | -92.1 | -12.7 | 9.9 | 65.1 | 4.7 |
| S076 | NM287 | Hunter Ridge Nest 1 Well 2 | 12 | na | 6/21/1997 | -98.0 | -13.5 | 10.1 | 40.6 | 3.3 |
| S077 | NM288 | Hunter Ridge Nest 1 Well 3 | 12 | na | 6/20/1997 | -96.0 | -12.8 | 6.2 | 156. | 3.1 |
| S078 | NM289 | Hunter Ridge Nest 2 Well 1 | 12 | na | 6/21/1997 | -100. | -13.5 | 7.8 | 84.6 | 3.2 |

**Table A9.** Summary of stable hydrogen, oxygen, and sulfur isotopic data from wells and springs-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secondary hydro-chemical zone | Date | $\delta^2H$ (per mil) | $\delta^{18}O$ (per mil) | $^2H$ excess (per mil) | $SO_4^{2-}$ (mg/L) | $\delta^{34}S$ (per mil) |
|---|---|---|---|---|---|---|---|---|---|---|
| S079 | NM290 | Hunter Ridge Nest 2 Well 2 | 12 | na | 6/21/1997 | -97.5 | -13.5 | 10.6 | 93.5 | 3.5 |
| S080 | NM291 | Hunter Ridge Nest 2 Well 3 | 12 | na | 6/21/1997 | -98.7 | -13.3 | 7.5 | 137. | 3.1 |
| S081 | NM292 | Private Production Well #19 | 12 | na | 7/2/1997 | -98.5 | -13.2 | 7.4 | 44.4 | nd |
| S084 | NM063 | Windmill #04 | 12 | na | 8/21/1996 | -99.8 | -13.3 | 6.5 | 57.4 | nd |
| S087 | NM493 | Isleta MD | 12 | 3 | 7/29/1998 | -98.6 | -13.3 | 7.6 | 46.2 | nd |
| S088 | NM494 | Isleta MS | 12 | na | 7/29/1998 | -99.9 | -13.4 | 7.4 | 30.0 | 6.5 |
| S089 | NM495 | Isleta S | 12 | na | 7/29/1998 | -91.8 | -12.2 | 5.6 | 140. | 3.3 |
| S092 | NM066 | JMC-1 | 12 | na | 6/28/1996 | -89.9 | -12.1 | 7.0 | 123. | - 9.3 |
| S097 | NM070 | Kirtland 14 | 12 | na | 6/25/1996 | -98.1 | -13.2 | 7.7 | 26.8 | 3.3 |
| S100 | NM073 | LALF-9 | 12 | na | 6/29/1996 | -94.2 | -12.5 | 6.2 | 120. | nd |
| S102 | NM074 | Leyendecker 1 | 12 | na | 6/21/1996 | -99.1 | -13.4 | 7.7 | 32.0 | 2.9 |
| S120 | NM301 | Mesa Del Sol D | 12 | na | 6/29/1997 | -88.6 | -12.3 | 9.4 | 42.6 | - 2.5 |
| S120 | NM303 | Mesa Del Sol D | 12 | na | 6/28/1997 | -91.8 | -12.5 | 8.4 | 73.0 | - 5.0 |
| S120 | NM503 | Mesa Del Sol D | 12 | na | 8/2/1998 | -98.4 | -13.2 | 7.0 | 65.6 | - 0.3 |
| S121 | NM302 | Mesa Del Sol M | 12 | na | 6/28/1997 | -105. | -14.1 | 7.6 | 37.0 | - 0.7 |
| S121 | NM504 | Mesa Del Sol M | 12 | na | 7/25/1998 | -105. | -14.0 | 7.5 | 32.5 | - 0.9 |
| S123 | NM081 | MONT - 5A | 12 | na | 6/27/1996 | -97.4 | -12.8 | 5.2 | 140. | -11.4 |
| S124 | NM082 | Montaňo 2 D | 12 | na | 6/19/1996 | -93.1 | -12.5 | 7.0 | 74.0 | - 2.3 |
| S125 | NM083 | Montaňo 2 M | 12 | na | 6/19/1996 | -96.2 | -12.5 | 4.0 | 101. | - 2.6 |
| S126 | NM084 | Montaňo 2 S | 12 | na | 6/19/1996 | -93.4 | -12.3 | 5.2 | 97.7 | - 6.1 |
| S127 | NM085 | Montaňo 4 D | 12 | na | 6/20/1996 | -94.5 | -12.8 | 7.6 | 63.3 | - 3.9 |
| S128 | NM086 | Montaňo 4 M | 12 | na | 6/19/1996 | -93.7 | -12.4 | 5.8 | 173. | -11.8 |
| S130 | NM088 | Montaňo 5 D | 12 | na | 6/24/1996 | -89.8 | -12.1 | 6.8 | 67.5 | - 0.9 |
| S131 | NM089 | Montaňo 5 M | 12 | na | 6/24/1996 | -95.5 | -12.6 | 5.0 | 57.1 | - 4.7 |
| S132 | NM090 | Montaňo 5 S | 12 | na | 6/24/1996 | -90.3 | -11.5 | 2.0 | 67.3 | - 5.9 |
| S133 | NM091 | Montaňo 6 D | 12 | na | 6/18/1996 | -94.5 | -12.7 | 7.4 | 57.1 | 2.3 |
| S134 | NM092 | Montaňo 6 MD | 12 | na | 6/18/1996 | -95.6 | -12.9 | 7.9 | 44.9 | 3.7 |
| S135 | NM093 | Montaňo 6 MS | 12 | na | 6/18/1996 | -97.1 | -13.2 | 8.9 | 49.8 | - 0.3 |
| S136 | NM094 | Montaňo 6 S | 12 | na | 6/18/1996 | -95.1 | -12.8 | 6.9 | 73.9 | - 5.5 |
| S137 | NM506 | Montesa M | 12 | na | 7/27/1998 | -95.5 | -13.0 | 8.2 | 31.2 | 3.9 |
| S138 | NM507 | Montesa S | 12 | na | 7/27/1998 | -99.7 | -13.3 | 6.5 | 30.7 | 2.4 |
| S139 | NM305 | Domestic Well #27 | 12 | na | 6/17/1997 | -96.8 | -12.8 | 5.7 | 45.2 | 3.7 |
| S142 | NM307 | Domestic Well #28 | 12 | na | 6/17/1997 | -98.0 | -13.4 | 9.0 | 105. | nd |
| S146 | NM309 | NM Utilities 2 | 12 | na | 6/18/1997 | -98.4 | -13.2 | 6.8 | 42.2 | nd |
| S151 | NM314 | Nor Este S | 12 | na | 7/2/1997 | -99.0 | -13.5 | 9.0 | 45.0 | - 0.3 |
| S151 | NM508 | Nor Este S | 12 | na | 7/20/1998 | -100. | -13.5 | 8.2 | 37.6 | 0.5 |
| S153 | NM315 | Open Space | 12 | 10 | 6/17/1997 | -98.5 | -13.4 | 9.0 | 31.6 | nd |
| S153 | NM411 | Open Space | 12 | na | 11/18/1997 | -101. | -12.7 | 1.0 | 28.9 | nd |
| S154 | NM099 | ORLF-2 | 12 | na | 6/27/1996 | -95.9 | -12.6 | 5.0 | 53.7 | - 1.9 |
| S155 | NM316 | Domestic Well #29 | 12 | na | 6/27/1997 | -97.9 | -13.3 | 8.5 | 48.3 | nd |
| S156 | NM100 | Paseo 2D | 12 | na | 6/26/1996 | -98.1 | -13.3 | 8.4 | 59.1 | 0.3 |
| S157 | NM101 | Paseo 2MD | 12 | na | 6/26/1996 | -95.3 | -12.7 | 5.9 | 85.9 | - 0.6 |
| S158 | NM102 | Paseo 2MS | 12 | na | 6/26/1996 | -93.7 | -12.6 | 6.8 | 81.9 | - 3.9 |
| S159 | NM103 | Paseo 2S | 12 | na | 6/26/1996 | -93.3 | -12.5 | 7.1 | 103. | - 4.3 |
| S160 | NM104 | Paseo 3D | 12 | na | 6/21/1996 | -99.7 | -13.5 | 8.4 | 26.8 | 2.2 |
| S161 | NM105 | Paseo 3M | 12 | na | 6/21/1996 | -92.7 | -12.4 | 6.1 | 125. | - 7.6 |
| S171 | NM321 | Ridgecrest 4 | 12 | na | 6/26/1997 | -93.3 | -12.7 | 8.6 | 31.6 | 2.8 |
| S173 | NM323 | Rio Bravo 5 M | 12 | 3 | 7/4/1997 | -89.9 | -12.2 | 7.9 | 69.1 | nd |
| S176 | NM111 | Rio Bravo 1 S | 12 | na | 6/17/1996 | -92.9 | -12.2 | 5.1 | 99.4 | - 3.2 |
| S177 | NM112 | Rio Bravo 2 D | 12 | 3 | 6/25/1996 | -96.8 | -13.0 | 7.5 | 70.4 | - 0.2 |
| S178 | NM113 | Rio Bravo 2 M | 12 | na | 6/25/1996 | -94.5 | -12.6 | 6.5 | 107. | - 1.6 |
| S179 | NM114 | Rio Bravo 2 S | 12 | na | 6/25/1996 | -91.5 | -12.1 | 5.5 | 101. | - 2.0 |
| S180 | NM115 | Rio Bravo 4 D | 12 | na | 6/25/1996 | -96.0 | -13.0 | 8.0 | 29.4 | 3.6 |
| S181 | NM116 | Rio Bravo 4 M | 12 | na | 6/25/1996 | -88.5 | -11.8 | 5.6 | 137. | - 0.7 |
| S183 | NM126 | Rio Grande Utility 5 | 12 | 3 | 8/15/1996 | -91.9 | -12.4 | 7.1 | 63.1 | nd |
| S184 | NM127 | Rio Grande Utility 6 | 12 | na | 8/15/1996 | -98.3 | -13.2 | 7.6 | 31.8 | nd |
| S190 | NM325 | Rio Rancho 2 | 12 | na | 6/20/1997 | -99.4 | -13.4 | 7.8 | 59.2 | nd |
| S203 | NM331 | Private Production Well #20 | 12 | na | 7/3/1997 | -93.9 | -12.6 | 7.0 | 121. | nd |
| S205 | NM333 | Private Production Well #21 | 12 | na | 7/3/1997 | -98.2 | -13.6 | 11.0 | 37.4 | nd |

**Table A9.** Summary of stable hydrogen, oxygen, and sulfur isotopic data from wells and springs-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secondary hydro-chemical zone | Date | $\delta^2H$ (per mil) | $\delta^{18}O$ (per mil) | $^2H$ excess (per mil) | $SO_4^{2-}$ (mg/L) | $\delta^{34}S$ (per mil) |
|---|---|---|---|---|---|---|---|---|---|---|
| S208 | NM140 | San Jose 2 | 12 | 3 | 6/20/1996 | -99.2 | -13.3 | 7.0 | 58.4 | nd |
| S210 | NM511 | Sandia D | 12 | na | 7/30/1998 | -92.3 | -12.6 | 8.4 | 58.3 | - 8.7 |
| S214 | NM513 | Sandia S | 12 | na | 7/30/1998 | -95.4 | -12.9 | 7.5 | 78.8 | 0.9 |
| S220 | NM147 | Santa Barbara 1 | 12 | na | 6/19/1996 | -98.8 | -13.3 | 7.6 | 36.8 | 2.1 |
| S220 | NM337 | Santa Barbara 1 | 12 | na | 6/26/1997 | -98.9 | -13.4 | 7.9 | 41.2 | 1.9 |
| S231 | NM517 | Sierra Vista M | 12 | 3 | 7/22/1998 | -95.5 | -13.0 | 8.7 | 49.4 | 2.2 |
| S232 | NM518 | Sierra Vista S | 12 | na | 7/22/1998 | -95.0 | -12.8 | 7.7 | 61.2 | 3.2 |
| S234 | NM339 | Sister Cities D | 12 | na | 6/30/1997 | -95.4 | -12.8 | 6.8 | 52.8 | - 2.1 |
| S235 | NM340 | Sister Cities M | 12 | na | 6/27/1997 | -102. | -13.6 | 7.0 | 22.0 | 3.7 |
| S244 | NM158 | SWAB 3 - 760 | 12 | na | 7/1/1996 | -96.2 | -13.0 | 8.0 | 13.3 | 16.2 |
| S245 | NM159 | SWAB 3 - 980 | 12 | na | 7/1/1996 | -98.3 | -13.2 | 7.7 | 6.3 | 19.7 |
| S245 | NM160 | SWAB 3 - 980 | 12 | na | 7/1/1996 | -97.3 | -13.2 | 8.2 | 8.2 | nd |
| S253 | NM522 | Tome D | 12 | na | 8/6/1998 | -93.1 | -12.7 | 8.4 | 43.7 | - 3.9 |
| S257 | NM344 | Domestic Well #34 | 12 | na | 6/17/1997 | -93.8 | -12.6 | 7.1 | 92.7 | nd |
| S259 | NM171 | VGP-1 | 12 | na | 6/27/1996 | -90.6 | -12.0 | 5.7 | 167. | 0.8 |
| S261 | NM172 | Vol Andia 2 | 12 | na | 6/21/1996 | -97.3 | -13.4 | 10.1 | 34.0 | 2.1 |
| S262 | NM173 | Vol Andia 5 | 12 | na | 6/18/1996 | -96.4 | -13.3 | 9.8 | 67.0 | - 0.9 |
| S265 | NM175 | Webster 1 | 12 | na | 6/18/1996 | -97.0 | -13.0 | 7.2 | 38.3 | 5.0 |
| S267 | NM348 | West Bluff Nest 1 Well 2 | 12 | 3 | 6/23/1997 | -95.0 | -12.8 | 7.6 | 56.8 | nd |
| S268 | NM349 | West Bluff Nest 1 Well 3 | 12 | na | 6/24/1997 | -95.0 | -13.1 | 9.6 | 55.5 | nd |
| S269 | NM350 | West Bluff Nest 2 Well 1 | 12 | na | 6/24/1997 | -93.7 | -12.5 | 6.5 | 91.9 | nd |
| S270 | NM351 | West Bluff Nest 2 Well 2 | 12 | na | 6/24/1997 | -92.9 | -12.5 | 6.8 | 79.9 | nd |
| S271 | NM352 | West Bluff Nest 2 Well 3 | 12 | na | 6/24/1997 | -89.7 | -12.1 | 6.8 | 60.4 | nd |
| S275 | NM178 | Yale 1 | 12 | na | 6/19/1996 | -98.2 | -13.2 | 7.7 | 47.2 | nd |
| SXXX | NM045 | Geoprobe #1 (45.3') | 12 | na | 7/1/1996 | -95.5 | -12.7 | 5.9 | 58.8 | nd |
| SXXX | NM049 | Geoprobe #1 (25') | 12 | na | 7/1/1996 | -96.3 | -12.9 | 7.2 | 51.3 | nd |
| SXXX | NM051 | Geoprobe #2 (40.5') | 12 | na | 7/1/1996 | -93.3 | -12.4 | 6.1 | 58.8 | nd |
| | | **Zone 13: Discharge** | | | | | | | | |
| S143 | NM096 | Private Production Well #05 | 13 | na | 8/19/1996 | -90.8 | -12.1 | 6.4 | 203. | nd |
| S194 | NM327 | Domestic Well #32 | 13 | na | 6/30/1997 | -81.5 | -11.0 | 6.9 | 290. | nd |
| S226 | NM150 | Domestic Well #15 | 13 | na | 8/19/1996 | -90.8 | -12.3 | 7.4 | 450. | 3.6 |
| | | **No Zone: Exotic Water** | | | | | | | | |
| S009 | NM485 | Arroyo Salado Spring | E | E | 8/6/1998 | -65.2 | -7.66 | - 3.9 | 3,750. | nd |
| S023 | NM010 | Burn Site Well | E | E | 6/25/1996 | -76.3 | -10.6 | 8.3 | 165. | - 9.8 |
| S028 | NM014 | Cerro Colorado Landfill MW | E | E | 8/12/1996 | -79.8 | -9.45 | - 4.2 | 2,190. | 7.4 |
| S038 | NM265 | Windmill #19 | E | E | 7/1/1997 | -99.7 | -13.3 | 6.4 | 2,134. | 13.9 |
| S054 | NM041 | Domestic Well #04 | E | E | 8/17/1996 | -82.7 | -10.3 | - 0.5 | 296. | 8.9 |
| S057 | NM044 | Embudo Spring | E | E | 7/2/1996 | -85.8 | -11.7 | 7.8 | 94.8 | 4.4 |
| S057 | NM215 | Embudo Spring | E | E | 3/21/1997 | -80.0 | -11.2 | 9.6 | 103. | nd |
| S057 | NM228 | Embudo Spring | E | E | 4/29/1997 | -81.9 | -11.5 | 10.3 | 63.8 | nd |
| S057 | NM241 | Embudo Spring | E | E | 5/27/1997 | -81.6 | -11.7 | 11.6 | 48.6 | nd |
| S057 | NM242 | Embudo Spring | E | E | 5/27/1997 | nd | nd | nd | 46.2 | nd |
| S057 | NM365 | Embudo Spring | E | E | 7/17/1997 | -81.8 | -11.6 | 11.2 | nd | nd |
| S063 | NM282 | Windmill #22 | E | E | 6/28/1997 | -62.3 | -9.06 | 10.2 | 344. | nd |
| S067 | NM284 | Granite Hill | E | E | 7/4/1997 | -69.7 | -9.40 | 5.5 | 153. | nd |
| S070 | NM059 | HERTF | E | E | 6/28/1996 | -71.6 | -9.80 | 6.9 | 85.0 | - 1.3 |
| S091 | NM496 | Private Production Well #23 | E | E | 8/4/1998 | -79.8 | -10.8 | 6.7 | 40.7 | nd |
| S094 | NM293 | Stock Well #02 | E | E | 6/20/1997 | -58.5 | -8.07 | 6.1 | 170. | 0. |
| S099 | NM072 | LALF-1 | E | E | 6/29/1996 | -89.8 | -12.0 | 6.4 | 280. | nd |
| S112 | NM296 | Domestic Well #24 | E | E | 6/21/1997 | -58.5 | -8.60 | 10.2 | 247. | nd |
| S112 | NM297 | Domestic Well #24 | E | E | 6/21/1997 | -59.7 | -8.43 | 7.7 | 247. | 7.4 |
| S129 | NM087 | Montaňo 4 S | E | E | 6/19/1996 | -90.7 | -12.1 | 6.0 | 312. | -23. |
| S152 | NM098 | Private Production Well #07 | E | E | 8/22/1996 | -79.2 | -10.6 | 5.7 | 107. | nd |
| S182 | NM117 | Rio Bravo 4 S | E | E | 6/25/1996 | -90.0 | -11.8 | 4.7 | 271. | -14.7 |
| S202 | NM330 | Windmill #27 | E | E | 7/2/1997 | -61.5 | -9.03 | 10.7 | 672. | nd |
| S211 | NM512 | Sandia M | E | E | 7/30/1998 | -87.4 | -11.9 | 8.2 | 45.5 | 2.2 |
| S225 | NM149 | SBM-1 | E | E | 6/29/1996 | -91.2 | -12.0 | 4.6 | 573. | -17.4 |
| S249 | NM163 | Private Production Well #09 | E | E | 6/26/1996 | -80.4 | -11.2 | 8.9 | 30.0 | 5.7 |

**Table A9.** Summary of stable hydrogen, oxygen, and sulfur isotopic data from wells and springs-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Secondary hydro-chemical zone | Date | $\delta^2H$ (per mil) | $\delta^{18}O$ (per mil) | $^2H$ excess (per mil) | $SO_4^{2-}$ (mg/L) | $\delta^{34}S$ (per mil) |
|---|---|---|---|---|---|---|---|---|---|---|
| S249 | NM164 | Private Production Well #09 | E | E | 6/26/1996 | -80.5 | -11.2 | 9.0 | 29.3 | nd |
| S250 | NM165 | Private Production Well #10 | E | E | 6/26/1996 | -75.1 | -10.2 | 6.3 | 62.1 | nd |
| S251 | NM166 | Private Production Well #11 | E | E | 6/26/1996 | -80.2 | -11.3 | 10.5 | 38.4 | nd |
| S256 | NM169 | Tunnel Spring 1 | E | E | 6/18/1996 | -89.1 | -12.6 | 11.4 | 19.5 | - 5.6 |
| S256 | NM170 | Tunnel Spring 2 | E | E | 6/18/1996 | -89.2 | -12.6 | 11.7 | 19.5 | nd |
| S258 | NM524 | Vallecito Springs | E | E | 8/4/1998 | -81.9 | -11.4 | 9.3 | 35.4 | nd |
| S273 | NM176 | Windmill #11 | E | E | 8/19/1996 | -74.2 | -10.7 | 11.3 | 89.3 | nd |
| S282 | NM529 | Windmill #44 | E | E | 7/29/1998 | -72.3 | -9.74 | 5.6 | 829. | nd |
| SXXX | NM065 | Jemez Spring | E | E | 8/20/1996 | -84.7 | -11.0 | 3.2 | 41.6 | nd |
| SXXX | NM154 | Soda Dam Spring | E | E | 8/20/1996 | -85.9 | -10.5 | - 2.3 | 42.1 | nd |

**Table A10.** Summary of all stable hydrogen and oxygen isotope data for water from City of Albuquerque production wells

[NMXXX, sample number of this report; RWS, original "raw water sample number" of C. Yapp; COA, City of Albuquerque; Yapp (1985), see references; Lambert and Balsley (1997), see references; dms, degrees-minutes-seconds; $\delta^2$H, deuterium; $\delta^{18}$O, oxygen-18; $\delta=((R_{sample}/R_{standard})-1)\times1000$, where R is an isotope ratio; per mil, parts per thousand; nd, not determined]

| Sample no. or RWS no. | Well name | Date | Reported latitude (dms) | Reported longitude (dms) | Sample Collection | USGS $\delta^2$H (per mil) | USGS $\delta^{18}$O (per mil) | Reported Yapp (1985) $\delta^2$H (per mil) | Reported Lambert and Balsley (1997) $\delta^2$H (per mil) | Reported Lambert and Balsley (1997) $\delta^{18}$O (per mil) |
|---|---|---|---|---|---|---|---|---|---|---|
| 193 | Alameda 1 | 1/20/1982 | nd | nd | C. Yapp | -93.9 | -12.7 | -92 | | |
| 59 | Atrisco 1 | 2/10/1981 | 350418 | 1064122 | C. Yapp | -95.6 | -12.8 | | | |
| nd | Atrisco 1 | 8/7/1997 | 350418 | 1064122 | COA | -94.8 | -12.6 | | | |
| 7 | Atrisco 2 | 10/1/1980 | 350445 | 1064115 | C. Yapp | -93.3 | -12.6 | | | |
| 36 | Atrisco 2 | 11/6/1980 | 350445 | 1064115 | C. Yapp | -95.2 | -12.7 | | | |
| 47 | Atrisco 2 | 12/16/1980 | 350445 | 1064115 | C. Yapp | -93.1 | -12.5 | | | |
| 54 | Atrisco 2 | 1/14/1981 | 350445 | 1064115 | C. Yapp | -93.0 | -12.5 | | | |
| 58 | Atrisco 2 | 2/10/1981 | 350445 | 1064115 | C. Yapp | -93.2 | -12.5 | | | |
| 69 | Atrisco 2 | 4/8/1981 | 350445 | 1064115 | C. Yapp | -95.4 | -12.6 | | | |
| 77 | Atrisco 2 | 5/28/1981 | 350445 | 1064115 | C. Yapp | -92.8 | -12.6 | | | |
| 114 | Atrisco 2 | 6/29/1981 | 350445 | 1064115 | C. Yapp | -93.6 | -12.5 | | | |
| 123 | Atrisco 2 | 7/23/1981 | 350445 | 1064115 | C. Yapp | -93.0 | -12.5 | | | |
| 141 | Atrisco 2 | 8/18/1981 | 350445 | 1064115 | C. Yapp | -91.8 | -12.5 | -92 | | |
| 161 | Atrisco 2 | 9/29/1981 | 350445 | 1064115 | C. Yapp | -94.6 | -12.6 | | | |
| 170 | Atrisco 2 | 10/27/1981 | 350445 | 1064115 | C. Yapp | -96.3 | -12.6 | | | |
| 183 | Atrisco 2 | 11/20/1981 | 350445 | 1064115 | C. Yapp | -90.8 | -12.7 | | | |
| 270 | Atrisco 2 | 6/9/1982 | 350445 | 1064115 | C. Yapp | -94.7 | -12.7 | | | |
| nd | Atrisco 2 | 8/7/1997 | 350445 | 1064115 | COA | -93.0 | -12.5 | | | |
| 200 | Atrisco 3 | 1/20/1982 | 350513 | 1064118 | C. Yapp | -93.5 | -12.7 | | | |
| NM005 | Atrisco 3 | 6/20/1996 | 350516 | 1064121 | USGS | -93.6 | -12.6 | | | |
| nd | Atrisco 3 | 9/4/1997 | 350513 | 1064118 | COA | -93.7 | -12.7 | | | |
| nd | Atrisco 4 | 9/4/1997 | 350509 | 1064142 | COA | -94.9 | -12.7 | | | |
| nd | Burton 1 | 8/6/1997 | 350359 | 1063624 | COA | -97.4 | -13.0 | | | |
| NM012 | Burton 2 | 6/19/1996 | 350421 | 1063613 | USGS | -96.4 | -13.1 | | | |
| nd | Burton 2 | 8/15/1997 | 350421 | 1063610 | COA | -95.9 | -13.1 | | | |
| 144 | Burton 3 | 8/18/1981 | 350440 | 1063558 | C. Yapp | -97.5 | -13.2 | -96 | | |
| 209 | Burton 3 | 1/20/1982 | 350440 | 1063558 | C. Yapp | -96.7 | -13.1 | -95 | | |
| nd | Burton 3 | 8/15/1997 | 350440 | 1063558 | COA | -97.3 | -13.2 | | -96.0 | -13.2 |
| nd | Burton 4 | 8/6/1997 | 350343 | 1063633 | COA | -96.0 | -13.2 | | | |
| NM013 | Burton 5 | 6/19/1996 | 350355 | 1063517 | USGS | -96.0 | -13.1 | | | |
| nd | Burton 5 | 9/19/1997 | 350355 | 1063515 | COA | -96.9 | -13.2 | | | |
| 134 | Candelaria 1 | 8/18/1981 | 350705 | 1063813 | C. Yapp | -97.8 | -12.8 | -94 | | |
| 159 | Candelaria 1 | 9/29/1981 | 350705 | 1063813 | C. Yapp | -94.8 | -12.6 | | | |
| 168 | Candelaria 1 | 10/27/1981 | 350705 | 1063813 | C. Yapp | -97.6 | -12.7 | | | |
| 45 | Candelaria 4 | 12/16/1980 | 350705 | 1063817 | C. Yapp | -96.6 | -13.1 | | | |
| 112 | Candelaria 4 | 6/29/1981 | 350705 | 1063817 | C. Yapp | -96.8 | -12.9 | | | |
| 121 | Candelaria 4 | 7/23/1981 | 350705 | 1063817 | C. Yapp | -97.0 | -12.9 | | | |
| nd | Charles 1 | 8/8/1997 | 350628 | 1063348 | COA | -95.9 | -13.2 | | | |
| nd | Charles 2 | 8/1/1997 | 350606 | 1063411 | COA | -96.8 | -13.3 | | | |
| nd | Charles 3 | 8/1/1997 | 350640 | 1063426 | COA | -99.3 | -13.5 | | | |
| 213 | Charles 4 | 1/20/1982 | 350640 | 1063426 | C. Yapp | -85.2 | -11.8 | -83 | | |
| NM016 | Charles 4 | 6/22/1996 | 350559 | 1063339 | USGS | -88.9 | -12.2 | | | |
| NM017 | Charles 4 | 6/27/1996 | 350559 | 1063339 | USGS | -88.0 | -12.2 | | | |
| NM018 | Charles 4 | 6/27/1996 | 350559 | 1063339 | USGS | -89.6 | -12.1 | | | |
| NM019 | Charles 4 | 6/27/1996 | 350559 | 1063339 | USGS | -87.4 | -12.1 | | | |
| NM020 | Charles 4 | 6/27/1996 | 350559 | 1063339 | USGS | -90.7 | -12.1 | | | |
| NM021 | Charles 4 | 6/27/1996 | 350559 | 1063339 | USGS | -88.4 | -12.2 | | | |

**Table A10.** Summary of all stable hydrogen, and oxygen isotope data for water from City of Albuquerque production wells-- Continued

| Sample no. or RWS no. | Well name | Date | Reported latitude (dms) | Reported longitude (dms) | Sample Collection | USGS $\delta^{2}H$ (per mil) | USGS $\delta^{18}O$ (per mil) | Reported Yapp (1985) $\delta^{2}H$ (per mil) | Reported Lambert and Balsley (1997) $\delta^{2}H$ (per mil) | Reported Lambert and Balsley (1997) $\delta^{18}O$ (per mil) |
|---|---|---|---|---|---|---|---|---|---|---|
| NM022 | Charles 4 | 6/27/1996 | 350559 | 1063339 | USGS | -89.6 | -12.2 | | | |
| NM023 | Charles 4 | 6/27/1996 | 350559 | 1063339 | USGS | -91.2 | -12.2 | | | |
| NM024 | Charles 4 | 6/27/1996 | 350559 | 1063339 | USGS | -89.1 | -12.2 | | | |
| nd | Charles 4 | 8/1/1997 | 350602 | 1063332 | COA | -87.0 | -12.3 | | | |
| nd | Charles 5 | 8/8/1997 | 350615 | 1063459 | COA | -97.9 | -13.3 | | | |
| 202 | College 1 | 1/20/1982 | 350643 | 1064442 | C. Yapp | -92.1 | -12.2 | -90 | | |
| nd | College 1 | 8/13/1997 | 350646 | 1064433 | COA | -88.4 | -11.8 | | -92.0 | -12.0 |
| 266 | College 2 | 6/9/1982 | 350647 | 1064400 | C. Yapp | -98.9 | -12.9 | | | |
| NM264 | College 2 | 6/19/1997 | 350647 | 1064400 | USGS | -109.0 | -14.4 | | | |
| nd | College 2 | 7/11/1997 | 350647 | 1064400 | COA | -107.5 | -14.4 | | | |
| NM028 | Coronado 1 | 6/18/1996 | 351023 | 1063418 | USGS | -94.7 | -12.6 | | | |
| nd | Coronado 1 | 7/25/1997 | 351025 | 1063417 | COA | -94.0 | -12.6 | | | |
| nd | Coronado 2 | 7/25/1997 | 351007 | 1063438 | COA | -95.6 | -13.1 | | | |
| 139 | Don 1 | 8/18/1981 | 350416 | 1064518 | C. Yapp | -105.2 | -13.8 | -104 | | |
| 204 | Don 1 | 1/20/1982 | 350416 | 1064518 | C. Yapp | -105.6 | -13.9 | -103 | | |
| 268 | Don 1 | 6/9/1982 | 350416 | 1064518 | C. Yapp | -104.6 | -13.7 | | | |
| NM032 | Duranes 1 | 6/20/1996 | 350641 | 1064006 | USGS | -93.5 | -12.4 | | | |
| NM033 | Duranes 1 | 6/28/1996 | 350641 | 1064006 | USGS | -92.0 | -12.3 | | | |
| NM034 | Duranes 1 | 6/28/1996 | 350641 | 1064006 | USGS | -92.8 | -12.4 | | | |
| NM035 | Duranes 1 | 6/28/1996 | 350641 | 1064006 | USGS | -92.3 | -12.5 | | | |
| NM036 | Duranes 1 | 6/28/1996 | 350641 | 1064006 | USGS | -92.4 | -12.4 | | | |
| NM037 | Duranes 1 | 6/28/1996 | 350641 | 1064006 | USGS | -91.8 | -12.3 | | | |
| NM038 | Duranes 1 | 6/28/1996 | 350641 | 1064006 | USGS | -92.3 | -12.4 | | | |
| NM039 | Duranes 1 | 6/28/1996 | 350641 | 1064006 | USGS | -94.2 | -12.3 | | | |
| NM040 | Duranes 1 | 6/28/1996 | 350641 | 1064006 | USGS | -95.1 | -12.3 | | | |
| nd | Duranes 1 | 8/1/1997 | 350640 | 1064005 | COA | -93.3 | -12.6 | | | |
| nd | Duranes 2 | 8/14/1997 | 350708 | 1064058 | COA | -94.4 | -12.9 | | | |
| 6 | Duranes 3 | 10/1/1980 | 350629 | 1064051 | C. Yapp | -96.0 | -12.7 | | | |
| 38 | Duranes 3 | 11/6/1980 | 350629 | 1064051 | C. Yapp | -95.0 | -12.7 | | | |
| 46 | Duranes 3 | 12/16/1980 | 350629 | 1064051 | C. Yapp | -90.9 | -12.3 | | | |
| 136 | Duranes 3 | 8/18/1981 | 350629 | 1064051 | C. Yapp | -94.1 | -12.7 | -92 | | |
| nd | Duranes 3 | 9/11/1997 | 350629 | 1064051 | COA | -94.4 | -12.7 | | | |
| 53 | Duranes 4 | 1/14/1981 | 350628 | 1064115 | C. Yapp | -96.2 | -12.8 | | | |
| 60 | Duranes 4 | 2/10/1981 | 350628 | 1064115 | C. Yapp | -95.2 | -12.7 | | | |
| 68 | Duranes 4 | 4/8/1981 | 350628 | 1064115 | C. Yapp | -96.4 | -12.7 | | | |
| 76 | Duranes 4 | 5/28/1981 | 350628 | 1064115 | C. Yapp | -93.9 | -12.8 | | | |
| 113 | Duranes 4 | 6/29/1981 | 350628 | 1064115 | C. Yapp | -95.3 | -12.8 | | | |
| 122 | Duranes 4 | 7/23/1981 | 350628 | 1064115 | C. Yapp | -94.6 | -12.7 | | | |
| 160 | Duranes 4 | 9/29/1981 | 350628 | 1064115 | C. Yapp | -95.5 | -12.8 | | | |
| 169 | Duranes 4 | 10/27/1981 | 350628 | 1064115 | C. Yapp | -97.3 | -12.9 | | | |
| 184 | Duranes 4 | 11/20/1981 | 350628 | 1064115 | C. Yapp | -96.0 | -12.8 | | | |
| 199 | Duranes 4 | 1/20/1982 | 350628 | 1064115 | C. Yapp | -93.9 | -12.8 | -92 | | |
| 271 | Duranes 4 | 6/9/1982 | 350628 | 1064115 | C. Yapp | -96.3 | -12.8 | | | |
| nd | Duranes 4 | 9/11/1997 | 350628 | 1064115 | COA | -94.5 | -12.8 | | -94.0 | -12.9 |
| nd | Duranes 5 | 9/18/1997 | 350605 | 1064118 | COA | -93.5 | -12.7 | | | |
| nd | Duranes 6 | 8/1/1997 | 350653 | 1064030 | COA | -92.0 | -12.6 | | | |
| NM270 | Duranes 7 | 6/26/1997 | 350656 | 1064112 | USGS | -93.4 | -12.7 | | | |
| nd | Duranes 7 | 8/14/1997 | 350656 | 1064110 | COA | -94.8 | -12.7 | | | |
| NM056 | Gonzales 1 | 6/20/1996 | 350641 | 1064232 | USGS | -100.2 | -13.2 | | | |
| nd | Gonzales 1 | 8/27/1997 | 350642 | 1064228 | COA | -98.1 | -13.3 | | | |

**Table A10.** Summary of all stable hydrogen, and oxygen isotope data for water from City of Albuquerque production wells-- Continued

| Sample no. or RWS no. | Well name | Date | Reported latitude (dms) | Reported longitude (dms) | Sample Collection | USGS $\delta^2H$ (per mil) | USGS $\delta^{18}O$ (per mil) | Reported Yapp (1985) $\delta^2H$ (per mil) | Reported Lambert and Balsley (1997) $\delta^2H$ (per mil) | Reported Lambert and Balsley (1997) $\delta^{18}O$ (per mil) |
|---|---|---|---|---|---|---|---|---|---|---|
| nd | Gonzales 2 | 8/27/1997 | 350635 | 1064150 | COA | -95.3 | -12.9 | | | |
| nd | Gonzales 3 | 8/7/1997 | nd | nd | COA | -96.5 | -13.1 | | | |
| nd | Griegos 1 | 8/22/1997 | 350827 | 1063950 | COA | -94.3 | -13.0 | | | |
| NM057 | Griegos 3 | 6/21/1996 | 350811 | 1064003 | USGS | -96.0 | -12.9 | | | |
| nd | Griegos 3 | 12/10/1997 | 350802 | 1064029 | COA | -95.4 | -12.8 | | | |
| 135 | Griegos 4 | 8/18/1981 | 350821 | 1063901 | C. Yapp | -96.2 | -13.1 | -96 | | |
| 198 | Griegos 4 | 1/20/1982 | 350821 | 1063901 | C. Yapp | -96.9 | -13.1 | -95 | | |
| nd | Griegos 4 | 8/22/1997 | 350821 | 1063901 | COA | -96.4 | -13.1 | | -97.0 | -13.2 |
| 140 | Leavitt 1 | 8/18/1981 | 350309 | 1064345 | C. Yapp | -104.7 | -13.7 | -103 | | |
| 172 | Leavitt 1 | 10/27/1981 | 350309 | 1064345 | C. Yapp | -105.3 | -13.8 | | | |
| 182 | Leavitt 1 | 11/20/1981 | 350309 | 1064345 | C. Yapp | -102.5 | -13.9 | | | |
| 205 | Leavitt 1 | 1/20/1982 | 350309 | 1064345 | C. Yapp | -106.3 | -13.8 | -102 | | |
| 269 | Leavitt 1 | 6/9/1982 | 350309 | 1064345 | C. Yapp | -106.3 | -13.7 | | | |
| nd | Leavitt 1 | 8/28/1997 | 350309 | 1064345 | COA | -99.7 | -13.3 | | | |
| nd | Leavitt 2 | 8/28/1997 | 350248 | 1064340 | COA | -96.1 | -12.8 | | | |
| nd | Leavitt 3 | 8/29/1997 | 350223 | 1064354 | COA | -100.1 | -13.4 | | | |
| NM074 | Leyendecker 1 | 6/21/1996 | 350752 | 1063423 | USGS | -99.1 | -13.4 | | | |
| nd | Leyendecker 1 | 7/10/1997 | 350752 | 1063421 | COA | -96.2 | -13.4 | | | |
| nd | Leyendecker 2 | 7/24/1997 | 350727 | 1063408 | COA | -98.3 | -13.4 | | | |
| 196 | Leyendecker 3 | 1/20/1982 | 350819 | 1063440 | C. Yapp | -99.6 | -13.5 | -98 | | |
| nd | Leyendecker 3 | 7/10/1997 | 350819 | 1063440 | COA | -100.1 | -13.4 | | -98.0 | -13.6 |
| 132 | Leyendecker 4 | 8/18/1981 | 350815 | 1063406 | C. Yapp | -98.0 | -13.5 | -98 | | |
| nd | Leyendecker 4 | 7/24/1997 | 350815 | 1063406 | COA | -98.0 | -13.3 | | -97.0 | -13.5 |
| NM075 | Lomas 1 | 6/22/1996 | 350431 | 1063028 | USGS | -76.2 | -10.5 | | | |
| nd | Lomas 1 | 9/12/1997 | 350430 | 1063024 | COA | -75.7 | -10.4 | | | |
| 147 | Lomas 2 | 8/18/1981 | 350459 | 1063046 | C. Yapp | -78.7 | -10.8 | -78 | | |
| 210 | Lomas 2 | 1/20/1982 | 350459 | 1063046 | C. Yapp | -78.7 | -10.9 | -77 | | |
| nd | Lomas 5 | 8/15/1997 | 350422 | 1063124 | COA | -78.2 | -11.1 | | | |
| nd | Lomas 6 | 8/6/1997 | 350408 | 1063101 | COA | -80.4 | -11.0 | | | |
| NM078 | Love 1 | 6/22/1996 | 350517 | 1063145 | USGS | -80.2 | -11.2 | | | |
| nd | Love 1 | 8/14/1997 | 350517 | 1063144 | COA | -78.6 | -11.2 | | | |
| 146 | Love 3 | 8/18/1981 | 350511 | 1063214 | C. Yapp | -78.6 | -11.4 | -80 | | |
| 211 | Love 3 | 1/20/1982 | 350511 | 1063214 | C. Yapp | -80.9 | -11.4 | -80 | | |
| nd | Love 3 | 9/11/1997 | 350511 | 1063214 | COA | -82.0 | -11.4 | | -82.0 | -11.6 |
| nd | Love 4 | 8/14/1997 | 350511 | 1063256 | COA | -84.6 | -11.8 | | | |
| nd | Love 5 | 9/11/1997 | 350452 | 1063239 | COA | -86.1 | -11.8 | | | |
| nd | Love 6 | 9/5/1997 | 350553 | 1063138 | COA | -80.1 | -11.2 | | | |
| 212 | Love 7 | 1/20/1982 | 350607 | 1063213 | C. Yapp | -81.8 | -11.5 | -79 | | |
| nd | Love 7 | 9/5/1997 | 350607 | 1063213 | COA | -81.6 | -11.5 | | -83.0 | -11.6 |
| nd | Love 8 | 9/12/1997 | nd | nd | COA | -91.4 | -12.6 | | | |
| nd | Miles 1 | 7/31/1997 | 350308 | 1063746 | COA | -95.2 | -13.1 | | | |
| NM106 | Ponderosa 1 | 6/20/1996 | 350931 | 1063156 | USGS | -89.3 | -12.1 | | | |
| nd | Ponderosa 1 | 8/15/1997 | 350933 | 1063155 | COA | -88.3 | -12.1 | | | |
| 3 | Ponderosa 2 | 10/1/1980 | 350800 | 1063150 | C. Yapp | -78.2 | -11.1 | | | |
| 35 | Ponderosa 2 | 11/6/1980 | 350800 | 1063150 | C. Yapp | -81.4 | -11.2 | | | |
| 44 | Ponderosa 2 | 12/16/1980 | 350800 | 1063150 | C. Yapp | -79.8 | -11.0 | | | |
| 62 | Ponderosa 2 | 2/10/1981 | 350800 | 1063150 | C. Yapp | -77.6 | -11.2 | | | |
| 66 | Ponderosa 2 | 4/8/1981 | 350800 | 1063150 | C. Yapp | -80.4 | -11.1 | | | |
| 73 | Ponderosa 2 | 5/28/1981 | 350800 | 1063150 | C. Yapp | -78.5 | -11.1 | | | |
| 108 | Ponderosa 2 | 6/29/1981 | 350800 | 1063150 | C. Yapp | -79.7 | -11.1 | | | |

**Table A10.** Summary of all stable hydrogen, and oxygen isotope data for water from City of Albuquerque production wells-- Continued

| Sample no. or RWS no. | Well name | Date | Reported latitude (dms) | Reported longitude (dms) | Sample Collection | USGS $\delta^{2}H$ (per mil) | USGS $\delta^{18}O$ (per mil) | Reported Yapp (1985) $\delta^{2}H$ (per mil) | Reported Lambert and Balsley (1997) $\delta^{2}H$ (per mil) | Reported Lambert and Balsley (1997) $\delta^{18}O$ (per mil) |
|---|---|---|---|---|---|---|---|---|---|---|
| 118 | Ponderosa 2 | 7/23/1981 | 350800 | 1063150 | C. Yapp | -78.6 | -11.2 | | | |
| 129 | Ponderosa 2 | 8/18/1981 | 350800 | 1063150 | C. Yapp | -77.2 | -11.2 | -77 | | |
| 155 | Ponderosa 2 | 9/29/1981 | 350800 | 1063150 | C. Yapp | -81.0 | -11.2 | | | |
| 188 | Ponderosa 2 | 11/20/1981 | 350800 | 1063150 | C. Yapp | -77.8 | -11.1 | | | |
| nd | Ponderosa 2 | 9/19/1997 | 350800 | 1063150 | COA | -81.7 | -11.5 | | -81.0 | -11.6 |
| nd | Ponderosa 3 | 9/12/1997 | 350820 | 1063217 | COA | -91.8 | -12.6 | | | |
| nd | Ponderosa 5 | 8/22/1997 | 350918 | 1063154 | COA | -84.0 | -11.7 | | | |
| nd | Ponderosa 6 | 8/22/1997 | 350851 | 1063220 | COA | -91.4 | -12.6 | | | |
| nd | Ridgecrest 1 | 7/24/1997 | 350405 | 1063220 | COA | -79.0 | -11.0 | | | |
| nd | Ridgecrest 2 | 7/24/1997 | 350427 | 1063234 | COA | -84.0 | -11.7 | | | |
| 145 | Ridgecrest 3 | 8/18/1981 | 350401 | 1063314 | C. Yapp | -83.9 | -11.7 | -82 | | |
| NM108 | Ridgecrest 3 | 6/22/1996 | 350413 | 1063313 | USGS | -85.9 | -11.7 | | -84.0 | -11.9 |
| nd | Ridgecrest 3 | 7/25/1997 | 350401 | 1063314 | COA | -83.3 | -11.8 | | -84.0 | -11.9 |
| NM321 | Ridgecrest 4 | 6/26/1997 | 350445 | 1063341 | USGS | -93.3 | -12.7 | | | |
| nd | Ridgecrest 4 | 7/25/1997 | 350445 | 1063340 | COA | -92.4 | -12.8 | | | |
| nd | Ridgecrest 5 | 7/31/1997 | 350420 | 1063344 | COA | -94.9 | -12.8 | | | |
| nd | San Jose 1 | 8/29/1997 | 350316 | 1063848 | COA | -92.9 | -12.4 | | | |
| NM140 | San Jose 2 | 6/20/1996 | 350338 | 1063832 | USGS | -99.2 | -13.3 | | | |
| nd | San Jose 2 | 8/29/1997 | 350336 | 1063832 | COA | -99.2 | -13.3 | | | |
| nd | San Jose 3 | 8/29/1997 | 350343 | 1063901 | COA | -97.8 | -13.2 | | | |
| 142 | San Jose 5 | 8/18/1981 | 350240 | 1063839 | C. Yapp | -99.5 | -13.2 | -98 | | |
| 207 | San Jose 5 | 1/20/1982 | nd | nd | C. Yapp | -98.9 | -13.2 | -96 | | |
| 272 | San Jose 5 | 6/9/1982 | 350240 | 1063839 | C. Yapp | -99.0 | -13.3 | | | |
| 214 | Santa Barbara 1 | 1/20/1982 | 350648 | 1063625 | C. Yapp | -98.3 | -13.4 | -96 | | |
| NM147 | Santa Barbara 1 | 6/19/1996 | 350648 | 1063625 | USGS | -98.8 | -13.3 | | -98.0 | -13.4 |
| NM337 | Santa Barbara 1 | 6/26/1997 | 350648 | 1063628 | USGS | -98.9 | -13.4 | | -98.0 | -13.4 |
| nd | Santa Barbara 1 | 9/18/1997 | 350648 | 1063625 | COA | -98.2 | -13.3 | | -98.0 | -13.4 |
| nd | Thomas 1 | 7/11/1997 | 350753 | 1063256 | COA | -85.1 | -11.8 | | | |
| nd | Thomas 2 | 7/11/1997 | 350747 | 1063233 | COA | -84.7 | -11.6 | | | |
| 4 | Thomas 3 | 10/1/1980 | nd | nd | C. Yapp | -90.3 | -12.3 | | | |
| 34 | Thomas 3 | 11/6/1980 | 350813 | 1063321 | C. Yapp | -93.5 | -12.5 | | | |
| 43 | Thomas 3 | 12/16/1980 | 350813 | 1063321 | C. Yapp | -96.6 | -13.0 | | | |
| 52 | Thomas 3 | 1/14/1981 | 350813 | 1063321 | C. Yapp | -96.0 | -12.9 | | | |
| 61 | Thomas 3 | 2/10/1981 | 350813 | 1063321 | C. Yapp | -92.9 | -12.7 | | | |
| 67 | Thomas 3 | 4/8/1981 | 350813 | 1063321 | C. Yapp | -92.1 | -12.5 | | | |
| 74 | Thomas 3 | 5/28/1981 | 350813 | 1063321 | C. Yapp | -91.5 | -12.4 | | | |
| 110 | Thomas 3 | 6/29/1981 | 350813 | 1063321 | C. Yapp | -93.5 | -12.8 | | | |
| 119 | Thomas 3 | 7/23/1981 | 350813 | 1063321 | C. Yapp | -91.5 | -12.5 | | | |
| 131 | Thomas 3 | 8/18/1981 | 350813 | 1063321 | C. Yapp | -94.5 | -13.0 | -94 | | |
| 156 | Thomas 3 | 9/29/1981 | 350813 | 1063321 | C. Yapp | -90.7 | -12.4 | | | |
| 186 | Thomas 3 | 11/20/1981 | 350813 | 1063321 | C. Yapp | -97.3 | -13.0 | | | |
| 195 | Thomas 3 | 1/20/1982 | 350813 | 1063321 | C. Yapp | -95.0 | -13.0 | -93 | | |
| nd | Thomas 3 | 9/5/1997 | 350813 | 1063321 | COA | -92.1 | -12.7 | | | |
| 109 | Thomas 4 | 6/29/1981 | 350813 | 1063240 | C. Yapp | -87.4 | -12.1 | | | |
| 130 | Thomas 4 | 8/18/1981 | 350813 | 1063240 | C. Yapp | -88.3 | -12.1 | -87 | | |
| 157 | Thomas 4 | 9/29/1981 | 350813 | 1063240 | C. Yapp | -87.5 | -12.1 | | | |
| 165 | Thomas 4 | 10/27/1981 | 350813 | 1063240 | C. Yapp | -89.3 | -12.1 | | | |
| 166 | Thomas 4 | 10/27/1981 | 350813 | 1063240 | C. Yapp | -95.4 | -13.1 | | | |
| 187 | Thomas 4 | 11/20/1981 | 350813 | 1063240 | C. Yapp | -87.9 | -12.2 | | | |
| 194 | Thomas 4 | 1/20/1982 | 350813 | 1063240 | C. Yapp | -88.9 | -12.2 | -86 | | |

**Table A10.** Summary of all stable hydrogen, and oxygen isotope data for water from City of Albuquerque production wells-- Continued

| Sample no. or RWS no. | Well name | Date | Reported latitude (dms) | Reported longitude (dms) | Sample Collection | USGS $\delta^2H$ (per mil) | USGS $\delta^{18}O$ (per mil) | Reported Yapp (1985) $\delta^2H$ (per mil) | Reported Lambert and Balsley (1997) $\delta^2H$ (per mil) | Reported Lambert and Balsley (1997) $\delta^{18}O$ (per mil) |
|---|---|---|---|---|---|---|---|---|---|---|
| nd | Thomas 4 | 8/15/1997 | 350813 | 1063240 | COA | -87.0 | -12.2 | | -86.0 | -12.1 |
| nd | Thomas 5 | 8/6/1997 | 350744 | 1063335 | COA | -98.2 | -13.3 | | | |
| NM162 | Thomas 6 | 6/21/1996 | 350720 | 1063305 | USGS | -89.0 | -12.3 | | | |
| nd | Thomas 6 | 1/6/1998 | 350720 | 1063304 | COA | -94.6 | -12.8 | | | |
| nd | Thomas 7 | 8/6/1997 | 350719 | 1063334 | COA | -94.1 | -13.1 | | | |
| nd | Thomas 8 | 8/15/1997 | 350711 | 1063231 | COA | -91.9 | -12.5 | | | |
| 206 | Valley Gardens | 1/20/1982 | 350028 | 1064224 | C. Yapp | -96.2 | -12.9 | -92 | | |
| 167 | Vol Andia 1 | 10/27/1981 | 350805 | 1063549 | C. Yapp | -99.7 | -13.4 | | | |
| nd | Vol Andia 1 | 8/13/1997 | 350805 | 1063549 | COA | -96.3 | -13.1 | | | |
| NM172 | Vol Andia 2 | 6/21/1996 | 350732 | 1063504 | USGS | -97.3 | -13.4 | | | |
| nd | Vol Andia 2 | 1/6/1998 | 350732 | 1063501 | COA | -100.2 | -13.4 | | | |
| nd | Vol Andia 3 | 8/13/1997 | 350747 | 1063614 | COA | -98.5 | -13.3 | | | |
| 51 | Vol Andia 4 | 1/4/1981 | 350803 | 1063511 | C. Yapp | -99.9 | -13.4 | | | |
| nd | Vol Andia 4 | 9/12/1997 | 350803 | 1063511 | COA | -98.9 | -13.4 | | | |
| 42 | Vol Andia 5 | 12/16/1980 | 350809 | 1063609 | C. Yapp | -99.6 | -13.4 | | | |
| NM173 | Vol Andia 5 | 6/18/1996 | 350805 | 1063611 | USGS | -96.4 | -13.3 | | | |
| nd | Vol Andia 5 | 7/31/1997 | 350809 | 1063609 | COA | -99.5 | -13.3 | | | |
| 5 | Vol Andia 6 | 10/1/1980 | 350828 | 1063521 | C. Yapp | -100.9 | -13.4 | | | |
| 75 | Vol Andia 6 | 5/28/1981 | 350828 | 1063521 | C. Yapp | -100.0 | -13.5 | | | |
| 111 | Vol Andia 6 | 6/29/1981 | 350828 | 1063521 | C. Yapp | -102.2 | -13.5 | | | |
| 120 | Vol Andia 6 | 7/23/1981 | 350828 | 1063521 | C. Yapp | -97.7 | -13.5 | | | |
| 133 | Vol Andia 6 | 8/18/1981 | 350828 | 1063521 | C. Yapp | -100.8 | -13.5 | -98 | | |
| 158 | Vol Andia 6 | 9/29/1981 | 350828 | 1063521 | C. Yapp | -100.7 | -13.5 | | | |
| 185 | Vol Andia 6 | 11/20/1981 | 350828 | 1063521 | C. Yapp | -99.1 | -13.6 | | | |
| 197 | Vol Andia 6 | 1/20/1982 | 350828 | 1063521 | C. Yapp | -98.3 | -13.3 | -96 | | |
| nd | Vol Andia 6 | 7/31/1997 | 350828 | 1063521 | COA | -97.6 | -13.4 | | -99.0 | -13.4 |
| 252 | Volcano Cliffs 1 | 4/9/1982 | 350950 | 1064340 | C. Yapp | -94.5 | -12.7 | | | |
| NM346 | Volcano Cliffs 1 | 6/19/1997 | 350935 | 1064343 | USGS | -96.4 | -12.7 | | | |
| nd | Volcano Cliffs 1 | 8/7/1997 | 350950 | 1064340 | COA | -95.1 | -12.6 | | | |
| 137 | Volcano Cliffs 2 | 8/18/1981 | 350914 | 1064340 | C. Yapp | -91.2 | -12.7 | -94 | | |
| 173 | Volcano Cliffs 2 | 10/27/1981 | 350914 | 1064340 | C. Yapp | -96.9 | -12.7 | | | |
| 180 | Volcano Cliffs 2 | 11/20/1981 | 350914 | 1064340 | C. Yapp | -92.1 | -12.6 | | | |
| 201 | Volcano Cliffs 2 | 1/20/1982 | 350914 | 1064340 | C. Yapp | -93.8 | -12.5 | -90 | | |
| 253 | Volcano Cliffs 2 | 4/9/1982 | 350914 | 1064340 | C. Yapp | -94.6 | -12.6 | | | |
| 265 | Volcano Cliffs 2 | 6/9/1982 | 350914 | 1064340 | C. Yapp | -95.8 | -12.6 | | | |
| nd | Volcano Cliffs 2 | 8/27/1997 | 350914 | 1064340 | COA | -95.3 | -12.8 | | -97.0 | -12.9 |
| nd | Volcano Cliffs 3 | 8/27/1997 | 351002 | 1064346 | COA | -93.7 | -12.7 | | | |
| NM174 | Walker 1 | 6/18/1996 | 351025 | 1063140 | USGS | -84.1 | -11.9 | | | |
| nd | Walker 1 | 8/21/1997 | 351026 | 1063139 | COA | -85.9 | -11.8 | | -83.0 | -12.0 |
| nd | Walker 2 | 8/21/1997 | 351023 | 1063214 | COA | -92.3 | -12.5 | | -91.0 | -12.7 |
| NM175 | Webster 1 | 6/18/1996 | 351029 | 1063320 | USGS | -97.0 | -13.0 | | | |
| nd | Webster 1 | 8/28/1997 | 351029 | 1063320 | COA | -97.0 | -13.0 | | | |
| nd | Webster 2 | 8/28/1997 | 351013 | 1063335 | COA | -98.9 | -13.3 | | | |
| nd | West Mesa 1 | 7/10/1997 | 350428 | 1064418 | COA | -108.2 | -14.3 | | | |
| 8 | West Mesa 3 | 10/1/1980 | 350444 | 1064354 | C. Yapp | -102.9 | -13.4 | | | |
| 37 | West Mesa 3 | 11/6/1980 | 350444 | 1064354 | C. Yapp | -107.1 | -13.9 | | | |
| 48 | West Mesa 3 | 12/16/1980 | nd | nd | C. Yapp | -91.2 | -12.1 | | | |
| 55 | West Mesa 3 | 1/14/1981 | 350444 | 1064354 | C. Yapp | -93.6 | -12.2 | | | |
| 57 | West Mesa 3 | 2/10/1981 | 350444 | 1064354 | C. Yapp | -93.3 | -12.2 | | | |
| 70 | West Mesa 3 | 4/8/1981 | 350444 | 1064354 | C. Yapp | -103.7 | -13.7 | | | |

**Table A10.** Summary of all stable hydrogen, and oxygen isotope data for water from City of Albuquerque production wells-- Continued

| Sample no. or RWS no. | Well name | Date | Reported latitude (dms) | Reported longitude (dms) | Sample Collection | USGS $\delta^2H$ (per mil) | USGS $\delta^{18}O$ (per mil) | Reported Yapp (1985) $\delta^2H$ (per mil) | Reported Lambert and Balsley (1997) $\delta^2H$ (per mil) | Reported Lambert and Balsley (1997) $\delta^{18}O$ (per mil) |
|---|---|---|---|---|---|---|---|---|---|---|
| 78 | West Mesa 3 | 5/28/1981 | 350444 | 1064354 | C. Yapp | -104.2 | -13.8 | | | |
| 115 | West Mesa 3 | 6/29/1981 | 350444 | 1064354 | C. Yapp | -103.0 | -13.7 | | | |
| 124 | West Mesa 3 | 7/23/1981 | 350444 | 1064354 | C. Yapp | -103.8 | -13.7 | | | |
| 138 | West Mesa 3 | 8/18/1981 | 350444 | 1064354 | C. Yapp | -103.6 | -13.8 | -102 | | |
| 162 | West Mesa 3 | 9/29/1981 | 350444 | 1064354 | C. Yapp | -93.2 | -12.2 | | | |
| 171 | West Mesa 3 | 10/27/1981 | 350444 | 1064354 | C. Yapp | -99.2 | -13.3 | | | |
| 181 | West Mesa 3 | 11/20/1981 | 350444 | 1064354 | C. Yapp | -105.4 | -13.7 | | | |
| 203 | West Mesa 3 | 1/20/1982 | 350444 | 1064354 | C. Yapp | -104.4 | -13.8 | -102 | | |
| 267 | West Mesa 3 | 6/9/1982 | 350444 | 1064354 | C. Yapp | -104.4 | -13.7 | | | |
| NM353 | West Mesa 3 | 6/19/1997 | 350444 | 1064354 | USGS | -92.5 | -12.2 | | | |
| nd | West Mesa 3 | 7/10/1997 | 350444 | 1064354 | COA | -99.8 | -13.1 | | | |
| nd | West Mesa 4 | 8/29/1997 | 350442 | 1064318 | COA | -104.2 | -13.8 | | | |
| 143 | Yale 1 | 8/18/1981 | 350426 | 1063726 | C. Yapp | -98.3 | -13.2 | -96 | | |
| 208 | Yale 1 | 1/20/1982 | nd | nd | C. Yapp | -98.8 | -13.2 | -95 | | |
| NM178 | Yale 1 | 6/19/1996 | 350427 | 1063729 | USGS | -98.2 | -13.2 | | -97 | -13.3 |
| nd | Yale 1 | 9/10/1997 | 350426 | 1063726 | COA | -97.3 | -13.2 | | -97 | -13.3 |
| nd | Yale 2 | 9/10/1997 | 350358 | 1063729 | COA | -95.2 | -13.0 | | | |
| nd | Yale 3 | 9/19/1997 | 350435 | 1063801 | COA | -97.8 | -13.1 | | | |
| nd | Zamora 1 | 8/13/1997 | 350918 | 1064254 | COA | -95.3 | -12.9 | | | |

## **Table A11.** Summary of Tritium, CFC-12, $^{13}C$, and $^{14}C$ data for wells and springs

[SXXX, no site number assigned; Hydrochemical Zone "E", exotic water, no primary or secondary zone assigned; CFC-12, dichlorodifluoromethane ($CF_2Cl_2$); $\delta^{13}C$, carbon-13; $^{14}C$, carbon-14; per mil, parts per thousand; pmC, percent modern carbon; TU, Tritium Unit, 1 TU=1 atom of $^3H$ in $10^{18}$ atoms of H; 1σ, one standard deviation; pg/kg, picograms per kilogram; $\delta=((R_{sample}/R_{standard})-1)x1000$, where R is an isotope ratio; Source of tritium data: L, Noble Gas Laboratory of Lamont-Doherty Earth Observatory, Palisades New York, by $^3He$ ingrowth; M, US Geological Survey Low-Level Tritium Laboratory in Menlo Park, California, by liquid scintillation counting of enriched samples; all ground-water tritium data from source M included in this table. See table A12 for additional tritium data from source L; na, not applicable; nd, not determined]

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Second-ary hydro-chemical zone | Date | Tritium (TU) | Tritium error ± 1σ (TU) | Source of tritium data L or M | CFC-12 (pg/kg) | $\delta^{13}C$ (per mil) | $^{14}C$ (pmC) | $^{14}C$ error (pmC) | Unadjusted $^{14}C$ age, Libby half-life (years) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Zone 1: Northern Mountain Front** | | | | | | | | | | | |
| S027 | NM486 | CEPO 02 | 1 | na | 8/3/1998 | nd | nd | na | 2 | -6.89 | 21.3 | 0.2 | 12,415 |
| S034 | NM027 | Private Production Well #04 | 1 | na | 8/28/1996 | nd | nd | na | 0 | -10.8 | 51.9 | 0.6 | 5,264 |
| S035 | NM487 | Windmill #37 | 1 | na | 7/31/1998 | 17.2 | 0.6 | M | nd | -11.7 | 97.9 | 0.7 | 170 |
| S036 | NM026 | Private Production Well #03 | 1 | na | 8/28/1996 | nd | nd | na | 1 | -8.10 | 82.6 | 0.9 | 1,540 |
| S065 | NM055 | Domestic Well #05 | 1 | na | 8/17/1996 | nd | nd | na | 6 | -6.18 | 27.0 | 0.3 | 10,518 |
| S187 | NM131 | Rio Rancho 12 | 1 | na | 8/13/1996 | 0.4 | 0.3 | M | 6 | -9.60 | 24.8 | 0.2 | 11,188 |
| S206 | NM510 | Windmill #38 | 1 | 3 | 8/3/1998 | -0.1 | 0.3 | M | nd | -8.90 | 13.0 | 0.2 | 16,395 |
| S216 | NM143 | Windmill #09 | 1 | na | 8/27/1996 | 0.1 | 0.3 | M | 17 | -6.08 | 39.7 | 0.5 | 7,421 |
| S221 | NM530 | Windmill #45 | 1 | na | 8/20/1998 | 0.2 | 0.2 | M | nd | -5.83 | 12.2 | 0.2 | 16,926 |
| S222 | NM514 | Windmill #39 | 1 | 3 | 8/6/1998 | 0.5 | 0.3 | M | nd | -4.31 | 10.4 | 0.2 | 18,181 |
| S254 | NM168 | Private Production Well #12 | 1 | na | 8/28/1996 | nd | nd | na | 0 | -10.8 | 92.0 | 0.8 | 667 |
| S277 | NM525 | Windmill #40 | 1 | na | 7/28/1998 | 1.0 | 0.3 | M | nd | -7.47 | 50.7 | 0.4 | 5,456 |
| S279 | NM527 | Windmill #42 | 1 | na | 7/28/1998 | 8.1 | 0.4 | M | nd | -13.4 | 106. | 0.8 | -489 |
| S281 | NM528 | Windmill #43 | 1 | 3 | 7/28/1998 | 0.3 | 0.3 | M | nd | -10.3 | 22.3 | 0.2 | 12,043 |
| | | **Zone 2: Northwestern** | | | | | | | | | | | |
| S103 | NM497 | Lincoln D | 2 | na | 7/23/1998 | nd | nd | na | 3 | -8.44 | 13.8 | 0.2 | 15,909 |
| S104 | NM498 | Lincoln M | 2 | na | 7/23/1998 | nd | nd | na | 0 | -7.08 | 15.5 | 0.2 | 14,997 |
| S105 | NM499 | Lincoln S | 2 | na | 7/23/1998 | 0.01 | 0.05 | L | 4 | -6.46 | 29.6 | 0.4 | 9,768 |
| S191 | NM326 | Rio Rancho 4 | 2 | 3 | 6/20/1997 | nd | nd | na | 108 | -6.70 | 19.8 | 0.2 | 13,021 |
| S192 | NM128 | Rio Rancho 8 | 2 | 3 | 8/13/1996 | nd | nd | na | 0 | -7.62 | 14.7 | 0.2 | 15,385 |
| S189 | NM133 | Rio Rancho 15 | 2 | na | 8/13/1996 | nd | nd | na | 0 | -6.93 | 18.3 | 0.2 | 13,655 |
| S276 | NM179 | Windmill #12 | 2 | na | 8/27/1996 | 0.0 | 0.3 | M | nd | -7.25 | 38.1 | 0.4 | 7,756 |
| S278 | NM526 | Windmill #41 | 2 | na | 7/29/1998 | 0.6 | 0.3 | M | nd | -7.09 | 71.3 | 0.5 | 2,718 |
| S280 | NM180 | Windmill #13 | 2 | na | 8/27/1996 | 0.4 | 0.3 | M | nd | -5.04 | 84.5 | 0.9 | 1,356 |
| S286 | NM184 | Private Production Well #13 | 2 | na | 8/26/1996 | nd | nd | na | 5 | -6.61 | 71.2 | 0.6 | 2,729 |
| S287 | NM185 | Private Production Well #14 | 2 | na | 8/26/1996 | nd | nd | na | 0 | -6.20 | 37.4 | 0.4 | 7,903 |
| | | **Zone 3: West Central** | | | | | | | | | | | |
| S003 | NM251 | 98th St. D | 3 | na | 6/17/1997 | nd | nd | na | 3 | -7.40 | 0.62 | 0.1 | 40,833 |
| S003 | NM481 | 98th St. D | 3 | na | 8/4/1998 | nd | nd | na | 16 | -7.15 | 0.13 | 0.1 | 53,382 |
| S004 | NM252 | 98th St. MD | 3 | na | 6/18/1997 | nd | nd | na | 1 | -7.40 | 3.98 | 0.1 | 25,897 |
| S004 | NM482 | 98th St. MD | 3 | na | 8/4/1998 | nd | nd | na | 29 | -7.51 | 3.69 | 0.1 | 26,505 |
| S005 | NM253 | 98th St. MS | 3 | na | 7/4/1997 | nd | nd | na | 4 | nd | nd | nd | nd |
| S005 | NM483 | 98th St. MS | 3 | na | 8/4/1998 | nd | nd | na | 21 | -4.95 | 0.79 | 0.1 | 38,887 |
| S006 | NM484 | 98th St. S | 3 | na | 8/5/1998 | 0.06 | 0.04 | L | 31 | -7.62 | 6.37 | 0.2 | 22,119 |
| S006 | NM254 | 98th St. S | 3 | na | 6/17/1997 | nd | nd | na | 74 | nd | nd | nd | nd |
| S008 | NM003 | Private Production Well #01 | 3 | na | 8/12/1996 | 0.7 | 0.3 | M | 0 | -7.76 | 5.47 | 0.1 | 23,343 |
| S010 | NM255 | Private Production Well #16 | 3 | na | 6/23/1997 | nd | nd | na | 72,872 | -8.60 | 9.31 | 0.3 | 19,071 |
| S018 | NM260 | Domestic Well #21 | 3 | na | 6/26/1997 | nd | nd | na | 32 | -7.30 | 11.0 | 0.1 | 17,753 |
| S019 | NM007 | Belen 4 | 3 | 5 | 8/16/1996 | 0.5 | 0.3 | M | 45 | -7.18 | 14.6 | 0.2 | 15,484 |
| S020 | NM008 | Belen 5 | 3 | 5 | 8/16/1996 | nd | nd | na | 0 | -6.65 | 16.4 | 0.2 | 14,537 |
| S029 | NM015 | Cerro Colorado Landfill PW | 3 | 5 | 8/12/1996 | nd | nd | na | 0 | -7.22 | 7.35 | 0.1 | 20,970 |
| S037 | NM264 | College 2 | 3 | na | 6/19/1997 | nd | nd | na | 1 | -7.80 | 5.39 | 0.1 | 23,461 |
| S066 | NM056 | Gonzales 1 | 3 | 12 | 6/20/1996 | 2.66 | 0.17 | L | 7 | -7.30 | 47.0 | 0.4 | 6,058 |
| S086 | NM492 | Isleta D | 3 | na | 7/29/1998 | nd | nd | na | 7 | -8.74 | 2.71 | 0.2 | 28,985 |
| S101 | NM294 | Leavitt 1 | 3 | na | 6/26/1997 | nd | nd | na | 6 | -7.10 | 17.3 | 0.1 | 14,103 |
| S108 | NM076 | Los Lunas 3 | 3 | 12 | 8/14/1996 | nd | nd | na | 1 | -7.52 | 27.6 | 0.2 | 10,356 |
| S109 | NM077 | Los Lunas 4 | 3 | 12 | 8/14/1996 | nd | nd | na | 0 | -8.65 | 50.5 | 0.4 | 5,496 |
| S145 | NM308 | NM Utilities 1 | 3 | na | 6/18/1997 | nd | nd | na | 0 | -6.60 | 13.9 | 0.2 | 15,845 |
| S147 | NM310 | NM Utilities 3 | 3 | na | 6/18/1997 | nd | nd | na | 0 | -7.70 | 15.7 | 0.2 | 14,878 |
| S148 | NM311 | NM Utilities 4 | 3 | na | 6/18/1997 | nd | nd | na | 0 | -7.00 | 7.36 | 0.1 | 20,959 |
| S166 | NM509 | Rabbit Hill | 3 | na | 8/4/1998 | nd | nd | na | 2 | -4.53 | 8.59 | 0.1 | 19,717 |
| S167 | NM107 | Domestic Well #12 | 3 | na | 8/14/1996 | nd | nd | na | 0 | -7.89 | 5.85 | 0.1 | 22,803 |
| S172 | NM322 | Rio Bravo 5 D | 3 | na | 7/4/1997 | nd | nd | na | 0 | -8.90 | 3.11 | 0.1 | 27,879 |
| S174 | NM109 | Rio Bravo 1 D | 3 | 12 | 6/17/1996 | 0.00 | 0.01 | L | 0 | -7.27 | 15.1 | 0.2 | 15,181 |
| S175 | NM110 | Rio Bravo 1 M | 3 | 12 | 6/17/1996 | 0.00 | 0.02 | L | 2 | -7.09 | 33.2 | 0.3 | 8,855 |
| S186 | NM130 | Rio Rancho 10 | 3 | na | 8/13/1996 | nd | nd | na | 0 | -7.03 | 12.2 | 0.2 | 16,912 |
| S188 | NM132 | Rio Rancho 13 | 3 | na | 8/13/1996 | nd | nd | na | 0 | -7.10 | 3.00 | 0.1 | 28,168 |

**Table A11.** Summary of Tritium, CFC-12, $^{13}C$, and $^{14}C$ data for wells and springs-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Second-ary hydro-chemical zone | Date | Tritium (TU) | Tritium error ± 1 σ (TU) | Source of tritium data L or M | CFC-12 (pg/kg) | $\delta^{13}C$ (per mil) | $^{14}C$ (pmC) | $^{14}C$ error (pmC) | Unadjusted $^{14}C$ age, Libby half-life (years) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S193 | NM129 | Rio Rancho 9 | 3 | na | 8/13/1996 | 0.0 | 0.3 | M | 26 | -7.81 | 7.72 | 0.1 | 20,575 |
| S196 | NM135 | Windmill #05 | 3 | na | 8/21/1996 | 0.0 | 0.3 | M | 94 | -7.38 | 36.8 | 0.3 | 8,037 |
| S200 | NM139 | Private Production Well #08 | 3 | na | 8/29/1996 | nd | nd | na | 1 | -7.08 | 9.23 | 0.2 | 19,140 |
| S217 | NM144 | Santa Ana Boundary D | 3 | na | 8/22/1996 | nd | nd | na | 1 | -7.18 | 6.47 | 0.1 | 21,994 |
| S218 | NM145 | Santa Ana Boundary M | 3 | na | 8/22/1996 | nd | nd | na | 6 | -6.81 | 8.24 | 0.1 | 20,052 |
| S219 | NM146 | Santa Ana Boundary S | 3 | na | 8/22/1996 | nd | nd | na | 4 | -6.64 | 5.54 | 0.2 | 23,241 |
| S230 | NM516 | Sierra Vista D | 3 | na | 7/22/1998 | nd | nd | na | 0 | -5.53 | 1.89 | 0.1 | 31,879 |
| S236 | NM155 | SAF (Soil Amendment Facility) | 3 | na | 8/12/1996 | 0.4 | 0.3 | M | 77 | -8.01 | 4.50 | 0.1 | 24,911 |
| S241 | NM519 | SWAB Test Hole 1 D | 3 | 1 | 8/5/1998 | 0.1 | 0.3 | M | nd | -6.87 | 6.57 | 0.2 | 21,871 |
| S242 | NM520 | SWAB Test Hole 1 S | 3 | 1 | 8/1/1998 | -0.1 | 0.3 | M | nd | -8.92 | 9.12 | 0.1 | 19,236 |
| S243 | NM521 | SWAB Test Hole 2 D | 3 | na | 8/7/1998 | 0.1 | 0.3 | M | nd | -8.28 | 14.4 | 0.2 | 15,595 |
| S263 | NM346 | Volcano Cliff 1 | 3 | na | 6/19/1997 | nd | nd | na | 3 | -7.10 | 9.45 | 0.1 | 18,951 |
| S266 | NM347 | West Bluff Nest 1 Well 1 | 3 | na | 6/23/1997 | nd | nd | na | 0 | -6.40 | 2.00 | 0.1 | 31,425 |
| S272 | NM353 | West Mesa 3 | 3 | na | 6/19/1997 | nd | nd | na | 0 | -6.80 | 9.00 | 0.1 | 19,343 |
| S283 | NM181 | Zia Ball Park D | 3 | na | 8/26/1996 | nd | nd | na | 0 | -6.12 | 18.3 | 0.2 | 13,625 |
| S284 | NM182 | Zia Ball Park M | 3 | na | 8/26/1996 | nd | nd | na | 1 | -6.39 | 20.7 | 0.2 | 12,660 |
| S285 | NM183 | Zia Ball Park S | 3 | 2 | 8/26/1996 | nd | nd | na | 1 | -6.93 | 22.2 | 0.3 | 12,079 |
| S288 | NM186 | Zia BMT D | 3 | na | 8/27/1996 | 1.0 | 0.4 | M | nd | -8.27 | 8.29 | 0.2 | 20,003 |
| | | **Zone 4: Western Boundary** | | | | | | | | | | | |
| S031 | NM263 | Windmill #18 | 4 | na | 6/24/1997 | -0.7 | 0.2 | M | nd | -4.60 | 8.14 | 0.1 | 20,150 |
| S039 | NM266 | Windmill #20 | 4 | na | 6/21/1997 | -0.1 | 0.3 | M | nd | -1.70 | 0.79 | 0.1 | 38,887 |
| S059 | NM278 | Windmill #21 | 4 | na | 6/23/1997 | 0.1 | 0.3 | M | 14 | -6.90 | 9.80 | 0.1 | 18,659 |
| S074 | NM285 | Windmill #23 | 4 | na | 6/21/1997 | 0.1 | 0.3 | M | nd | -0.90 | 4.24 | 0.1 | 25,389 |
| S169 | NM320 | Rest Area | 4 | na | 6/30/1997 | 15.6 | 0.6 | M | nd | -5.50 | 80.7 | 0.7 | 1,720 |
| S201 | NM329 | Windmill #26 | 4 | na | 7/2/1997 | 0.0 | 0.3 | M | nd | -4.80 | 2.68 | 0.1 | 29,074 |
| S252 | NM167 | Windmill #10 | 4 | na | 8/29/1996 | 0.5 | 0.3 | M | nd | -6.17 | 9.69 | 0.2 | 18,749 |
| S260 | NM345 | Windmill #33 | 4 | na | 6/25/1997 | 0.5 | 0.3 | M | nd | -3.20 | 3.29 | 0.1 | 27,427 |
| | | **Zone 5: Rio Puerco** | | | | | | | | | | | |
| S032 | NM262 | Windmill #17 | 5 | na | 6/24/1997 | 0.3 | 0.3 | M | nd | -3.50 | 29.8 | 0.2 | 9,736 |
| S069 | NM058 | Domestic Well #06 | 5 | na | 8/16/1996 | 0.2 | 0.3 | M | 52 | -9.31 | 36.5 | 0.4 | 8,107 |
| S073 | NM062 | Windmill #03 | 5 | na | 8/16/1996 | -0.2 | 0.3 | M | nd | -6.99 | 49.1 | 0.4 | 5,720 |
| S082 | NM409 | Windmill #36 | 5 | na | 9/10/1997 | 0.1 | 0.3 | M | 42 | -12.3 | 43.3 | 0.4 | 6,733 |
| S085 | NM408 | Windmill #35 | 5 | na | 9/10/1997 | 0.2 | 0.3 | M | 99 | -9.80 | 13.2 | 0.1 | 16,254 |
| S111 | NM079 | Domestic Well #10 | 5 | na | 8/16/1996 | nd | nd | na | 0 | -6.76 | 54.7 | 0.5 | 4,842 |
| S185 | NM324 | Domestic Well #31 | 5 | na | 6/16/1997 | nd | nd | na | 12 | -10.6 | 36.3 | 0.4 | 8,134 |
| S198 | NM137 | Windmill #07 | 5 | na | 8/21/1996 | 7.3 | 0.4 | M | 44 | -4.65 | 84.5 | 0.7 | 1,354 |
| S237 | NM341 | Windmill #30 | 5 | 4 | 6/24/1997 | 0.0 | 0.3 | M | nd | -7.40 | 23.8 | 0.3 | 11,538 |
| S238 | NM342 | Windmill #31 | 5 | na | 6/24/1997 | -0.3 | 0.3 | M | nd | -7.90 | 32.9 | 0.4 | 8,935 |
| | | **Zone 6: Southwestern Mountain Front** | | | | | | | | | | | |
| S022 | NM009 | Windmill #02 | 6 | na | 8/19/1996 | 0.0 | 0.3 | M | nd | -5.76 | 40.0 | 0.4 | 7,356 |
| | | **Zone 7: Abo Arroyo** | | | | | | | | | | | |
| S021 | NM261 | Stock Well #01 | 7 | na | 6/23/1997 | 11.77 | 0.23 | L | 221 | -5.40 | 83.9 | 0.7 | 1,407 |
| S024 | NM011 | Domestic Well #02 | 7 | 8 | 8/17/1996 | 0.0 | 0.3 | M | 2 | -6.94 | 17.1 | 0.2 | 14,201 |
| S090 | NM064 | Domestic Well #08 | 7 | na | 8/19/1996 | nd | nd | na | 3 | -6.49 | 13.0 | 0.2 | 16,395 |
| S093 | NM067 | Domestic Well #09 | 7 | 8 | 8/15/1996 | nd | nd | na | 1 | -8.54 | 31.1 | 0.3 | 9,382 |
| | | **Zone 8: Eastern Mountain Front** | | | | | | | | | | | |
| S007 | NM002 | Domestic Well #01 | 8 | na | 6/21/1996 | 10.57 | 0.18 | L | 327 | -11.8 | 113. | 1.0 | -1,010 |
| S013 | NM256 | Windmill #14 | 8 | na | 6/24/1997 | 1.7 | 0.2 | M | nd | -9.60 | 74.0 | 0.6 | 2,421 |
| S014 | NM257 | Private Production Well #17 | 8 | na | 6/19/1997 | -0.2 | 0.3 | M | nd | -7.40 | 79.8 | 0.7 | 1,810 |
| S015 | NM006 | Windmill #01 | 8 | na | 8/24/1996 | 7.2 | 0.4 | M | nd | -8.26 | 97.7 | 0.9 | 184 |
| S030 | NM018 | Charles 4 | 8 | na | 6/27/1996 | nd | nd | na | 1 | nd | nd | nd | nd |
| S030 | NM020 | Charles 4 | 8 | na | 6/27/1996 | nd | nd | na | 0 | nd | nd | nd | nd |
| S030 | NM019 | Charles 4 | 8 | na | 6/27/1996 | 0.01 | 0.01 | L | 0 | nd | nd | nd | nd |
| S030 | NM021 | Charles 4 | 8 | na | 6/27/1996 | 0.01 | 0.01 | L | 0 | nd | nd | nd | nd |
| S030 | NM023 | Charles 4 | 8 | na | 6/27/1996 | 0.01 | 0.01 | L | 0 | nd | nd | nd | nd |
| S030 | NM024 | Charles 4 | 8 | na | 6/27/1996 | 0.01 | 0.01 | L | 0 | nd | nd | nd | nd |
| S030 | NM016 | Charles 4 | 8 | na | 6/22/1996 | 0.03 | 0.01 | L | 0 | -8.54 | 51.4 | 0.4 | 5,348 |
| S030 | NM022 | Charles 4 | 8 | na | 6/27/1996 | nd | nd | na | 0 | nd | nd | nd | nd |
| S042 | NM031 | Domestic Well #03 | 8 | na | 8/14/1996 | nd | nd | na | 0 | -7.95 | 21.0 | 0.2 | 12,537 |
| S055 | NM042 | Elena Gallegos | 8 | na | 6/25/1996 | nd | nd | na | 207 | -10.5 | 109. | 0.9 | -705 |
| S056 | NM043 | Embudito Spring | 8 | na | 7/2/1996 | 7.82 | 0.16 | L | 220 | -14.1 | 115. | 1.1 | -1,095 |
| S056 | NM227 | Embudito Spring | 8 | na | 4/29/1997 | 10.0 | 0.5 | M | 287 | nd | nd | nd | nd |
| S056 | NM227 | Embudito Spring | 8 | na | 4/29/1997 | 10.0 | 0.5 | M | 324 | nd | nd | nd | nd |
| S056 | NM364 | Embudito Spring | 8 | na | 7/17/1997 | 10.1 | 0.5 | M | nd | nd | nd | nd | nd |
| S056 | NM239 | Embudito Spring | 8 | na | 5/27/1997 | 11.2 | 0.5 | M | nd | nd | nd | nd | nd |

**Table A11.** Summary of Tritium, CFC-12, $^{13}C$, and $^{14}C$ data for wells and springs-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Second-ary hydro-chemical zone | Date | Tritium (TU) | Tritium error ± 1 σ (TU) | Source of tritium data L or M | CFC-12 (pg/kg) | $\delta^{13}C$ (per mil) | $^{14}C$ (pmC) | $^{14}C$ error (pmC) | Unadjusted $^{14}C$ age, Libby half-life (years) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S056 | NM213 | Embudito Spring | 8 | na | 3/21/1997 | nd | nd | na | 419 | nd | nd | nd | nd |
| S056 | NM214 | Embudito Spring | 8 | na | 3/21/1997 | nd | nd | na | 401 | nd | nd | nd | nd |
| S071 | NM060 | Domestic Well #07 | 8 | na | 6/19/1996 | 0.19 | 0.01 | L | 0 | -8.75 | 97.5 | 0.8 | 205 |
| S083 | NM407 | Windmill #34 | 8 | na | 9/10/1997 | -0.2 | 0.3 | M | 17 | -5.50 | 17.2 | 0.3 | 14,159 |
| S095 | NM068 | Kirtland 1 | 8 | na | 6/25/1996 | 0.05 | 0.01 | L | 12 | -8.89 | 59.4 | 0.5 | 4,187 |
| S106 | NM295 | Domestic Well #23 | 8 | na | 6/26/1997 | -0.01 | 0.04 | L | 0 | -8.20 | 11.2 | 0.1 | 17,615 |
| S110 | NM078 | Love 1 | 8 | na | 6/22/1996 | 0.05 | 0.01 | L | 10 | -7.63 | 47.2 | 0.4 | 6,029 |
| S113 | NM080 | Domestic Well #11 | 8 | na | 8/15/1996 | nd | nd | na | 1 | -7.43 | 8.33 | 0.1 | 19,964 |
| S114 | NM500 | Matheson D | 8 | na | 7/31/1998 | nd | nd | na | 50 | -11.0 | 35.4 | 0.3 | 8,353 |
| S115 | NM501 | Matheson M | 8 | na | 8/1/1998 | nd | nd | na | 43 | -10.2 | 55.9 | 0.4 | 4,676 |
| S116 | NM502 | Matheson S | 8 | na | 8/1/1998 | 0.01 | 0.05 | L | 5 | -9.35 | 64.9 | 0.5 | 3,475 |
| S117 | NM298 | Domestic Well #25 | 8 | na | 6/17/1997 | 0.22 | 0.03 | L | 13 | -9.00 | 95.1 | 0.7 | 406 |
| S118 | NM299 | Windmill #24 | 8 | na | 6/27/1997 | 0.5 | 0.3 | M | nd | -5.90 | 37.4 | 0.4 | 7,898 |
| S119 | NM300 | Domestic Well #26 | 8 | 11 | 6/19/1997 | nd | nd | na | 551 | -7.80 | 47.4 | 0.3 | 6,000 |
| S122 | NM505 | Mesa Del Sol S | 8 | na | 7/25/1998 | 0.02 | 0.05 | L | 12 | -9.88 | 33.4 | 0.3 | 8,819 |
| S122 | NM304 | Mesa Del Sol S | 8 | na | 6/29/1997 | nd | nd | na | 18 | -10.8 | 19.3 | 0.2 | 13,227 |
| S140 | NM306 | MRN 1 | 8 | na | 7/5/1997 | nd | nd | na | 0 | -7.70 | 42.2 | 0.3 | 6,925 |
| S141 | NM095 | National Utility 7 | 8 | na | 8/14/1996 | -0.3 | 0.3 | M | 785 | -5.97 | 68.8 | 0.6 | 3,001 |
| S149 | NM312 | Nor Este D | 8 | na | 7/3/1997 | nd | nd | na | 0 | -8.70 | 7.96 | 0.1 | 20,329 |
| S150 | NM313 | Nor Este M | 8 | na | 7/2/1997 | nd | nd | na | 0 | -8.60 | 17.1 | 0.2 | 14,177 |
| S162 | NM317 | Stock Well #03 | 8 | na | 6/30/1997 | nd | nd | na | 0 | -8.20 | 52.7 | 0.5 | 5,152 |
| S163 | NM318 | PL 2 | 8 | na | 7/7/1997 | nd | nd | na | 0 | -8.20 | 38.8 | 0.4 | 7,599 |
| S164 | NM106 | Ponderosa 1 | 8 | na | 6/20/1996 | 0.03 | 0.01 | L | 0 | -9.25 | 42.5 | 0.4 | 6,883 |
| S165 | NM328 | Windmill #25 | 8 | na | 6/24/1997 | 0.0 | 0.3 | M | nd | -8.90 | 10.2 | 0.2 | 18,377 |
| S168 | NM319 | Domestic Well #30 | 8 | na | 6/27/1997 | nd | nd | na | 9 | -9.20 | 5.41 | 0.1 | 23,431 |
| S170 | NM108 | Ridgecrest 3 | 8 | na | 6/22/1996 | nd | nd | na | 0 | -12.2 | 70.3 | 0.7 | 2,837 |
| S170 | NM412 | Ridgecrest 3 | 8 | na | 11/18/1997 | 0.0 | 0.3 | M | nd | nd | nd | nd | nd |
| S195 | NM134 | Domestic Well #13 | 8 | na | 8/14/1996 | nd | nd | na | 0 | -8.24 | 22.2 | 0.2 | 12,076 |
| S199 | NM138 | Windmill #08 | 8 | na | 8/23/1996 | 0.2 | 0.3 | M | nd | -6.30 | 57.2 | 0.5 | 4,494 |
| S209 | NM336 | Domestic Well #33 | 8 | na | 6/27/1997 | nd | nd | na | 0 | -8.70 | 15.8 | 0.2 | 14,817 |
| S212 | NM141 | Sandia Peak 1 | 8 | na | 6/26/1996 | 0.02 | 0.01 | L | 3 | -9.73 | 78.0 | 0.7 | 1,998 |
| S213 | NM142 | Sandia Peak 3 | 8 | na | 6/26/1996 | 0.02 | 0.01 | L | 13 | -9.30 | 83.2 | 0.7 | 1,475 |
| S224 | NM148 | Domestic Well #14 | 8 | na | 8/23/1996 | nd | nd | na | 0 | -7.56 | 79.9 | 0.7 | 1,802 |
| S229 | NM515 | SH03 UNM | 8 | na | 7/28/1998 | 8.28 | 0.17 | L | 4 | -9.42 | 96.3 | 0.8 | 302 |
| S233 | NM153 | Domestic Well #16 | 8 | na | 8/23/1996 | nd | nd | na | 1 | -7.14 | 32.6 | 0.3 | 9,011 |
| S239 | NM156 | Domestic Well #17 | 8 | na | 8/17/1996 | nd | nd | na | 10,691 | -8.92 | 22.0 | 0.3 | 12,163 |
| S240 | NM157 | Domestic Well #18 | 8 | na | 6/19/1996 | 0.01 | 0.01 | L | 0 | -10.5 | 66.4 | 0.6 | 3,287 |
| S246 | NM343 | Windmill #32 | 8 | na | 6/24/1997 | -0.1 | 0.3 | M | nd | -5.90 | 31.2 | 0.3 | 9,364 |
| S247 | NM161 | Domestic Well #19 | 8 | na | 8/15/1996 | nd | nd | na | 1 | -8.50 | 4.86 | 0.1 | 24,293 |
| S248 | NM162 | Thomas 6 | 8 | na | 6/21/1996 | 0.02 | 0.01 | L | 0 | -8.95 | 44.2 | 0.4 | 6,557 |
| S255 | NM523 | Tramway East | 8 | na | 7/30/1998 | -0.1 | 0.3 | M | 4 | -10.4 | 54.0 | 0.4 | 4,954 |
| S264 | NM174 | Walker 1 | 8 | na | 6/18/1996 | -0.4 | 0.3 | M | 0 | -9.26 | 41.6 | 0.3 | 7,038 |
| S274 | NM177 | Domestic Well #20 | 8 | na | 8/15/1996 | nd | nd | na | 0 | -5.80 | 24.7 | 0.2 | 11,246 |
| | | **Zone 9: Tijeras Fault Zone** | | | | | | | | | | | |
| S041 | NM029 | Coyote Spring | 9 | na | 6/28/1996 | 0.29 | 0.03 | L | 92 | nd | nd | nd | nd |
| S041 | NM030 | Coyote Spring | 9 | na | 7/1/1996 | nd | nd | na | nd | -0.60 | 4.83 | 0.1 | 24,342 |
| S072 | NM061 | Hubbell Spring | 9 | 8 | 8/23/1996 | nd | nd | na | 78 | -6.40 | 42.8 | 0.4 | 6,817 |
| S098 | NM071 | KAFB-1902 | 9 | na | 6/28/1996 | 2.69 | 0.05 | L | 1,626 | nd | nd | nd | nd |
| S197 | NM136 | Windmill #06 | 9 | na | 8/23/1996 | 0.2 | 0.3 | M | 31 | -8.22 | 4.76 | 0.1 | 24,460 |
| S227 | NM151 | SFR 3D | 9 | na | 8/24/1996 | nd | nd | na | 4 | -0.98 | 9.67 | 0.1 | 18,766 |
| S228 | NM152 | SFR 3S | 9 | na | 8/24/1996 | nd | nd | na | 10 | -0.95 | 13.2 | 0.2 | 16,242 |
| | | **Zone 10: Tijeras Arroyo** | | | | | | | | | | | |
| S001 | NM001 | 4Hills-1 | 10 | 8 | 6/29/1996 | 3.95 | 0.08 | L | 364 | -8.40 | 94.0 | 0.7 | 501 |
| S002 | NM250 | Private Production Well #15 | 10 | 8 | 7/3/1997 | nd | nd | na | 785 | -6.80 | 82.7 | 0.7 | 1,526 |
| S058 | NM277 | Eubank 1 | 10 | 8 | 7/4/1997 | 1.7 | 0.4 | M | 185 | -6.20 | 62.0 | 0.5 | 3,835 |
| S096 | NM069 | Kirtland 11 | 10 | 8 | 6/25/1996 | 0.04 | 0.01 | L | 0 | -7.90 | 46.0 | 0.4 | 6,241 |
| S107 | NM075 | Lomas 1 | 10 | 8 | 6/22/1996 | nd | nd | na | 0 | -6.20 | 72.8 | 0.6 | 2,552 |
| | | **Zone 11: Northeastern** | | | | | | | | | | | |
| S016 | NM258 | Windmill #15 | 11 | na | 6/18/1997 | 0.0 | 0.2 | M | nd | -5.30 | 28.5 | 0.2 | 10,078 |
| S017 | NM259 | Windmill #16 | 11 | na | 6/18/1997 | -0.2 | 0.3 | M | nd | -7.40 | 18.1 | 0.2 | 13,726 |
| S053 | NM276 | Private Production Well #18 | 11 | na | 6/25/1997 | 13.7 | 0.6 | M | nd | -5.60 | 76.5 | 0.7 | 2,150 |
| S144 | NM097 | Private Production Well #06 | 11 | na | 8/28/1996 | nd | nd | na | 1 | -6.80 | 29.2 | 0.4 | 9,886 |
| S204 | NM332 | Windmill #28 | 11 | na | 7/3/1997 | -0.3 | 0.3 | M | nd | -6.40 | 19.6 | 0.3 | 13,107 |
| S207 | NM334 | Private Production Well #22 | 11 | na | 7/3/1997 | nd | nd | na | 0 | -6.10 | 69.3 | 0.5 | 2,941 |
| S223 | NM338 | Windmill #29 | 11 | na | 6/25/1997 | 0.1 | 0.3 | M | nd | -6.70 | 19.5 | 0.3 | 13,115 |

**Table A11.** Summary of Tritium, CFC-12, $^{13}C$, and $^{14}C$ data for wells and springs-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Second-ary hydro-chemical zone | Date | Tritium (TU) | Tritium error ± 1 σ (TU) | Source of tritium data L or M | CFC-12 (pg/kg) | $\delta^{13}C$ (per mil) | $^{14}C$ (pmC) | $^{14}C$ error (pmC) | Unadjusted $^{14}C$ age, Libby half-life (years) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Zone 12: Central** | | | | | | | | | | | |
| S011 | NM004 | Atris-1 | 12 | na | 6/22/1996 | 11.01 | 0.22 | L | 82 | -8.34 | 96.8 | 0.8 | 264 |
| S012 | NM005 | Atrisco 3 | 12 | 3 | 6/20/1996 | 9.65 | 0.20 | L | 10 | -8.31 | 64.7 | 0.5 | 3,496 |
| S025 | NM012 | Burton 2 | 12 | na | 6/19/1996 | 0.08 | 0.01 | L | 47 | -9.08 | 47.7 | 0.4 | 5,941 |
| S026 | NM013 | Burton 5 | 12 | na | 6/19/1996 | 0.01 | 0.01 | L | 0 | -9.35 | 44.7 | 0.4 | 6,475 |
| S033 | NM025 | Private Production Well #02 | 12 | na | 8/21/1996 | 16.0 | 0.6 | M | 29 | -10.6 | 96.4 | 1.2 | 297 |
| S040 | NM028 | Coronado 1 | 12 | na | 6/18/1996 | 0.03 | 0.01 | L | 332 | -8.50 | 32.8 | 0.3 | 8,962 |
| S043 | NM267 | Del Sol D | 12 | na | 7/1/1997 | nd | nd | na | 1 | -8.00 | 6.37 | 0.1 | 22,119 |
| S043 | NM488 | Del Sol D | 12 | na | 7/21/1998 | nd | nd | na | 0 | -8.27 | 6.20 | 0.1 | 22,337 |
| S044 | NM268 | Del Sol M | 12 | na | 6/26/1997 | nd | nd | na | 0 | -8.00 | 14.5 | 0.2 | 15,523 |
| S044 | NM489 | Del Sol M | 12 | na | 7/21/1998 | nd | nd | na | 0 | -8.33 | 13.7 | 0.2 | 15,997 |
| S045 | NM490 | Del Sol S | 12 | na | 7/21/1998 | 0.18 | 0.04 | L | 16 | -9.06 | 62.2 | 0.5 | 3,813 |
| S045 | NM269 | Del Sol S | 12 | na | 6/26/1997 | nd | nd | na | 19 | nd | nd | nd | nd |
| S046 | NM032 | Duranes 1 | 12 | na | 6/20/1996 | 10.6 | 0.5 | M | 78 | -10.9 | 73.1 | 0.6 | 2,516 |
| S046 | NM036 | Duranes 1 | 12 | na | 6/29/1996 | nd | nd | na | 163 | nd | nd | nd | nd |
| S046 | NM033 | Duranes 1 | 12 | na | 6/29/1996 | nd | nd | na | 179 | nd | nd | nd | nd |
| S046 | NM034 | Duranes 1 | 12 | na | 6/29/1996 | 11.90 | 0.30 | L | 160 | nd | nd | nd | nd |
| S046 | NM035 | Duranes 1 | 12 | na | 6/29/1996 | 17.06 | 0.34 | L | 165 | nd | nd | nd | nd |
| S046 | NM037 | Duranes 1 | 12 | na | 6/29/1996 | nd | nd | na | 173 | nd | nd | nd | nd |
| S046 | NM038 | Duranes 1 | 12 | na | 6/29/1996 | nd | nd | na | 176 | nd | nd | nd | nd |
| S046 | NM039 | Duranes 1 | 12 | na | 6/29/1996 | nd | nd | na | 180 | nd | nd | nd | nd |
| S046 | NM040 | Duranes 1 | 12 | na | 6/29/1996 | nd | nd | na | 183 | nd | nd | nd | nd |
| S047 | NM270 | Duranes 7 | 12 | na | 6/26/1997 | 7.6 | 0.4 | M | 33 | -9.10 | 72.0 | 0.6 | 2,644 |
| S048 | NM271 | Duranes Yard 1 | 12 | na | 7/5/1997 | 16.4 | 0.6 | M | 5 | nd | nd | nd | nd |
| S049 | NM272 | Duranes Yard 2 | 12 | na | 7/5/1997 | 8.4 | 0.5 | M | 16 | nd | nd | nd | nd |
| S050 | NM273 | Duranes Yard 3 | 12 | na | 7/5/1997 | 9.9 | 0.5 | M | 67 | nd | nd | nd | nd |
| S051 | NM274 | Duranes Yard 4 | 12 | na | 7/5/1997 | 10.0 | 0.5 | M | 136 | nd | nd | nd | nd |
| S052 | NM275 | Duranes Yard 5 | 12 | na | 7/5/1997 | 9.4 | 0.4 | M | 197 | nd | nd | nd | nd |
| S060 | NM279 | Garfield D | 12 | 3 | 6/19/1997 | nd | nd | na | 0 | -8.40 | 12.6 | 0.2 | 16,672 |
| S061 | NM280 | Garfield M | 12 | na | 6/19/1997 | 0.03 | 0.14 | L | 0 | -8.60 | 22.3 | 0.2 | 12,047 |
| S062 | NM281 | Garfield S | 12 | na | 6/19/1997 | 8.89 | 0.18 | L | 861 | nd | nd | nd | nd |
| S062 | NM491 | Garfield S | 12 | na | 7/28/1998 | 9.18 | 0.12 | L | 964 | -10.7 | 81.8 | 0.7 | 1,610 |
| S064 | NM283 | Domestic Well #22 | 12 | na | 6/20/1997 | nd | nd | na | 10 | -9.70 | 82.8 | 0.7 | 1,516 |
| S068 | NM057 | Griegos 3 | 12 | na | 6/21/1996 | 13.30 | 0.27 | L | 0 | -8.81 | 67.0 | 0.6 | 3,217 |
| S075 | NM286 | Hunter Ridge Nest 1 Well 1 | 12 | 3 | 6/20/1997 | nd | nd | na | 0 | -7.90 | 25.3 | 0.2 | 11,034 |
| S076 | NM287 | Hunter Ridge Nest 1 Well 2 | 12 | na | 6/21/1997 | nd | nd | na | 0 | -9.80 | 60.4 | 0.5 | 4,046 |
| S077 | NM288 | Hunter Ridge Nest 1 Well 3 | 12 | na | 6/20/1997 | nd | nd | na | 36 | nd | nd | nd | nd |
| S078 | NM289 | Hunter Ridge Nest 2 Well 1 | 12 | na | 6/21/1997 | 0.08 | 0.04 | L | 2 | -9.00 | 73.8 | 0.6 | 2,440 |
| S079 | NM290 | Hunter Ridge Nest 2 Well 2 | 12 | na | 6/21/1997 | -0.10 | 0.18 | L | 0 | nd | nd | nd | nd |
| S080 | NM291 | Hunter Ridge Nest 2 Well 3 | 12 | na | 6/21/1997 | -0.01 | 0.03 | L | 3 | nd | nd | nd | nd |
| S081 | NM292 | Private Production Well #19 | 12 | na | 7/2/1997 | nd | nd | na | 0 | -8.80 | 55.2 | 0.5 | 4,769 |
| S084 | NM063 | Windmill #04 | 12 | na | 8/21/1996 | -0.2 | 0.3 | M | 39 | -8.77 | 79.5 | 0.7 | 1,847 |
| S087 | NM493 | Isleta MD | 12 | 3 | 7/29/1998 | nd | nd | na | 4 | -7.92 | 35.8 | 0.3 | 8,261 |
| S088 | NM494 | Isleta MS | 12 | na | 7/29/1998 | nd | nd | na | 4 | -8.37 | 72.3 | 0.5 | 2,603 |
| S089 | NM495 | Isleta S | 12 | na | 7/29/1998 | 19.94 | 0.40 | L | 18 | -12.5 | 118. | 0.8 | -1,345 |
| S092 | NM066 | JMC-1 | 12 | na | 6/28/1996 | 4.5 | 0.5 | M | 279 | nd | nd | nd | nd |
| S097 | NM070 | Kirtland 14 | 12 | na | 6/25/1996 | 0.02 | 0.01 | L | 28 | -8.74 | 48.9 | 0.4 | 5,753 |
| S100 | NM073 | LALF-9 | 12 | na | 6/29/1996 | 0.19 | 0.01 | L | 45,228 | nd | nd | nd | nd |
| S102 | NM074 | Leyendecker 1 | 12 | na | 6/21/1996 | 0.08 | 0.08 | L | 126 | -8.92 | 72.8 | 0.7 | 2,546 |
| S120 | NM301 | Mesa Del Sol D | 12 | na | 6/29/1997 | nd | nd | na | 89 | nd | nd | nd | nd |
| S120 | NM303 | Mesa Del Sol D | 12 | na | 6/28/1997 | nd | nd | na | 109 | nd | nd | nd | nd |
| S120 | NM503 | Mesa Del Sol D | 12 | na | 8/2/1998 | nd | nd | na | 1 | -9.24 | 5.99 | 0.2 | 22,613 |
| S121 | NM302 | Mesa Del Sol M | 12 | na | 6/28/1997 | nd | nd | na | 7 | -8.50 | 8.32 | 0.1 | 19,974 |
| S121 | NM504 | Mesa Del Sol M | 12 | na | 7/25/1998 | nd | nd | na | 2 | -8.58 | 3.24 | 0.2 | 27,550 |
| S123 | NM081 | MONT - 5A | 12 | na | 6/27/1996 | 7.56 | 0.15 | L | 79 | nd | nd | nd | nd |
| S124 | NM082 | Montaño 2 D | 12 | na | 6/19/1996 | 19.48 | 0.21 | L | 54 | -10.0 | 103. | 0.9 | -263 |
| S125 | NM083 | Montaño 2 M | 12 | na | 6/19/1996 | 25.50 | 0.51 | L | 37 | -11.1 | 110. | 0.9 | -748 |
| S126 | NM084 | Montaño 2 S | 12 | na | 6/19/1996 | 4.73 | 0.10 | L | 214 | nd | nd | nd | nd |
| S127 | NM085 | Montaño 4 D | 12 | na | 6/20/1996 | 13.51 | 0.27 | L | 9 | -11.1 | 95.0 | 0.8 | 412 |
| S128 | NM086 | Montaño 4 M | 12 | na | 6/19/1996 | 19.59 | 0.39 | L | 56 | -12.3 | 114. | 1.0 | -1,026 |
| S130 | NM088 | Montaño 5 D | 12 | na | 6/24/1996 | 11.02 | 0.22 | L | 4 | -9.00 | 97.6 | 1.0 | 197 |
| S131 | NM089 | Montaño 5 M | 12 | na | 6/24/1996 | 9.92 | 0.20 | L | 200 | -8.51 | 95.0 | 0.8 | 411 |
| S132 | NM090 | Montaño 5 S | 12 | na | 6/24/1996 | 19.48 | 0.39 | L | 177 | nd | nd | nd | nd |
| S133 | NM091 | Montaño 6 D | 12 | na | 6/18/1996 | 0.01 | 0.01 | L | 0 | -9.57 | 25.2 | 0.2 | 11,075 |
| S134 | NM092 | Montaño 6 MD | 12 | na | 6/18/1996 | 0.02 | 0.01 | L | 0 | -8.62 | 38.0 | 0.3 | 7,783 |
| S135 | NM093 | Montaño 6 MS | 12 | na | 6/18/1996 | 2.03 | 0.04 | L | 0 | -7.69 | 67.5 | 0.6 | 3,153 |
| S136 | NM094 | Montaño 6 S | 12 | na | 6/18/1996 | 15.21 | 0.30 | L | 267 | nd | nd | nd | nd |

**Table A11.** Summary of Tritium, CFC-12, $^{13}C$, and $^{14}C$ data for wells and springs-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Second-ary hydro-chemical zone | Date | Tritium (TU) | Tritium error ± 1 σ (TU) | Source of tritium data L or M | CFC-12 (pg/kg) | $\delta^{13}C$ (per mil) | $^{14}C$ (pmC) | $^{14}C$ error (pmC) | Unadjusted $^{14}C$ age, Libby half-life (years) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S137 | NM506 | Montesa M | 12 | na | 7/27/1998 | nd | nd | na | 2 | -8.97 | 18.6 | 0.2 | 13,499 |
| S138 | NM507 | Montesa S | 12 | na | 7/27/1998 | 0.03 | 0.05 | L | 53 | -9.28 | 52.5 | 0.4 | 5,175 |
| S139 | NM305 | Domestic Well #27 | 12 | na | 6/17/1997 | nd | nd | na | 0 | -8.60 | 43.4 | 0.3 | 6,711 |
| S142 | NM307 | Domestic Well #28 | 12 | na | 6/17/1997 | nd | nd | na | 0 | -8.30 | 73.3 | 0.6 | 2,498 |
| S146 | NM309 | NM Utilities 2 | 12 | na | 6/18/1997 | nd | nd | na | 0 | -8.30 | 50.9 | 0.5 | 5,418 |
| S151 | NM508 | Nor Este S | 12 | na | 7/20/1998 | -0.02 | 0.05 | L | 6 | -9.49 | 47.6 | 0.4 | 5,960 |
| S151 | NM314 | Nor Este S | 12 | na | 7/2/1997 | nd | nd | na | 207 | nd | nd | nd | nd |
| S153 | NM315 | Open Space | 12 | 10 | 6/17/1997 | -0.1 | 0.3 | M | nd | -8.30 | 55.2 | 0.5 | 4,781 |
| S153 | NM411 | Open Space | 12 | na | 11/18/1997 | 0.2 | 0.3 | M | 37 | nd | nd | nd | nd |
| S154 | NM099 | ORLF-2 | 12 | na | 6/27/1996 | 11.42 | 0.26 | L | 118 | nd | nd | nd | nd |
| S155 | NM316 | Domestic Well #29 | 12 | na | 6/27/1997 | 0.12 | 0.06 | L | 0 | -8.50 | 55.5 | 0.5 | 4,731 |
| S156 | NM100 | Paseo 2D | 12 | na | 6/26/1996 | 1.78 | 0.04 | L | 3 | -8.27 | 76.7 | 0.7 | 2,132 |
| S157 | NM101 | Paseo 2MD | 12 | na | 6/26/1996 | 15.09 | 0.30 | L | 42 | -10.5 | 103. | 0.8 | -204 |
| S158 | NM102 | Paseo 2MS | 12 | na | 6/26/1996 | 11.09 | 0.22 | L | 453 | nd | nd | nd | nd |
| S159 | NM103 | Paseo 2S | 12 | na | 6/26/1996 | 10.72 | 0.21 | L | 2,068 | nd | nd | nd | nd |
| S160 | NM104 | Paseo 3D | 12 | na | 6/21/1996 | 0.15 | 0.01 | L | 27 | -8.66 | 64.5 | 0.5 | 3,521 |
| S161 | NM105 | Paseo 3M | 12 | na | 6/21/1996 | 10.67 | 0.21 | L | 2,205 | -10.7 | 98.1 | 0.7 | 152 |
| S171 | NM321 | Ridgecrest 4 | 12 | na | 6/26/1997 | nd | nd | na | 21 | -9.20 | 46.1 | 0.4 | 6,224 |
| S173 | NM323 | Rio Bravo 5 M | 12 | 3 | 7/4/1997 | 13.14 | 0.30 | L | 1,713 | -9.70 | 97.3 | 1.1 | 224 |
| S176 | NM111 | Rio Bravo 1 S | 12 | na | 6/17/1996 | 11.34 | 0.23 | L | 69 | nd | nd | nd | nd |
| S177 | NM112 | Rio Bravo 2 D | 12 | 3 | 6/25/1996 | 15.69 | 0.30 | L | 33 | -7.96 | 61.6 | 0.5 | 3,888 |
| S178 | NM113 | Rio Bravo 2 M | 12 | na | 6/25/1996 | 13.50 | 0.27 | L | 5 | -10.6 | 78.4 | 0.6 | 1,959 |
| S179 | NM114 | Rio Bravo 2 S | 12 | na | 6/25/1996 | 13.58 | 0.27 | L | 8 | -10.3 | 99.5 | 0.9 | 39 |
| S180 | NM115 | Rio Bravo 4 D | 12 | na | 6/25/1996 | 0.02 | 0.01 | L | 1 | -9.05 | 34.6 | 0.3 | 8,516 |
| S181 | NM116 | Rio Bravo 4 M | 12 | na | 6/25/1996 | 7.86 | 0.16 | L | 38 | -10.8 | 77.7 | 0.8 | 2,028 |
| S183 | NM126 | Rio Grande Utility 5 | 12 | 3 | 8/15/1996 | nd | nd | na | 1 | -8.12 | 33.2 | 0.3 | 8,862 |
| S184 | NM127 | Rio Grande Utility 6 | 12 | na | 8/15/1996 | nd | nd | na | 0 | -8.30 | 51.3 | 0.5 | 5,356 |
| S190 | NM325 | Rio Rancho 2 | 12 | na | 6/20/1997 | nd | nd | na | 1 | -8.60 | 71.6 | 0.7 | 2,689 |
| S203 | NM331 | Private Production Well #20 | 12 | na | 7/3/1997 | 9.1 | 0.5 | M | 129 | -8.76 | 77.1 | 0.5 | 2,090 |
| S205 | NM333 | Private Production Well #21 | 12 | na | 7/3/1997 | nd | nd | na | 0 | -8.40 | 58.8 | 0.4 | 4,260 |
| S208 | NM140 | San Jose 2 | 12 | 3 | 6/20/1996 | 3.1 | 0.4 | M | 15 | -8.65 | 29.1 | 0.3 | 9,916 |
| S210 | NM511 | Sandia D | 12 | na | 7/30/1998 | nd | nd | na | 18 | -8.66 | 15.3 | 0.2 | 15,065 |
| S214 | NM513 | Sandia S | 12 | na | 7/30/1998 | 0.07 | 0.06 | L | 21 | -9.31 | 62.9 | 0.5 | 3,726 |
| S220 | NM147 | Santa Barbara 1 | 12 | na | 6/19/1996 | 0.3 | 0.3 | M | 1,285 | -8.97 | 49.1 | 0.5 | 5,719 |
| S231 | NM517 | Sierra Vista M | 12 | 3 | 7/22/1998 | nd | nd | na | 1 | -8.24 | 34.2 | 0.3 | 8,609 |
| S232 | NM518 | Sierra Vista S | 12 | na | 7/22/1998 | 0.03 | 0.05 | L | 28 | -9.92 | 68.9 | 0.5 | 2,998 |
| S234 | NM339 | Sister Cities D | 12 | na | 6/30/1997 | nd | nd | na | 3 | -7.30 | 8.03 | 0.1 | 20,259 |
| S235 | NM340 | Sister Cities M | 12 | na | 6/27/1997 | nd | nd | na | 0 | -8.80 | 66.3 | 0.5 | 3,306 |
| S244 | NM158 | SWAB 3 - 760 | 12 | na | 7/1/1996 | 0.00 | 0.01 | L | 66 | -9.81 | 44.1 | 0.5 | 6,584 |
| S245 | NM159 | SWAB 3 - 980 | 12 | na | 7/1/1996 | 0.03 | 0.01 | L | 56 | -9.06 | 44.1 | 0.4 | 6,580 |
| S245 | NM160 | SWAB 3 - 980 | 12 | na | 7/1/1996 | 0.04 | 0.01 | L | 23 | nd | nd | nd | nd |
| S253 | NM522 | Tome D | 12 | na | 8/6/1998 | nd | nd | na | 7 | -8.00 | 8.80 | 0.1 | 19,523 |
| S257 | NM344 | Domestic Well #34 | 12 | na | 6/17/1997 | 16.3 | 0.6 | M | 19 | -10.8 | 85.3 | 0.6 | 1,277 |
| S259 | NM171 | VGP-1 | 12 | na | 6/27/1996 | 28.56 | 0.57 | L | 29 | -11.6 | 123. | 1.0 | -1,669 |
| S261 | NM172 | Vol Andia 2 | 12 | na | 6/21/1996 | 0.25 | 0.03 | L | 16 | -8.63 | 70.6 | 0.6 | 2,800 |
| S262 | NM173 | Vol Andia 5 | 12 | na | 6/18/1996 | 1.26 | 0.03 | L | 1,942 | -9.80 | 57.8 | 0.5 | 4,406 |
| S265 | NM175 | Webster 1 | 12 | na | 6/18/1996 | -0.1 | 0.3 | M | 0 | -8.50 | 45.5 | 0.4 | 6,333 |
| S267 | NM348 | West Bluff Nest 1 Well 2 | 12 | 3 | 6/23/1997 | nd | nd | na | 6 | -9.20 | 32.3 | 0.3 | 9,071 |
| S268 | NM349 | West Bluff Nest 1 Well 3 | 12 | na | 6/24/1997 | nd | nd | na | 1 | nd | nd | nd | nd |
| S269 | NM350 | West Bluff Nest 2 Well 1 | 12 | na | 6/24/1997 | 11.5 | 0.5 | M | 4 | -8.40 | 63.5 | 0.5 | 3,647 |
| S270 | NM351 | West Bluff Nest 2 Well 2 | 12 | na | 6/24/1997 | 28.2 | 0.9 | M | 4 | nd | nd | nd | nd |
| S271 | NM352 | West Bluff Nest 2 Well 3 | 12 | na | 6/24/1997 | 9.0 | 0.4 | M | 261 | nd | nd | nd | nd |
| S275 | NM178 | Yale 1 | 12 | na | 6/19/1996 | 0.59 | 0.01 | L | 161 | -9.90 | 39.2 | 0.4 | 7,531 |
| SXXX | NM045 | Geoprobe #1 (45.3') | 12 | na | 7/1/1996 | nd | nd | na | 2,633 | nd | nd | nd | nd |
| SXXX | NM046 | Geoprobe #1 (40.8') | 12 | na | 7/1/1996 | nd | nd | na | 2,734 | nd | nd | nd | nd |
| SXXX | NM047 | Geoprobe #1 (35.8') | 12 | na | 7/1/1996 | nd | nd | na | 2,587 | nd | nd | nd | nd |
| SXXX | NM048 | Geoprobe #1 (30.5') | 12 | na | 7/1/1996 | nd | nd | na | 831 | nd | nd | nd | nd |
| SXXX | NM049 | Geoprobe #1 (25') | 12 | na | 7/1/1996 | nd | nd | na | 34 | nd | nd | nd | nd |
| SXXX | NM050 | Geoprobe #1 (20.2') | 12 | na | 7/1/1996 | nd | nd | na | 26 | nd | nd | nd | nd |
| SXXX | NM051 | Geoprobe #2 (40.5') | 12 | na | 7/1/1996 | nd | nd | na | 9 | nd | nd | nd | nd |
| SXXX | NM052 | Geoprobe #2 (35.3') | 12 | na | 7/1/1996 | nd | nd | na | 6 | nd | nd | nd | nd |
| SXXX | NM053 | Geoprobe #2 (30.2') | 12 | na | 7/1/1996 | nd | nd | na | 17 | nd | nd | nd | nd |
| SXXX | NM054 | Geoprobe #2 (23.4') | 12 | na | 7/1/1996 | nd | nd | na | 5 | nd | nd | nd | nd |
| | | **Zone 13: Discharge** | | | | | | | | | | | |
| S143 | NM096 | Private Production Well #05 | 13 | na | 8/19/1996 | nd | nd | na | 1 | -7.33 | 7.46 | 0.1 | 20,850 |
| S194 | NM327 | Domestic Well #32 | 13 | na | 6/30/1997 | 1.16 | 0.0 | L | 6 | -7.00 | 10.8 | 0.1 | 17,863 |
| S226 | NM150 | Domestic Well #15 | 13 | na | 8/19/1996 | nd | nd | na | 2 | -5.33 | 11.6 | 0.2 | 17,290 |

**Table A11.** Summary of Tritium, CFC-12, $^{13}C$, and $^{14}C$ data for wells and springs-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chemical zone | Second-ary hydro-chemical zone | Date | Tritium (TU) | Tritium error ± 1 σ (TU) | Source of tritium data L or M | CFC-12 (pg/kg) | $\delta^{13}C$ (per mil) | $^{14}C$ (pmC) | $^{14}C$ error (pmC) | Unadjusted $^{14}C$ age, Libby half-life (years) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **No Zone: Exotic Water** | | | | | | | | | | | |
| S009 | NM485 | Arroyo Salado Spring | E | E | 8/6/1998 | 2.6 | 0.3 | M | nd | 1.79 | 7.64 | 0.2 | 20,659 |
| S023 | NM010 | Burn Site Well | E | E | 6/25/1996 | 0.74 | 0.01 | L | 68,206 | -7.70 | 49.6 | 0.4 | 5,639 |
| S028 | NM014 | Cerro Colorado Landfill MW | E | E | 8/12/1996 | nd | nd | na | 37 | 2.00 | 1.59 | 0.1 | 33,268 |
| S038 | NM265 | Windmill #19 | E | E | 7/1/1997 | -0.1 | 0.3 | M | nd | -10.90 | 6.68 | 0.1 | 21,738 |
| S054 | NM041 | Domestic Well #04 | E | E | 8/17/1996 | nd | nd | na | 0 | -7.55 | 29.3 | 0.3 | 9,867 |
| S057 | NM241 | Embudo Spring | E | E | 5/27/1997 | 9.9 | 0.5 | M | 269 | nd | nd | nd | nd |
| S057 | NM365 | Embudo Spring | E | E | 7/17/1997 | 10.1 | 0.5 | M | nd | nd | nd | nd | nd |
| S057 | NM044 | Embudo Spring | E | E | 7/2/1996 | 10.76 | 0.22 | L | 219 | -13.2 | 111. | 1.1 | -840 |
| S057 | NM228 | Embudo Spring | E | E | 4/29/1997 | 10.8 | 0.5 | M | nd | nd | nd | nd | nd |
| S057 | NM215 | Embudo Spring | E | E | 3/21/1997 | nd | nd | na | 309 | nd | nd | nd | nd |
| S063 | NM282 | Windmill #22 | E | E | 6/28/1997 | 0.2 | 0.2 | M | nd | -5.60 | 46.4 | 0.5 | 6,177 |
| S067 | NM284 | Granite Hill | E | E | 7/4/1997 | nd | nd | na | 52 | -7.90 | 34.5 | 0.3 | 8,549 |
| S070 | NM059 | HERTF | E | E | 6/28/1996 | 0.31 | 0.01 | L | 1,014 | -7.50 | 40.6 | 0.4 | 7,239 |
| S091 | NM496 | Private Production Well #23 | E | E | 8/4/1998 | 12.97 | 0.26 | L | 33 | -10.2 | 93.8 | 0.7 | 515 |
| S094 | NM293 | Stock Well #02 | E | E | 6/20/1997 | nd | nd | na | 173 | -5.50 | 79.3 | 0.6 | 1,866 |
| S099 | NM072 | LALF-1 | E | E | 6/29/1996 | 16.1 | 0.7 | M | 77,578 | nd | nd | nd | nd |
| S112 | NM297 | Domestic Well #24 | E | E | 6/21/1997 | nd | nd | na | 5 | -7.20 | 13.6 | 0.1 | 16,038 |
| S129 | NM087 | Montaňo 4 S | E | E | 6/19/1996 | 14.0 | 0.6 | M | 809 | nd | nd | nd | nd |
| S152 | NM098 | Private Production Well #07 | E | E | 8/22/1996 | 0.1 | 0.3 | M | 18 | -6.11 | 62.7 | 0.6 | 3,745 |
| S182 | NM117 | Rio Bravo 4 S | E | E | 6/25/1996 | 15.75 | 0.32 | L | 22 | nd | nd | nd | nd |
| S202 | NM330 | Windmill #27 | E | E | 7/2/1997 | 6.4 | 0.4 | M | nd | -4.70 | 47.2 | 0.4 | 6,036 |
| S211 | NM512 | Sandia M | E | E | 7/30/1998 | nd | nd | na | 4 | -8.20 | 10.4 | 0.1 | 18,158 |
| S225 | NM149 | SBM-1 | E | E | 6/29/1996 | 17.83 | 0.40 | L | 71 | nd | nd | nd | nd |
| S249 | NM163 | Private Production Well #09 | E | E | 6/26/1996 | 10.6 | 0.5 | M | 886 | nd | nd | nd | nd |
| S249 | NM164 | Private Production Well #09 | E | E | 6/26/1996 | nd | nd | na | nd | -11.0 | 51.3 | 0.4 | 5,360 |
| S250 | NM165 | Private Production Well #10 | E | E | 6/26/1996 | 0.93 | 0.03 | L | 137 | nd | nd | nd | nd |
| S251 | NM166 | Private Production Well #11 | E | E | 6/26/1996 | 9.62 | 0.19 | L | 1,094 | nd | nd | nd | nd |
| S256 | NM169 | Tunnel Spring 1 | E | E | 6/18/1996 | 12.16 | 0.24 | L | 240 | -11.3 | 92.6 | 0.8 | 622 |
| S256 | NM170 | Tunnel Spring 2 | E | E | 6/18/1996 | nd | nd | na | 217 | nd | nd | nd | nd |
| S258 | NM524 | Vallecito Springs | E | E | 8/4/1998 | -0.5 | 0.3 | M | nd | -10.1 | 43.4 | 0.3 | 6,713 |
| S273 | NM176 | Windmill #11 | E | E | 8/19/1996 | 0.8 | 0.3 | M | nd | -3.99 | 36.5 | 0.3 | 8,100 |
| S282 | NM529 | Windmill #44 | E | E | 7/29/1998 | 0.0 | 0.3 | M | nd | -8.47 | 51.6 | 0.4 | 5,323 |
| SXXX | NM065 | Jemez Spring | E | E | 8/20/1996 | nd | nd | na | 4 | nd | nd | nd | nd |
| SXXX | NM154 | Soda Dam Spring | E | E | 8/20/1996 | nd | nd | na | 33 | nd | nd | nd | nd |

## Table A12. Data on Tritium, Helium-3, Helium-4, Neon, and Estimation of $^3H/^3He$ Age

[Hydrochemical Zone "E", exotic water, no primary or secondary zone assigned; $\delta^3He$, helium-3; $\delta^3He=(R_s/R_{air} - 1)100$; R= $^3He/^4He$; $R_s$, $^3He/^4He$ of sample; $^4He$, helium; TU, Tritium Unit, 1 TU=1 atom of $^3H$ in $10^{18}$ atoms of H; $^4He$, Helium-4; Ne, Neon; ccSTP/g, cubic centimeters at standard temperature and pressure per gram; $\Delta$, percent difference from concentration at solubility equilibrium; Uncorrected age, age not corrected for terrigenic He; Corrected age, age corrected for terrigenic helium assuming R(terrigenic)=$2x10^{-8}$ nd, not determined; Note- Calculated age applies to the young fraction in mixtures. Tritium by helium-3 ingrowth from Lamont-Doherty Earth Observatory, except for values in parentheses which are from the USGS Low-Level Tritium Laboratory by liquid-scintillation counting on enriched samples.]

| Site no. | Sample no. | Site name | Primary hydro-chem-ical zone | Second-ary hydro-chem-ical zone | Date | Tritium (TU) | Tritium error (TU) | $\delta^3He$ (percent) | $\delta^3He$ error (percent) | $^3He/^4He$ ratio $x10^{-6}$ | $^3He/^4He$ ratio error (percent) | $^4He$ (ccSTP/g) | $^4He$ error (ccSTP/g) | Ne (ccSTP/g) | Ne error (ccSTP/g) | $\Delta^4He$ (percent) | $\Delta Ne$ (percent) | Uncor-rected age (years) | Uncor-rected age error (years) | Cor-rected age (years) | Cor-rected age error (years) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Zone 2: Northwestern** | | | | | | | | | | | | | | | | | | | |
| S105 | NM499 | Lincoln S | 2 | na | 7/23/1998 | 0.01 | 0.05 | -15.9 | 0.24 | 1.164 | 0.47 | 4.875E-08 | 2.574E-10 | 1.686E-07 | 6.169E-10 | 33.2 | 11.8 | nd | nd | nd | nd |
| | | **Zone 3: West Central** | | | | | | | | | | | | | | | | | | | |
| S006 | NM484 | 98th St. S | 3 | na | 8/5/1998 | 0.06 | 0.04 | -33.9 | 0.35 | 0.914 | 0.53 | 9.705E-08 | 1.883E-10 | 1.792E-07 | 6.740E-10 | 166. | 20.4 | nd | nd | nd | nd |
| S066 | NM056 | Gonzales 1 (11/20/1997) | 3 | 12 | 11/20/1997 | 2.66 | 0.17 | -35.2 | 0.15 | 0.898 | 0.43 | 5.035E-07 | 5.135E-10 | 1.865E-07 | 2.469E-10 | 1,220. | 14.7 | nd | nd | nd | nd |
| S174 | NM109 | Rio Bravo 1 D | 3 | 12 | 6/17/1996 | 0.00 | 0.01 | -32.2 | nd | 0.938 | nd | 6.875E-06 | nd | 1.980E-07 | nd | 17,930. | 21.8 | nd | nd | nd | nd |
| S175 | NM110 | Rio Bravo 1 M | 3 | 12 | 6/17/1996 | 0.01 | 0.02 | -17.9 | 1.00 | 1.137 | 1.08 | 4.889E-06 | 9.778E-08 | 1.883E-07 | 1.883E-09 | 12,721. | 15.8 | nd | nd | nd | nd |
| | | **Zone 7: Abo Arroyo** | | | | | | | | | | | | | | | | | | | |
| S021 | NM261 | Stock Well #01 | 7 | na | 6/23/1997 | 11.77 | 0.23 | 50.7 | 0.34 | 2.086 | 0.52 | 6.243E-08 | 8.803E-11 | 2.367E-07 | 1.413E-09 | 63.7 | 45.6 | 16.6 | 0.3 | 17.6 | 0.2 |
| | | **Zone 8: Eastern Mountain Front** | | | | | | | | | | | | | | | | | | | |
| S007 | NM002 | Domestic Well #01 | 8 | na | 6/21/1996 | 10.57 | 0.18 | -10.0 | 1.00 | 1.245 | 1.08 | 9.362E-08 | 1.872E-09 | 3.671E-07 | 7.341E-09 | 146. | 126. | nd | nd | nd | nd |
| S030 | NM016 | Charles 4 | 8 | na | 6/22/1996 | 0.03 | 0.01 | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| S030 | NM019 | Charles 4 | 8 | na | 6/27/1996 | 0.01 | 0.01 | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| S030 | NM021 | Charles 4 | 8 | na | 6/27/1996 | 0.01 | 0.01 | -31.7 | nd | 0.945 | nd | 1.768E-06 | nd | 1.826E-07 | nd | 4,536. | 12.3 | nd | nd | nd | nd |
| S030 | NM023 | Charles 4 | 8 | na | 6/27/1996 | 0.01 | 0.01 | -34.0 | nd | 0.913 | nd | 1.390E-06 | nd | 1.831E-07 | nd | 3,544. | 12.6 | nd | nd | nd | nd |
| S030 | NM024 | Charles 4 | 8 | na | 6/27/1996 | 0.01 | 0.01 | -32.4 | nd | 0.936 | nd | 6.683E-07 | nd | 1.776E-07 | nd | 1,653. | 9.20 | nd | nd | nd | nd |
| S055 | NM042 | Elena Gallegos | 8 | na | 6/25/1996 | nd | nd | nd | nd | nd | nd | 8.111E-08 | 3.658E-10 | 1.677E-07 | 8.082E-10 | 113. | 3.15 | nd | nd | nd | nd |
| S056 | NM043 | Embudito Spring | 8 | na | 7/2/1996 | 7.82 | 0.16 | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| S071 | NM060 | Domestic Well #07 | 8 | na | 6/19/1996 | 0.19 | 0.01 | 2.06 | 0.23 | 1.413 | 0.46 | 5.629E-08 | 1.013E-10 | 2.282E-07 | 1.266E-09 | 47.6 | 40.3 | 33.1 | 1.0 | 25.8 | 4.9 |
| S095 | NM068 | Kirtland 1 | 8 | na | 6/25/1996 | 0.05 | 0.01 | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| S106 | NM295 | Domestic Well #23 | 8 | na | 6/26/1997 | -0.01 | 0.04 | -37.1 | nd | 0.871 | nd | 3.311E-06 | nd | 1.853E-07 | nd | 8,583. | 14.0 | nd | nd | nd | nd |
| S110 | NM078 | Love 1 | 8 | na | 6/22/1996 | 0.05 | 0.01 | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| S116 | NM502 | Matheson S | 8 | na | 8/1/1998 | 0.01 | 0.05 | -8.82 | 0.35 | 1.262 | 0.53 | 6.762E-08 | 1.467E-10 | 2.111E-07 | 8.050E-10 | 85.5 | 40.5 | nd | nd | nd | nd |
| S117 | NM298 | Domestic Well #25 | 8 | na | 6/17/1997 | 0.22 | 0.03 | -0.10 | 0.36 | 1.383 | 0.54 | 6.433E-08 | 8.877E-11 | 2.639E-07 | 1.583E-09 | 68.7 | 62.3 | 16.6 | 4.2 | nd | nd |
| S122 | NM505 | Mesa Del Sol S | 8 | na | 7/25/1998 | 0.02 | 0.05 | -97.1 | 0.33 | 0.040 | 0.52 | 1.837E-06 | 4.041E-09 | 1.780E-07 | 6.673E-10 | 4,930. | 19.6 | nd | nd | nd | nd |
| S164 | NM106 | Ponderosa 1 | 8 | na | 6/20/1996 | 0.03 | 0.01 | -31.5 | 2.70 | 0.948 | 2.73 | 1.164E-05 | 9.229E-07 | 2.039E-07 | 1.129E-09 | 30,421. | 25.4 | nd | nd | nd | nd |
| S170 | NM108 | Ridgecrest 3 ($^3H$, 11/18/97) | 8 | na | 6/22/1996 | (0.0) | (0.3) | nd | nd | nd | nd | 1.330E-06 | nd | 1.835E-07 | nd | 3,388. | 12.8 | nd | nd | nd | nd |
| S212 | NM141 | Sandia Peak 1 | 8 | na | 6/26/1996 | 0.02 | 0.01 | -22.7 | nd | 1.070 | nd | 6.205E-08 | nd | 2.272E-07 | nd | 72.3 | 48.0 | nd | nd | nd | nd |
| S213 | NM142 | Sandia Peak 3 | 8 | na | 6/26/1996 | 0.02 | 0.01 | -5.97 | 0.32 | 1.301 | 0.51 | 5.734E-08 | 2.351E-10 | 2.190E-07 | 6.629E-10 | 50.4 | 34.7 | nd | nd | nd | nd |
| S229 | NM515 | SH03 UNM | 8 | na | 7/28/1998 | 8.28 | 0.17 | 10.1 | 0.35 | 1.524 | 0.53 | 4.927E-08 | 9.754E-11 | 2.047E-07 | 6.718E-10 | 35.8 | 34.3 | 5.7 | 0.2 | 4.3 | 0.3 |
| S240 | NM157 | Domestic Well #18 | 8 | na | 6/19/1996 | 0.01 | 0.01 | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| S248 | NM162 | Thomas 6 | 8 | na | 6/21/1996 | 0.02 | 0.01 | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| S264 | NM174 | Walker 1 | 8 | na | 6/18/1996 | (-0.4) | (0.3) | nd | nd | nd | nd | 7.495E-06 | 1.499E-07 | 1.997E-07 | 1.997E-09 | 19,556. | 22.8 | nd | nd | nd | nd |
| | | **Zone 9: Tijeras Fault Zone** | | | | | | | | | | | | | | | | | | | |
| S041 | NM029 | Coyote Spring | 9 | na | 6/28/1996 | 0.29 | 0.03 | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| S098 | NM071 | KAFB-1902 | 9 | na | 6/28/1996 | 2.69 | 0.05 | nd | nd | nd | nd | nd | nd | 1.820E-07 | 7.457E-10 | nd | 11.9 | nd | nd | nd | nd |
| | | **Zone 10: Tijeras Arroyo** | | | | | | | | | | | | | | | | | | | |
| S001 | NM001 | 4Hills-1 | 10 | 8 | 6/29/1996 | 3.95 | 0.08 | -4.76 | 0.39 | 1.318 | 0.56 | 5.574E-08 | 1.945E-10 | 2.120E-07 | 6.189E-10 | 46.2 | 30.4 | -6.1 | 0.8 | 2.6 | 0.8 |
| S001 | NM001 | 4Hills-1 | 10 | 8 | 6/29/1996 | 3.95 | 0.08 | -5.17 | 0.27 | 1.312 | 0.48 | 5.715E-08 | 1.137E-10 | 2.209E-07 | 1.081E-09 | 49.9 | 35.8 | -7.2 | 0.8 | -0.8 | 0.9 |
| S058 | NM277 | Eubank 1 | 10 | 8 | 7/4/1997 | (1.7) | (0.4) | -4.41 | nd | 1.323 | nd | 4.233E-08 | nd | 1.691E-07 | nd | 11.0 | 3.99 | -9.4 | 3.3 | 5.2 | 1.3 |
| S096 | NM069 | Kirtland 11 | 10 | 8 | 6/25/1996 | 0.04 | 0.01 | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| | | **Zone 12: Central** | | | | | | | | | | | | | | | | | | | |
| S011 | NM004 | Atris-1 | 12 | na | 6/22/1996 | 11.01 | 0.22 | 10.8 | 0.48 | 1.534 | 0.62 | 3.929E-08 | 7.779E-11 | 1.757E-07 | 5.909E-10 | 3.04 | 8.07 | 4.0 | 0.2 | 2.0 | 0.2 |
| S012 | NM005 | Atrisco 3 | 12 | 3 | 6/20/1996 | 9.65 | 0.20 | -7.16 | 1.00 | 1.285 | 1.08 | 7.419E-07 | 1.484E-08 | 1.763E-07 | 1.763E-09 | 1,846. | 8.44 | nd | nd | nd | nd |

**Table A12.** Data on Tritium, Helium-3, Helium-4, Neon, and Estimation of $^3H/^3He$ Age-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chem-ical zone | Second-ary hydro-chem-ical zone | Date | Tritium (TU) | Tritium error (TU) | $\delta^3He$ (percent) | $\delta^3He$ error (percent) | $^3He/^4He$ ratio x10$^{-6}$ | $^3He/^4He$ ratio error (percent) | $^4He$ (ccSTP/g) | $^4He$ error (ccSTP/g) | Ne (ccSTP/g) | Ne error (ccSTP/g) | $\Delta^4He$ (percent) | ΔNe (percent) | Uncor-rected age (years) | Uncor-rected age error (years) | Cor-rected age (years) | Cor-rected age error (years) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S025 | NM012 | Burton 2 | 12 | na | 6/19/1996 | 0.08 | 0.01 | -28.8 | 3.61 | 0.986 | 3.63 | 2.763E-07 | 2.873E-08 | 3.305E-07 | 1.829E-09 | 625. | 103. | nd | nd | nd | nd |
| S026 | NM013 | Burton 5 | 12 | na | 6/19/1996 | 0.01 | 0.01 | -31.0 | 3.62 | 0.955 | 3.64 | 8.251E-07 | 1.139E-07 | 1.905E-07 | 1.053E-09 | 2,064. | 17.2 | nd | nd | nd | nd |
| S026 | NM013 | Burton 5 | 12 | na | 6/19/1996 | 0.01 | 0.01 | nd | nd | nd | nd | nd | nd | 2.045E-07 | 1.136E-09 | nd | 25.8 | nd | nd | nd | nd |
| S040 | NM028 | Coronado 1 | 12 | na | 6/18/1996 | 0.03 | 0.01 | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| S045 | NM490 | Del Sol S | 12 | na | 7/21/1998 | 0.18 | 0.04 | -29.9 | 0.30 | 0.970 | 0.50 | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| S046 | NM032 | Duranes 1 | 12 | na | 6/20/1996 | 11.90 | 0.30 | nd | nd | nd | nd | 9.225E-08 | 2.168E-10 | nd | nd | 142. | nd | nd | nd | nd | nd |
| S046 | NM034 | Duranes 1 | 12 | na | 6/29/1996 | 17.06 | 0.34 | 201. | 0.22 | 4.163 | 0.46 | 4.640E-08 | 2.111E-10 | 1.817E-07 | 8.814E-10 | 21.7 | 11.8 | 25.1 | 0.3 | 25.5 | 0.3 |
| S046 | NM035 | Duranes 1 | 12 | na | 6/29/1996 | 17.06 | 0.34 | 202. | 0.22 | 4.176 | 0.46 | 4.662E-08 | 2.135E-10 | 1.823E-07 | 8.836E-10 | 22.3 | 12.1 | 25.3 | 0.3 | 25.6 | 0.3 |
| S047 | NM270 | Duranes 7 | 12 | na | 6/26/1997 | 8.38 | 0.17 | 30.4 | 0.35 | 1.805 | 0.53 | 8.477E-08 | 1.882E-10 | 1.773E-07 | 7.845E-10 | 122. | 9.05 | 18.2 | 0.3 | 30.7 | 0.3 |
| S048 | NM271 | Duranes Yard 1 | 12 | na | 7/5/1997 | 15.42 | 0.18 | 101. | 0.35 | 2.781 | 0.53 | 4.041E-08 | 5.414E-11 | 1.718E-07 | 1.037E-09 | 5.96 | 5.68 | 16.4 | 0.2 | 16.5 | 0.1 |
| S049 | NM272 | Duranes Yard 2 | 12 | na | 7/5/1997 | 7.94 | 0.16 | 5.08 | 0.42 | 1.454 | 0.58 | 3.958E-08 | 4.631E-11 | 1.678E-07 | 7.692E-10 | 3.79 | 3.17 | 3.1 | 0.1 | 4.1 | 0.2 |
| S050 | NM273 | Duranes Yard 3 | 12 | na | 7/5/1997 | 8.15 | 0.16 | 0.66 | 0.38 | 1.393 | 0.55 | 3.889E-08 | 5.250E-11 | 1.622E-07 | 9.709E-10 | 1.99 | -0.26 | 1.1 | 0.2 | 2.1 | 0.4 |
| S051 | NM274 | Duranes Yard 4 | 12 | na | 7/5/1997 | 8.19 | 0.16 | 0.15 | 0.37 | 1.386 | 0.54 | 4.109E-08 | 5.506E-11 | 1.773E-07 | 1.058E-09 | 7.75 | 9.04 | 0.9 | 0.2 | 1.3 | 0.4 |
| S052 | NM275 | Duranes Yard 5 | 12 | na | 7/5/1997 | (9.4) | (0.4) | -2.12 | 0.45 | 1.355 | 0.60 | 3.990E-08 | 8.578E-11 | 1.750E-07 | 7.739E-10 | 4.64 | 7.62 | -0.2 | 0.2 | -1.0 | 0.3 |
| S061 | NM280 | Garfield M | 12 | na | 6/19/1997 | 0.03 | 0.14 | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| S062 | NM281 | Garfield S | 12 | na | 6/19/1997 | 8.89 | 0.18 | 4.49 | 0.37 | 1.446 | 0.54 | 4.177E-08 | 6.140E-11 | 1.757E-07 | 1.052E-09 | 9.53 | 8.04 | 2.7 | 0.2 | 2.5 | 0.4 |
| S062 | NM491 | Garfield S | 12 | na | 7/28/1998 | 9.18 | 0.12 | 3.34 | 0.37 | 1.430 | 0.54 | 4.373E-08 | 8.965E-11 | 1.830E-07 | 6.900E-10 | 16.3 | 16.5 | 2.1 | 0.2 | 0.8 | 0.3 |
| S068 | NM057 | Griegos 3 | 12 | na | 6/21/1996 | 13.30 | 0.27 | 95.8 | 0.22 | 2.710 | 0.46 | 8.119E-08 | 1.405E-10 | 1.924E-07 | 1.067E-09 | 113. | 18.3 | 26.1 | 0.0 | 31.2 | 0.2 |
| S078 | NM289 | Hunter Ridge Nest 2 Well 1 | 12 | na | 6/21/1997 | 0.08 | 0.04 | 9.49 | 0.35 | 1.515 | 0.53 | 6.073E-08 | 7.105E-11 | 2.224E-07 | 1.021E-09 | 59.3 | 36.8 | nd | nd | nd | nd |
| S079 | NM290 | Hunter Ridge Nest 2 Well 2 | 12 | na | 6/21/1997 | -0.10 | 0.18 | 10.5 | 0.37 | 1.530 | 0.54 | 4.307E-08 | 9.389E-11 | 1.802E-07 | 7.951E-10 | 13.0 | 10.8 | nd | nd | nd | nd |
| S080 | NM291 | Hunter Ridge Nest 2 Well 3 | 12 | na | 6/21/1997 | -0.01 | 0.03 | 6.16 | 0.34 | 1.469 | 0.52 | 1.251E-07 | 2.752E-10 | 4.475E-07 | 1.985E-09 | 228. | 175. | nd | nd | nd | nd |
| S089 | NM495 | Isleta S | 12 | na | 7/29/1998 | 19.94 | 0.40 | 268. | 0.32 | 5.098 | 0.51 | 4.296E-08 | 8.377E-11 | 1.795E-07 | 6.763E-10 | 13.8 | 13.6 | 25.9 | 0.3 | 25.8 | 0.1 |
| S092 | NM066 | JMC-1 | 12 | na | 6/28/1996 | 10.32 | 0.21 | 11.7 | 0.48 | 1.546 | 0.62 | 4.280E-08 | 1.143E-10 | 1.788E-07 | 3.141E-10 | 12.3 | 9.99 | 4.8 | 0.2 | 4.8 | 0.2 |
| S097 | NM070 | Kirtland 14 | 12 | na | 6/25/1996 | 0.02 | 0.01 | -34.6 | nd | 0.905 | nd | 9.503E-07 | nd | 1.832E-07 | nd | 2,392. | 12.7 | nd | nd | nd | nd |
| S100 | NM073 | LALF-9 | 12 | na | 6/29/1996 | 0.19 | 0.01 | 194. | 0.17 | 4.072 | 0.43 | 4.431E-08 | 1.010E-10 | 1.848E-07 | 3.931E-10 | 16.2 | 13.7 | nd | nd | nd | nd |
| S102 | NM074 | Leyendecker 1 | 12 | na | 6/21/1996 | 0.12 | 0.08 | -7.19 | nd | 1.284 | nd | 5.060E-08 | nd | 1.898E-07 | nd | 32.7 | 16.8 | nd | nd | 38.2 | nd |
| S123 | NM081 | MONT - 5A | 12 | na | 6/27/1996 | 7.56 | 0.15 | 83.0 | 0.21 | 2.533 | 0.45 | 4.624E-08 | 2.173E-10 | 1.868E-07 | 9.059E-10 | 21.3 | 14.9 | 24.2 | 0.1 | 24.6 | 0.2 |
| S124 | NM082 | Montaño 2 D | 12 | na | 6/19/1996 | 19.48 | 0.21 | 229. | 0.23 | 4.554 | 0.46 | 4.747E-08 | 5.981E-11 | 1.979E-07 | 5.131E-10 | 24.5 | 21.7 | 25.4 | 0.3 | 25.3 | 0.3 |
| S125 | NM083 | Montaño 2 M | 12 | na | 6/19/1996 | 25.50 | 0.51 | 221. | 0.23 | 4.447 | 0.46 | 4.613E-08 | 7.796E-11 | 1.980E-07 | 1.096E-09 | 21.0 | 21.8 | 21.1 | 0.3 | 20.8 | 0.3 |
| S126 | NM084 | Montaño 2 S | 12 | na | 6/19/1996 | 4.73 | 0.10 | 8.15 | nd | 1.497 | nd | 4.349E-08 | 7.394E-11 | 1.816E-07 | 1.009E-09 | 14.1 | 11.7 | 7.2 | nd | 7.1 | nd |
| S127 | NM085 | Montaño 4 D | 12 | na | 6/20/1996 | 13.51 | 0.27 | 187. | 1.00 | 3.969 | 1.08 | 4.572E-08 | 9.144E-10 | 1.915E-07 | 1.915E-09 | 19.9 | 17.8 | 27.1 | 0.4 | 27.0 | 0.5 |
| S128 | NM086 | Montaño 4 M | 12 | na | 6/19/1996 | 19.59 | 0.39 | 114. | 1.00 | 2.960 | 1.08 | 4.912E-08 | 9.824E-10 | 2.053E-07 | 2.053E-09 | 28.8 | 26.3 | 17.2 | 0.3 | 16.9 | 0.4 |
| S130 | NM088 | Montaño 5 D | 12 | na | 6/24/1996 | 11.02 | 0.22 | 12.2 | 0.29 | 1.553 | 0.49 | 3.926E-08 | 1.398E-10 | 1.698E-07 | 6.482E-10 | 2.97 | 4.43 | 4.4 | 0.1 | 3.7 | 0.2 |
| S131 | NM089 | Montaño 5 M | 12 | na | 6/24/1996 | 9.92 | 0.20 | -0.96 | 0.56 | 1.371 | 0.69 | 4.012E-08 | 8.265E-11 | 1.763E-07 | 5.928E-10 | 5.22 | 8.42 | 0.3 | 0.2 | -1.7 | 0.3 |
| S132 | NM090 | Montaño 5 S | 12 | na | 6/24/1996 | 19.48 | 0.39 | -5.22 | nd | 1.332 | nd | 3.742E-08 | 1.400E-10 | 1.533E-07 | 5.900E-08 | -1.86 | -5.75 | -0.7 | nd | 0.3 | nd |
| S133 | NM091 | Montaño 6 D | 12 | na | 6/18/1996 | 0.01 | 0.01 | -23.1 | nd | 1.064 | nd | 6.268E-08 | nd | 1.885E-07 | nd | 64.4 | 16.0 | nd | nd | nd | nd |
| S134 | NM092 | Montaño 6 MD | 12 | na | 6/18/1996 | 0.02 | 0.01 | -6.73 | 0.24 | 1.291 | 0.47 | 5.274E-08 | 1.139E-10 | 1.822E-07 | 1.009E-09 | 38.3 | 12.1 | nd | nd | nd | nd |
| S135 | NM093 | Montaño 6 MS | 12 | na | 6/18/1996 | 2.03 | 0.04 | 84.6 | 0.23 | 2.555 | 0.46 | 4.083E-08 | 7.757E-11 | 1.391E-07 | 7.741E-10 | 7.09 | -14.4 | 42.4 | 0.1 | 46.3 | 0.2 |
| S136 | NM094 | Montaño 6 S | 12 | na | 6/18/1996 | 15.21 | 0.30 | 52.1 | 0.24 | 2.105 | 0.47 | 4.167E-08 | 1.921E-10 | 1.774E-07 | 7.266E-10 | 9.28 | 9.12 | 10.7 | 0.1 | 10.5 | 0.1 |
| S138 | NM507 | Montesa S | 12 | na | 7/27/1998 | 0.03 | 0.05 | nd | nd | nd | nd | 2.944E-07 | 1.563E-09 | 3.657E-07 | 1.326E-09 | 694. | 140. | nd | nd | nd | nd |
| S151 | NM508 | Nor Este S | 12 | na | 7/20/1998 | -0.02 | 0.05 | -22.7 | 0.31 | 1.070 | 0.51 | 3.144E-07 | 6.319E-10 | 3.745E-07 | 1.402E-09 | 760. | 149. | nd | nd | nd | nd |
| S153 | NM411 | Open Space | 12 | na | 11/18/1997 | -0.04 | 0.14 | nd | nd | nd | nd | 5.382E-08 | 6.404E-11 | 1.922E-07 | 3.084E-10 | nd | nd | nd | nd | nd | nd |
| S154 | NM099 | ORLF-2 | 12 | na | 6/27/1996 | 11.42 | 0.26 | 5.08 | 0.29 | 1.454 | 0.49 | 3.958E-08 | 1.587E-10 | 1.702E-07 | 6.494E-10 | 3.79 | 4.65 | 2.2 | 0.1 | 1.6 | 0.2 |
| S155 | NM316 | Domestic Well #29 | 12 | na | 6/27/1997 | 0.12 | 0.06 | 9.08 | 0.50 | 1.510 | 0.64 | 4.215E-08 | 8.431E-10 | 1.756E-07 | 3.513E-09 | 10.6 | 8.01 | nd | nd | nd | nd |
| S156 | NM100 | Paseo 2D | 12 | na | 6/26/1996 | 1.78 | 0.04 | 48.0 | 0.21 | 2.048 | 0.45 | 3.894E-08 | 1.791E-10 | 1.645E-07 | 7.979E-10 | 2.12 | 1.17 | 35.0 | 0.1 | 35.2 | 0.3 |
| S157 | NM101 | Paseo 2MD | 12 | na | 6/26/1996 | 15.09 | 0.30 | 120. | 0.25 | 3.045 | 0.47 | 4.151E-08 | 1.270E-10 | 1.775E-07 | 6.346E-10 | 8.85 | 9.19 | 19.0 | 0.2 | 18.8 | 0.3 |
| S158 | NM102 | Paseo 2MS | 12 | na | 6/26/1996 | 11.09 | 0.22 | 11.7 | 0.24 | 1.546 | 0.47 | 4.097E-08 | 1.893E-10 | 1.752E-07 | 7.181E-10 | 7.43 | 7.76 | 4.3 | 0.1 | 3.8 | 0.2 |
| S159 | NM103 | Paseo 2S | 12 | na | 6/26/1996 | 10.72 | 0.21 | 2.62 | 0.22 | 1.420 | 0.46 | 5.115E-08 | 2.292E-10 | 2.083E-07 | 1.001E-09 | 34.2 | 28.1 | 1.8 | 0.1 | 1.6 | 0.3 |
| S160 | NM104 | Paseo 3D | 12 | na | 6/21/1996 | 0.15 | 0.01 | -5.47 | nd | 1.308 | nd | 4.088E-08 | nd | 1.829E-07 | nd | 7.22 | 12.5 | nd | nd | nd | nd |
| S161 | NM105 | Paseo 3M | 12 | na | 6/21/1996 | 10.67 | 0.21 | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| S173 | NM323 | Rio Bravo 5 M | 12 | 3 | 7/4/1997 | 13.14 | 0.30 | 57.0 | 0.35 | 2.173 | 0.53 | 4.459E-08 | 5.573E-11 | 1.753E-07 | 8.052E-10 | 16.9 | 7.78 | 13.3 | 0.2 | 14.3 | 0.3 |
| S176 | NM111 | Rio Bravo 1 S | 12 | na | 6/17/1996 | 11.34 | 0.23 | 9.87 | 1.00 | 1.521 | 1.08 | 4.422E-08 | 8.845E-10 | 1.785E-07 | 1.785E-09 | 16.0 | 9.80 | 4.0 | 0.3 | 5.0 | 0.5 |
| S177 | NM112 | Rio Bravo 2 D | 12 | 3 | 6/25/1996 | 15.69 | 0.30 | -14.8 | 1.00 | 1.179 | 1.08 | 6.157E-07 | 1.231E-08 | 1.910E-07 | 1.910E-09 | 1,515. | 17.5 | nd | nd | nd | nd |

## **Table A12.** Data on Tritium, Helium-3, Helium-4, Neon, and Estimation of $^{3}H/^{3}He$ Age-- Continued

| Site no. | Sample no. | Site name | Primary hydro-chem-ical zone | Second-ary hydro-chem-ical zone | Date | Tritium (TU) | Tritium error (TU) | $\delta^{3}He$ (percent) | $\delta^{3}He$ error (percent) | $^{3}He/^{4}He$ ratio x$10^{-6}$ | $^{3}He/^{4}He$ ratio error (percent) | $^{4}He$ (ccSTP/g) | $^{4}He$ error (ccSTP/g) | Ne (ccSTP/g) | Ne error (ccSTP/g) | $\Delta^{4}He$ (percent) | ΔNe (percent) | Uncor-rected age (years) | Uncor-rected age error (years) | Cor-rected age (years) | Cor-rected age error (years) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S178 | NM113 | Rio Bravo 2 M | 12 | na | 6/25/1996 | 13.50 | 0.27 | -23.1 | 1.00 | 1.064 | 1.08 | 1.206E-06 | 2.412E-08 | 1.934E-07 | 1.934E-09 | 3,063. | 19.0 | nd | nd | nd | nd |
| S179 | NM114 | Rio Bravo 2 S | 12 | na | 6/25/1996 | 13.58 | 0.27 | -10.4 | 0.26 | 1.240 | 0.48 | 2.146E-07 | 7.791E-10 | 2.006E-07 | 7.674E-10 | 463. | 23.4 | nd | nd | 34.3 | 0.3 |
| S180 | NM115 | Rio Bravo 4 D | 12 | na | 6/25/1996 | 0.02 | 0.01 | -22.5 | 0.80 | 1.073 | 0.89 | 8.055E-07 | 2.376E-09 | 1.816E-07 | 6.292E-10 | 2,012. | 11.7 | nd | nd | nd | nd |
| S181 | NM116 | Rio Bravo 4 M | 12 | na | 6/25/1996 | 7.86 | 0.16 | 2.07 | 1.00 | 1.413 | 1.08 | 2.472E-07 | 4.943E-09 | 1.607E-07 | 1.607E-09 | 548. | -1.16 | 6.2 | 2.2 | 49.7 | 0.5 |
| S208 | NM140 | San Jose 2 | 12 | 3 | 6/20/1996 | (3.1) | (0.4) | nd | nd | nd | nd | 1.210E-06 | 2.419E-08 | 1.884E-07 | 1.884E-09 | 3,073. | 15.9 | nd | nd | nd | nd |
| S214 | NM513 | Sandia S | 12 | na | 7/30/1998 | 0.07 | 0.06 | -40.0 | 0.22 | 0.831 | 0.46 | 2.093E-06 | 2.470E-09 | 2.080E-07 | 3.411E-10 | 5,577. | 35.5 | nd | nd | nd | nd |
| S220 | NM147 | Santa Barbara 1 (6/26/97) | 12 | na | 6/26/1997 | 0.63 | 0.13 | -1.58 | 0.31 | 1.362 | 0.51 | 6.050E-08 | 7.078E-11 | 1.761E-07 | 2.827E-10 | 58.7 | 8.33 | nd | nd | 52.0 | 2.0 |
| S232 | NM518 | Sierra Vista S | 12 | na | 7/22/1998 | 0.03 | 0.05 | -4.50 | 0.36 | 1.322 | 0.54 | 4.901E-08 | 9.557E-11 | 1.790E-07 | 5.792E-10 | 31.6 | 15.8 | nd | nd | nd | nd |
| S244 | NM158 | SWAB 3 - 760 | 12 | na | 7/1/1996 | 0.00 | 0.01 | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| S245 | NM159 | SWAB 3 - 980 | 12 | na | 7/1/1996 | 0.03 | 0.01 | -9.43 | nd | 1.254 | nd | 3.985E-08 | nd | 1.824E-07 | nd | 4.5 | 12.2 | nd | nd | nd | nd |
| S245 | NM159 | SWAB 3 - 980 | 12 | na | 7/1/1996 | 0.03 | 0.01 | 2.01 | 0.39 | 1.412 | 0.56 | 4.330E-08 | 1.533E-10 | 1.772E-07 | 5.177E-10 | 13.6 | 8.95 | nd | nd | nd | nd |
| S245 | NM160 | SWAB 3 - 980 | 12 | na | 7/1/1996 | 0.04 | 0.01 | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| S257 | NM344 | Domestic Well #34 | 12 | na | 6/17/1997 | 15.22 | 0.19 | -16.9 | 0.50 | 1.150 | 0.64 | 9.816E-07 | 1.963E-08 | 1.881E-07 | 3.762E-09 | 2,474. | 15.7 | nd | nd | nd | nd |
| S259 | NM171 | VGP-1 | 12 | na | 6/27/1996 | 28.56 | 0.57 | 260. | 0.30 | 4.978 | 0.50 | 5.194E-08 | 1.844E-10 | 2.101E-07 | 8.008E-10 | 36.2 | 29.2 | 23.2 | 0.1 | 23.2 | 0.1 |
| S261 | NM172 | Vol Andia 2 | 12 | na | 6/21/1996 | 0.25 | 0.03 | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| S262 | NM173 | Vol Andia 5 | 12 | na | 6/18/1996 | 1.26 | 0.03 | 15.8 | 0.21 | 1.602 | 0.45 | 4.571E-08 | 2.103E-10 | 1.756E-07 | 8.515E-10 | 19.9 | 7.98 | 26.9 | 0.2 | 32.6 | 0.4 |
| S265 | NM175 | Webster 1 | 12 | na | 6/18/1996 | 0.01 | 0.01 | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| S269 | NM350 | West Bluff Nest 2 Well 1 | 12 | na | 6/24/1997 | 10.54 | 0.21 | 289. | 0.50 | 5.379 | 0.64 | 4.953E-08 | 9.907E-10 | 1.914E-07 | 3.828E-09 | 29.9 | 17.7 | 38.5 | 0.5 | 38.9 | 0.7 |
| S270 | NM351 | West Bluff Nest 2 Well 2 | 12 | na | 6/24/1997 | 27.84 | 0.56 | 394. | 0.28 | 6.832 | 0.49 | 4.530E-08 | 1.826E-10 | 1.923E-07 | 7.231E-10 | 18.8 | 18.3 | 27.3 | 0.3 | 27.2 | 0.1 |
| S271 | NM352 | West Bluff Nest 2 Well 3 | 12 | na | 6/24/1997 | 7.28 | 0.15 | -0.51 | 0.31 | 1.377 | 0.51 | 4.906E-08 | 1.521E-10 | 2.112E-07 | 7.952E-10 | 28.7 | 29.9 | 0.6 | 0.2 | -1.1 | 0.5 |
| S275 | NM178 | Yale 1 | 12 | na | 6/19/1996 | 0.59 | 0.01 | -30.6 | nd | 0.960 | nd | 2.206E-07 | nd | 2.598E-07 | nd | 479. | 59.8 | nd | nd | nd | nd |
| | | **Zone 13: Discharge** | | | | | | | | | | | | | | | | | | | |
| S194 | NM327 | Domestic Well #32 | 13 | na | 6/30/1997 | 1.16 | 0.04 | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| | | **No Zone: Exotic Water** | | | | | | | | | | | | | | | | | | | |
| S023 | NM010 | Burn Site Well | E | E | 6/25/1996 | 0.74 | 0.01 | -42.5 | 0.22 | 0.796 | 0.46 | 8.669E-08 | 4.040E-10 | 1.867E-07 | 9.054E-10 | 127. | 14.8 | nd | nd | 27.5 | 0.9 |
| S057 | NM044 | Embudo Spring | E | E | 7/2/1996 | 10.76 | 0.22 | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| S070 | NM059 | HERTF | E | E | 6/28/1996 | 0.31 | 0.01 | -58.6 | 1.00 | 0.572 | 1.08 | 1.093E-07 | 2.185E-09 | 2.167E-07 | 4.333E-09 | 187. | 33.2 | nd | nd | nd | nd |
| S091 | NM496 | Private Production Well #23 | E | E | 8/4/1998 | 12.97 | 0.26 | -22.8 | 0.31 | 1.069 | 0.51 | 3.862E-07 | 8.304E-10 | 1.914E-07 | 7.250E-10 | 936. | 20.9 | nd | nd | nd | nd |
| S099 | NM072 | LALF-1 | E | E | 6/29/1996 | (16.1) | (0.7) | nd | nd | nd | nd | 3.872E-08 | 7.899E-11 | 1.665E-07 | 8.144E-10 | 1.55 | 2.40 | nd | nd | nd | nd |
| S129 | NM087 | Montaňo 4 S | E | E | 6/19/1996 | (14.0) | (0.6) | nd | nd | nd | nd | 4.150E-08 | 1.880E-10 | 1.769E-07 | 8.536E-10 | 8.83 | 8.76 | nd | nd | nd | nd |
| S182 | NM117 | Rio Bravo 4 S | E | E | 6/25/1996 | 15.75 | 0.32 | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| S225 | NM149 | SBM-1 | E | E | 6/29/1996 | 17.83 | 0.40 | 83.8 | 0.22 | 2.544 | 0.46 | 4.042E-08 | 1.851E-10 | 1.683E-07 | 6.894E-10 | 6.01 | 3.49 | 13.0 | 0.2 | 13.1 | 0.2 |
| S249 | NM163 | Private Production Well #09 | E | E | 6/26/1996 | (10.6) | (0.5) | nd | nd | nd | nd | 6.333E-08 | 1.444E-10 | 1.687E-07 | 3.593E-10 | 66.1 | 3.81 | nd | nd | nd | nd |
| S250 | NM165 | Private Production Well #10 | E | E | 6/26/1996 | 0.93 | 0.03 | -84.8 | nd | 0.210 | nd | 3.676E-07 | nd | 2.231E-07 | nd | 921. | 45.3 | nd | nd | nd | nd |
| S251 | NM166 | Private Production Well #11 | E | E | 6/26/1996 | 9.62 | 0.19 | -8.29 | 0.22 | 1.269 | 0.46 | 5.356E-08 | 2.437E-10 | 1.821E-07 | 8.733E-10 | 40.5 | 12.0 | nd | nd | 5.3 | 0.2 |
| S256 | NM169 | Tunnel Spring 1 | E | E | 6/18/1996 | 12.16 | 0.24 | -1.85 | 0.39 | 1.358 | 0.56 | 4.043E-08 | 5.499E-11 | 1.676E-07 | 7.375E-10 | 6.03 | 3.07 | -0.1 | 0.1 | 0.6 | 0.2 |

# Appendix B. Chemical and isotopic composition of surface water from the Middle Rio Grande Basin, June 1996 through March 1999, and stable isotopic composition of surface water and precipitation in archived samples from the 1980s

**Table B1.** Identification of surface-water sites from the Middle Rio Grande Basin and vicinity

[dms, degrees-minutes-seconds; Altitude, altitude of the land surface]

| Site no. | Site name | Latitude[1] (dms) | Longitude[1] (dms) | Altitude (feet) |
|---|---|---|---|---|
| S290 | Abo Arroyo at US 60 | 342647 | 1062946 | 5,730 |
| S291 | Alameda Drain at Alameda | 351114 | 1063652 | 4,995 |
| S292 | Bear Canyon Arroyo | 350902 | 1062729 | 6,640 |
| S293 | Canyon del Trigo Stream | 344013 | 1062751 | 6,250 |
| S294 | Chamizal Lateral at Alameda | 351125 | 1063718 | 4,995 |
| S297 | Jemez River below Jemez Canyon Dam | 352324 | 1063203 | 5,100 |
| S298 | Jemez River at Jemez | 353942 | 1064434 | 5,622 |
| S299 | Bear Canyon Arroyo (lower) | 350859 | 1062745 | 6,640 |
| S300 | Rio Grande at Alameda | 351150 | 1063829 | 4,995 |
| S301 | Rio Grande at Campbell | 350724 | 1064124 | 4,960 |
| S302 | Rio Grande at Isleta Below Diversion | 345420 | 1064115 | 5,905 |
| S303 | Rio Grande at Rio Bravo | 350139 | 1064017 | 4,927 |
| S304 | Rio Grande at San Felipe | 352640 | 1062624 | 5,116 |
| S305 | Rio Grande at Central | 350548 | 1064124 | 4,946 |
| S306 | Rio Grande at Nature Center | 350725 | 1064124 | 4,960 |
| S307 | Rio Puerco at Hwy 6 | 344746 | 1065925 | 5,010 |
| S308 | Riverside Drain at Alameda | 351146 | 1063825 | 4,995 |
| S309 | Riverside Drain at Campbell | 350723 | 1064114 | 4,960 |
| S310 | Riverside Drain at Rio Bravo | 350139 | 1064009 | 4,927 |
| S311 | Stream in Monte Largo Canyon | 343607 | 1062940 | 6,250 |
| S312 | Tijeras Arroyo at Four Hills | 350339 | 1062941 | 5,550 |
| S313 | West Riverside drain at Rio Bravo | 350138 | 1064627 | 4,927 |
| S314 | Rio Grande at Arroyo de la Baranca | 351658 | 1063552 | 4,982 |

[1]Latitude and longitude are given in degrees-minutes-seconds. For example, 384531 is 38°45'31".

**Table B2.** Surface-water field parameters and major-element chemistry

[mm Hg, millimeters of mercury; Temp., field water temperature; °C, degrees Celsius; $O_2$, dissolved oxygen; mg/L, milligrams per liter; Sp. Cond., specific conductance in µS/cm, microsiemens per centimeter at 25 °C; $Ca^{2+}$, calcium; $Mg^{2+}$, magnesium, $Na^+$, sodium; $K^+$, potassium; $Cl^-$, chloride; $Br^-$, Bromide; $SO_4^{2-}$, sulfate; $HCO_3^-$, total titration alkalinity as bicarbonate; nd, not determined]

| Site no. | Sample no. | Site name | Date | Barometric pressure (mm Hg) | Temp. °C | pH | $O_2$ (mg/L) | Sp. Cond. (µS/cm at 25° C) | $Ca^{2+}$ (mg/L) | $Mg^{2+}$ (mg/L) | $Na^+$ (mg/L) | $K^+$ (mg/L) | $Cl^-$ (mg/L) | $Br^-$ (mg/L) | $SO_4^{2-}$ (mg/L) | Alkalinity $HCO_3^-$ (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S290 | NM194 | Abo Arroyo at US 60 | 1/16/1997 | 625 | 0.4 | 8.2 | 11.4 | 2,100 | 305. | 97.6 | 95.0 | 0.9 | 53.0 | nd | 68.7 | 132.6 |
| S290 | NM202 | Abo Arroyo at US 60 | 3/12/1997 | 624 | 7.9 | 8.3 | 11.4 | 2,370 | 289. | 112. | 150. | 2.0 | 68.6 | 0.49 | 65.2 | 129.9 |
| S290 | NM622 | Abo Arroyo at US 60 | 10/8/1998 | nd | nd | nd | nd | 1,633 | nd | nd | nd | nd | nd | nd | 83.7 | 109.8 |
| S290 | NM621 | Abo Arroyo at US 60 | 6/23/1998 | nd | nd | nd | nd | 1,914 | nd | nd | nd | nd | nd | nd | 71.0 | 145.2 |
| S290 | NM620 | Abo Arroyo at US 60 | 2/3/1998 | nd | nd | nd | nd | 2,210 | nd | nd | nd | nd | nd | nd | 65.6 | 130.4 |
| S291 | NM428 | Alameda Drain at Alameda | 3/31/1998 | 633 | 8.0 | 8.5 | 9.3 | 351 | 38.6 | 6.90 | 22.3 | 3.3 | 9.7 | 0.06 | 70.6 | 174.6 |
| S291 | NM220 | Alameda Drain at Alameda | 4/22/1997 | 633 | 13.4 | 8.2 | 8.6 | 375 | 41.6 | 7.62 | 19.3 | 3.6 | 9.5 | <0.05 | 86.4 | 113.0 |
| S291 | NM381 | Alameda Drain at Alameda | 10/21/1997 | 639 | 13.8 | 7.8 | 9.4 | 297 | 34.3 | 5.67 | 15.5 | 3.0 | 6.3 | <0.05 | 64.8 | 178.8 |
| S291 | NM443 | Alameda Drain at Alameda | 5/5/1998 | 634 | 14.1 | 8.2 | 8.5 | 372 | 41.6 | 7.30 | 21.6 | 3.3 | 10.1 | 0.05 | 60.3 | 177.0 |
| S291 | NM457 | Alameda Drain at Alameda | 6/11/1998 | 636 | 15.3 | 8.1 | 7.6 | 318 | 36.2 | 6.52 | 16.7 | 2.8 | 6.3 | <0.05 | 69.2 | 172.2 |
| S291 | NM548 | Alameda Drain at Alameda | 9/22/1998 | 637 | 18.4 | 8.2 | nd | 359 | 42.4 | 7.35 | 18.1 | 3.2 | 6.6 | <0.05 | 138. | 190.7 |
| S291 | NM366 | Alameda Drain at Alameda | 7/9/1997 | 637 | 20.8 | 8.0 | 7.7 | 341 | 37.3 | 6.80 | 19.2 | 3.2 | 6.9 | <0.05 | 92.3 | 113.0 |
| S291 | NM370 | Alameda Drain at Alameda | 9/16/1997 | 636 | 21.0 | 8.5 | 8.0 | 342 | 40.5 | 6.66 | 16.8 | 3.2 | 8.0 | <0.05 | 88.6 | 130.4 |
| S291 | NM534 | Alameda Drain at Alameda | 8/18/1998 | 638 | 22.0 | 8.3 | 6.5 | 367 | 43.2 | 7.27 | 19.9 | 3.4 | 7.3 | <0.05 | 69.0 | 171.1 |
| S291 | NM471 | Alameda Drain at Alameda | 7/22/1998 | 637 | 24.2 | 8.4 | 6.7 | 355 | 40.2 | 7.24 | 20.1 | 3.7 | 9.8 | <0.05 | 63.4 | 178.2 |
| S292 | NM406 | Bear Canyon Arroyo | 1/9/1998 | 597 | 4.3 | 8.2 | 9.0 | 487 | 70.9 | 14.7 | 12.6 | 2.2 | 5.4 | <0.05 | 133. | 239.9 |
| S292 | NM615 | Bear Canyon Arroyo | 4/2/1999 | 591 | 6.1 | 8.3 | 9.1 | 443 | 62.4 | 12.7 | 11.4 | 2.1 | 3.9 | <0.1 | 47.5 | 139.4 |
| S292 | NM203 | Bear Canyon Arroyo | 3/19/1997 | 609 | 6.6 | 8.1 | 9.0 | 509 | 72.6 | 15.4 | 13.5 | 2.0 | 6.1 | 0.09 | 976. | 254.4 |
| S292 | NM591 | Bear Canyon Arroyo | 1/5/1999 | 599 | 6.8 | 8.2 | 9.0 | 481 | 68.5 | 14.8 | 12.6 | 1.9 | 6.8 | <0.1 | 143. | 275.7 |
| S292 | NM421 | Bear Canyon Arroyo | 2/20/1998 | 594 | 6.9 | 8.3 | 8.8 | 449 | 66.0 | 13.4 | 11.8 | 1.8 | 4.6 | 0.06 | 1,122. | 254.2 |
| S292 | NM602 | Bear Canyon Arroyo | 2/3/1999 | 598 | 7.0 | 8.3 | 9.3 | 462 | 65.1 | 13.9 | 12.4 | 1.8 | 4.5 | <0.1 | 33.4 | 238.0 |
| S292 | NM435 | Bear Canyon Arroyo | 3/31/1998 | 595 | 7.5 | 8.4 | 9.4 | 322 | 45.1 | 9.31 | 8.7 | 1.9 | 3.6 | <0.05 | 47.9 | 273.2 |
| S292 | NM436 | Bear Canyon Arroyo | 3/31/1998 | 597 | 8.1 | 8.5 | 9.5 | 322 | 44.9 | 8.55 | 8.7 | 1.9 | 3.6 | 0.07 | 57.6 | 157.2 |
| S292 | NM216 | Bear Canyon Arroyo | 4/23/1997 | 595 | 9.0 | 8.1 | 8.4 | 444 | 62.5 | 13.0 | 11.2 | 2.2 | 4.7 | 0.06 | 60.3 | 169.1 |
| S292 | NM229 | Bear Canyon Arroyo | 5/28/1997 | 603 | 9.0 | 8.3 | 8.7 | 388 | 53.4 | 10.1 | 9.8 | 1.8 | 3.6 | <0.05 | 72.7 | 177.4 |
| S292 | NM397 | Bear Canyon Arroyo | 11/18/1997 | 603 | 9.9 | 8.1 | 7.1 | 561 | 81.5 | 17.0 | 14.7 | 2.1 | 5.4 | <0.05 | 69.6 | 172.8 |
| S292 | NM579 | Bear Canyon Arroyo | 12/1/1998 | 602 | 10.5 | 8.1 | 7.6 | 533 | 75.1 | 16.5 | 14.4 | 2.0 | 5.8 | <0.07 | 60.4 | 165.0 |
| S292 | NM450 | Bear Canyon Arroyo | 5/5/1998 | 598 | 11.6 | 8.4 | 8.8 | 333 | 46.0 | 8.29 | 8.4 | 2.0 | 2.8 | <0.05 | 65.5 | 169.1 |
| S292 | NM388 | Bear Canyon Arroyo | 10/23/1997 | 596 | 11.9 | 7.3 | 6.1 | 593 | 89.5 | 17.3 | 14.9 | 1.9 | 5.6 | 0.06 | 56.4 | 162.7 |
| S292 | NM567 | Bear Canyon Arroyo | 10/23/1998 | 604 | 13.2 | 7.8 | 6.0 | 575 | 82.3 | 17.7 | 15.5 | 2.0 | 5.9 | <0.05 | 64.2 | 155.4 |
| S292 | NM464 | Bear Canyon Arroyo | 6/11/1998 | 599 | 13.2 | 8.3 | 8.0 | 368 | 51.2 | 10.0 | 9.7 | 1.9 | 3.2 | <0.05 | 63.0 | 153.1 |
| S292 | NM555 | Bear Canyon Arroyo | 9/29/1998 | 601 | 14.2 | 7.9 | nd | 590 | 85.0 | 17.7 | 16.2 | 1.9 | 5.8 | 0.10 | 58.1 | 161.5 |
| S292 | NM478 | Bear Canyon Arroyo | 7/23/1998 | 603 | 14.5 | 8.1 | 7.3 | 453 | 64.3 | 13.1 | 12.5 | 1.9 | 4.2 | 0.06 | 58.4 | 161.6 |
| S292 | NM354 | Bear Canyon Arroyo | 7/9/1997 | 600 | 14.9 | 7.6 | 6.9 | 463 | 64.2 | 13.4 | 13.4 | 1.7 | 4.6 | <0.05 | 55.3 | 162.1 |
| S292 | NM377 | Bear Canyon Arroyo | 9/18/1997 | 600 | 15.0 | 7.8 | 6.5 | 596 | 93.8 | 17.7 | 14.9 | 1.8 | 5.5 | 0.08 | 69.4 | 175.4 |
| S292 | NM541 | Bear Canyon Arroyo | 8/18/1998 | 600 | 17.2 | 7.9 | 6.6 | 499 | 69.6 | 14.7 | 13.8 | 2.0 | 4.4 | 0.08 | 63.5 | 153.0 |
| S293 | NM244 | Canyon del Trigo Stream | 5/29/1997 | nd | 12.5 | 7.8 | 7.9 | 140 | 18.0 | 3.70 | 4.1 | 0.5 | 2.5 | <0.05 | 50.4 | 129.4 |
| S294 | NM427 | Chamizal Lateral at Alameda | 3/31/1998 | 633 | 8.3 | 8.5 | 9.4 | 349 | 38.2 | 6.92 | 21.1 | 3.1 | 9.7 | 0.06 | 57.2 | 160.0 |

**Table B2.** Surface-water field parameters and major-element chemistry-- Continued

| Site no. | Sample no. | Site name | Date | Barometric pressure (mm Hg) | Temp. °C | pH | $O_2$ (mg/L) | Sp. Cond. (µS/cm at 25° C) | $Ca^{2+}$ (mg/L) | $Mg^{2+}$ (mg/L) | $Na^+$ (mg/L) | $K^+$ (mg/L) | $Cl^-$ (mg/L) | $Br^-$ (mg/L) | $SO_4^{2-}$ (mg/L) | Alkalinity $HCO_3^-$ (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S294 | NM204 | Chamizal Lateral at Alameda | 3/18/1997 | 642 | 10.0 | 8.3 | 9.6 | 397 | 42.3 | 8.08 | 24.1 | 3.6 | 10.5 | 0.08 | 49.7 | 144.1 |
| S294 | NM217 | Chamizal Lateral at Alameda | 4/22/1997 | 633 | 13.4 | 8.3 | 8.5 | 364 | 40.0 | 7.38 | 18.1 | 3.4 | 9.2 | <0.05 | 47.3 | 147.4 |
| S294 | NM442 | Chamizal Lateral at Alameda | 5/5/1998 | 634 | 13.4 | 8.3 | 8.4 | 369 | 40.7 | 7.21 | 20.9 | 3.3 | 9.6 | <0.05 | 128. | 268.8 |
| S294 | NM380 | Chamizal Lateral at Alameda | 10/21/1997 | 640 | 13.7 | 7.8 | 8.2 | 297 | 34.9 | 5.75 | 15.5 | 3.0 | 6.5 | <0.05 | 49.3 | 146.9 |
| S294 | NM608 | Chamizal Lateral at Alameda | 3/30/1999 | 633 | 14.1 | 8.6 | 8.3 | 361 | 38.0 | 7.02 | 24.7 | 3.5 | 10.1 | <0.1 | 50.0 | 132.4 |
| S294 | NM560 | Chamizal Lateral at Alameda | 10/20/1998 | 639 | 14.9 | 8.1 | 7.8 | 374 | 43.5 | 7.57 | 20.8 | 3.4 | 7.3 | <0.05 | 42.8 | 103.6 |
| S294 | NM456 | Chamizal Lateral at Alameda | 6/11/1998 | 636 | 15.3 | 8.1 | 7.8 | 316 | 37.3 | 6.49 | 16.6 | 2.8 | 6.1 | <0.05 | 26.9 | 208.0 |
| S294 | NM230 | Chamizal Lateral at Alameda | 5/21/1997 | 637 | 15.7 | 8.2 | 7.3 | 340 | 37.7 | 6.64 | 18.0 | 2.8 | 7.6 | <0.05 | 50.8 | 129.7 |
| S294 | NM547 | Chamizal Lateral at Alameda | 9/22/1998 | 637 | 19.0 | 8.5 | nd | 356 | 41.9 | 7.29 | 18.7 | 3.0 | 6.5 | <0.05 | 50.0 | 132.1 |
| S294 | NM355 | Chamizal Lateral at Alameda | 7/9/1997 | 637 | 19.8 | 7.8 | 7.1 | 338 | 36.4 | 6.70 | 19.2 | 3.1 | 6.9 | <0.05 | 49.6 | 143.7 |
| S294 | NM369 | Chamizal Lateral at Alameda | 9/16/1997 | 637 | 20.5 | 8.2 | 7.4 | 350 | 42.7 | 6.90 | 17.5 | 3.1 | 7.1 | <0.05 | 52.6 | 133.8 |
| S294 | NM533 | Chamizal Lateral at Alameda | 8/18/1998 | 638 | 21.6 | 8.3 | 6.4 | 364 | 43.7 | 7.30 | 20.2 | 3.4 | 7.4 | <0.05 | 42.5 | 102.8 |
| S294 | NM470 | Chamizal Lateral at Alameda | 7/22/1998 | 637 | 23.0 | 8.4 | 5.8 | 355 | 39.8 | 6.90 | 20.0 | 3.5 | 6.8 | <0.05 | 48.5 | 123.3 |
| S297 | NM592 | Jemez River below Jemez Canyon Dam | 1/6/1999 | 637 | 3.5 | 8.5 | 10.4 | 958 | 64.5 | 8.49 | 119. | 10. | 115. | 0.22 | 45.9 | 134.1 |
| S297 | NM603 | Jemez River below Jemez Canyon Dam | 2/3/1999 | 633 | 4.8 | 8.6 | 10.4 | 972 | 62.8 | 8.67 | 124. | 10. | 121. | 0.27 | 41.0 | 115.9 |
| S297 | NM422 | Jemez River below Jemez Canyon Dam | 2/20/1998 | 624 | 8.0 | 8.7 | 10.6 | 1,072 | 63.0 | 8.62 | 137. | 11. | 132. | 0.29 | 43.4 | 105.5 |
| S297 | NM580 | Jemez River below Jemez Canyon Dam | 12/3/1998 | 630 | 8.2 | 8.6 | 10.8 | 939 | 66.0 | 8.27 | 110. | 9.3 | 110. | 0.21 | 41.0 | 114.4 |
| S297 | NM437 | Jemez River below Jemez Canyon Dam | 4/7/1998 | 629 | 10.1 | 8.5 | 9.5 | 950 | 59.4 | 7.79 | 125. | 10. | 119. | 0.22 | 50.6 | 136.9 |
| S297 | NM616 | Jemez River below Jemez Canyon Dam | 4/1/1999 | 624 | 11.8 | 8.7 | 8.2 | 1,098 | 65.2 | 9.27 | 147. | 12. | 137. | 0.30 | 45.6 | 133.5 |
| S297 | NM451 | Jemez River below Jemez Canyon Dam | 5/7/1998 | 632 | 12.3 | 8.5 | 9.8 | 821 | 55.5 | 6.98 | 98.0 | 8.4 | 95.6 | 0.19 | 55.0 | 150.6 |
| S297 | NM568 | Jemez River below Jemez Canyon Dam | 10/27/1998 | 635 | 13.0 | 8.2 | 7.5 | 935 | 61.8 | 8.57 | 116. | 9.7 | 103. | 0.12 | 46.4 | 131.6 |
| S297 | NM465 | Jemez River below Jemez Canyon Dam | 6/12/1998 | 635 | 15.1 | 8.1 | 6.6 | 703 | 47.1 | 6.33 | 78.6 | 7.3 | 77.4 | 0.14 | 127. | 251.0 |
| S297 | NM556 | Jemez River below Jemez Canyon Dam | 9/24/1998 | 634 | 16.3 | 8.1 | nd | 913 | 60.8 | 8.51 | 102. | 9.1 | 97.6 | 0.23 | 34.3 | 249.7 |
| S297 | NM479 | Jemez River below Jemez Canyon Dam | 7/23/1998 | 635 | 18.5 | 7.9 | 6.0 | 839 | 56.0 | 7.65 | 97.1 | 8.5 | 89.1 | 0.17 | 16.3 | 60.0 |
| S297 | NM542 | Jemez River below Jemez Canyon Dam | 8/19/1998 | 635 | 19.3 | 8.0 | 6.2 | 825 | 56.7 | 7.37 | 94.5 | 8.3 | 88.5 | 0.18 | 12.8 | 69.1 |
| S298 | NM593 | Jemez River at Jemez | 1/6/1999 | 626 | 2.2 | 8.4 | 12.0 | 559 | 48.4 | 5.37 | 60.1 | 9.9 | 74.2 | 0.20 | 44.2 | 121.0 |
| S298 | NM604 | Jemez River at Jemez | 2/3/1999 | 620 | 3.0 | 8.6 | 11.1 | 635 | 49.0 | 5.48 | 67.8 | 12. | 89.6 | 0.26 | 50.7 | 143.5 |
| S298 | NM617 | Jemez River at Jemez | 4/2/1999 | 613 | 6.2 | 8.5 | 10.9 | 318 | 31.2 | 3.09 | 27.9 | 5.1 | 32.5 | 0.10 | 44.7 | 125.3 |
| S298 | NM438 | Jemez River at Jemez | 4/7/1998 | 616 | 6.3 | 8.3 | 10.4 | 212 | 22.8 | 2.72 | 13.9 | 3.2 | 13.5 | 0.05 | 47.0 | 133.1 |
| S298 | NM581 | Jemez River at Jemez | 12/3/1998 | 618 | 6.3 | 8.4 | 11.0 | 400 | 38.3 | 4.18 | 37.9 | 6.4 | 41.9 | 0.10 | 50.2 | 140.8 |
| S298 | NM452 | Jemez River at Jemez | 5/7/1998 | 619 | 7.5 | 8.2 | 11.4 | 164 | 21.4 | 2.07 | 8.2 | 1.8 | 10.0 | <0.05 | 47.1 | 136.3 |
| S298 | NM569 | Jemez River at Jemez | 10/27/1998 | 622 | 11.1 | 8.4 | 8.0 | 223 | 20.3 | 3.40 | 17.3 | 4.7 | 20.3 | <0.05 | 50.5 | 143.2 |
| S298 | NM423 | Jemez River at Jemez | 2/20/1998 | 610 | 11.3 | 8.7 | 9.4 | 509 | 44.0 | 4.89 | 45.2 | 8.8 | 63.9 | 0.20 | 41.7 | 116.8 |
| S298 | NM557 | Jemez River at Jemez | 9/24/1998 | 622 | 13.7 | 8.4 | nd | 667 | 53.3 | 6.03 | 65.6 | 13. | 90.4 | 0.26 | 49.3 | 146.2 |
| S298 | NM466 | Jemez River at Jemez | 6/12/1998 | 623 | 14.0 | 8.3 | 8.5 | 366 | 37.2 | 3.97 | 26.4 | 5.3 | 34.5 | 0.10 | 125. | 166.5 |
| S298 | NM543 | Jemez River at Jemez | 8/19/1998 | 625 | 19.7 | 8.5 | 7.6 | 547 | 47.1 | 5.48 | 49.9 | 9.5 | 66.6 | 0.16 | 44.3 | 124.7 |
| S298 | NM480 | Jemez River at Jemez | 7/23/1998 | 624 | 20.3 | 8.5 | 7.9 | 579 | 49.7 | 5.92 | 52.7 | 10. | 72.5 | 0.18 | 46.7 | 136.7 |
| S300 | NM187 | Rio Grande at Alameda | 1/14/1997 | 632 | 0.7 | 8.5 | 12.0 | 431 | 51.1 | 9.14 | 23.8 | 3.9 | 11.4 | nd | 135. | 246.0 |
| S300 | NM583 | Rio Grande at Alameda | 1/5/1999 | 640 | 3.0 | 8.4 | 11.0 | 422 | 46.4 | 8.48 | 28.0 | 3.8 | 15.9 | <0.1 | 46.9 | 141.3 |
| S300 | NM398 | Rio Grande at Alameda | 1/8/1998 | 634 | 3.2 | 8.2 | 10.6 | 376 | 40.8 | 6.70 | 25.9 | 3.4 | 15.3 | <0.05 | 45.6 | 133.4 |
| S300 | NM195 | Rio Grande at Alameda | 2/11/1997 | 635 | 4.1 | 8.5 | 10.6 | 415 | 47.0 | 8.52 | 26.6 | 3.7 | 14.0 | nd | 43.8 | 336.0 |
| S300 | NM413 | Rio Grande at Alameda | 2/19/1998 | 637 | 5.7 | 8.5 | 10.4 | 368 | 41.6 | 7.00 | 24.2 | 3.3 | 13.1 | <0.05 | 49.2 | 143.8 |

**Table B2.** Surface-water field parameters and major-element chemistry-- Continued

| Site no. | Sample no. | Site name | Date | Barometric pressure (mm Hg) | Temp. ºC | pH | $O_2$ (mg/L) | Sp. Cond. (µS/cm at 25º C) | $Ca^{2+}$ (mg/L) | $Mg^{2+}$ (mg/L) | $Na^+$ (mg/L) | $K^+$ (mg/L) | $Cl^-$ (mg/L) | $Br^-$ (mg/L) | $SO_4^{2-}$ (mg/L) | Alkalinity $HCO_3^-$ (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S300 | NM389 | Rio Grande at Alameda | 11/20/1997 | 635 | 7.0 | 8.6 | 9.7 | 300 | 33.3 | 5.81 | 17.2 | 2.8 | 7.1 | <0.05 | 33.3 | 99.3 |
| S300 | NM594 | Rio Grande at Alameda | 2/2/1999 | 639 | 7.0 | 8.7 | 10.7 | 421 | 43.1 | 7.82 | 28.6 | 3.8 | 16.5 | <0.1 | 137. | 282.3 |
| S300 | NM571 | Rio Grande at Alameda | 12/1/1998 | 642 | 7.5 | 8.5 | 9.0 | 424 | 47.7 | 8.47 | 27.6 | 3.8 | 13.2 | <0.07 | 50.3 | 158.2 |
| S300 | NM425 | Rio Grande at Alameda | 3/31/1998 | 633 | 8.0 | 8.6 | 9.2 | 350 | 33.1 | 6.22 | 27.3 | 3.2 | 14.6 | <0.05 | 136. | 268.3 |
| S300 | NM206 | Rio Grande at Alameda | 3/18/1997 | 642 | 8.6 | 8.6 | 9.5 | 437 | 41.0 | 7.87 | 35.6 | 4.1 | 22.2 | 0.10 | 33.1 | 98.9 |
| S300 | NM218 | Rio Grande at Alameda | 4/22/1997 | 632 | 12.0 | 8.6 | 8.6 | 396 | 37.4 | 6.58 | 27.0 | 4.0 | 20.6 | 0.06 | 43.7 | 130.3 |
| S300 | NM378 | Rio Grande at Alameda | 10/21/1997 | 639 | 12.5 | 8.0 | 7.9 | 240 | 28.2 | 4.80 | 11.9 | 2.3 | 4.1 | <0.05 | 43.6 | 84.7 |
| S300 | NM558 | Rio Grande at Alameda | 10/20/1998 | 639 | 13.0 | 8.2 | 8.3 | 376 | 43.4 | 7.62 | 20.7 | 3.3 | 10.0 | <0.05 | 38.4 | 125.4 |
| S300 | NM440 | Rio Grande at Alameda | 5/5/1998 | 634 | 13.4 | 8.2 | 8.5 | 351 | 36.9 | 6.53 | 22.2 | 3.2 | 12.1 | 0.06 | 43.6 | 336.4 |
| S300 | NM231 | Rio Grande at Alameda | 5/21/1997 | 636 | 15.5 | 8.2 | 8.0 | 296 | 35.6 | 2.16 | 16.5 | 0.5 | 8.0 | <0.05 | 42.8 | 122.8 |
| S300 | NM454 | Rio Grande at Alameda | 6/11/1998 | 635 | 15.6 | 8.4 | 7.6 | 273 | 31.3 | 5.73 | 13.6 | 2.5 | 4.7 | <0.05 | 40.1 | 126.2 |
| S300 | NM606 | Rio Grande at Alameda | 3/30/1999 | 634 | 16.0 | 8.6 | 8.2 | 420 | 39.0 | 7.02 | 37.5 | 4.3 | 22.5 | <0.1 | 42.4 | 323.9 |
| S300 | NM545 | Rio Grande at Alameda | 9/22/1998 | 637 | 17.4 | 8.6 | nd | 323 | 38.6 | 6.77 | 15.8 | 2.6 | 5.3 | <0.05 | 44.9 | 142.7 |
| S300 | NM123 | Rio Grande at Alameda | 6/22/1996 | nd | 19.9 | 7.8 | 6.4 | 372 | 43.6 | 6.62 | 22.2 | 3.9 | 6.3 | <0.05 | 50.1 | 146.7 |
| S300 | NM367 | Rio Grande at Alameda | 9/16/1997 | 637 | 19.9 | 8.4 | 7.1 | 307 | 36.4 | 5.95 | 15.8 | 2.7 | 6.5 | <0.05 | 32.5 | 96.7 |
| S300 | NM356 | Rio Grande at Alameda | 7/9/1997 | 637 | 20.7 | 8.2 | 7.0 | 293 | 31.5 | 5.90 | 17.0 | 3.0 | 5.7 | <0.05 | 43.3 | 120.7 |
| S300 | NM531 | Rio Grande at Alameda | 8/18/1998 | 638 | 22.5 | 8.6 | 6.0 | 328 | 39.6 | 6.68 | 17.8 | 3.1 | 5.8 | <0.05 | 37.8 | 123.1 |
| S300 | NM468 | Rio Grande at Alameda | 7/22/1998 | 637 | 25.1 | 8.6 | 6.5 | 322 | 36.6 | 6.54 | 17.9 | 3.2 | 5.5 | <0.05 | 48.4 | 147.3 |
| S300 | NM118 | Rio Grande at Alameda | 6/29/1996 | nd | 26.6 | 8.5 | 7.8 | 355 | 43.9 | 6.50 | 18.9 | 3.6 | 7.3 | 0.17 | 48.9 | 145.5 |
| S301 | NM189 | Rio Grande at Campbell | 1/14/1997 | 632 | 0.4 | 8.5 | 11.6 | 418 | 49.0 | 9.03 | 25.3 | 3.7 | 10.8 | nd | 52.2 | 150.0 |
| S301 | NM585 | Rio Grande at Campbell | 1/5/1999 | 640 | 2.0 | 8.2 | 11.2 | 412 | 46.1 | 8.09 | 27.7 | 3.7 | 16.2 | <0.1 | 12.4 | 187.3 |
| S301 | NM400 | Rio Grande at Campbell | 1/8/1998 | 634 | 2.5 | 8.7 | 11.1 | 372 | 39.1 | 6.50 | 25.9 | 3.2 | 16.2 | 0.06 | 50.0 | 148.1 |
| S301 | NM197 | Rio Grande at Campbell | 2/11/1997 | 635 | 4.8 | 8.5 | 10.9 | 399 | 44.8 | 8.22 | 25.5 | 3.6 | 13.7 | nd | 48.3 | 149.1 |
| S301 | NM415 | Rio Grande at Campbell | 2/19/1998 | 636 | 6.2 | 8.4 | 11.0 | 352 | 38.9 | 6.82 | 24.4 | 3.3 | 13.1 | 0.06 | 53.6 | 155.6 |
| S301 | NM573 | Rio Grande at Campbell | 12/1/1998 | 642 | 6.5 | 8.5 | 9.5 | 408 | 44.8 | 8.05 | 31.3 | 3.5 | 12.9 | <0.07 | 151. | 220.7 |
| S301 | NM391 | Rio Grande at Campbell | 11/20/1997 | 635 | 7.2 | 8.6 | 9.8 | 286 | 31.7 | 5.61 | 17.3 | 2.7 | 6.7 | <0.05 | 40.0 | 276.3 |
| S301 | NM596 | Rio Grande at Campbell | 2/2/1999 | 639 | 7.5 | 8.7 | 10.2 | 409 | 41.2 | 7.39 | 28.8 | 3.9 | 16.8 | <0.1 | 1,080. | 267.8 |
| S301 | NM429 | Rio Grande at Campbell | 3/31/1998 | 633 | 8.2 | 8.7 | 8.9 | 352 | 34.2 | 6.30 | 26.8 | 3.2 | 14.9 | 0.06 | 47.1 | 146.6 |
| S301 | NM208 | Rio Grande at Campbell | 3/18/1997 | nd | 11.0 | 8.5 | 9.4 | 440 | 41.4 | 7.89 | 36.4 | 4.2 | 22.8 | 0.10 | 50.6 | 146.4 |
| S301 | NM382 | Rio Grande at Campbell | 10/21/1997 | 639 | 13.8 | 7.6 | 8.1 | 236 | 27.8 | 4.75 | 12.1 | 2.3 | 3.9 | <0.05 | 141. | 264.5 |
| S301 | NM444 | Rio Grande at Campbell | 5/5/1998 | 635 | 15.0 | 8.4 | 8.3 | 356 | 36.9 | 6.74 | 22.2 | 2.8 | 12.4 | 0.07 | 50.8 | 151.9 |
| S301 | NM221 | Rio Grande at Campbell | 4/22/1997 | 635 | 15.3 | 8.5 | 8.6 | 399 | 36.5 | 6.42 | 26.6 | 4.1 | 21.1 | 0.07 | 46.2 | 144.6 |
| S301 | NM233 | Rio Grande at Campbell | 5/21/1997 | 637 | 15.8 | 8.1 | 7.4 | 298 | 32.3 | 5.68 | 16.8 | 2.4 | 8.2 | <0.05 | 49.0 | 145.6 |
| S301 | NM561 | Rio Grande at Campbell | 10/20/1998 | 639 | 15.9 | 8.3 | 7.7 | 344 | 39.6 | 6.92 | 19.2 | 3.1 | 8.0 | <0.05 | 36.7 | 257.2 |
| S301 | NM458 | Rio Grande at Campbell | 6/11/1998 | 636 | 16.2 | 8.3 | 7.6 | 278 | 31.7 | 5.84 | 13.6 | 2.5 | 5.3 | <0.05 | 46.7 | 146.4 |
| S301 | NM609 | Rio Grande at Campbell | 3/30/1999 | 633 | 16.4 | 8.5 | 8.0 | 429 | 38.8 | 7.11 | 38.7 | 4.2 | 23.8 | <0.1 | 46.4 | 135.6 |
| S301 | NM549 | Rio Grande at Campbell | 9/22/1998 | 638 | 17.7 | 8.2 | nd | 324 | 38.5 | 6.79 | 15.4 | 2.6 | 5.3 | <0.05 | 146. | 229.8 |
| S301 | NM371 | Rio Grande at Campbell | 9/16/1997 | 637 | 22.3 | 8.3 | 7.1 | 302 | 35.1 | 5.79 | 15.1 | 2.7 | 6.6 | <0.05 | 50.3 | 143.7 |
| S301 | NM358 | Rio Grande at Campbell | 7/9/1997 | 638 | 23.0 | 8.3 | 6.8 | 294 | 32.3 | 6.10 | 17.6 | 3.0 | 5.8 | <0.05 | 48.4 | 154.6 |
| S301 | NM535 | Rio Grande at Campbell | 8/18/1998 | 638 | 23.1 | 8.3 | 6.2 | 333 | 39.4 | 6.70 | 17.5 | 3.0 | 6.0 | <0.05 | 51.9 | 148.7 |
| S301 | NM472 | Rio Grande at Campbell | 7/22/1998 | 637 | 26.6 | 8.4 | 6.2 | 326 | 37.7 | 6.64 | 18.5 | 3.2 | 5.7 | <0.05 | 48.9 | 154.6 |
| S302 | NM124 | Rio Grande at Isleta Below Diversion | 6/22/1996 | nd | 26.3 | 8.2 | 7.7 | 431 | 44.4 | 6.80 | 21.5 | 3.6 | 6.3 | 0.06 | 49.2 | 146.1 |

**Table B2.** Surface-water field parameters and major-element chemistry-- Continued

| Site no. | Sample no. | Site name | Date | Barometric pressure (mm Hg) | Temp. ºC | pH | $O_2$ (mg/L) | Sp. Cond. (µS/cm at 25º C) | $Ca^{2+}$ (mg/L) | $Mg^{2+}$ (mg/L) | $Na^+$ (mg/L) | $K^+$ (mg/L) | $Cl^-$ (mg/L) | $Br^-$ (mg/L) | $SO_4^{2-}$ (mg/L) | Alkalinity $HCO_3^-$ (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S303 | NM191 | Rio Grande at Rio Bravo | 1/15/1997 | 640 | 0.3 | 8.5 | 11.4 | 428 | 50.4 | 9.03 | 25.4 | 3.6 | 10.9 | nd | 49.2 | 145.0 |
| S303 | NM587 | Rio Grande at Rio Bravo | 1/5/1999 | 641 | 4.0 | 8.3 | 11.4 | 401 | 44.6 | 8.07 | 27.5 | 3.4 | 14.5 | <0.1 | 52.2 | 149.6 |
| S303 | NM402 | Rio Grande at Rio Bravo | 1/8/1998 | 634 | 4.5 | 8.7 | 10.9 | 369 | 38.8 | 6.55 | 26.0 | 3.1 | 15.8 | 0.06 | 140. | 198.8 |
| S303 | NM598 | Rio Grande at Rio Bravo | 2/2/1999 | 638 | 8.0 | 8.5 | 10.3 | 427 | 42.2 | 7.51 | 31.6 | 3.8 | 19.5 | <0.1 | 53.4 | 152.1 |
| S303 | NM199 | Rio Grande at Rio Bravo | 2/11/1997 | 633 | 8.1 | 8.5 | 10.7 | 402 | 44.7 | 8.10 | 25.1 | 3.6 | 13.9 | nd | 47.5 | 135.1 |
| S303 | NM575 | Rio Grande at Rio Bravo | 12/1/1998 | 642 | 8.2 | 8.5 | 9.9 | 391 | 44.1 | 7.82 | 24.6 | 3.3 | 10.6 | <0.07 | 51.3 | 131.5 |
| S303 | NM393 | Rio Grande at Rio Bravo | 11/20/1997 | 635 | 8.5 | 8.4 | 9.8 | 294 | 33.0 | 5.77 | 17.5 | 2.8 | 6.9 | <0.05 | 30.7 | 167.0 |
| S303 | NM417 | Rio Grande at Rio Bravo | 2/19/1998 | 637 | 8.7 | 8.5 | 11.0 | 356 | 39.0 | 6.76 | 24.4 | 3.3 | 12.9 | <0.05 | 7.8 | 96.5 |
| S303 | NM431 | Rio Grande at Rio Bravo | 3/31/1998 | 634 | 9.0 | 8.5 | 9.5 | 357 | 34.6 | 6.42 | 27.4 | 3.5 | 14.9 | 0.08 | 1,130. | 305.4 |
| S303 | NM210 | Rio Grande at Rio Bravo | 3/18/1997 | nd | 13.2 | 8.4 | 9.1 | 450 | 42.2 | 8.10 | 36.6 | 4.2 | 23.4 | 0.09 | 48.1 | 145.1 |
| S303 | NM384 | Rio Grande at Rio Bravo | 10/21/1997 | 639 | 15.1 | 7.5 | 8.3 | 244 | 28.5 | 4.79 | 12.0 | 2.4 | 4.2 | <0.05 | 29.9 | 166.1 |
| S303 | NM446 | Rio Grande at Rio Bravo | 5/5/1998 | 634 | 16.2 | 8.4 | 8.3 | 355 | 36.7 | 6.70 | 22.3 | 3.0 | 12.5 | 0.05 | 51.6 | 129.6 |
| S303 | NM235 | Rio Grande at Rio Bravo | 5/21/1997 | 636 | 16.4 | 8.1 | 7.5 | 304 | 33.0 | 5.81 | 17.3 | 2.6 | 8.4 | <0.05 | 48.7 | 147.9 |
| S303 | NM563 | Rio Grande at Rio Bravo | 10/20/1998 | 639 | 16.9 | 8.2 | 7.2 | 272 | 31.1 | 5.13 | 15.1 | 3.3 | 5.9 | <0.05 | 52.8 | 146.6 |
| S303 | NM611 | Rio Grande at Rio Bravo | 3/30/1999 | 633 | 16.9 | 8.4 | 8.2 | 400 | 38.9 | 7.13 | 33.0 | 4.0 | 18.1 | <0.1 | 151. | 235.0 |
| S303 | NM223 | Rio Grande at Rio Bravo | 4/22/1997 | 633 | 17.0 | 8.4 | 8.4 | 414 | 38.3 | 6.78 | 26.8 | 4.2 | 22.8 | 0.08 | 48.7 | 136.5 |
| S303 | NM460 | Rio Grande at Rio Bravo | 6/11/1998 | 637 | 18.0 | 8.3 | 7.2 | 275 | 31.1 | 5.81 | 13.3 | 2.3 | 4.6 | <0.05 | 53.4 | 144.5 |
| S303 | NM121 | Rio Grande at Rio Bravo | 6/29/1996 | nd | 21.5 | 8.1 | 7.1 | 361 | 45.5 | 7.79 | 28.0 | 5.1 | 17.1 | 0.08 | 48.6 | 144.3 |
| S303 | NM551 | Rio Grande at Rio Bravo | 9/22/1998 | 637 | 23.5 | 8.4 | nd | 334 | 39.6 | 6.95 | 15.9 | 2.7 | 5.4 | <0.05 | 52.0 | 129.8 |
| S303 | NM373 | Rio Grande at Rio Bravo | 9/16/1997 | 636 | 24.1 | 8.3 | 7.0 | 305 | 36.1 | 5.93 | 17.1 | 2.8 | 6.9 | <0.05 | 163. | 256.8 |
| S303 | NM537 | Rio Grande at Rio Bravo | 8/18/1998 | 639 | 25.2 | 8.4 | 6.3 | 339 | 41.0 | 6.83 | 18.6 | 3.1 | 6.2 | <0.05 | 54.0 | 145.9 |
| S303 | NM360 | Rio Grande at Rio Bravo | 7/9/1997 | 638 | 25.2 | 8.4 | 6.9 | 302 | 32.7 | 6.10 | 17.6 | 3.1 | 5.9 | <0.05 | 51.9 | 149.6 |
| S303 | NM474 | Rio Grande at Rio Bravo | 7/22/1998 | 637 | 27.8 | 8.3 | 6.0 | 339 | 37.9 | 6.83 | 19.1 | 3.3 | 6.1 | <0.05 | 53.2 | 144.4 |
| S304 | NM122 | Rio Grande at San Felipe | 6/22/1996 | nd | 18.1 | 7.8 | 8.2 | 348 | 40.0 | 7.00 | 23.3 | 3.8 | 5.8 | <0.05 | 24.5 | 176.8 |
| S305 | NM120 | Rio Grande at Central | 6/29/1996 | nd | 20.6 | 7.8 | 6.5 | 386 | 40.3 | 7.90 | 19.0 | 3.1 | 5.8 | <0.05 | 113. | 182.6 |
| S306 | NM119 | Rio Grande at Nature Center | 6/29/1996 | nd | 20.3 | 7.8 | 6.3 | 386 | 42.3 | 7.95 | 18.7 | 2.9 | 5.2 | <0.05 | 5.8 | 78.3 |
| S307 | NM424 | Rio Puerco at Hwy 6 | 2/20/1998 | 630 | 1.2 | 8.6 | 11.8 | 3,300 | 176. | 97.8 | 410. | 14. | 350. | 0.80 | 909. | 186.6 |
| S307 | NM605 | Rio Puerco at Hwy 6 | 2/3/1999 | 634 | 4.0 | 8.4 | 12.6 | 5,230 | 280. | 133. | 780. | 28. | 676. | 1.11 | 41.0 | 109.2 |
| S307 | NM618 | Rio Puerco at Hwy 6 | 4/2/1999 | 625 | 8.0 | 8.5 | 9.7 | 4,170 | 204. | 114. | 630. | 19. | 479. | 1.04 | 47.0 | 132.2 |
| S307 | NM439 | Rio Puerco at Hwy 6 | 4/7/1998 | 630 | 10.1 | 8.4 | 9.8 | 3,330 | 172. | 88.9 | 470. | 16. | 326. | 0.80 | 40.5 | 107.4 |
| S307 | NM582 | Rio Puerco at Hwy 6 | 12/3/1998 | 631 | 12.0 | 8.5 | 9.7 | 3,210 | 173. | 85.7 | 447. | 15. | 353. | 0.67 | 46.5 | 129.4 |
| S307 | NM570 | Rio Puerco at Hwy 6 | 10/23/1998 | 639 | 16.2 | 8.1 | 7.6 | 2,010 | 136. | 43.1 | 235. | 13. | 144. | 0.15 | 41.4 | 107.8 |
| S307 | NM453 | Rio Puerco at Hwy 6 | 5/7/1998 | 634 | 16.3 | 8.4 | 8.2 | 2,180 | 165. | 44.5 | 274. | 9.6 | 71.8 | 0.18 | 46.8 | 128.5 |
| S307 | NM544 | Rio Puerco at Hwy 6 | 8/19/1998 | 636 | 24.8 | 8.1 | 5.9 | 2,720 | 190. | 45.9 | 351. | 14. | 236. | 0.41 | 46.5 | 126.4 |
| S307 | NM467 | Rio Puerco at Hwy 6 | 6/12/1998 | 637 | 28.0 | 8.4 | 7.4 | 2,600 | 180. | 51.4 | 322. | 12. | 195. | 0.37 | 46.6 | 125.2 |
| S308 | NM196 | Riverside Drain at Alameda | 2/11/1997 | 635 | 7.0 | 8.1 | 8.0 | 457 | 56.4 | 9.37 | 24.8 | 3.3 | 15.5 | nd | 149. | 226.1 |
| S308 | NM188 | Riverside Drain at Alameda | 1/14/1997 | 632 | 8.3 | 8.2 | 8.4 | 450 | 55.4 | 9.19 | 23.2 | 3.5 | 11.4 | nd | 50.9 | 141.0 |
| S308 | NM426 | Riverside Drain at Alameda | 3/31/1998 | 633 | 8.5 | 8.3 | 8.3 | 354 | 39.0 | 6.99 | 22.9 | 3.0 | 10.5 | <0.05 | 53.5 | 142.2 |
| S308 | NM414 | Riverside Drain at Alameda | 2/19/1998 | 637 | 8.5 | 8.4 | 10.2 | 376 | 45.4 | 7.20 | 22.2 | 2.9 | 11.7 | 0.05 | 50.8 | 132.4 |
| S308 | NM399 | Riverside Drain at Alameda | 1/8/1998 | 634 | 8.7 | 8.1 | 7.3 | 355 | 42.0 | 6.59 | 20.1 | 2.8 | 9.7 | <0.05 | 54.2 | 143.8 |
| S308 | NM207 | Riverside Drain at Alameda | 3/18/1997 | 642 | 9.2 | 8.2 | 8.9 | 405 | 44.3 | 8.24 | 24.7 | 3.5 | 11.1 | 0.08 | 28.2 | 197.2 |
| S308 | NM584 | Riverside Drain at Alameda | 1/5/1999 | 640 | 9.5 | 7.9 | 7.1 | 417 | 48.0 | 8.27 | 23.8 | 3.4 | 12.9 | <0.1 | 50.3 | 134.3 |

**Table B2.** Surface-water field parameters and major-element chemistry-- Continued

| Site no. | Sample no. | Site name | Date | Barometric pressure (mm Hg) | Temp. °C | pH | $O_2$ (mg/L) | Sp. Cond. (µS/cm at 25° C) | $Ca^{2+}$ (mg/L) | $Mg^{2+}$ (mg/L) | $Na^+$ (mg/L) | $K^+$ (mg/L) | $Cl^-$ (mg/L) | $Br^-$ (mg/L) | $SO_4^{2-}$ (mg/L) | Alkal-inity $HCO_3^-$ (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S308 | NM595 | Riverside Drain at Alameda | 2/2/1999 | 639 | 10.0 | 8.4 | 8.7 | 422 | 47.2 | 8.21 | 24.4 | 3.2 | 13.4 | <0.1 | 54.2 | 147.8 |
| S308 | NM219 | Riverside Drain at Alameda | 4/22/1997 | 632 | 12.2 | 8.2 | 8.6 | 382 | 40.5 | 7.41 | 20.5 | 3.3 | 11.2 | <0.05 | 84.2 | 175.4 |
| S308 | NM441 | Riverside Drain at Alameda | 5/5/1998 | 634 | 12.7 | 8.2 | 7.7 | 372 | 41.3 | 7.16 | 22.2 | 3.2 | 10.7 | 0.04 | 53.5 | 136.1 |
| S308 | NM390 | Riverside Drain at Alameda | 11/20/1997 | 635 | 12.9 | 8.6 | 7.6 | 352 | 40.0 | 6.59 | 19.8 | 3.2 | 8.4 | <0.05 | 54.6 | 143.9 |
| S308 | NM572 | Riverside Drain at Alameda | 12/1/1998 | 642 | 13.0 | 7.8 | 5.8 | 402 | 47.1 | 8.05 | 22.3 | 3.7 | 11.2 | <0.07 | 9.1 | 216.4 |
| S308 | NM607 | Riverside Drain at Alameda | 3/30/1999 | 634 | 13.0 | 8.4 | 8.6 | 371 | 39.4 | 7.10 | 25.4 | 3.6 | 11.1 | <0.1 | 55.8 | 148.6 |
| S308 | NM232 | Riverside Drain at Alameda | 5/21/1997 | 636 | 14.7 | 8.1 | 6.9 | 363 | 40.3 | 6.91 | 18.6 | 2.8 | 9.5 | <0.05 | 7.4 | 154.6 |
| S308 | NM379 | Riverside Drain at Alameda | 10/21/1997 | 639 | 14.8 | 7.5 | 7.0 | 316 | 36.2 | 5.90 | 16.9 | 3.1 | 7.2 | <0.05 | 52.8 | 142.5 |
| S308 | NM455 | Riverside Drain at Alameda | 6/11/1998 | 636 | 14.8 | 8.1 | 6.6 | 325 | 38.1 | 6.45 | 17.6 | 2.8 | 6.9 | <0.05 | 54.8 | 146.1 |
| S308 | NM559 | Riverside Drain at Alameda | 10/20/1998 | 639 | 15.6 | 7.9 | 6.6 | 371 | 42.9 | 7.49 | 20.7 | 3.5 | 7.3 | <0.05 | 124. | 190.9 |
| S308 | NM357 | Riverside Drain at Alameda | 7/9/1997 | 637 | 18.8 | 8.0 | 6.3 | 340 | 36.6 | 6.60 | 20.7 | 3.2 | 7.1 | <0.05 | 995. | 174.4 |
| S308 | NM546 | Riverside Drain at Alameda | 9/22/1998 | 638 | 19.2 | 8.1 | nd | 357 | 42.0 | 7.24 | 17.9 | 3.3 | 6.7 | <0.05 | 34.5 | 247.4 |
| S308 | NM368 | Riverside Drain at Alameda | 9/16/1997 | 636 | 20.2 | 8.0 | 6.1 | 350 | 41.6 | 6.84 | 18.3 | 3.2 | 8.0 | <0.05 | 49.6 | 130.7 |
| S308 | NM532 | Riverside Drain at Alameda | 8/18/1998 | 638 | 21.1 | 8.2 | 5.2 | 364 | 42.3 | 7.17 | 20.0 | 3.5 | 7.5 | <0.05 | 142. | 214.0 |
| S308 | NM469 | Riverside Drain at Alameda | 7/22/1998 | 638 | 21.8 | 8.2 | 5.6 | 352 | 41.3 | 7.10 | 19.1 | 3.3 | 6.7 | <0.05 | 53.6 | 139.5 |
| S309 | NM190 | Riverside Drain at Campbell | 1/14/1997 | 632 | 7.9 | 8.2 | 8.8 | 438 | 53.4 | 8.82 | 23.4 | 3.4 | 10.9 | nd | 55.2 | 150.2 |
| S309 | NM198 | Riverside Drain at Campbell | 2/11/1997 | 635 | 8.6 | 8.2 | 9.0 | 447 | 55.2 | 9.22 | 23.6 | 3.3 | 14.3 | nd | 50.7 | 136.1 |
| S309 | NM430 | Riverside Drain at Campbell | 3/31/1998 | 634 | 8.7 | 8.3 | 8.6 | 355 | 39.9 | 7.10 | 22.3 | 2.9 | 10.5 | 0.05 | 52.2 | 128.9 |
| S309 | NM416 | Riverside Drain at Campbell | 2/19/1998 | 636 | 9.0 | 8.3 | 9.6 | 366 | 44.1 | 7.01 | 21.2 | 2.9 | 11.1 | 0.06 | 962. | 173.5 |
| S309 | NM401 | Riverside Drain at Campbell | 1/8/1998 | 634 | 9.5 | 8.2 | 8.5 | 344 | 40.9 | 6.39 | 19.2 | 2.8 | 9.4 | <0.05 | 8.3 | 202.8 |
| S309 | NM586a | Riverside Drain at Campbell | 1/5/1999 | 641 | 9.7 | 7.9 | 7.8 | 411 | 47.3 | 8.19 | 23.0 | 3.4 | 13.4 | <0.1 | 142. | 227.4 |
| S309 | NM586 | Riverside Drain at Campbell | 1/5/1999 | 641 | 9.7 | 7.9 | 7.8 | 411 | 47.4 | 8.16 | 22.7 | 3.4 | 12.8 | <0.1 | 55.5 | 149.2 |
| S309 | NM209 | Riverside Drain at Campbell | 3/18/1997 | nd | 10.6 | 8.2 | 9.0 | 408 | 44.7 | 8.32 | 24.8 | 3.5 | 11.3 | 0.06 | 54.8 | 148.0 |
| S309 | NM597 | Riverside Drain at Campbell | 2/2/1999 | 638 | 10.6 | 8.3 | 10.4 | 416 | 47.3 | 8.14 | 23.3 | 3.5 | 13.5 | <0.1 | 44.5 | 329.5 |
| S309 | NM610 | Riverside Drain at Campbell | 3/30/1999 | 633 | 13.0 | 8.2 | 9.2 | 372 | 39.4 | 7.10 | 26.5 | 3.4 | 11.1 | <0.1 | 130. | 216.1 |
| S309 | NM445 | Riverside Drain at Campbell | 5/5/1998 | 634 | 13.0 | 8.3 | 8.3 | 375 | 41.0 | 7.23 | 21.7 | 2.9 | 11.5 | 0.04 | 55.6 | 142.0 |
| S309 | NM222 | Riverside Drain at Campbell | 4/22/1997 | 635 | 13.4 | 8.3 | 8.8 | 385 | 40.8 | 7.44 | 20.4 | 3.3 | 11.6 | 0.06 | 51.1 | 139.5 |
| S309 | NM574 | Riverside Drain at Campbell | 12/1/1998 | 642 | 13.6 | 8.2 | 6.5 | 393 | 45.4 | 7.85 | 22.1 | 3.6 | 10.7 | <0.07 | 56.2 | 146.7 |
| S309 | NM392 | Riverside Drain at Campbell | 11/20/1997 | 635 | 14.0 | 8.6 | 7.1 | 334 | 38.3 | 6.31 | 18.8 | 3.2 | 7.6 | <0.05 | 116. | 195.6 |
| S309 | NM459 | Riverside Drain at Campbell | 6/11/1998 | 637 | 14.9 | 8.1 | 7.2 | 326 | 38.4 | 6.49 | 18.2 | 2.8 | 7.1 | <0.05 | 56.8 | 143.2 |
| S309 | NM234 | Riverside Drain at Campbell | 5/21/1997 | 637 | 15.0 | 8.1 | 7.2 | 364 | 40.7 | 6.99 | 20.3 | 2.9 | 10.0 | 0.06 | 54.7 | 151.6 |
| S309 | NM383 | Riverside Drain at Campbell | 10/21/1997 | 639 | 16.2 | 7.9 | 7.3 | 313 | 36.4 | 5.93 | 17.9 | 3.1 | 7.1 | <0.05 | 38.2 | 270.1 |
| S309 | NM562 | Riverside Drain at Campbell | 10/20/1998 | 639 | 16.8 | 8.1 | 7.5 | 365 | 42.3 | 7.34 | 19.9 | 3.6 | 7.3 | <0.05 | 52.2 | 133.8 |
| S309 | NM550 | Riverside Drain at Campbell | 9/22/1998 | 638 | 19.4 | 8.2 | nd | 355 | 41.4 | 7.12 | 18.3 | 3.3 | 6.6 | <0.05 | 55.0 | 143.2 |
| S309 | NM359 | Riverside Drain at Campbell | 7/9/1997 | 638 | 19.5 | 8.2 | 6.9 | 340 | 35.9 | 6.40 | 19.8 | 3.2 | 6.9 | <0.05 | 54.2 | 147.8 |
| S309 | NM536 | Riverside Drain at Campbell | 8/18/1998 | 638 | 21.2 | 8.2 | 5.6 | 363 | 42.3 | 7.06 | 19.6 | 3.4 | 7.5 | <0.05 | 51.6 | 130.1 |
| S309 | NM473 | Riverside Drain at Campbell | 7/22/1998 | 636 | 22.3 | 8.1 | 5.2 | 350 | 41.2 | 6.98 | 19.7 | 3.3 | 6.8 | <0.05 | 56.8 | 145.4 |
| S309 | NM372 | Riverside Drain at Campbell | 9/16/1997 | 636 | 22.4 | 8.0 | 6.6 | 346 | 41.9 | 6.81 | 17.6 | 3.4 | 8.0 | <0.05 | 146. | 225.6 |
| S310 | NM192 | Riverside Drain at Rio Bravo | 1/15/1997 | 640 | 7.7 | 8.2 | 8.4 | 435 | 53.7 | 8.45 | 23.1 | 3.9 | 10.1 | nd | 9.7 | 235.1 |
| S310 | NM432 | Riverside Drain at Rio Bravo | 3/31/1998 | 634 | 9.2 | 8.4 | 9.5 | 356 | 39.3 | 6.95 | 23.3 | 3.2 | 10.1 | 0.08 | 139. | 208.3 |
| S310 | NM588 | Riverside Drain at Rio Bravo | 1/5/1999 | 640 | 10.7 | 8.0 | 7.7 | 397 | 46.1 | 7.66 | 23.3 | 3.5 | 13.8 | <0.1 | 55.4 | 160.0 |
| S310 | NM403 | Riverside Drain at Rio Bravo | 1/8/1998 | 634 | 11.3 | 8.3 | 8.0 | 362 | 42.5 | 6.44 | 22.2 | 3.3 | 8.9 | <0.05 | 143. | 260.7 |

**Table B2.** Surface-water field parameters and major-element chemistry-- Continued

| Site no. | Sample no. | Site name | Date | Barometric pressure (mm Hg) | Temp. °C | pH | $O_2$ (mg/L) | Sp. Cond. (µS/cm at 25° C) | $Ca^{2+}$ (mg/L) | $Mg^{2+}$ (mg/L) | $Na^{+}$ (mg/L) | $K^{+}$ (mg/L) | $Cl^{-}$ (mg/L) | $Br^{-}$ (mg/L) | $SO_4^{2-}$ (mg/L) | Alkalinity $HCO_3^{-}$ (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S310 | NM200 | Riverside Drain at Rio Bravo | 2/11/1997 | 633 | 12.4 | 8.2 | 8.6 | 433 | 53.0 | 8.40 | 23.3 | 3.7 | 11.2 | nd | 57.0 | 146.3 |
| S310 | NM576 | Riverside Drain at Rio Bravo | 12/1/1998 | 642 | 12.8 | 7.9 | 6.9 | 386 | 43.4 | 7.18 | 23.6 | 3.7 | 9.5 | <0.07 | 55.6 | 160.4 |
| S310 | NM211 | Riverside Drain at Rio Bravo | 3/18/1997 | nd | 12.9 | 8.3 | 9.2 | 413 | 45.5 | 8.40 | 24.7 | 3.6 | 11.1 | 0.06 | 55.7 | 150.8 |
| S310 | NM599 | Riverside Drain at Rio Bravo | 2/2/1999 | 638 | 13.0 | 8.2 | 7.8 | 407 | 45.5 | 7.59 | 24.0 | 3.5 | 11.1 | <0.1 | 61.5 | 155.3 |
| S310 | NM418 | Riverside Drain at Rio Bravo | 2/19/1998 | 637 | 13.0 | 8.4 | 8.6 | 364 | 43.2 | 6.72 | 21.7 | 3.4 | 9.7 | 0.05 | 44.4 | 326.9 |
| S310 | NM612 | Riverside Drain at Rio Bravo | 3/30/1999 | 633 | 14.1 | 8.3 | 9.0 | 371 | 40.3 | 7.21 | 26.1 | 3.5 | 10.7 | <0.1 | 145. | 247.0 |
| S310 | NM394 | Riverside Drain at Rio Bravo | 11/20/1997 | 635 | 14.2 | 8.2 | 7.2 | 376 | 42.4 | 6.70 | 21.7 | 3.9 | 9.3 | <0.05 | 54.7 | 149.0 |
| S310 | NM447 | Riverside Drain at Rio Bravo | 5/5/1998 | 635 | 14.5 | 8.3 | 8.9 | 378 | 41.8 | 7.30 | 22.3 | 2.9 | 10.9 | 0.05 | 13.1 | 84.9 |
| S310 | NM224 | Riverside Drain at Rio Bravo | 4/22/1997 | 633 | 15.4 | 8.4 | 9.6 | 386 | 40.8 | 7.40 | 20.2 | 3.4 | 10.8 | <0.05 | 56.2 | 152.5 |
| S310 | NM564 | Riverside Drain at Rio Bravo | 10/20/1998 | 640 | 15.7 | 8.1 | 7.3 | 338 | 38.9 | 6.62 | 18.9 | 4.0 | 7.0 | <0.05 | 58.7 | 157.4 |
| S310 | NM461 | Riverside Drain at Rio Bravo | 6/11/1998 | 637 | 15.7 | 8.1 | 7.6 | 331 | 37.2 | 6.56 | 17.7 | 3.0 | 7.3 | <0.05 | 704. | 158.9 |
| S310 | NM385 | Riverside Drain at Rio Bravo | 10/21/1997 | 639 | 16.1 | 7.8 | 7.9 | 320 | 37.5 | 6.07 | 17.4 | 3.2 | 7.4 | 0.05 | 49.5 | 135.1 |
| S310 | NM236 | Riverside Drain at Rio Bravo | 5/21/1997 | 637 | 16.1 | 8.1 | 8.1 | 371 | 41.6 | 7.00 | 20.2 | 3.0 | 10.2 | 0.06 | 51.4 | 137.3 |
| S310 | NM552 | Riverside Drain at Rio Bravo | 9/22/1998 | 636 | 20.4 | 8.1 | nd | 367 | 42.6 | 7.24 | 19.2 | 3.4 | 6.9 | <0.05 | 58.5 | 166.2 |
| S310 | NM374 | Riverside Drain at Rio Bravo | 9/16/1997 | 636 | 21.4 | 8.1 | 6.7 | 349 | 42.3 | 6.91 | 17.3 | 3.4 | 7.3 | <0.05 | 37.7 | 107.1 |
| S310 | NM538 | Riverside Drain at Rio Bravo | 8/18/1998 | 638 | 21.5 | 8.1 | 6.6 | 375 | 43.3 | 7.22 | 20.0 | 3.5 | 7.8 | <0.05 | 60.1 | 160.7 |
| S310 | NM475 | Riverside Drain at Rio Bravo | 7/22/1998 | 637 | 22.8 | 8.0 | 6.4 | 363 | 43.0 | 7.20 | 19.9 | 3.4 | 7.2 | <0.05 | 62.2 | 170.3 |
| S310 | NM361 | Riverside Drain at Rio Bravo | 7/9/1997 | 638 | 25.8 | 8.2 | 7.3 | 355 | 38.8 | 6.80 | 21.5 | 3.2 | 7.6 | 0.05 | 54.8 | 148.9 |
| S311 | NM243 | Stream in Monte Largo Canyon | 5/28/1997 | nd | 19.4 | 8.0 | 7.1 | 143 | 16.0 | 3.65 | 5.7 | 0.7 | 2.9 | <0.05 | 43.9 | 298.0 |
| S312 | NM405 | Tijeras Arroyo at Four Hills | 1/9/1998 | 620 | 3.1 | 8.4 | 10.8 | 1,007 | 121. | 27.7 | 45.9 | 3.2 | 110. | 0.49 | 56.0 | 163.7 |
| S312 | NM396 | Tijeras Arroyo at Four Hills | 11/18/1997 | 628 | 5.3 | 6.1 | 10.1 | 1,030 | 122. | 31.4 | 44.8 | 3.8 | 109. | 0.45 | 54.7 | 165.9 |
| S312 | NM193 | Tijeras Arroyo at Four Hills | 1/15/1997 | 640 | 5.4 | 8.5 | 10.1 | 1,054 | 130. | 30.6 | 43.9 | 4.7 | 115. | nd | 140. | 199.6 |
| S312 | NM212 | Tijeras Arroyo at Four Hills | 3/19/1997 | 631 | 5.5 | 8.4 | 10.2 | 1,057 | 122. | 30.2 | 46.9 | 3.7 | 112. | 0.44 | 1,003. | 276.8 |
| S312 | NM590 | Tijeras Arroyo at Four Hills | 1/5/1999 | 626 | 9.0 | 8.3 | 9.5 | 998 | 120. | 29.0 | 48.4 | 3.2 | 98.9 | 0.34 | 56.1 | 160.6 |
| S312 | NM601 | Tijeras Arroyo at Four Hills | 2/2/1999 | 624 | 9.2 | 8.4 | 10.4 | 994 | 114. | 28.4 | 48.4 | 3.3 | 98.9 | 0.35 | 56.5 | 164.9 |
| S312 | NM420 | Tijeras Arroyo at Four Hills | 2/20/1998 | 620 | 9.3 | 8.5 | 9.0 | 1,006 | 123. | 31.2 | 45.2 | 3.8 | 111. | 0.34 | 61.5 | 161.1 |
| S312 | NM226 | Tijeras Arroyo at Four Hills | 4/23/1997 | 619 | 9.4 | 8.5 | 8.9 | 1,068 | 126. | 33.5 | 43.9 | 4.2 | 114. | 0.42 | 60.3 | 170.0 |
| S312 | NM238 | Tijeras Arroyo at Four Hills | 5/27/1997 | 626 | 11.2 | 8.3 | 8.8 | 1,025 | 125. | 32.3 | 48.4 | 3.5 | 114. | 0.39 | 60.1 | 167.5 |
| S312 | NM387 | Tijeras Arroyo at Four Hills | 10/23/1997 | 619 | 11.5 | 8.2 | 8.6 | 995 | 117. | 26.7 | 38.7 | 5.0 | 108. | 0.39 | 58.6 | 165.6 |
| S312 | NM201 | Tijeras Arroyo at Four Hills | 2/11/1997 | 618 | 11.8 | 8.4 | 8.6 | 1,036 | 126. | 29.5 | 42.6 | 4.0 | 110. | nd | 10.2 | 154.6 |
| S312 | NM578 | Tijeras Arroyo at Four Hills | 12/1/1998 | 635 | 12.5 | 8.4 | 9.0 | 1,001 | 115. | 28.1 | 49.0 | 3.3 | 99.2 | 0.37 | 58.1 | 164.6 |
| S312 | NM434 | Tijeras Arroyo at Four Hills | 3/31/1998 | 619 | 14.0 | 8.3 | 8.3 | 1,064 | 125. | 29.7 | 58.9 | 3.3 | 114. | 0.33 | 148. | 267.6 |
| S312 | NM566 | Tijeras Arroyo at Four Hills | 10/23/1998 | 630 | 14.7 | 8.2 | 8.3 | 967 | 112. | 27.5 | 48.6 | 3.7 | 98.9 | 0.28 | 52.8 | 158.6 |
| S312 | NM376 | Tijeras Arroyo at Four Hills | 9/18/1997 | 623 | 18.0 | 8.2 | 7.8 | 981 | 116. | 28.7 | 41.0 | 4.1 | 107. | 0.40 | 58.5 | 166.0 |
| S312 | NM614 | Tijeras Arroyo at Four Hills | 3/30/1999 | 619 | 18.8 | 8.2 | 7.7 | 991 | 108. | 28.5 | 55.3 | 3.5 | 100. | 0.33 | 60.7 | 162.0 |
| S312 | NM477 | Tijeras Arroyo at Four Hills | 7/23/1998 | 625 | 19.2 | 8.2 | 7.5 | 933 | 101. | 26.3 | 44.0 | 3.4 | 97.0 | 0.36 | 14.8 | 207.2 |
| S312 | NM449 | Tijeras Arroyo at Four Hills | 5/5/1998 | 620 | 20.3 | 8.2 | 7.7 | 988 | 111. | 27.8 | 44.2 | 3.1 | 104. | 0.35 | 40.5 | 266.8 |
| S312 | NM463 | Tijeras Arroyo at Four Hills | 6/11/1998 | 322 | 20.9 | 8.2 | 7.3 | 991 | 109. | 27.3 | 43.8 | 3.4 | 102. | 0.38 | 141. | 209.6 |
| S312 | NM554 | Tijeras Arroyo at Four Hills | 9/22/1998 | 623 | 22.1 | 8.1 | nd | 959 | 103. | 27.3 | 47.6 | 3.7 | 98.1 | 0.37 | 58.4 | 166.7 |
| S312 | NM540 | Tijeras Arroyo at Four Hills | 8/18/1998 | 624 | 24.8 | 8.1 | 6.4 | 952 | 101. | 26.5 | 45.9 | 3.8 | 96.3 | 0.37 | 55.7 | 163.9 |
| S312 | NM363 | Tijeras Arroyo at Four Hills | 7/9/1997 | 623 | 27.4 | 8.1 | 6.4 | 980 | 108. | 29.0 | 45.4 | 3.9 | 112. | 0.39 | 56.2 | 167.4 |
| S313 | NM433 | West Riverside drain at Rio Bravo | 3/31/1998 | 634 | 12.4 | 8.5 | 9.3 | 370 | 40.1 | 6.95 | 25.5 | 3.3 | 11.6 | 0.05 | 47.5 | 153.9 |

**Table B2.** Surface-water field parameters and major-element chemistry-- Continued

| Site no. | Sample no. | Site name | Date | Barometric pressure (mm Hg) | Temp. °C | pH | $O_2$ (mg/L) | Sp. Cond. (µS/cm at 25° C) | $Ca^{2+}$ (mg/L) | $Mg^{2+}$ (mg/L) | $Na^{+}$ (mg/L) | $K^{+}$ (mg/L) | $Cl^{-}$ (mg/L) | $Br^{-}$ (mg/L) | $SO_4^{2-}$ (mg/L) | Alkalinity $HCO_3^{-}$ (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S313 | NM404 | West Riverside drain at Rio Bravo | 1/8/1998 | 634 | 13.7 | 8.4 | 7.3 | 347 | 39.6 | 6.26 | 21.4 | 3.4 | 9.3 | <0.05 | 43.6 | 151.4 |
| S313 | NM589 | West Riverside drain at Rio Bravo | 1/5/1999 | 640 | 14.1 | 8.1 | 6.8 | 404 | 48.0 | 7.74 | 24.3 | 4.0 | 12.4 | <0.1 | 1,380. | 281.0 |
| S313 | NM600 | West Riverside drain at Rio Bravo | 2/2/1999 | 638 | 14.8 | 8.3 | 7.2 | 414 | 45.4 | 7.84 | 25.0 | 3.8 | 12.5 | <0.1 | nd | nd |
| S313 | NM237 | West Riverside drain at Rio Bravo | 5/21/1997 | 636 | 14.8 | 8.5 | 8.2 | 413 | 46.1 | 7.54 | 25.5 | 3.6 | 14.5 | 0.07 | 140. | 217.7 |
| S313 | NM419 | West Riverside drain at Rio Bravo | 2/19/1998 | 636 | 15.2 | 8.6 | 9.1 | 363 | 42.4 | 6.81 | 22.1 | 3.5 | 10.7 | 0.06 | 49.8 | 154.2 |
| S313 | NM613 | West Riverside drain at Rio Bravo | 3/30/1999 | 633 | 15.9 | 8.2 | 8.0 | 401 | 43.0 | 7.43 | 28.3 | 3.8 | 12.5 | <0.1 | nd | nd |
| S313 | NM205 | West Riverside drain at Rio Bravo | 3/18/1997 | nd | 16.2 | 8.2 | 7.4 | 434 | 48.0 | 8.55 | 25.9 | 3.9 | 12.7 | 0.08 | 152. | 266.9 |
| S313 | NM577 | West Riverside drain at Rio Bravo | 12/1/1998 | 642 | 16.4 | 7.8 | 5.9 | 397 | 44.6 | 7.63 | 24.4 | 4.1 | 10.6 | <0.07 | 7.0 | 126.5 |
| S313 | NM448 | West Riverside drain at Rio Bravo | 5/5/1998 | 634 | 16.8 | 8.6 | 8.7 | 390 | 43.9 | 7.34 | 23.8 | 3.1 | 13.8 | 0.07 | 45.9 | 154.3 |
| S313 | NM462 | West Riverside drain at Rio Bravo | 6/11/1998 | 637 | 17.3 | 8.5 | 8.0 | 358 | 39.1 | 6.73 | 21.1 | 3.4 | 10.2 | <0.05 | 47.2 | 155.5 |
| S313 | NM225 | West Riverside drain at Rio Bravo | 4/22/1997 | 633 | 17.6 | 7.9 | 6.9 | 432 | 46.6 | 8.10 | 24.2 | 4.0 | 14.4 | 0.06 | 36.9 | 257.3 |
| S313 | NM395 | West Riverside drain at Rio Bravo | 11/20/1997 | 635 | 17.7 | 8.3 | 7.9 | 336 | 37.8 | 6.07 | 20.7 | 3.5 | 7.8 | <0.05 | 47.6 | 153.8 |
| S313 | NM565 | West Riverside drain at Rio Bravo | 10/20/1998 | 640 | 18.6 | 7.8 | 5.0 | 367 | 41.1 | 7.04 | 21.6 | 4.1 | 7.7 | <0.05 | 137. | 232.5 |
| S313 | NM386 | West Riverside drain at Rio Bravo | 10/21/1997 | 638 | 20.5 | 7.7 | 6.5 | 347 | 39.7 | 6.33 | 20.2 | 3.9 | 9.1 | <0.05 | 49.2 | 153.2 |
| S313 | NM362 | West Riverside drain at Rio Bravo | 7/9/1997 | 638 | 21.2 | 8.7 | 9.5 | 352 | 36.7 | 6.30 | 21.5 | 3.2 | 8.3 | <0.05 | 12.4 | 217.2 |
| S313 | NM539 | West Riverside drain at Rio Bravo | 8/18/1998 | 638 | 22.7 | 8.5 | 7.0 | 362 | 41.5 | 6.87 | 20.7 | 3.9 | 8.5 | <0.05 | 145. | 255.3 |
| S313 | NM375 | West Riverside drain at Rio Bravo | 9/16/1997 | 636 | 23.0 | 8.0 | 7.2 | 353 | 41.9 | 6.62 | 19.3 | 3.5 | 9.1 | <0.05 | 1,711. | 330.5 |
| S313 | NM553 | West Riverside drain at Rio Bravo | 9/22/1998 | 637 | 23.4 | 8.3 | nd | 369 | 41.4 | 6.91 | 21.2 | 4.0 | 7.9 | <0.05 | 33.1 | 244.4 |
| S313 | NM476 | West Riverside drain at Rio Bravo | 7/22/1998 | 636 | 24.0 | 8.7 | 7.2 | 352 | 38.8 | 6.48 | 22.1 | 3.9 | 8.3 | <0.05 | 54.0 | 161.0 |
| S314 | NM125 | Rio Grande at Arroyo de la Baranca | 7/1/1996 | nd | 26.9 | 8.0 | 5.9 | 406 | 47.0 | 8.40 | 19.1 | 4.2 | 6.4 | 0.24 | nd | nd |

**Table B3.** Summary of minor-element chemistry in surface water

[Sr, strontium, $SiO_2$, silica; Fe, iron; $NO_3$ as N, dissolved nitrate as nitrogen; Mn, manganese; F, fluoride; mg/L, milligrams per liter; nd, not determined]

| Site no. | Sample no. | Site name | Date | Sr (mg/L) | $SiO_2$ (mg/L) | Fe (mg/L) | Mn (mg/L) | $NO_3$ as N (mg/L) | F (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| S290 | NM202 | Abo Arroyo at US 60 | 3/12/1997 | 3.6 | 12.3 | 0.39 | 0.022 | 0.21 | 0.54 |
| S290 | NM194 | Abo Arroyo at US 60 | 1/16/1997 | 3.8 | 26.1 | 0.30 | 0.149 | 2.75 | 0.72 |
| S291 | NM428 | Alameda Drain at Alameda | 3/31/1998 | 0.30 | 22.7 | 0.04 | 0.003 | <0.02 | 0.36 |
| S291 | NM548 | Alameda Drain at Alameda | 9/22/1998 | 0.36 | 19.2 | 0.03 | 0.004 | <0.02 | 0.29 |
| S291 | NM381 | Alameda Drain at Alameda | 10/21/1997 | 0.26 | 20.7 | 0.04 | 0.006 | <0.02 | 0.26 |
| S291 | NM370 | Alameda Drain at Alameda | 9/16/1997 | 0.29 | 20.3 | 0.03 | 0.008 | <0.01 | 0.30 |
| S291 | NM471 | Alameda Drain at Alameda | 7/22/1998 | 0.32 | 18.8 | 0.03 | 0.008 | <0.02 | 0.34 |
| S291 | NM534 | Alameda Drain at Alameda | 8/18/1998 | 0.34 | 17.7 | 0.03 | 0.009 | <0.02 | 0.36 |
| S291 | NM366 | Alameda Drain at Alameda | 7/9/1997 | 0.28 | 18.2 | 0.05 | 0.010 | <0.01 | 0.29 |
| S291 | NM457 | Alameda Drain at Alameda | 6/11/1998 | 0.27 | 17.6 | 0.03 | 0.010 | <0.02 | 0.36 |
| S291 | NM443 | Alameda Drain at Alameda | 5/5/1998 | 0.32 | 18.8 | 0.04 | 0.012 | <0.02 | 0.43 |
| S291 | NM220 | Alameda Drain at Alameda | 4/22/1997 | 0.30 | 19.4 | 0.03 | 0.014 | <0.01 | 0.31 |
| S292 | NM436 | Bear Canyon Arroyo | 3/31/1998 | 0.11 | 21.0 | 0.03 | 0.001 | <0.02 | 1.17 |
| S292 | NM435 | Bear Canyon Arroyo | 3/31/1998 | 0.11 | 21.2 | 0.04 | 0.001 | <0.02 | 1.18 |
| S292 | NM464 | Bear Canyon Arroyo | 6/11/1998 | 0.12 | 22.0 | 0.03 | 0.001 | <0.02 | 1.74 |
| S292 | NM203 | Bear Canyon Arroyo | 3/19/1997 | 0.18 | 21.8 | 0.07 | 0.003 | 0.01 | 1.33 |
| S292 | NM216 | Bear Canyon Arroyo | 4/23/1997 | 0.14 | 21.1 | 0.04 | 0.004 | 0.04 | 1.38 |
| S292 | NM478 | Bear Canyon Arroyo | 7/23/1998 | 0.16 | 24.8 | 0.04 | 0.004 | <0.02 | 1.34 |
| S292 | NM602 | Bear Canyon Arroyo | 2/3/1999 | 0.18 | 21.8 | 0.04 | 0.004 | <0.05 | 1.51 |
| S292 | NM591 | Bear Canyon Arroyo | 1/5/1999 | 0.19 | 22.2 | 0.05 | 0.004 | <0.05 | 1.27 |
| S292 | NM450 | Bear Canyon Arroyo | 5/5/1998 | 0.10 | 20.4 | 0.03 | 0.005 | <0.02 | 1.41 |
| S292 | NM229 | Bear Canyon Arroyo | 5/28/1997 | 0.12 | 21.6 | 0.03 | 0.006 | <0.01 | 1.41 |
| S292 | NM541 | Bear Canyon Arroyo | 8/18/1998 | 0.18 | 25.9 | 0.04 | 0.006 | <0.02 | 1.33 |
| S292 | NM406 | Bear Canyon Arroyo | 1/9/1998 | 0.18 | 22.5 | 0.06 | 0.006 | <0.02 | 1.38 |
| S292 | NM579 | Bear Canyon Arroyo | 12/1/1998 | 0.23 | 25.4 | 0.06 | 0.008 | <0.05 | 1.42 |
| S292 | NM397 | Bear Canyon Arroyo | 11/18/1997 | 0.21 | 25.9 | 0.06 | 0.008 | <0.02 | 1.43 |
| S292 | NM567 | Bear Canyon Arroyo | 10/23/1998 | 0.23 | 27.8 | 0.08 | 0.009 | <0.02 | 1.81 |
| S292 | NM354 | Bear Canyon Arroyo | 7/9/1997 | 0.16 | 24.6 | 0.05 | 0.010 | <0.01 | 1.43 |
| S292 | NM555 | Bear Canyon Arroyo | 9/29/1998 | 0.22 | 28.5 | 0.08 | 0.014 | <0.02 | 1.31 |
| S292 | NM388 | Bear Canyon Arroyo | 10/23/1997 | 0.23 | 27.2 | 0.07 | 0.015 | <0.02 | 1.37 |
| S292 | NM377 | Bear Canyon Arroyo | 9/18/1997 | 0.22 | 28.0 | 0.07 | 0.018 | <0.01 | 1.48 |
| S292 | NM421 | Bear Canyon Arroyo | 2/20/1998 | 0.17 | 21.6 | 0.07 | <0.001 | <0.02 | 1.25 |
| S292 | NM615 | Bear Canyon Arroyo | 4/2/1999 | 0.16 | 20.6 | 0.02 | <0.001 | <0.05 | 1.57 |
| S293 | NM244 | Canyon del Trigo Stream | 5/29/1997 | 0.07 | 15.9 | 0.01 | <0.001 | <0.01 | 0.13 |
| S294 | NM547 | Chamizal Lateral at Alameda | 9/22/1998 | 0.35 | 18.7 | 0.04 | 0.002 | <0.02 | 0.29 |
| S294 | NM470 | Chamizal Lateral at Alameda | 7/22/1998 | 0.31 | 18.8 | 0.03 | 0.003 | 0.04 | 0.33 |
| S294 | NM533 | Chamizal Lateral at Alameda | 8/18/1998 | 0.33 | 18.1 | 0.03 | 0.003 | <0.02 | 0.35 |
| S294 | NM230 | Chamizal Lateral at Alameda | 5/21/1997 | 0.29 | 18.9 | 0.05 | 0.004 | 0.08 | 0.26 |
| S294 | NM560 | Chamizal Lateral at Alameda | 10/20/1998 | 0.37 | 18.7 | 0.03 | 0.004 | <0.02 | 0.71 |
| S294 | NM355 | Chamizal Lateral at Alameda | 7/9/1997 | 0.28 | 18.7 | 0.04 | 0.005 | <0.01 | 0.30 |
| S294 | NM427 | Chamizal Lateral at Alameda | 3/31/1998 | 0.30 | 22.0 | 0.05 | 0.005 | <0.02 | 0.36 |
| S294 | NM608 | Chamizal Lateral at Alameda | 3/30/1999 | 0.29 | 20.2 | 0.01 | 0.005 | <0.05 | 0.57 |
| S294 | NM380 | Chamizal Lateral at Alameda | 10/21/1997 | 0.28 | 21.6 | 0.04 | 0.006 | 0.06 | 0.26 |
| S294 | NM217 | Chamizal Lateral at Alameda | 4/22/1997 | 0.28 | 19.9 | 0.03 | 0.006 | 0.09 | 0.29 |
| S294 | NM456 | Chamizal Lateral at Alameda | 6/11/1998 | 0.26 | 17.9 | 0.02 | 0.006 | <0.02 | 0.39 |
| S294 | NM204 | Chamizal Lateral at Alameda | 3/18/1997 | 0.32 | 22.7 | 0.05 | 0.007 | 0.03 | 0.40 |
| S294 | NM369 | Chamizal Lateral at Alameda | 9/16/1997 | 0.30 | 20.1 | 0.03 | 0.007 | <0.01 | 0.32 |
| S294 | NM442 | Chamizal Lateral at Alameda | 5/5/1998 | 0.32 | 19.3 | 0.04 | 0.011 | <0.02 | 0.40 |
| S297 | NM437 | Jemez River below Jemez Canyon Dam | 4/7/1998 | 0.58 | 26.1 | 0.07 | 0.003 | <0.02 | 0.99 |
| S297 | NM451 | Jemez River below Jemez Canyon Dam | 5/7/1998 | 0.57 | 24.8 | 0.06 | 0.006 | 0.04 | 0.73 |
| S297 | NM580 | Jemez River below Jemez Canyon Dam | 12/3/1998 | 0.82 | 24.9 | 0.06 | 0.007 | <0.05 | 0.78 |
| S297 | NM422 | Jemez River below Jemez Canyon Dam | 2/20/1998 | 0.65 | 26.5 | 0.08 | 0.010 | <0.02 | 0.86 |
| S297 | NM603 | Jemez River below Jemez Canyon Dam | 2/3/1999 | 0.82 | 26.6 | 0.05 | 0.011 | <0.05 | 1.13 |
| S297 | NM616 | Jemez River below Jemez Canyon Dam | 4/1/1999 | 0.55 | 26.5 | 0.03 | 0.011 | <0.05 | 1.40 |
| S297 | NM592 | Jemez River below Jemez Canyon Dam | 1/6/1999 | 0.83 | 25.9 | 0.05 | 0.014 | <0.05 | 0.91 |
| S297 | NM556 | Jemez River below Jemez Canyon Dam | 9/24/1998 | 0.69 | 23.3 | 0.06 | 0.042 | <0.02 | 0.76 |

**Table B3.** Summary of minor-element chemistry in surface water-- Continued

| Site no. | Sample no. | Site name | Date | Sr (mg/L) | $SiO_2$ (mg/L) | Fe (mg/L) | Mn (mg/L) | $NO_3$ as N (mg/L) | F (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| S297 | NM568 | Jemez River below Jemez Canyon Dam | 10/27/1998 | 0.73 | 23.1 | 0.06 | 0.044 | 0.02 | 1.29 |
| S297 | NM465 | Jemez River below Jemez Canyon Dam | 6/12/1998 | 0.47 | 21.3 | 0.05 | 0.080 | <0.02 | 0.86 |
| S297 | NM542 | Jemez River below Jemez Canyon Dam | 8/19/1998 | 0.62 | 22.5 | 0.05 | 0.104 | <0.02 | 0.67 |
| S297 | NM479 | Jemez River below Jemez Canyon Dam | 7/23/1998 | 0.63 | 22.7 | 0.05 | 0.154 | 0.06 | 0.67 |
| S298 | NM569 | Jemez River at Jemez | 10/27/1998 | 0.15 | 18.8 | 0.05 | 0.007 | 0.05 | 0.80 |
| S298 | NM438 | Jemez River at Jemez | 4/7/1998 | 0.10 | 22.5 | 0.06 | 0.007 | <0.02 | 0.25 |
| S298 | NM617 | Jemez River at Jemez | 4/2/1999 | 0.12 | 23.7 | 0.04 | 0.008 | <0.05 | 0.68 |
| S298 | NM581 | Jemez River at Jemez | 12/3/1998 | 0.17 | 33.7 | 0.06 | 0.012 | <0.05 | 0.78 |
| S298 | NM466 | Jemez River at Jemez | 6/12/1998 | 0.14 | 24.4 | 0.05 | 0.012 | <0.02 | 0.74 |
| S298 | NM543 | Jemez River at Jemez | 8/19/1998 | 0.20 | 35.7 | 0.05 | 0.014 | <0.02 | 0.82 |
| S298 | NM452 | Jemez River at Jemez | 5/7/1998 | 0.07 | 18.5 | 0.32 | 0.016 | 0.02 | 0.17 |
| S298 | NM423 | Jemez River at Jemez | 2/20/1998 | 0.17 | 38.5 | 0.07 | 0.016 | <0.02 | 0.87 |
| S298 | NM557 | Jemez River at Jemez | 9/24/1998 | 0.22 | 42.4 | 0.06 | 0.016 | <0.02 | 0.98 |
| S298 | NM480 | Jemez River at Jemez | 7/23/1998 | 0.21 | 35.7 | 0.05 | 0.017 | <0.02 | 0.89 |
| S298 | NM593 | Jemez River at Jemez | 1/6/1999 | 0.21 | 44.1 | 0.06 | 0.023 | 0.07 | 1.10 |
| S298 | NM604 | Jemez River at Jemez | 2/3/1999 | 0.22 | 47.6 | 0.07 | 0.029 | <0.05 | 1.31 |
| S300 | NM468 | Rio Grande at Alameda | 7/22/1998 | 0.30 | 16.7 | 0.02 | 0.001 | 0.03 | 0.31 |
| S300 | NM531 | Rio Grande at Alameda | 8/18/1998 | 0.32 | 15.5 | 0.03 | 0.001 | 0.03 | 0.32 |
| S300 | NM545 | Rio Grande at Alameda | 9/22/1998 | 0.33 | 16.5 | 0.03 | 0.001 | <0.02 | 0.26 |
| S300 | NM413 | Rio Grande at Alameda | 2/19/1998 | 0.31 | 23.3 | 0.06 | 0.002 | 0.08 | 0.37 |
| S300 | NM454 | Rio Grande at Alameda | 6/11/1998 | 0.23 | 15.4 | 0.03 | 0.002 | 0.14 | 0.33 |
| S300 | NM378 | Rio Grande at Alameda | 10/21/1997 | 0.22 | 19.4 | 0.04 | 0.003 | 0.08 | 0.21 |
| S300 | NM356 | Rio Grande at Alameda | 7/9/1997 | 0.24 | 18.0 | 0.04 | 0.003 | 0.08 | 0.26 |
| S300 | NM425 | Rio Grande at Alameda | 3/31/1998 | 0.29 | 21.4 | 0.04 | 0.003 | <0.02 | 0.38 |
| S300 | NM606 | Rio Grande at Alameda | 3/30/1999 | 0.32 | 20.8 | 0.02 | 0.003 | <0.05 | 0.66 |
| S300 | NM571 | Rio Grande at Alameda | 12/1/1998 | 0.45 | 21.8 | 0.03 | 0.003 | <0.05 | 0.50 |
| S300 | NM123 | Rio Grande at Alameda | 6/22/1996 | 0.32 | 16.0 | 0.03 | 0.004 | 0.03 | 0.31 |
| S300 | NM218 | Rio Grande at Alameda | 4/22/1997 | 0.29 | 19.3 | 0.03 | 0.004 | 0.04 | 0.38 |
| S300 | NM558 | Rio Grande at Alameda | 10/20/1998 | 0.37 | 17.8 | 0.03 | 0.004 | 0.05 | 0.75 |
| S300 | NM231 | Rio Grande at Alameda | 5/21/1997 | 0.26 | 17.1 | <0.01 | 0.004 | 0.13 | 0.22 |
| S300 | NM389 | Rio Grande at Alameda | 11/20/1997 | 0.24 | 22.0 | 0.04 | 0.005 | 0.03 | 0.34 |
| S300 | NM398 | Rio Grande at Alameda | 1/8/1998 | 0.32 | 23.3 | 0.05 | 0.005 | 0.05 | 0.45 |
| S300 | NM206 | Rio Grande at Alameda | 3/18/1997 | 0.34 | 23.3 | 0.05 | 0.005 | 0.08 | 0.45 |
| S300 | NM440 | Rio Grande at Alameda | 5/5/1998 | 0.29 | 17.6 | 0.04 | 0.005 | <0.02 | 0.37 |
| S300 | NM583 | Rio Grande at Alameda | 1/5/1999 | 0.42 | 22.2 | 0.04 | 0.005 | <0.05 | 0.42 |
| S300 | NM187 | Rio Grande at Alameda | 1/14/1997 | 0.36 | 23.5 | 0.05 | 0.006 | 0.20 | 0.44 |
| S300 | NM594 | Rio Grande at Alameda | 2/2/1999 | 0.39 | 22.5 | 0.04 | 0.006 | <0.05 | 0.67 |
| S300 | NM195 | Rio Grande at Alameda | 2/11/1997 | 0.35 | 23.7 | 0.04 | 0.007 | 0.09 | 0.42 |
| S300 | NM367 | Rio Grande at Alameda | 9/16/1997 | 0.27 | 17.9 | 0.02 | <0.003 | 0.05 | 0.29 |
| S300 | NM118 | Rio Grande at Alameda | 6/29/1996 | 0.45 | 12.1 | 0.04 | <0.004 | 0.26 | 0.43 |
| S301 | NM535 | Rio Grande at Campbell | 8/18/1998 | 0.32 | 15.4 | 0.03 | 0.001 | 0.06 | 0.31 |
| S301 | NM561 | Rio Grande at Campbell | 10/20/1998 | 0.34 | 15.8 | 0.03 | 0.001 | 0.07 | 0.65 |
| S301 | NM549 | Rio Grande at Campbell | 9/22/1998 | 0.33 | 16.0 | 0.03 | 0.001 | 0.08 | 0.26 |
| S301 | NM472 | Rio Grande at Campbell | 7/22/1998 | 0.30 | 16.9 | 0.03 | 0.002 | 0.06 | 0.32 |
| S301 | NM609 | Rio Grande at Campbell | 3/30/1999 | 0.31 | 20.6 | 0.02 | 0.002 | 0.06 | 0.66 |
| S301 | NM233 | Rio Grande at Campbell | 5/21/1997 | 0.25 | 16.8 | 0.05 | 0.002 | 0.12 | 0.20 |
| S301 | NM415 | Rio Grande at Campbell | 2/19/1998 | 0.30 | 22.9 | 0.05 | 0.002 | 0.13 | 0.38 |
| S301 | NM458 | Rio Grande at Campbell | 6/11/1998 | 0.23 | 15.5 | 0.03 | 0.002 | 0.13 | 0.34 |
| S301 | NM429 | Rio Grande at Campbell | 3/31/1998 | 0.29 | 21.4 | 0.05 | 0.002 | <0.02 | 0.35 |
| S301 | NM573 | Rio Grande at Campbell | 12/1/1998 | 0.42 | 20.3 | 0.03 | 0.003 | 0.07 | 0.43 |
| S301 | NM400 | Rio Grande at Campbell | 1/8/1998 | 0.30 | 22.5 | 0.05 | 0.003 | 0.06 | 0.45 |
| S301 | NM585 | Rio Grande at Campbell | 1/5/1999 | 0.41 | 21.4 | 0.03 | 0.003 | 0.07 | 0.42 |
| S301 | NM391 | Rio Grande at Campbell | 11/20/1997 | 0.24 | 22.0 | 0.04 | 0.004 | 0.05 | 0.31 |
| S301 | NM382 | Rio Grande at Campbell | 10/21/1997 | 0.22 | 19.4 | 0.03 | 0.004 | 0.08 | 0.21 |
| S301 | NM358 | Rio Grande at Campbell | 7/9/1997 | 0.24 | 17.9 | 0.03 | 0.004 | 0.08 | 0.27 |
| S301 | NM444 | Rio Grande at Campbell | 5/5/1998 | 0.28 | 17.4 | 0.04 | 0.004 | <0.02 | 0.43 |
| S301 | NM221 | Rio Grande at Campbell | 4/22/1997 | 0.29 | 18.8 | 0.03 | 0.005 | 0.03 | 0.37 |
| S301 | NM189 | Rio Grande at Campbell | 1/14/1997 | 0.35 | 22.9 | 0.05 | 0.005 | 0.27 | 0.44 |

**Table B3.** Summary of minor-element chemistry in surface water-- Continued

| Site no. | Sample no. | Site name | Date | Sr (mg/L) | $SiO_2$ (mg/L) | Fe (mg/L) | Mn (mg/L) | $NO_3$ as N (mg/L) | F (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| S301 | NM596 | Rio Grande at Campbell | 2/2/1999 | 0.39 | 22.1 | 0.04 | 0.005 | <0.05 | 0.67 |
| S301 | NM208 | Rio Grande at Campbell | 3/18/1997 | 0.34 | 23.1 | 0.05 | 0.006 | 0.08 | 0.45 |
| S301 | NM197 | Rio Grande at Campbell | 2/11/1997 | 0.34 | 24.0 | 0.04 | 0.007 | 0.13 | 0.42 |
| S301 | NM371 | Rio Grande at Campbell | 9/16/1997 | 0.26 | 17.6 | 0.03 | <0.003 | 0.06 | 0.29 |
| S302 | NM124 | Rio Grande at Isleta Below Diversion | 6/22/1996 | 0.34 | 21.4 | 0.04 | 0.017 | 1.01 | 0.52 |
| S303 | NM360 | Rio Grande at Rio Bravo | 7/9/1997 | 0.25 | 18.0 | 0.04 | 0.000 | 0.08 | 0.29 |
| S303 | NM474 | Rio Grande at Rio Bravo | 7/22/1998 | 0.30 | 17.1 | 0.03 | 0.001 | 0.10 | 0.32 |
| S303 | NM611 | Rio Grande at Rio Bravo | 3/30/1999 | 0.30 | 20.2 | 0.02 | 0.002 | 0.07 | 0.62 |
| S303 | NM551 | Rio Grande at Rio Bravo | 9/22/1998 | 0.34 | 16.9 | 0.04 | 0.002 | 0.08 | 0.26 |
| S303 | NM537 | Rio Grande at Rio Bravo | 8/18/1998 | 0.33 | 16.0 | 0.03 | 0.002 | 0.08 | 0.34 |
| S303 | NM235 | Rio Grande at Rio Bravo | 5/21/1997 | 0.26 | 17.2 | 0.05 | 0.002 | 0.11 | 0.23 |
| S303 | NM460 | Rio Grande at Rio Bravo | 6/11/1998 | 0.23 | 15.4 | 0.02 | 0.002 | <0.02 | 0.34 |
| S303 | NM587 | Rio Grande at Rio Bravo | 1/5/1999 | 0.41 | 20.1 | 0.03 | 0.003 | 0.08 | 0.41 |
| S303 | NM575 | Rio Grande at Rio Bravo | 12/1/1998 | 0.41 | 19.3 | 0.04 | 0.003 | 0.06 | 0.40 |
| S303 | NM417 | Rio Grande at Rio Bravo | 2/19/1998 | 0.30 | 22.2 | 0.05 | 0.003 | 0.14 | 0.38 |
| S303 | NM563 | Rio Grande at Rio Bravo | 10/20/1998 | 0.26 | 12.8 | 0.03 | 0.003 | 0.21 | 0.61 |
| S303 | NM446 | Rio Grande at Rio Bravo | 5/5/1998 | 0.29 | 17.6 | 0.04 | 0.003 | <0.02 | 0.41 |
| S303 | NM431 | Rio Grande at Rio Bravo | 3/31/1998 | 0.29 | 22.0 | 0.06 | 0.003 | <0.02 | 0.39 |
| S303 | NM384 | Rio Grande at Rio Bravo | 10/21/1997 | 0.22 | 19.3 | 0.03 | 0.004 | 0.08 | 0.21 |
| S303 | NM393 | Rio Grande at Rio Bravo | 11/20/1997 | 0.25 | 21.8 | 0.04 | 0.004 | 0.10 | 0.34 |
| S303 | NM210 | Rio Grande at Rio Bravo | 3/18/1997 | 0.35 | 23.3 | 0.05 | 0.005 | 0.05 | 0.45 |
| S303 | NM223 | Rio Grande at Rio Bravo | 4/22/1997 | 0.30 | 19.1 | 0.03 | 0.005 | 0.06 | 0.38 |
| S303 | NM191 | Rio Grande at Rio Bravo | 1/15/1997 | 0.37 | 21.8 | 0.05 | 0.005 | 0.21 | 0.43 |
| S303 | NM598 | Rio Grande at Rio Bravo | 2/2/1999 | 0.39 | 21.4 | 0.04 | 0.005 | 0.09 | 0.68 |
| S303 | NM199 | Rio Grande at Rio Bravo | 2/11/1997 | 0.34 | 22.2 | 0.04 | 0.006 | 0.15 | 0.41 |
| S303 | NM402 | Rio Grande at Rio Bravo | 1/8/1998 | 0.31 | 22.2 | 0.04 | 0.033 | 0.11 | 0.41 |
| S303 | NM373 | Rio Grande at Rio Bravo | 9/16/1997 | 0.27 | 17.8 | 0.02 | <0.003 | 0.07 | 0.29 |
| S303 | NM121 | Rio Grande at Rio Bravo | 6/29/1996 | 0.41 | 16.2 | 0.04 | <0.004 | 0.21 | 0.34 |
| S304 | NM122 | Rio Grande at San Felipe | 6/22/1996 | 0.33 | 16.7 | 0.05 | 0.006 | 0.11 | 0.30 |
| S305 | NM120 | Rio Grande at Central | 6/29/1996 | 0.44 | 12.6 | 0.03 | <0.004 | <0.01 | 0.38 |
| S306 | NM119 | Rio Grande at Nature Center | 6/29/1996 | 0.44 | 12.2 | 0.04 | <0.004 | 0.32 | 0.37 |
| S307 | NM618 | Rio Puerco at Hwy 6 | 4/2/1999 | 3.4 | 20.8 | 0.15 | 0.001 | <0.05 | 1.88 |
| S307 | NM467 | Rio Puerco at Hwy 6 | 6/12/1998 | 2.5 | 9.4 | 0.23 | 0.004 | <0.02 | 1.39 |
| S307 | NM453 | Rio Puerco at Hwy 6 | 5/7/1998 | 2.1 | 8.9 | 0.23 | 0.011 | 0.18 | 1.34 |
| S307 | NM582 | Rio Puerco at Hwy 6 | 12/3/1998 | 2.9 | 21.9 | 0.21 | 0.014 | 0.06 | 0.84 |
| S307 | NM605 | Rio Puerco at Hwy 6 | 2/3/1999 | 4.4 | 26.0 | 0.28 | 0.019 | 0.21 | 0.83 |
| S307 | NM424 | Rio Puerco at Hwy 6 | 2/20/1998 | 3.2 | 22.2 | 0.31 | <0.001 | 0.06 | 0.85 |
| S307 | NM570 | Rio Puerco at Hwy 6 | 10/23/1998 | 2.0 | 9.5 | 0.18 | <0.001 | 0.19 | 2.10 |
| S307 | NM544 | Rio Puerco at Hwy 6 | 8/19/1998 | 2.6 | 9.8 | 0.23 | <0.001 | 0.69 | 1.28 |
| S307 | NM439 | Rio Puerco at Hwy 6 | 4/7/1998 | 3.2 | 18.5 | 0.31 | <0.001 | <0.02 | 0.93 |
| S308 | NM219 | Riverside Drain at Alameda | 4/22/1997 | 0.31 | 20.1 | 0.02 | 0.007 | <0.01 | 0.33 |
| S308 | NM532 | Riverside Drain at Alameda | 8/18/1998 | 0.32 | 18.8 | 0.03 | 0.007 | <0.02 | 0.34 |
| S308 | NM368 | Riverside Drain at Alameda | 9/16/1997 | 0.30 | 21.2 | 0.03 | 0.008 | 0.03 | 0.32 |
| S308 | NM469 | Riverside Drain at Alameda | 7/22/1998 | 0.32 | 20.0 | 0.03 | 0.008 | 0.04 | 0.33 |
| S308 | NM546 | Riverside Drain at Alameda | 9/22/1998 | 0.35 | 19.7 | 0.03 | 0.008 | <0.02 | 0.38 |
| S308 | NM559 | Riverside Drain at Alameda | 10/20/1998 | 0.37 | 19.2 | 0.03 | 0.009 | 0.02 | 0.77 |
| S308 | NM357 | Riverside Drain at Alameda | 7/9/1997 | 0.28 | 19.3 | 0.04 | 0.010 | <0.01 | 0.30 |
| S308 | NM232 | Riverside Drain at Alameda | 5/21/1997 | 0.30 | 20.0 | 0.04 | 0.011 | 0.10 | 0.27 |
| S308 | NM207 | Riverside Drain at Alameda | 3/18/1997 | 0.34 | 22.5 | 0.06 | 0.012 | 0.05 | 0.39 |
| S308 | NM455 | Riverside Drain at Alameda | 6/11/1998 | 0.26 | 18.7 | 0.03 | 0.012 | <0.02 | 0.39 |
| S308 | NM426 | Riverside Drain at Alameda | 3/31/1998 | 0.30 | 21.2 | 0.04 | 0.012 | <0.02 | 0.36 |
| S308 | NM607 | Riverside Drain at Alameda | 3/30/1999 | 0.30 | 19.9 | 0.02 | 0.013 | <0.05 | 0.49 |
| S308 | NM379 | Riverside Drain at Alameda | 10/21/1997 | 0.28 | 20.6 | 0.03 | 0.017 | 0.07 | 0.31 |
| S308 | NM441 | Riverside Drain at Alameda | 5/5/1998 | 0.32 | 19.4 | 0.04 | 0.017 | <0.02 | 0.43 |
| S308 | NM390 | Riverside Drain at Alameda | 11/20/1997 | 0.30 | 20.6 | 0.03 | 0.034 | 0.03 | 0.38 |
| S308 | NM414 | Riverside Drain at Alameda | 2/19/1998 | 0.34 | 19.5 | 0.06 | 0.041 | 0.04 | 0.34 |
| S308 | NM196 | Riverside Drain at Alameda | 2/11/1997 | 0.41 | 18.0 | 0.05 | 0.042 | 0.09 | 0.35 |
| S308 | NM595 | Riverside Drain at Alameda | 2/2/1999 | 0.41 | 17.9 | 0.04 | 0.047 | <0.05 | 0.43 |

**Table B3.** Summary of minor-element chemistry in surface water-- Continued

| Site no. | Sample no. | Site name | Date | Sr (mg/L) | $SiO_2$ (mg/L) | Fe (mg/L) | Mn (mg/L) | $NO_3$ as N (mg/L) | F (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| S308 | NM188 | Riverside Drain at Alameda | 1/14/1997 | 0.40 | 17.9 | 0.05 | 0.050 | 0.07 | 0.35 |
| S308 | NM584 | Riverside Drain at Alameda | 1/5/1999 | 0.42 | 17.9 | 0.03 | 0.052 | <0.05 | 0.31 |
| S308 | NM399 | Riverside Drain at Alameda | 1/8/1998 | 0.31 | 18.3 | 0.04 | 0.057 | 0.06 | 0.35 |
| S308 | NM572 | Riverside Drain at Alameda | 12/1/1998 | 0.42 | 18.9 | 0.03 | 0.061 | 0.05 | 0.34 |
| S309 | NM473 | Riverside Drain at Campbell | 7/22/1998 | 0.31 | 20.0 | 0.03 | 0.004 | 0.04 | 0.32 |
| S309 | NM550 | Riverside Drain at Campbell | 9/22/1998 | 0.34 | 20.0 | 0.03 | 0.004 | <0.02 | 0.39 |
| S309 | NM536 | Riverside Drain at Campbell | 8/18/1998 | 0.32 | 18.9 | 0.03 | 0.005 | <0.02 | 0.32 |
| S309 | NM222 | Riverside Drain at Campbell | 4/22/1997 | 0.31 | 19.6 | 0.03 | 0.006 | 0.04 | 0.34 |
| S309 | NM234 | Riverside Drain at Campbell | 5/21/1997 | 0.31 | 19.9 | 0.05 | 0.006 | 0.10 | 0.31 |
| S309 | NM359 | Riverside Drain at Campbell | 7/9/1997 | 0.29 | 19.2 | 0.04 | 0.006 | <0.01 | 0.32 |
| S309 | NM372 | Riverside Drain at Campbell | 9/16/1997 | 0.30 | 21.2 | 0.03 | 0.006 | <0.01 | 0.33 |
| S309 | NM562 | Riverside Drain at Campbell | 10/20/1998 | 0.35 | 18.9 | 0.03 | 0.006 | <0.02 | 0.77 |
| S309 | NM459 | Riverside Drain at Campbell | 6/11/1998 | 0.27 | 18.9 | 0.03 | 0.007 | <0.02 | 0.40 |
| S309 | NM430 | Riverside Drain at Campbell | 3/31/1998 | 0.31 | 21.2 | 0.04 | 0.007 | <0.02 | 0.38 |
| S309 | NM610 | Riverside Drain at Campbell | 3/30/1999 | 0.30 | 19.2 | 0.02 | 0.009 | <0.05 | 0.47 |
| S309 | NM383 | Riverside Drain at Campbell | 10/21/1997 | 0.28 | 20.9 | 0.03 | 0.010 | 0.05 | 0.29 |
| S309 | NM209 | Riverside Drain at Campbell | 3/18/1997 | 0.35 | 22.0 | 0.05 | 0.010 | 0.05 | 0.38 |
| S309 | NM445 | Riverside Drain at Campbell | 5/5/1998 | 0.31 | 18.8 | 0.04 | 0.012 | <0.02 | 0.45 |
| S309 | NM392 | Riverside Drain at Campbell | 11/20/1997 | 0.28 | 20.1 | 0.04 | 0.021 | 0.04 | 0.38 |
| S309 | NM416 | Riverside Drain at Campbell | 2/19/1998 | 0.33 | 18.5 | 0.05 | 0.021 | 0.05 | 0.31 |
| S309 | NM597 | Riverside Drain at Campbell | 2/2/1999 | 0.41 | 17.2 | 0.03 | 0.023 | <0.05 | 0.43 |
| S309 | NM574 | Riverside Drain at Campbell | 12/1/1998 | 0.41 | 19.0 | 0.03 | 0.024 | <0.05 | 0.32 |
| S309 | NM586 | Riverside Drain at Campbell | 1/5/1999 | 0.42 | 17.9 | 0.04 | 0.025 | <0.05 | 0.31 |
| S309 | NM586a | Riverside Drain at Campbell | 1/5/1999 | 0.43 | 17.8 | 0.04 | 0.025 | <0.05 | 0.32 |
| S309 | NM401 | Riverside Drain at Campbell | 1/8/1998 | 0.31 | 17.8 | 0.04 | 0.028 | 0.04 | 0.32 |
| S309 | NM198 | Riverside Drain at Campbell | 2/11/1997 | 0.40 | 17.2 | 0.05 | 0.037 | 0.07 | 0.33 |
| S309 | NM190 | Riverside Drain at Campbell | 1/14/1997 | 0.39 | 17.3 | 0.04 | 0.039 | 0.05 | 0.34 |
| S310 | NM224 | Riverside Drain at Rio Bravo | 4/22/1997 | 0.31 | 18.9 | 0.02 | 0.008 | 0.01 | 0.33 |
| S310 | NM538 | Riverside Drain at Rio Bravo | 8/18/1998 | 0.33 | 19.0 | 0.03 | 0.008 | 0.03 | 0.35 |
| S310 | NM552 | Riverside Drain at Rio Bravo | 9/22/1998 | 0.35 | 20.2 | 0.04 | 0.008 | <0.02 | 0.31 |
| S310 | NM475 | Riverside Drain at Rio Bravo | 7/22/1998 | 0.33 | 20.1 | 0.03 | 0.009 | 0.05 | 0.34 |
| S310 | NM564 | Riverside Drain at Rio Bravo | 10/20/1998 | 0.33 | 17.2 | 0.03 | 0.009 | 0.07 | 0.75 |
| S310 | NM374 | Riverside Drain at Rio Bravo | 9/16/1997 | 0.31 | 21.1 | 0.03 | 0.011 | <0.01 | 0.33 |
| S310 | NM461 | Riverside Drain at Rio Bravo | 6/11/1998 | 0.27 | 18.0 | 0.03 | 0.014 | <0.02 | 0.42 |
| S310 | NM432 | Riverside Drain at Rio Bravo | 3/31/1998 | 0.31 | 21.4 | 0.05 | 0.015 | <0.02 | 0.35 |
| S310 | NM447 | Riverside Drain at Rio Bravo | 5/5/1998 | 0.31 | 18.8 | 0.04 | 0.015 | <0.02 | 0.41 |
| S310 | NM612 | Riverside Drain at Rio Bravo | 3/30/1999 | 0.30 | 19.7 | 0.02 | 0.015 | <0.05 | 0.48 |
| S310 | NM361 | Riverside Drain at Rio Bravo | 7/9/1997 | 0.29 | 18.8 | 0.05 | 0.016 | 0.02 | 0.31 |
| S310 | NM236 | Riverside Drain at Rio Bravo | 5/21/1997 | 0.32 | 20.3 | 0.04 | 0.016 | 0.09 | 0.31 |
| S310 | NM385 | Riverside Drain at Rio Bravo | 10/21/1997 | 0.28 | 20.6 | 0.04 | 0.018 | <0.02 | 0.30 |
| S310 | NM211 | Riverside Drain at Rio Bravo | 3/18/1997 | 0.36 | 22.0 | 0.05 | 0.025 | 0.13 | 0.38 |
| S310 | NM418 | Riverside Drain at Rio Bravo | 2/19/1998 | 0.34 | 20.6 | 0.05 | 0.120 | 0.05 | 0.35 |
| S310 | NM394 | Riverside Drain at Rio Bravo | 11/20/1997 | 0.32 | 22.5 | 0.04 | 0.130 | 0.04 | 0.43 |
| S310 | NM599 | Riverside Drain at Rio Bravo | 2/2/1999 | 0.40 | 20.8 | 0.04 | 0.134 | <0.05 | 0.40 |
| S310 | NM200 | Riverside Drain at Rio Bravo | 2/11/1997 | 0.39 | 21.0 | 0.05 | 0.139 | 0.02 | 0.33 |
| S310 | NM403 | Riverside Drain at Rio Bravo | 1/8/1998 | 0.34 | 21.2 | 0.05 | 0.139 | <0.02 | 0.42 |
| S310 | NM576 | Riverside Drain at Rio Bravo | 12/1/1998 | 0.40 | 22.1 | 0.05 | 0.162 | <0.05 | 0.46 |
| S310 | NM588 | Riverside Drain at Rio Bravo | 1/5/1999 | 0.40 | 21.4 | 0.04 | 0.168 | <0.05 | 0.31 |
| S310 | NM192 | Riverside Drain at Rio Bravo | 1/15/1997 | 0.39 | 21.8 | 0.05 | 0.178 | 0.02 | 0.34 |
| S311 | NM243 | Stream in Monte Largo Canyon | 5/28/1997 | 0.06 | 20.8 | 0.02 | <0.001 | <0.01 | 0.35 |
| S312 | NM554 | Tijeras Arroyo at Four Hills | 9/22/1998 | 0.66 | 18.4 | 0.10 | 0.002 | 1.16 | 0.49 |
| S312 | NM477 | Tijeras Arroyo at Four Hills | 7/23/1998 | 0.65 | 16.3 | 0.09 | 0.002 | 1.29 | 0.42 |
| S312 | NM614 | Tijeras Arroyo at Four Hills | 3/30/1999 | 0.50 | 13.2 | 0.05 | 0.003 | 1.07 | 0.70 |
| S312 | NM540 | Tijeras Arroyo at Four Hills | 8/18/1998 | 0.66 | 17.2 | 0.08 | 0.003 | 1.29 | 0.49 |
| S312 | NM566 | Tijeras Arroyo at Four Hills | 10/23/1998 | 0.69 | 17.3 | 0.09 | 0.004 | 1.12 | 0.95 |
| S312 | NM463 | Tijeras Arroyo at Four Hills | 6/11/1998 | 0.72 | 16.3 | 0.10 | 0.004 | 1.82 | 0.58 |
| S312 | NM238 | Tijeras Arroyo at Four Hills | 5/27/1997 | 0.72 | 16.2 | 0.11 | 0.007 | 0.77 | 0.48 |
| S312 | NM376 | Tijeras Arroyo at Four Hills | 9/18/1997 | 0.67 | 18.3 | 0.10 | 0.008 | 0.46 | 0.64 |

**Table B3.** Summary of minor-element chemistry in surface water-- Continued

| Site no. | Sample no. | Site name | Date | Sr (mg/L) | $SiO_2$ (mg/L) | Fe (mg/L) | Mn (mg/L) | $NO_3$ as N (mg/L) | F (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| S312 | NM420 | Tijeras Arroyo at Four Hills | 2/20/1998 | 0.63 | 15.0 | 0.13 | 0.008 | 0.98 | 0.47 |
| S312 | NM434 | Tijeras Arroyo at Four Hills | 3/31/1998 | 0.67 | 16.9 | 0.12 | 0.010 | 2.08 | 0.37 |
| S312 | NM578 | Tijeras Arroyo at Four Hills | 12/1/1998 | 0.76 | 16.7 | 0.08 | 0.010 | 1.11 | 0.51 |
| S312 | NM601 | Tijeras Arroyo at Four Hills | 2/2/1999 | 0.76 | 14.7 | 0.07 | 0.011 | 1.31 | 0.61 |
| S312 | NM363 | Tijeras Arroyo at Four Hills | 7/9/1997 | 0.66 | 17.8 | 0.11 | 0.011 | 0.52 | 0.57 |
| S312 | NM590 | Tijeras Arroyo at Four Hills | 1/5/1999 | 0.77 | 15.6 | 0.08 | 0.011 | 1.25 | 0.54 |
| S312 | NM449 | Tijeras Arroyo at Four Hills | 5/5/1998 | 0.72 | 14.7 | 0.12 | 0.014 | 2.17 | 0.35 |
| S312 | NM387 | Tijeras Arroyo at Four Hills | 10/23/1997 | 0.54 | 15.6 | 0.13 | 0.017 | 0.49 | 0.57 |
| S312 | NM226 | Tijeras Arroyo at Four Hills | 4/23/1997 | 0.66 | 14.7 | 0.09 | 0.018 | 0.70 | 0.55 |
| S312 | NM405 | Tijeras Arroyo at Four Hills | 1/9/1998 | 0.72 | 15.6 | 0.12 | 0.019 | 0.89 | 0.62 |
| S312 | NM201 | Tijeras Arroyo at Four Hills | 2/11/1997 | 0.70 | 16.2 | 0.11 | 0.020 | 0.77 | 0.55 |
| S312 | NM193 | Tijeras Arroyo at Four Hills | 1/15/1997 | 0.71 | 16.7 | 0.12 | 0.021 | 0.60 | 0.62 |
| S312 | NM212 | Tijeras Arroyo at Four Hills | 3/19/1997 | 0.69 | 15.9 | 0.13 | 0.023 | 0.81 | 0.50 |
| S312 | NM396 | Tijeras Arroyo at Four Hills | 11/18/1997 | 0.68 | 17.3 | 0.11 | 0.026 | 0.61 | 0.60 |
| S313 | NM539 | West Riverside drain at Rio Bravo | 8/18/1998 | 0.31 | 20.2 | 0.04 | 0.044 | <0.02 | 0.34 |
| S313 | NM476 | West Riverside drain at Rio Bravo | 7/22/1998 | 0.30 | 20.9 | 0.03 | 0.048 | <0.02 | 0.36 |
| S313 | NM462 | West Riverside drain at Rio Bravo | 6/11/1998 | 0.31 | 20.6 | 0.03 | 0.056 | <0.02 | 0.47 |
| S313 | NM362 | West Riverside drain at Rio Bravo | 7/9/1997 | 0.29 | 19.6 | 0.04 | 0.066 | 0.01 | 0.36 |
| S313 | NM433 | West Riverside drain at Rio Bravo | 3/31/1998 | 0.33 | 21.4 | 0.04 | 0.068 | <0.02 | 0.34 |
| S313 | NM448 | West Riverside drain at Rio Bravo | 5/5/1998 | 0.33 | 19.6 | 0.04 | 0.069 | <0.02 | 0.41 |
| S313 | NM613 | West Riverside drain at Rio Bravo | 3/30/1999 | 0.34 | 19.6 | 0.02 | 0.070 | <0.05 | 0.44 |
| S313 | NM237 | West Riverside drain at Rio Bravo | 5/21/1997 | 0.37 | 21.1 | 0.05 | 0.084 | 0.02 | 0.36 |
| S313 | NM375 | West Riverside drain at Rio Bravo | 9/16/1997 | 0.30 | 22.7 | 0.03 | 0.087 | <0.01 | 0.36 |
| S313 | NM205 | West Riverside drain at Rio Bravo | 3/18/1997 | 0.40 | 21.8 | 0.05 | 0.092 | 0.05 | 0.36 |
| S313 | NM395 | West Riverside drain at Rio Bravo | 11/20/1997 | 0.28 | 22.2 | 0.04 | 0.095 | <0.02 | 0.43 |
| S313 | NM419 | West Riverside drain at Rio Bravo | 2/19/1998 | 0.33 | 20.5 | 0.06 | 0.100 | 0.03 | 0.33 |
| S313 | NM225 | West Riverside drain at Rio Bravo | 4/22/1997 | 0.39 | 19.9 | 0.03 | 0.105 | 0.03 | 0.35 |
| S313 | NM404 | West Riverside drain at Rio Bravo | 1/8/1998 | 0.33 | 21.4 | 0.04 | 0.110 | 0.04 | 0.43 |
| S313 | NM386 | West Riverside drain at Rio Bravo | 10/21/1997 | 0.31 | 23.1 | 0.04 | 0.110 | <0.02 | 0.37 |
| S313 | NM565 | West Riverside drain at Rio Bravo | 10/20/1998 | 0.35 | 22.7 | 0.03 | 0.128 | 0.03 | 0.71 |
| S313 | NM600 | West Riverside drain at Rio Bravo | 2/2/1999 | 0.42 | 21.0 | 0.05 | 0.138 | <0.05 | 0.55 |
| S313 | NM589 | West Riverside drain at Rio Bravo | 1/5/1999 | 0.42 | 21.8 | 0.04 | 0.147 | <0.05 | 0.31 |
| S313 | NM577 | West Riverside drain at Rio Bravo | 12/1/1998 | 0.43 | 23.7 | 0.03 | 0.184 | <0.05 | 0.43 |
| S313 | NM553 | West Riverside drain at Rio Bravo | 9/22/1998 | 0.34 | 23.1 | 0.04 | 0.208 | 0.03 | 0.41 |
| S314 | NM125 | Rio Grande at Arroyo de la Baranca | 7/1/1996 | 0.47 | 17.5 | 0.05 | 0.009 | 0.20 | 0.36 |

**Table B4.** Summary of trace-element chemistry in surface water

[Al, aluminum; B, boron; Ba, barium; Li, lithium; Zn, zinc; Pb, lead; Cu, copper; Rb, rubidium; V, vanadium; Cr, chromium; Co, cobalt; Mo, molybdenum; As, arsenic; Se, selenium; U, uranium; Ag, silver; Cd, cadmium; mg/L, milligrams per liter; µg/L, micrograms per liter; nd, not determined]

| Site no. | Sample no. | Site name | Date | Al (µg/L) | B (mg/L) | Ba (mg/L) | Li (mg/L) | Zn (µg/L) | Pb (µg/L) | Cu (µg/L) | Rb (µg/L) | V (µg/L) | Cr (µg/L) | Co (µg/L) | Mo (µg/L) | As (µg/L) | Se (µg/L) | U (µg/L) | Ag (µg/L) | Cd (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S290 | NM194 | Abo Arroyo at US 60 | 1/16/1997 | 3. | 0.227 | 0.025 | 0.049 | 6 | <0.05 | 2.0 | 0.2 | 6.6 | <1 | 0.60 | 4.3 | 2.1 | 6 | 12. | nd | nd |
| S290 | NM202 | Abo Arroyo at US 60 | 3/12/1997 | 4. | 0.218 | 0.031 | 0.048 | 4 | <0.05 | 3.2 | 0.3 | 3.4 | <1 | 0.40 | 3.9 | 1.4 | 5 | 16. | nd | nd |
| S291 | NM366 | Alameda Drain at Alameda | 7/9/1997 | 1. | 0.043 | 0.062 | 0.020 | 4 | <0.05 | 0.9 | 2.0 | 4.3 | <1 | <0.1 | 3.3 | 2.0 | <1 | 2.3 | nd | nd |
| S291 | NM220 | Alameda Drain at Alameda | 4/22/1997 | 4. | 0.057 | 0.083 | 0.027 | 17 | 0.05 | 0.8 | 1.6 | 4.1 | <1 | 0.20 | 3.8 | 2.6 | <1 | 2.8 | nd | nd |
| S291 | NM428 | Alameda Drain at Alameda | 3/31/1998 | 5. | 0.075 | 0.061 | 0.024 | 1 | <0.05 | 0.8 | 1.3 | 4.6 | <1 | 0.10 | 3.8 | 3.0 | <1 | 3.4 | <0.01 | 0.04 |
| S291 | NM381 | Alameda Drain at Alameda | 10/21/1997 | 6. | 0.043 | 0.058 | 0.019 | 4 | 0.08 | 1.0 | 1.6 | 4.2 | <1 | 0.09 | 3.0 | 2.9 | <1 | 1.9 | <0.01 | 0.05 |
| S291 | NM370 | Alameda Drain at Alameda | 9/16/1997 | 6. | 0.045 | 0.078 | 0.022 | 4 | <0.05 | 0.8 | 1.7 | 5.7 | <1 | 0.10 | 3.9 | 3.3 | <1 | 2.5 | nd | nd |
| S291 | NM443 | Alameda Drain at Alameda | 5/5/1998 | 6. | 0.066 | 0.064 | 0.031 | 4 | <0.05 | 0.8 | 1.9 | 4.1 | <1 | 0.12 | 3.4 | 3.0 | <1 | 3.1 | <0.01 | 0.04 |
| S291 | NM471 | Alameda Drain at Alameda | 7/22/1998 | 7. | 0.038 | 0.076 | 0.023 | 11 | 0.05 | 1.0 | 1.8 | 5.9 | 1. | 0.13 | 3.8 | 3.4 | <1 | 2.7 | <0.01 | 0.03 |
| S291 | NM534 | Alameda Drain at Alameda | 8/18/1998 | 7. | 0.040 | 0.084 | 0.026 | 2 | <0.05 | 0.9 | 1.8 | 5.1 | <1 | 0.13 | 3.6 | 3.2 | <1 | 2.7 | <0.01 | 0.02 |
| S291 | NM457 | Alameda Drain at Alameda | 6/11/1998 | 8. | 0.039 | 0.057 | 0.023 | 4 | 0.05 | 1.0 | 1.7 | 3.3 | <1 | 0.10 | 2.7 | 2.6 | <1 | 2.1 | <0.01 | 0.03 |
| S291 | NM548 | Alameda Drain at Alameda | 9/22/1998 | 9. | 0.031 | 0.081 | 0.025 | 4 | <0.05 | 0.8 | 1.8 | 4.5 | <1 | 0.10 | 3.6 | 3.3 | <1 | 2.4 | 0.02 | <0.01 |
| S292 | NM602 | Bear Canyon Arroyo | 2/3/1999 | 1. | 0.500 | 0.034 | 0.017 | 3 | <0.05 | 0.4 | 0.4 | 0.9 | <1 | 0.08 | 0.7 | 0.2 | <1 | 5.4 | 0.08 | 0.02 |
| S292 | NM567 | Bear Canyon Arroyo | 10/23/1998 | 2. | 0.371 | 0.053 | 0.024 | 10 | <0.05 | 0.3 | 0.4 | 1.4 | 2. | 0.14 | 0.8 | 0.3 | <1 | 5.4 | <0.01 | 0.01 |
| S292 | NM203 | Bear Canyon Arroyo | 3/19/1997 | 3. | 0.012 | 0.047 | 0.018 | 4 | <0.05 | 0.4 | 0.4 | 1.1 | <1 | 0.10 | 0.8 | 0.5 | <1 | 7.3 | 0.02 | 0.02 |
| S292 | NM354 | Bear Canyon Arroyo | 7/9/1997 | 3. | 0.013 | 0.039 | 0.017 | 2 | <0.05 | 0.5 | 0.4 | 1.3 | <1 | <0.1 | 0.9 | 0.2 | <1 | 4.4 | 0.06 | 0.01 |
| S292 | NM216 | Bear Canyon Arroyo | 4/23/1997 | 3. | 0.015 | 0.040 | 0.018 | 4 | 0.05 | 0.6 | 0.4 | 1.1 | <1 | <0.1 | 1.0 | 0.2 | <1 | 5.1 | 0.01 | 0.02 |
| S292 | NM435 | Bear Canyon Arroyo | 3/31/1998 | 4. | 0.011 | 0.026 | 0.015 | 4 | <0.05 | 0.7 | 0.3 | 0.8 | <1 | 0.07 | 0.7 | 0.2 | <1 | 2.7 | <0.01 | <0.01 |
| S292 | NM229 | Bear Canyon Arroyo | 5/28/1997 | 4. | 0.014 | 0.033 | 0.017 | 2 | <0.05 | 0.5 | 0.3 | 0.9 | <1 | <0.1 | 0.9 | 0.2 | <1 | 3.6 | <0.01 | 0.02 |
| S292 | NM388 | Bear Canyon Arroyo | 10/23/1997 | 4. | 0.015 | 0.053 | 0.022 | 5 | 0.05 | 0.8 | 0.5 | 0.9 | 2. | 0.18 | 0.9 | 0.3 | <1 | 7.1 | 0.01 | 0.02 |
| S292 | NM464 | Bear Canyon Arroyo | 6/11/1998 | 4. | 0.357 | 0.030 | 0.018 | 6 | 0.05 | 0.5 | 0.3 | 1.1 | <1 | 0.07 | 0.8 | 0.2 | <1 | 2.7 | <0.01 | 0.01 |
| S292 | NM478 | Bear Canyon Arroyo | 7/23/1998 | 4. | 0.359 | 0.037 | 0.019 | 3 | <0.05 | 0.4 | 0.6 | 1.6 | 2. | 0.09 | 0.8 | 0.3 | <1 | 3.8 | <0.01 | 0.01 |
| S292 | NM541 | Bear Canyon Arroyo | 8/18/1998 | 4. | 0.381 | 0.041 | 0.022 | 3 | <0.05 | 0.5 | 0.4 | 1.0 | <1 | 0.12 | 0.8 | 0.3 | <1 | 4.1 | <0.01 | 0.01 |
| S292 | NM555 | Bear Canyon Arroyo | 9/29/1998 | 4. | 0.456 | 0.049 | 0.024 | 6 | <0.05 | 0.6 | 0.7 | 0.9 | <1 | 0.19 | 0.8 | 0.5 | <1 | 5.7 | <0.01 | 0.01 |
| S292 | NM421 | Bear Canyon Arroyo | 2/20/1998 | 4. | 0.492 | 0.041 | 0.018 | 2 | 0.05 | 0.5 | 0.4 | 1.1 | 1. | 0.08 | 0.8 | 0.2 | <1 | 6.2 | <0.01 | 0.01 |
| S292 | NM591 | Bear Canyon Arroyo | 1/5/1999 | 4. | 0.532 | 0.037 | 0.019 | 2 | <0.05 | 0.4 | 0.3 | 0.9 | <1 | 0.10 | 0.7 | 0.2 | <1 | 5.0 | 0.01 | <0.01 |
| S292 | NM436 | Bear Canyon Arroyo | 3/31/1998 | 4. | 0.570 | 0.027 | 0.015 | 1 | <0.05 | 0.6 | 0.3 | 0.9 | <1 | 0.07 | 0.7 | 0.2 | <1 | 2.7 | <0.01 | 0.01 |
| S292 | NM377 | Bear Canyon Arroyo | 9/18/1997 | 5. | 0.020 | 0.054 | 0.023 | 22 | 0.09 | 0.4 | 0.6 | 1.3 | <1 | 0.20 | 0.9 | 0.3 | <1 | 6.7 | <0.01 | 0.02 |
| S292 | NM450 | Bear Canyon Arroyo | 5/5/1998 | 7. | 0.441 | 0.026 | 0.016 | 3 | <0.05 | 0.4 | 0.3 | 0.9 | <1 | 0.08 | 0.7 | 0.2 | <1 | 2.4 | 0.01 | 0.01 |
| S292 | NM579 | Bear Canyon Arroyo | 12/1/1998 | 9. | 0.501 | 0.115 | 0.022 | 5 | <0.05 | 0.4 | 0.4 | 1.0 | <1 | 0.11 | 0.7 | 0.2 | <1 | 5.3 | <0.01 | 0.01 |
| S292 | NM397 | Bear Canyon Arroyo | 11/18/1997 | 13. | 0.018 | 0.051 | 0.021 | 4 | 0.10 | 1.3 | 0.5 | 0.9 | 2. | 0.11 | 0.9 | 0.3 | <1 | 7.2 | <0.01 | 0.02 |
| S292 | NM406 | Bear Canyon Arroyo | 1/9/1998 | 30. | 0.016 | 61.5 | 0.018 | 6 | 0.07 | 0.7 | 0.4 | 1.6 | <1 | 0.15 | 0.8 | 0.2 | <1 | 6.3 | 0.02 | <0.01 |
| S292 | NM615 | Bear Canyon Arroyo | 4/2/1999 | <1. | 1.04 | 0.036 | 0.014 | 4 | <0.05 | 0.5 | 0.4 | 0.9 | <1 | 0.05 | 0.8 | 0.1 | 3 | 4.9 | 0.02 | 0.01 |
| S293 | NM244 | Canyon del Trigo Stream | 5/29/1997 | 4. | 0.013 | 0.018 | 0.003 | 1 | <0.05 | 1.0 | 0.1 | 0.2 | <1 | <0.1 | 0.4 | 0.3 | <1 | <0.1 | 0.01 | 0.01 |
| S294 | NM355 | Chamizal Lateral at Alameda | 7/9/1997 | 2. | 0.040 | 0.061 | 0.020 | 2 | <0.05 | 0.9 | 2.1 | 4.4 | <1 | <0.1 | 3.2 | 2.9 | <1 | 2.3 | <0.01 | 0.01 |
| S294 | NM608 | Chamizal Lateral at Alameda | 3/30/1999 | 2. | 0.142 | 0.065 | 0.022 | 2 | <0.05 | 0.6 | 1.9 | 5.1 | <1 | 0.10 | 4.5 | 3.2 | <1 | 3.6 | <0.01 | 0.01 |
| S294 | NM560 | Chamizal Lateral at Alameda | 10/20/1998 | 4. | 0.042 | 0.094 | 0.026 | 4 | <0.05 | 0.6 | 1.8 | 4.5 | <1 | 0.08 | 3.9 | 3.2 | <1 | 2.7 | <0.01 | <0.01 |
| S294 | NM427 | Chamizal Lateral at Alameda | 3/31/1998 | 4. | 0.045 | 0.057 | 0.024 | 1 | 0.05 | 0.8 | 2.1 | 4.2 | <1 | 0.10 | 3.8 | 3.0 | <1 | 3.5 | <0.01 | 0.02 |
| S294 | NM442 | Chamizal Lateral at Alameda | 5/5/1998 | 4. | 0.053 | 0.062 | 0.030 | 3 | 0.07 | 0.8 | 2.0 | 3.9 | <1 | 0.11 | 3.4 | 3.0 | <1 | 3.0 | 0.05 | <0.01 |
| S294 | NM204 | Chamizal Lateral at Alameda | 3/18/1997 | 4. | 0.054 | 0.072 | 0.027 | 4 | <0.05 | 0.6 | 1.4 | 4.7 | <1 | 0.10 | 4.7 | 2.8 | <1 | 3.8 | <0.01 | 0.01 |
| S294 | NM533 | Chamizal Lateral at Alameda | 8/18/1998 | 5. | 0.044 | 0.078 | 0.026 | 2 | <0.05 | 0.9 | 1.8 | 5.3 | <1 | 0.10 | 3.6 | 3.3 | <1 | 2.6 | <0.01 | 0.01 |
| S294 | NM217 | Chamizal Lateral at Alameda | 4/22/1997 | 5. | 0.053 | 0.074 | 0.026 | 6 | <0.05 | 0.8 | 1.9 | 4.7 | <1 | <0.1 | 3.7 | 2.8 | <1 | 2.8 | <0.01 | 0.01 |
| S294 | NM547 | Chamizal Lateral at Alameda | 9/22/1998 | 6. | 0.035 | 0.077 | 0.024 | 2 | <0.05 | 1.0 | 1.9 | 4.8 | <1 | 0.09 | 3.6 | 3.5 | <1 | 2.4 | <0.01 | <0.01 |
| S294 | NM456 | Chamizal Lateral at Alameda | 6/11/1998 | 6. | 0.044 | 0.054 | 0.022 | 2 | <0.05 | 0.9 | 1.7 | 3.5 | <1 | 0.08 | 2.7 | 2.6 | <1 | 2.2 | <0.01 | <0.01 |
| S294 | NM230 | Chamizal Lateral at Alameda | 5/21/1997 | 6. | 0.044 | 0.068 | 0.024 | 4 | 0.12 | 1.0 | 1.8 | 3.6 | <1 | 0.10 | 2.8 | 2.5 | <1 | 2.4 | <0.01 | 0.01 |
| S294 | NM369 | Chamizal Lateral at Alameda | 9/16/1997 | 6. | 0.045 | 0.076 | 0.024 | 5 | 0.05 | 0.9 | 1.9 | 5.6 | <1 | 0.10 | 3.9 | 3.4 | <1 | 2.5 | 0.01 | 0.01 |
| S294 | NM470 | Chamizal Lateral at Alameda | 7/22/1998 | 6. | 0.046 | 0.073 | 0.022 | 3 | <0.05 | 0.9 | 1.8 | 5.4 | 1. | 0.10 | 3.6 | 3.3 | <1 | 2.6 | <0.01 | 0.04 |

**Table B4.** Summary of trace-element chemistry in surface water-- Continued

| Site no. | Sample no. | Site name | Date | Al (µg/L) | B (mg/L) | Ba (mg/L) | Li (mg/L) | Zn (µg/L) | Pb (µg/L) | Cu (µg/L) | Rb (µg/L) | V (µg/L) | Cr (µg/L) | Co (µg/L) | Mo (µg/L) | As (µg/L) | Se (µg/L) | U (µg/L) | Ag (µg/L) | Cd (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S294 | NM380 | Chamizal Lateral at Alameda | 10/21/1997 | 7. | 0.040 | 0.059 | 0.020 | 6 | 0.07 | 0.9 | 1.7 | 4.1 | <1 | 0.09 | 3.0 | 3.1 | <1 | 1.9 | <0.01 | <0.01 |
| S297 | NM603 | Jemez River below Jemez Canyon Dam | 2/3/1999 | 4. | 0.529 | 0.113 | 0.491 | 2 | <0.05 | 1.3 | 12. | 6.0 | <1 | 0.16 | 4.0 | 26 | 1 | 2.5 | <0.01 | <0.01 |
| S297 | NM592 | Jemez River below Jemez Canyon Dam | 1/6/1999 | 4. | 0.545 | 0.109 | 0.556 | 1 | <0.05 | 1.1 | 11. | 5.8 | <1 | 0.14 | 3.7 | 24 | 1 | 2.3 | <0.01 | <0.01 |
| S297 | NM556 | Jemez River below Jemez Canyon Dam | 9/24/1998 | 5. | 0.565 | 0.113 | 0.413 | 2 | <0.05 | 1.6 | 12. | 3.7 | <1 | 0.17 | 4.1 | 23 | 1 | 2.0 | <0.01 | <0.01 |
| S297 | NM479 | Jemez River below Jemez Canyon Dam | 7/23/1998 | 7. | 0.324 | 0.092 | 0.354 | 8 | <0.05 | 2.0 | 12. | 3.3 | 2. | 0.22 | 3.4 | 24 | <1 | 1.9 | <0.01 | 0.01 |
| S297 | NM542 | Jemez River below Jemez Canyon Dam | 8/19/1998 | 7. | 0.414 | 0.090 | 0.348 | 3 | <0.05 | 0.7 | 12. | 2.8 | <1 | 0.22 | 3.3 | 25 | <1 | 1.7 | <0.01 | <0.01 |
| S297 | NM465 | Jemez River below Jemez Canyon Dam | 6/12/1998 | 11. | 0.221 | 0.077 | 0.364 | 2 | <0.05 | 1.7 | 12. | 3.8 | <1 | 0.18 | 3.1 | 23 | 1 | 1.7 | 0.05 | <0.01 |
| S297 | NM568 | Jemez River below Jemez Canyon Dam | 10/27/1998 | 14. | 0.126 | 0.120 | 0.390 | 4 | <0.05 | 0.7 | 12. | 5.5 | 2. | 0.14 | 4.2 | 23 | 1 | 2.1 | <0.01 | <0.01 |
| S297 | NM616 | Jemez River below Jemez Canyon Dam | 4/1/1999 | 14. | 0.330 | 0.128 | 0.794 | 4 | <0.05 | 0.5 | 14. | 5.7 | <1 | 0.15 | 4.5 | 28 | 2 | 2.6 | <0.01 | <0.01 |
| S297 | NM422 | Jemez River below Jemez Canyon Dam | 2/20/1998 | 19. | 0.386 | 0.114 | 0.584 | 4 | <0.05 | 1.3 | 13. | 6.4 | <1 | 0.13 | 4.3 | 27 | 1 | 2.8 | <0.01 | <0.01 |
| S297 | NM437 | Jemez River below Jemez Canyon Dam | 4/7/1998 | 30. | 0.090 | 0.101 | 0.620 | 1 | <0.05 | 1.4 | 15. | 5.6 | <1 | 0.11 | 3.8 | 25 | 1 | 2.4 | <0.01 | <0.01 |
| S297 | NM580 | Jemez River below Jemez Canyon Dam | 12/3/1998 | 32. | 0.030 | 0.115 | 0.520 | 1 | <0.05 | 1.1 | 11. | 6.4 | <1 | 0.17 | 3.7 | 24 | 1 | 2.3 | <0.01 | <0.01 |
| S297 | NM451 | Jemez River below Jemez Canyon Dam | 5/7/1998 | 388. | 0.074 | 0.089 | 0.431 | 5 | 0.05 | 2.1 | 14. | 4.9 | <1 | 0.11 | 3.4 | 21 | 1 | 2.2 | <0.01 | 0.02 |
| S298 | NM438 | Jemez River at Jemez | 4/7/1998 | 2. | 0.530 | 0.051 | 0.103 | 2 | 0.05 | 1.1 | 13. | 1.2 | <1 | 0.10 | 1.0 | 9.8 | <1 | 0.8 | <0.01 | <0.01 |
| S298 | NM593 | Jemez River at Jemez | 1/6/1999 | 3. | 0.077 | 0.069 | 0.654 | <1 | <0.05 | 0.3 | 64. | 1.6 | <1 | 0.07 | 4.3 | 55 | 1 | 1.3 | <0.01 | 0.02 |
| S298 | NM557 | Jemez River at Jemez | 9/24/1998 | 4. | 0.044 | 0.092 | 0.608 | 2 | <0.05 | 0.5 | 92. | 2.3 | <1 | 0.11 | 5.1 | 77 | 1 | 1.6 | <0.01 | 0.03 |
| S298 | NM423 | Jemez River at Jemez | 2/20/1998 | 4. | 0.520 | 0.068 | 0.517 | 4 | <0.05 | 0.3 | 66. | 2.0 | <1 | 0.07 | 4.0 | 51 | <1 | 1.7 | <0.01 | <0.01 |
| S298 | NM604 | Jemez River at Jemez | 2/3/1999 | 4. | 1.57 | 0.071 | 0.598 | 1 | <0.05 | 0.3 | 85. | 2.1 | <1 | 0.06 | 5.6 | 69 | 1 | 1.3 | <0.01 | 0.02 |
| S298 | NM466 | Jemez River at Jemez | 6/12/1998 | 5. | 0.336 | 0.080 | 0.264 | 5 | <0.05 | 0.8 | 33. | 1.6 | <1 | 0.09 | 2.2 | 28 | <1 | 1.3 | <0.01 | <0.01 |
| S298 | NM581 | Jemez River at Jemez | 12/3/1998 | 5. | 0.830 | 0.063 | 0.384 | 1 | <0.05 | 0.4 | 41. | 1.3 | <1 | 0.08 | 2.8 | 34 | <1 | 1.2 | <0.01 | 0.02 |
| S298 | NM617 | Jemez River at Jemez | 4/2/1999 | 5. | 1.14 | 0.056 | 0.275 | 2 | <0.05 | 1.1 | 34. | 1.2 | <1 | 0.10 | 2.1 | 26 | 1 | 0.9 | <0.01 | 0.02 |
| S298 | NM480 | Jemez River at Jemez | 7/23/1998 | 8. | 0.042 | 0.091 | 0.399 | 3 | <0.05 | 0.4 | 70. | 2.7 | 2. | 0.11 | 4.2 | 62 | <1 | 1.7 | <0.01 | <0.01 |
| S298 | NM543 | Jemez River at Jemez | 8/19/1998 | 10. | 0.479 | 0.087 | 0.458 | 2 | <0.05 | 0.4 | 66. | 2.3 | <1 | 0.12 | 3.8 | 56 | <1 | 1.4 | <0.01 | 0.03 |
| S298 | NM452 | Jemez River at Jemez | 5/7/1998 | 12. | 0.208 | 0.051 | 0.073 | 5 | 0.23 | 1.0 | 8.4 | 1.2 | <1 | 0.16 | 0.6 | 6.7 | <1 | 0.6 | <0.01 | <0.01 |
| S298 | NM569 | Jemez River at Jemez | 10/27/1998 | <5. | 0.372 | 0.059 | 0.150 | 3 | 0.05 | 0.8 | 5.3 | 5.9 | <1 | 0.08 | 1.6 | 14 | <1 | 0.8 | <0.01 | 0.02 |
| S300 | NM571 | Rio Grande at Alameda | 12/1/1998 | 1. | 0.050 | 0.089 | 0.050 | 2 | <0.05 | 0.8 | 1.9 | 4.4 | <1 | 0.11 | 4.4 | 3.9 | <1 | 3.6 | <0.01 | 0.1 |
| S300 | NM583 | Rio Grande at Alameda | 1/5/1999 | 1. | 0.052 | 0.079 | 0.056 | 2 | <0.05 | 0.7 | 2.0 | 4.3 | <1 | 0.10 | 4.6 | 4.2 | <1 | 3.7 | <0.01 | 0.03 |
| S300 | NM594 | Rio Grande at Alameda | 2/2/1999 | 1. | 0.055 | 0.069 | 0.057 | 1 | <0.05 | 0.7 | 2.4 | 4.4 | <1 | 0.11 | 4.6 | 4.3 | <1 | 3.7 | 0.05 | 0.04 |
| S300 | NM606 | Rio Grande at Alameda | 3/30/1999 | 1. | 0.056 | 0.072 | 0.090 | 2 | <0.05 | 0.7 | 2.4 | 5.3 | <1 | 0.10 | 4.5 | 5.3 | <1 | 3.3 | <0.01 | <0.01 |
| S300 | NM558 | Rio Grande at Alameda | 10/20/1998 | 3. | 0.041 | 0.097 | 0.026 | 5 | <0.05 | 1.1 | 1.4 | 4.4 | <1 | 0.10 | 5.2 | 3.0 | <1 | 2.6 | <0.01 | 0.01 |
| S300 | NM413 | Rio Grande at Alameda | 2/19/1998 | 3. | 0.043 | 0.064 | 0.046 | 2 | 0.12 | 1.1 | 2.2 | 4.0 | <1 | 0.10 | 4.1 | 3.5 | <1 | 3.8 | <0.01 | 0.02 |
| S300 | NM545 | Rio Grande at Alameda | 9/22/1998 | 4. | 0.039 | 0.074 | 0.017 | 2 | <0.05 | 1.1 | 1.2 | 4.7 | <1 | 0.09 | 3.4 | 2.6 | <1 | 1.9 | 0.01 | 0.02 |
| S300 | NM425 | Rio Grande at Alameda | 3/31/1998 | 4. | 0.047 | 0.055 | 0.053 | 1 | 0.06 | 0.8 | 2.2 | 4.3 | <1 | 0.12 | 3.7 | 3.6 | <1 | 2.9 | 0.03 | 0.04 |
| S300 | NM454 | Rio Grande at Alameda | 6/11/1998 | 4. | 0.049 | 0.047 | 0.015 | 4 | 0.06 | 2.4 | 1.7 | 3.3 | <1 | 0.09 | 2.9 | 1.9 | <1 | 1.6 | <0.01 | 0.01 |
| S300 | NM440 | Rio Grande at Alameda | 5/5/1998 | 4. | 0.056 | 0.058 | 0.049 | 3 | <0.05 | 1.0 | 2.2 | 3.6 | <1 | 0.10 | 3.0 | 3.1 | <1 | 2.3 | <0.01 | 0.01 |
| S300 | NM187 | Rio Grande at Alameda | 1/14/1997 | 4. | 0.060 | 0.089 | 0.030 | 31 | 0.12 | 1.3 | 1.9 | 4.1 | <1 | 0.10 | 5.3 | 3.2 | <1 | 4.2 | <0.01 | 0.02 |
| S300 | NM206 | Rio Grande at Alameda | 3/18/1997 | 4. | 0.114 | 0.079 | 0.084 | 4 | <0.05 | 0.6 | 2.0 | 5.4 | <1 | 0.10 | 4.7 | 4.6 | <1 | 3.3 | <0.01 | 0.02 |
| S300 | NM356 | Rio Grande at Alameda | 7/9/1997 | 5. | 0.033 | 0.055 | 0.011 | 4 | <0.05 | 1.2 | 1.6 | 4.4 | <1 | <0.1 | 2.8 | 2.2 | <1 | 1.7 | <0.01 | 0.02 |
| S300 | NM531 | Rio Grande at Alameda | 8/18/1998 | 5. | 0.050 | 0.072 | 0.018 | 2 | <0.05 | 1.1 | 1.3 | 6.1 | <1 | 0.11 | 3.8 | 2.8 | <1 | 2.3 | <0.01 | 0.02 |
| S300 | NM195 | Rio Grande at Alameda | 2/11/1997 | 5. | 0.070 | 0.079 | 0.042 | 6 | <0.05 | 0.6 | 2.0 | 4.3 | <1 | 0.10 | 4.9 | 3.1 | <1 | 3.8 | <0.01 | 0.01 |
| S300 | NM389 | Rio Grande at Alameda | 11/20/1997 | 6. | 0.041 | 0.055 | 0.021 | 3 | 0.07 | 1.2 | 1.4 | 3.4 | <1 | 0.55 | 3.3 | 2.8 | <1 | 2.3 | <0.01 | 0.02 |
| S300 | NM468 | Rio Grande at Alameda | 7/22/1998 | 6. | 0.047 | 0.064 | 0.015 | 3 | <0.05 | 1.3 | 1.6 | 5.7 | <1 | 0.10 | 3.5 | 2.6 | <1 | 2.3 | 0.02 | 0.01 |
| S300 | NM218 | Rio Grande at Alameda | 4/22/1997 | 6. | 0.120 | 0.071 | 0.091 | 4 | <0.05 | 1.0 | 2.6 | 5.1 | <1 | 0.10 | 3.5 | 5.2 | <1 | 2.3 | <0.01 | 0.02 |
| S300 | NM231 | Rio Grande at Alameda | 5/21/1997 | 7. | 0.053 | 0.064 | 0.034 | 2 | <0.05 | 1.0 | 1.7 | 3.3 | <1 | 0.10 | 2.3 | 2.5 | <1 | 1.6 | <0.01 | 0.03 |
| S300 | NM367 | Rio Grande at Alameda | 9/16/1997 | 8. | 0.041 | 0.069 | 0.018 | 7 | 0.05 | 1.9 | 1.3 | 5.6 | <1 | <0.1 | 3.7 | 2.8 | <1 | 2.1 | <0.01 | <0.01 |
| S300 | NM378 | Rio Grande at Alameda | 10/21/1997 | 9. | 0.031 | 0.053 | 0.011 | 4 | 0.11 | 1.0 | 1.1 | 3.7 | <1 | 0.07 | 2.4 | 2.0 | <1 | 1.4 | <0.01 | 0.02 |
| S300 | NM123 | Rio Grande at Alameda | 6/22/1996 | 10. | 0.038 | 0.069 | 0.015 | nd | 0.20 | 0.2 | nd | 4.4 | <1 | nd | 4.0 | 1.8 | nd | 1.8 | <0.01 | 0.01 |
| S300 | NM118 | Rio Grande at Alameda | 6/29/1996 | 11. | 0.055 | 0.061 | 0.017 | nd | <0.1 | <0.1 | nd | 4.4 | <1 | nd | 3.4 | 2.3 | nd | 1.9 | <0.01 | 0.01 |

**Table B4.** Summary of trace-element chemistry in surface water-- Continued

| Site no. | Sample no. | Site name | Date | Al (µg/L) | B (mg/L) | Ba (mg/L) | Li (mg/L) | Zn (µg/L) | Pb (µg/L) | Cu (µg/L) | Rb (µg/L) | V (µg/L) | Cr (µg/L) | Co (µg/L) | Mo (µg/L) | As (µg/L) | Se (µg/L) | U (µg/L) | Ag (µg/L) | Cd (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S300 | NM398 | Rio Grande at Alameda | 1/8/1998 | 23. | 0.098 | 0.062 | 0.058 | 5 | 0.11 | 0.9 | 1.9 | 4.4 | <1 | 0.14 | 4.2 | 4.3 | <1 | 3.1 | <0.01 | 0.02 |
| S301 | NM585 | Rio Grande at Campbell | 1/5/1999 | 1. | 0.049 | 0.079 | 0.058 | 3 | <0.05 | 0.7 | 1.4 | 3.8 | <1 | 0.10 | 4.4 | 3.6 | <1 | 3.6 | <0.01 | <0.01 |
| S301 | NM596 | Rio Grande at Campbell | 2/2/1999 | 2. | 0.053 | 0.070 | 0.059 | 1 | <0.05 | 0.8 | 1.9 | 4.5 | <1 | 0.10 | 4.4 | 4.4 | <1 | 3.6 | <0.01 | 0.07 |
| S301 | NM561 | Rio Grande at Campbell | 10/20/1998 | 3. | 0.042 | 0.084 | 0.024 | 4 | <0.05 | 0.9 | 1.3 | 4.2 | <1 | 0.09 | 4.2 | 2.6 | <1 | 2.4 | <0.01 | <0.01 |
| S301 | NM549 | Rio Grande at Campbell | 9/22/1998 | 4. | 0.039 | 0.072 | 0.017 | 2 | <0.05 | 0.8 | 1.2 | 4.1 | <1 | 0.08 | 3.3 | 2.5 | <1 | 1.8 | <0.01 | <0.01 |
| S301 | NM415 | Rio Grande at Campbell | 2/19/1998 | 4. | 0.042 | 0.064 | 0.046 | 3 | 0.05 | 0.9 | 1.9 | 3.8 | <1 | 0.10 | 4.0 | 3.3 | <1 | 3.6 | <0.01 | 0.02 |
| S301 | NM429 | Rio Grande at Campbell | 3/31/1998 | 4. | 0.045 | 0.057 | 0.044 | 1 | 0.05 | 0.7 | 2.0 | 4.6 | <1 | 0.10 | 3.7 | 3.8 | <1 | 3.0 | <0.01 | 0.01 |
| S301 | NM444 | Rio Grande at Campbell | 5/5/1998 | 4. | 0.060 | 0.060 | 0.049 | 3 | 0.05 | 0.9 | 2.2 | 3.9 | <1 | 0.11 | 3.0 | 3.3 | <1 | 2.3 | <0.01 | 0.01 |
| S301 | NM189 | Rio Grande at Campbell | 1/14/1997 | 4. | 0.060 | 0.090 | 0.027 | 38 | <0.05 | 0.8 | 1.5 | 4.0 | <1 | 0.20 | 5.3 | 2.8 | <1 | 4.1 | <0.01 | 0.02 |
| S301 | NM197 | Rio Grande at Campbell | 2/11/1997 | 4. | 0.071 | 0.079 | 0.041 | 4 | <0.05 | 0.6 | 1.5 | 4.3 | <1 | 0.20 | 4.9 | 3.2 | <1 | 3.6 | 0.03 | 0.03 |
| S301 | NM208 | Rio Grande at Campbell | 3/18/1997 | 4. | 0.118 | 0.084 | 0.088 | 4 | <0.05 | 0.6 | 2.0 | 5.6 | <1 | 0.10 | 4.9 | 4.7 | <1 | 3.4 | <0.01 | 0.03 |
| S301 | NM358 | Rio Grande at Campbell | 7/9/1997 | 5. | 0.033 | 0.057 | 0.012 | 3 | <0.05 | 1.1 | 1.7 | 4.4 | <1 | <0.1 | 2.8 | 2.2 | <1 | 1.7 | <0.01 | 0.02 |
| S301 | NM472 | Rio Grande at Campbell | 7/22/1998 | 5. | 0.044 | 0.063 | 0.016 | 3 | <0.05 | 1.2 | 1.8 | 5.5 | 1. | 0.11 | 3.6 | 2.5 | <1 | 2.3 | <0.01 | <0.01 |
| S301 | NM535 | Rio Grande at Campbell | 8/18/1998 | 5. | 0.049 | 0.071 | 0.018 | 2 | <0.05 | 1.1 | 1.4 | 5.2 | <1 | 0.11 | 3.6 | 2.5 | <1 | 2.3 | <0.01 | 0.02 |
| S301 | NM458 | Rio Grande at Campbell | 6/11/1998 | 6. | 0.060 | 0.049 | 0.016 | 4 | 0.06 | 1.9 | 1.6 | 3.3 | <1 | 0.09 | 3.7 | 2.0 | <1 | 1.6 | <0.01 | 0.02 |
| S301 | NM221 | Rio Grande at Campbell | 4/22/1997 | 6. | 0.123 | 0.074 | 0.093 | 4 | 0.07 | 0.9 | 2.4 | 5.3 | <1 | 0.10 | 3.5 | 5.3 | <1 | 2.3 | <0.01 | 0.02 |
| S301 | NM391 | Rio Grande at Campbell | 11/20/1997 | 7. | 0.036 | 0.058 | 0.018 | 2 | 0.06 | 0.9 | 1.1 | 3.1 | <1 | 0.08 | 3.2 | 2.5 | <1 | 2.3 | <0.01 | 0.01 |
| S301 | NM233 | Rio Grande at Campbell | 5/21/1997 | 7. | 0.052 | 0.064 | 0.035 | 1 | 0.05 | 0.9 | 1.7 | 3.4 | <1 | 0.10 | 2.5 | 2.5 | <1 | 1.6 | <0.01 | 0.02 |
| S301 | NM382 | Rio Grande at Campbell | 10/21/1997 | 8. | 0.029 | 0.051 | 0.010 | 2 | 0.05 | 0.8 | 1.0 | 3.8 | <1 | 0.06 | 2.4 | 1.9 | <1 | 1.3 | <0.01 | 0.02 |
| S301 | NM371 | Rio Grande at Campbell | 9/16/1997 | 8. | 0.041 | 0.070 | 0.018 | 4 | <0.05 | 1.1 | 1.3 | 5.4 | <1 | 0.20 | 3.6 | 2.8 | <1 | 2.0 | <0.01 | 0.02 |
| S301 | NM400 | Rio Grande at Campbell | 1/8/1998 | 29. | 0.103 | 0.064 | 0.061 | 4 | 0.07 | 0.8 | 1.4 | 4.1 | <1 | 0.10 | 4.1 | 4.2 | <1 | 3.0 | <0.01 | 0.01 |
| S301 | NM573 | Rio Grande at Campbell | 12/1/1998 | <1. | 0.048 | 0.088 | 0.047 | 2 | <0.05 | 0.8 | 1.3 | 4.2 | <1 | 0.10 | 4.4 | 3.3 | <1 | 6.4 | <0.01 | <0.01 |
| S301 | NM609 | Rio Grande at Campbell | 3/30/1999 | <1. | 0.055 | 0.077 | 0.094 | 2 | <0.05 | 0.6 | 2.4 | 4.7 | <1 | 0.09 | 4.5 | 5.0 | <1 | 3.2 | <0.01 | 0.01 |
| S302 | NM124 | Rio Grande at Isleta Below Diversion | 6/22/1996 | 16. | 0.069 | 0.065 | 0.026 | nd | <0.1 | <0.1 | nd | 5.1 | <1 | nd | 6.9 | 3.0 | nd | 2.1 | <0.01 | 0.01 |
| S303 | NM575 | Rio Grande at Rio Bravo | 12/1/1998 | 1. | 0.050 | 0.085 | 0.034 | 2 | <0.05 | 0.9 | 1.3 | 4.1 | <1 | 0.09 | 4.2 | 3.0 | <1 | 3.3 | nd | 0.02 |
| S303 | NM598 | Rio Grande at Rio Bravo | 2/2/1999 | 2. | 0.050 | 0.079 | 0.073 | 2 | <0.05 | 0.8 | 1.7 | 4.3 | <1 | 0.11 | 4.4 | 4.7 | <1 | 3.6 | nd | 0.01 |
| S303 | NM417 | Rio Grande at Rio Bravo | 2/19/1998 | 3. | 0.044 | 0.069 | 0.043 | 2 | 0.13 | 1.0 | 1.7 | 3.9 | <1 | 0.10 | 4.0 | 3.3 | <1 | 3.7 | <0.01 | <0.01 |
| S303 | NM446 | Rio Grande at Rio Bravo | 5/5/1998 | 3. | 0.057 | 0.063 | 0.049 | 3 | 0.07 | 1.0 | 2.0 | 4.1 | <1 | 0.13 | 3.2 | 3.4 | <1 | 2.4 | nd | 0.01 |
| S303 | NM563 | Rio Grande at Rio Bravo | 10/20/1998 | 4. | 0.041 | 0.064 | 0.019 | 5 | 0.19 | 1.6 | 2.0 | 4.3 | <1 | 0.12 | 3.4 | 2.8 | <1 | 1.7 | nd | 0.01 |
| S303 | NM551 | Rio Grande at Rio Bravo | 9/22/1998 | 4. | 0.041 | 0.073 | 0.019 | 2 | <0.05 | 0.9 | 1.5 | 4.5 | <1 | 0.09 | 3.4 | 2.7 | <1 | 1.9 | nd | 0.01 |
| S303 | NM191 | Rio Grande at Rio Bravo | 1/15/1997 | 4. | 0.061 | 0.093 | 0.028 | 34 | 0.05 | 0.8 | 1.4 | 4.1 | <1 | 0.30 | 5.1 | 3.1 | <1 | 4.2 | <0.01 | 0.01 |
| S303 | NM360 | Rio Grande at Rio Bravo | 7/9/1997 | 5. | 0.032 | 0.057 | 0.012 | 2 | <0.05 | 1.1 | 1.8 | 4.4 | <1 | <0.1 | 2.9 | 2.3 | <1 | 1.7 | <0.01 | <0.01 |
| S303 | NM393 | Rio Grande at Rio Bravo | 11/20/1997 | 5. | 0.039 | 0.061 | 0.020 | 2 | 0.05 | 0.9 | 1.2 | 3.3 | <1 | 0.07 | 3.4 | 2.7 | <1 | 2.2 | <0.01 | <0.01 |
| S303 | NM474 | Rio Grande at Rio Bravo | 7/22/1998 | 5. | 0.045 | 0.065 | 0.018 | 3 | <0.05 | 1.2 | 2.0 | 5.2 | 1. | 0.12 | 3.5 | 2.6 | <1 | 2.3 | nd | 0.01 |
| S303 | NM460 | Rio Grande at Rio Bravo | 6/11/1998 | 5. | 0.051 | 0.049 | 0.016 | 3 | 0.05 | 1.1 | 1.4 | 3.2 | <1 | 0.07 | 2.4 | 1.9 | <1 | 1.6 | nd | 0.01 |
| S303 | NM199 | Rio Grande at Rio Bravo | 2/11/1997 | 5. | 0.070 | 0.083 | 0.039 | 5 | 0.05 | 0.7 | 1.5 | 4.2 | <1 | 0.10 | 4.8 | 3.2 | <1 | 3.7 | <0.01 | 0.01 |
| S303 | NM210 | Rio Grande at Rio Bravo | 3/18/1997 | 5. | 0.126 | 0.089 | 0.093 | 7 | <0.05 | 0.8 | 1.9 | 5.2 | <1 | 0.10 | 4.9 | 4.4 | <1 | 3.4 | 0.02 | 0.01 |
| S303 | NM537 | Rio Grande at Rio Bravo | 8/18/1998 | 6. | 0.050 | 0.071 | 0.020 | 2 | <0.05 | 1.0 | 1.6 | 5.1 | <1 | 0.11 | 3.6 | 2.7 | <1 | 2.3 | nd | 0.01 |
| S303 | NM223 | Rio Grande at Rio Bravo | 4/22/1997 | 6. | 0.133 | 0.080 | 0.100 | 9 | <0.05 | 0.9 | 2.2 | 5.1 | <1 | 0.10 | 3.6 | 5.1 | <1 | 2.3 | <0.01 | 0.01 |
| S303 | NM235 | Rio Grande at Rio Bravo | 5/21/1997 | 7. | 0.054 | 0.065 | 0.036 | 2 | <0.05 | 0.9 | 1.6 | 3.4 | <1 | 0.10 | 2.4 | 2.6 | <1 | 1.7 | <0.01 | <0.01 |
| S303 | NM384 | Rio Grande at Rio Bravo | 10/21/1997 | 8. | 0.030 | 0.053 | 0.012 | 5 | 0.08 | 0.9 | 1.1 | 4.1 | <1 | 0.10 | 2.5 | 2.2 | <1 | 1.4 | <0.01 | 0.01 |
| S303 | NM373 | Rio Grande at Rio Bravo | 9/16/1997 | 8. | 0.043 | 0.070 | 0.020 | 4 | <0.05 | 1.0 | 1.4 | 5.3 | <1 | 0.10 | 3.7 | 2.8 | <1 | 2.0 | <0.01 | <0.01 |
| S303 | NM431 | Rio Grande at Rio Bravo | 3/31/1998 | 13. | 0.045 | 0.061 | 0.052 | 2 | 0.10 | 0.9 | 1.9 | 4.4 | <1 | 0.11 | 3.7 | 3.7 | <1 | 3.0 | <0.01 | <0.01 |
| S303 | NM121 | Rio Grande at Rio Bravo | 6/29/1996 | 19. | 0.053 | 0.082 | 0.020 | nd | <0.1 | <0.1 | nd | 4.9 | <1 | nd | 3.6 | 2.6 | nd | 2.1 | <0.01 | 0.01 |
| S303 | NM402 | Rio Grande at Rio Bravo | 1/8/1998 | 21. | 0.103 | 0.069 | 0.059 | 3 | 0.05 | 0.8 | 1.3 | 3.8 | 1. | 0.09 | 4.1 | 3.9 | <1 | 2.9 | <0.01 | <0.01 |
| S303 | NM587 | Rio Grande at Rio Bravo | 1/5/1999 | <1. | 0.047 | 0.080 | 0.047 | 2 | <0.05 | 0.7 | 1.3 | 3.7 | <1 | 0.10 | 4.3 | 3.1 | <1 | 3.4 | nd | 0.01 |
| S303 | NM611 | Rio Grande at Rio Bravo | 3/30/1999 | <1. | 0.053 | 0.075 | 0.061 | 3 | <0.05 | 0.6 | 2.1 | 4.5 | <1 | 0.09 | 4.4 | 3.9 | <1 | 3.3 | nd | 0.01 |
| S304 | NM122 | Rio Grande at San Felipe | 6/22/1996 | 28. | 0.036 | 0.068 | 0.015 | nd | 0.20 | 0.2 | nd | 3.2 | <1 | nd | 3.3 | 1.8 | nd | 1.7 | nd | <0.01 |

**Table B4.** Summary of trace-element chemistry in surface water-- Continued

| Site no. | Sample no. | Site name | Date | Al (µg/L) | B (mg/L) | Ba (mg/L) | Li (mg/L) | Zn (µg/L) | Pb (µg/L) | Cu (µg/L) | Rb (µg/L) | V (µg/L) | Cr (µg/L) | Co (µg/L) | Mo (µg/L) | As (µg/L) | Se (µg/L) | U (µg/L) | Ag (µg/L) | Cd (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S305 | NM120 | Rio Grande at Central | 6/29/1996 | 8. | 0.059 | 0.083 | 0.015 | nd | <0.1 | <0.1 | nd | 4.9 | <1 | nd | 3.7 | 1.8 | nd | 1.8 | nd | <0.01 |
| S306 | NM119 | Rio Grande at Nature Center | 6/29/1996 | 8. | 0.057 | 0.088 | 0.015 | nd | <0.1 | <0.1 | nd | 4.7 | <1 | nd | 3.6 | 1.8 | nd | 1.8 | nd | <0.01 |
| S307 | NM582 | Rio Puerco at Hwy 6 | 12/3/1998 | 2. | 0.070 | 0.044 | 0.577 | <5 | <0.05 | 2.7 | 11. | 2.6 | <5 | 0.22 | 4.4 | 8.7 | 7 | 7.5 | nd | 0.01 |
| S307 | NM605 | Rio Puerco at Hwy 6 | 2/3/1999 | 2. | 0.132 | 0.049 | 1.09 | 5 | <0.05 | 4.6 | 19. | 2.5 | <5 | 0.24 | 4.7 | 12 | 9 | 12 | nd | 0.02 |
| S307 | NM570 | Rio Puerco at Hwy 6 | 10/23/1998 | 4. | 0.068 | 0.036 | 0.251 | 2 | <0.05 | 2.8 | 4.4 | 1.9 | <5 | 0.28 | 5.3 | 2.4 | 5 | 5.8 | nd | 0.01 |
| S307 | NM439 | Rio Puerco at Hwy 6 | 4/7/1998 | 5. | 0.065 | 0.056 | 0.520 | 2 | <0.05 | 5.3 | 3.7 | 2.2 | <1 | 0.32 | 4.5 | 5.5 | 5 | 18 | nd | 0.06 |
| S307 | NM424 | Rio Puerco at Hwy 6 | 2/20/1998 | 5. | 0.077 | 0.040 | 0.617 | <1 | 0.06 | 4.8 | 7.9 | 2.3 | <1 | 0.34 | 4.4 | 8.0 | 5 | 10 | nd | 0.03 |
| S307 | NM544 | Rio Puerco at Hwy 6 | 8/19/1998 | 6. | 0.029 | 0.100 | 0.341 | <5 | <0.05 | 6.5 | 2.7 | 1.2 | <5 | 0.24 | 8.5 | 1.7 | 6 | 9.3 | nd | 0.02 |
| S307 | NM453 | Rio Puerco at Hwy 6 | 5/7/1998 | 8. | 0.036 | 0.045 | 0.138 | 3 | <0.05 | 5.3 | 1.6 | 1.0 | <1 | 0.27 | 9.3 | 1.2 | 4 | 13 | nd | 0.04 |
| S307 | NM467 | Rio Puerco at Hwy 6 | 6/12/1998 | 9. | 0.041 | 0.073 | 0.262 | 2 | <0.05 | 5.4 | 2.1 | 1.3 | 1. | 0.38 | 8.9 | 1.5 | 4 | 12 | nd | 0.01 |
| S307 | NM618 | Rio Puerco at Hwy 6 | 4/2/1999 | nd | nd | 0.040 | 0.714 | <5 | <0.25 | 3.2 | 18. | 2.8 | <5 | <0.2 | 5.2 | 11 | <5 | 10 | nd | 0.02 |
| S308 | NM607 | Riverside Drain at Alameda | 3/30/1999 | 1. | 0.050 | 0.069 | 0.026 | 2 | <0.05 | 0.6 | 1.9 | 4.8 | <1 | 0.10 | 4.3 | 3.3 | <1 | 3.6 | 0.02 | 0.01 |
| S308 | NM572 | Riverside Drain at Alameda | 12/1/1998 | 2. | 0.063 | 0.094 | 0.036 | 2 | <0.05 | 0.9 | 2.0 | 4.4 | <1 | 0.09 | 3.7 | 3.5 | <1 | 3.2 | <0.01 | 0.01 |
| S308 | NM559 | Riverside Drain at Alameda | 10/20/1998 | 3. | 0.042 | 0.092 | 0.026 | 3 | <0.05 | 0.7 | 1.9 | 4.7 | <1 | 0.07 | 3.9 | 3.3 | <1 | 2.7 | 0.03 | 0.02 |
| S308 | NM584 | Riverside Drain at Alameda | 1/5/1999 | 3. | 0.073 | 0.092 | 0.037 | 2 | <0.05 | 0.8 | 1.8 | 3.8 | <1 | 0.08 | 3.8 | 3.4 | <1 | 3.7 | 0.15 | 0.02 |
| S308 | NM595 | Riverside Drain at Alameda | 2/2/1999 | 3. | 0.078 | 0.084 | 0.034 | 1 | <0.05 | 0.8 | 1.8 | 3.8 | <1 | 0.08 | 3.9 | 3.4 | <1 | 3.9 | 0.09 | 0.02 |
| S308 | NM357 | Riverside Drain at Alameda | 7/9/1997 | 4. | 0.043 | 0.064 | 0.023 | 11 | 0.09 | 0.9 | 2.0 | 4.4 | <1 | <0.1 | 3.3 | 3.2 | <1 | 2.3 | nd | 0.03 |
| S308 | NM532 | Riverside Drain at Alameda | 8/18/1998 | 4. | 0.043 | 0.077 | 0.027 | 2 | 0.05 | 0.9 | 1.9 | 5.2 | <1 | 0.11 | 3.6 | 3.5 | <1 | 2.4 | 0.17 | <0.01 |
| S308 | NM426 | Riverside Drain at Alameda | 3/31/1998 | 4. | 0.044 | 0.062 | 0.026 | 1 | <0.05 | 0.8 | 2.0 | 4.3 | <1 | 0.09 | 3.8 | 3.2 | <1 | 3.3 | 0.06 | 0.02 |
| S308 | NM441 | Riverside Drain at Alameda | 5/5/1998 | 4. | 0.052 | 0.066 | 0.031 | 3 | 0.05 | 0.9 | 1.9 | 4.0 | <1 | 0.10 | 3.4 | 3.1 | <1 | 3.1 | 0.03 | 0.02 |
| S308 | NM232 | Riverside Drain at Alameda | 5/21/1997 | 4. | 0.057 | 0.072 | 0.032 | 2 | <0.05 | 0.9 | 1.9 | 3.7 | <1 | 0.10 | 3.1 | 2.9 | <1 | 2.6 | nd | 0.03 |
| S308 | NM188 | Riverside Drain at Alameda | 1/14/1997 | 4. | 0.058 | 0.107 | 0.032 | 31 | 0.09 | 1.4 | 2.0 | 3.7 | <1 | 0.10 | 4.4 | 3.3 | <1 | 4.6 | nd | 0.02 |
| S308 | NM196 | Riverside Drain at Alameda | 2/11/1997 | 4. | 0.066 | 0.106 | 0.034 | 5 | <0.05 | 0.8 | 1.8 | 3.4 | <1 | 0.10 | 4.3 | 3.3 | <1 | 4.4 | nd | <0.01 |
| S308 | NM455 | Riverside Drain at Alameda | 6/11/1998 | 4. | 0.079 | 0.061 | 0.027 | 3 | <0.05 | 0.9 | 1.7 | 3.8 | <1 | 0.07 | 2.9 | 3.1 | <1 | 2.3 | 0.02 | 0.02 |
| S308 | NM546 | Riverside Drain at Alameda | 9/22/1998 | 5. | 0.035 | 0.077 | 0.026 | 2 | <0.05 | 0.9 | 2.0 | 4.7 | <1 | 0.10 | 3.7 | 3.5 | <1 | 2.3 | <0.01 | 0.03 |
| S308 | NM469 | Riverside Drain at Alameda | 7/22/1998 | 5. | 0.049 | 0.072 | 0.024 | 3 | <0.05 | 1.0 | 1.8 | 5.3 | 1. | 0.10 | 3.6 | 3.4 | <1 | 2.5 | <0.01 | 0.01 |
| S308 | NM207 | Riverside Drain at Alameda | 3/18/1997 | 5. | 0.059 | 0.082 | 0.029 | 13 | <0.05 | 0.6 | 1.8 | 4.7 | <1 | 0.10 | 4.6 | 3.0 | <1 | 3.9 | nd | 0.02 |
| S308 | NM414 | Riverside Drain at Alameda | 2/19/1998 | 5. | 0.060 | 0.084 | 0.033 | 2 | 0.24 | 0.9 | 1.9 | 4.1 | 2. | 0.14 | 4.1 | 4.0 | <1 | 4.1 | <0.01 | 0.02 |
| S308 | NM219 | Riverside Drain at Alameda | 4/22/1997 | 5. | 0.063 | 0.078 | 0.031 | 14 | <0.05 | 0.8 | 2.0 | 4.6 | <1 | <0.1 | 3.8 | 3.1 | <1 | 2.9 | nd | <0.01 |
| S308 | NM379 | Riverside Drain at Alameda | 10/21/1997 | 6. | 0.049 | 0.063 | 0.024 | 4 | <0.05 | 0.8 | 2.0 | 4.3 | <1 | 0.07 | 3.5 | 3.4 | <1 | 2.0 | <0.01 | 0.02 |
| S308 | NM368 | Riverside Drain at Alameda | 9/16/1997 | 6. | 0.049 | 0.075 | 0.026 | 8 | <0.05 | 1.0 | 2.1 | 2.3 | <1 | <0.1 | 4.1 | 3.5 | <1 | 2.3 | 0.02 | 0.02 |
| S308 | NM390 | Riverside Drain at Alameda | 11/20/1997 | 7. | 0.049 | 0.073 | 0.031 | 2 | <0.05 | 0.9 | 2.3 | 4.5 | <1 | 0.08 | 4.0 | 4.4 | <1 | 2.5 | <0.01 | 0.02 |
| S308 | NM399 | Riverside Drain at Alameda | 1/8/1998 | 22. | 0.067 | 0.084 | 0.030 | 5 | <0.05 | 0.9 | 1.7 | 4.1 | <1 | 0.09 | 4.2 | 3.9 | <1 | 2.8 | <0.01 | 0.05 |
| S309 | NM574 | Riverside Drain at Campbell | 12/1/1998 | 2. | 0.050 | 0.092 | 0.034 | 2 | <0.05 | 0.7 | 1.9 | 4.5 | <1 | 0.08 | 3.6 | 3.6 | <1 | 2.9 | <0.01 | 0.01 |
| S309 | NM586a | Riverside Drain at Campbell | 1/5/1999 | 2. | 0.065 | 0.089 | 0.036 | 2 | <0.05 | 0.7 | 1.7 | 3.7 | <1 | 0.08 | 3.6 | 3.4 | <1 | 3.5 | <0.01 | 0.01 |
| S309 | NM359 | Riverside Drain at Campbell | 7/9/1997 | 3. | 0.043 | 0.064 | 0.024 | 10 | <0.05 | 1.0 | 2.0 | 4.4 | <1 | 0.20 | 3.4 | 3.2 | <1 | 2.2 | 0.03 | 0.01 |
| S309 | NM597 | Riverside Drain at Campbell | 2/2/1999 | 3. | 0.091 | 0.082 | 0.032 | 2 | <0.05 | 0.8 | 1.7 | 3.7 | <1 | 0.07 | 3.7 | 3.4 | <1 | 3.9 | <0.01 | <0.01 |
| S309 | NM610 | Riverside Drain at Campbell | 3/30/1999 | 3. | 0.100 | 0.070 | 0.026 | 3 | <0.05 | 0.6 | 1.8 | 4.6 | <1 | 0.08 | 4.3 | 3.2 | <1 | 3.6 | <0.01 | 0.02 |
| S309 | NM190 | Riverside Drain at Campbell | 1/14/1997 | 4. | 0.055 | 0.104 | 0.031 | 33 | <0.05 | 0.8 | 2.1 | 3.5 | <1 | 0.10 | 4.3 | 3.4 | <1 | 5.1 | 0.02 | 0.02 |
| S309 | NM209 | Riverside Drain at Campbell | 3/18/1997 | 4. | 0.060 | 0.083 | 0.030 | 4 | <0.05 | 0.6 | 1.7 | 4.6 | <1 | 0.10 | 4.6 | 3.0 | <1 | 3.9 | 0.05 | 0.02 |
| S309 | NM198 | Riverside Drain at Campbell | 2/11/1997 | 4. | 0.063 | 0.107 | 0.033 | 5 | 0.06 | 0.8 | 1.9 | 3.2 | <1 | 0.10 | 4.2 | 3.4 | <1 | 5.0 | 0.07 | 0.02 |
| S309 | NM383 | Riverside Drain at Campbell | 10/21/1997 | 5. | 0.049 | 0.063 | 0.025 | 6 | 0.05 | 0.7 | 1.9 | 4.5 | <1 | 0.08 | 3.6 | 3.5 | <1 | 1.9 | <0.01 | <0.01 |
| S309 | NM234 | Riverside Drain at Campbell | 5/21/1997 | 5. | 0.059 | 0.072 | 0.033 | 2 | <0.05 | 0.8 | 1.8 | 3.7 | <1 | 0.10 | 3.2 | 2.9 | <1 | 2.6 | 0.03 | 0.02 |
| S309 | NM222 | Riverside Drain at Campbell | 4/22/1997 | 5. | 0.066 | 0.079 | 0.032 | 11 | <0.05 | 0.8 | 1.9 | 4.6 | <1 | <0.1 | 3.8 | 3.1 | <1 | 2.9 | 0.05 | 0.02 |
| S309 | NM550 | Riverside Drain at Campbell | 9/22/1998 | 6. | 0.032 | 0.077 | 0.027 | 3 | <0.05 | 1.0 | 2.0 | 4.6 | <1 | 0.08 | 3.7 | 3.6 | <1 | 2.2 | <0.01 | 0.02 |
| S309 | NM562 | Riverside Drain at Campbell | 10/20/1998 | 6. | 0.041 | 0.088 | 0.027 | 3 | <0.05 | 0.7 | 1.9 | 4.8 | <1 | 0.07 | 3.9 | 3.4 | <1 | 2.5 | <0.01 | 0.02 |
| S309 | NM372 | Riverside Drain at Campbell | 9/16/1997 | 6. | 0.050 | 0.075 | 0.026 | 6 | 0.05 | 0.8 | 2.0 | 5.3 | <1 | 0.10 | 4.3 | 3.7 | <1 | 2.3 | 0.01 | 0.02 |
| S309 | NM416 | Riverside Drain at Campbell | 2/19/1998 | 6. | 0.058 | 0.083 | 0.031 | 2 | 0.06 | 0.8 | 1.8 | 3.9 | <1 | <0.05 | 3.8 | 3.9 | <1 | 3.9 | <0.05 | <0.05 |

**Table B4.** Summary of trace-element chemistry in surface water-- Continued

| Site no. | Sample no. | Site name | Date | Al (µg/L) | B (mg/L) | Ba (mg/L) | Li (mg/L) | Zn (µg/L) | Pb (µg/L) | Cu (µg/L) | Rb (µg/L) | V (µg/L) | Cr (µg/L) | Co (µg/L) | Mo (µg/L) | As (µg/L) | Se (µg/L) | U (µg/L) | Ag (µg/L) | Cd (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S309 | NM445 | Riverside Drain at Campbell | 5/5/1998 | 6. | 0.068 | 0.067 | 0.034 | 4 | <0.05 | 0.8 | 1.9 | 3.9 | <1 | 0.10 | 3.4 | 3.2 | <1 | 3.1 | <0.01 | 0.02 |
| S309 | NM459 | Riverside Drain at Campbell | 6/11/1998 | 7. | 0.036 | 0.062 | 0.028 | 4 | <0.05 | 0.9 | 1.6 | 3.8 | <1 | 0.08 | 2.9 | 3.0 | <1 | 2.3 | <0.01 | 0.02 |
| S309 | NM473 | Riverside Drain at Campbell | 7/22/1998 | 7. | 0.041 | 0.074 | 0.024 | 3 | <0.05 | 0.9 | 1.8 | 5.4 | 1. | 0.13 | 3.6 | 3.6 | <1 | 2.5 | <0.01 | 0.02 |
| S309 | NM536 | Riverside Drain at Campbell | 8/18/1998 | 7. | 0.043 | 0.077 | 0.029 | 3 | <0.05 | 0.8 | 1.9 | 4.9 | <1 | 0.23 | 3.6 | 3.5 | <1 | 2.4 | <0.01 | 0.02 |
| S309 | NM392 | Riverside Drain at Campbell | 11/20/1997 | 7. | 0.044 | 0.073 | 0.029 | 5 | <0.05 | 0.9 | 2.1 | 4.7 | <1 | 0.08 | 4.1 | 4.4 | <1 | 2.2 | <0.01 | 0.02 |
| S309 | NM401 | Riverside Drain at Campbell | 1/8/1998 | 20. | 0.062 | 0.082 | 0.028 | 4 | <0.05 | 0.7 | 1.7 | 4.3 | <1 | 0.08 | 4.0 | 4.1 | <1 | 2.8 | <0.01 | 0.01 |
| S309 | NM430 | Riverside Drain at Campbell | 3/31/1998 | 20. | 0.071 | 0.062 | 0.026 | 2 | <0.05 | 0.8 | 1.9 | 4.2 | <1 | 9.0 | 3.7 | 3.3 | <1 | 3.4 | <0.01 | 0.01 |
| S309 | NM586 | Riverside Drain at Campbell | 1/5/1999 | <1. | 0.050 | 0.091 | 0.036 | 2 | <0.05 | 0.7 | 1.7 | 3.7 | <1 | 0.08 | 3.6 | 3.4 | <1 | 3.6 | <0.01 | 0.02 |
| S310 | NM612 | Riverside Drain at Rio Bravo | 3/30/1999 | 1. | 0.060 | 0.073 | 0.024 | 2 | <0.05 | 0.6 | 1.6 | 4.3 | <1 | 0.09 | 4.3 | 3.1 | <1 | 3.5 | <0.05 | <0.05 |
| S310 | NM361 | Riverside Drain at Rio Bravo | 7/9/1997 | 2. | 0.046 | 0.067 | 0.024 | 2 | <0.05 | 0.8 | 2.0 | 4.8 | <1 | <0.1 | 3.5 | 3.4 | <1 | 2.4 | <0.01 | 0.02 |
| S310 | NM599 | Riverside Drain at Rio Bravo | 2/2/1999 | 2. | 0.054 | 0.088 | 0.033 | 1 | <0.05 | 0.6 | 1.9 | 3.6 | <1 | 0.10 | 3.5 | 4.3 | <1 | 2.6 | <0.05 | <0.05 |
| S310 | NM564 | Riverside Drain at Rio Bravo | 10/20/1998 | 3. | 0.049 | 0.082 | 0.025 | 4 | 0.10 | 0.8 | 2.0 | 4.5 | <1 | 0.12 | 3.6 | 3.2 | <1 | 2.4 | <0.05 | <0.05 |
| S310 | NM211 | Riverside Drain at Rio Bravo | 3/18/1997 | 3. | 0.060 | 0.089 | 0.030 | 4 | <0.05 | 1.0 | 1.6 | 4.6 | <1 | 0.80 | 4.7 | 3.1 | <1 | 3.9 | <0.01 | 0.01 |
| S310 | NM447 | Riverside Drain at Rio Bravo | 5/5/1998 | 3. | 0.066 | 0.069 | 0.033 | 3 | <0.05 | 0.8 | 1.8 | 3.9 | <1 | 0.11 | 3.7 | 3.3 | <1 | 3.1 | <0.01 | 0.02 |
| S310 | NM418 | Riverside Drain at Rio Bravo | 2/19/1998 | 4. | 0.045 | 0.089 | 0.033 | 1 | 0.05 | 0.6 | 1.9 | 3.4 | <1 | 0.09 | 4.0 | 4.5 | <1 | 2.5 | <0.01 | 0.02 |
| S310 | NM538 | Riverside Drain at Rio Bravo | 8/18/1998 | 4. | 0.053 | 0.082 | 0.029 | 2 | <0.05 | 0.8 | 1.8 | 4.9 | <1 | 0.10 | 3.7 | 3.4 | <1 | 2.5 | <0.05 | <0.05 |
| S310 | NM475 | Riverside Drain at Rio Bravo | 7/22/1998 | 4. | 0.054 | 0.077 | 0.024 | 4 | <0.05 | 0.8 | 1.8 | 5.2 | 1. | 0.11 | 3.6 | 3.4 | <1 | 2.5 | <0.05 | <0.05 |
| S310 | NM236 | Riverside Drain at Rio Bravo | 5/21/1997 | 4. | 0.057 | 0.076 | 0.031 | 2 | <0.05 | 0.7 | 1.8 | 3.6 | <1 | 0.10 | 3.2 | 3.1 | <1 | 2.6 | <0.01 | 0.02 |
| S310 | NM192 | Riverside Drain at Rio Bravo | 1/15/1997 | 4. | 0.059 | 0.107 | 0.034 | 26 | <0.05 | 0.4 | 1.9 | 2.9 | <1 | 0.20 | 3.7 | 4.1 | <1 | 2.8 | <0.01 | 0.02 |
| S310 | NM200 | Riverside Drain at Rio Bravo | 2/11/1997 | 4. | 0.061 | 0.104 | 0.034 | 5 | <0.05 | 0.5 | 1.9 | 2.8 | <1 | 0.10 | 3.7 | 4.1 | <1 | 2.9 | <0.01 | 0.04 |
| S310 | NM461 | Riverside Drain at Rio Bravo | 6/11/1998 | 4. | 0.063 | 0.064 | 0.027 | 5 | 0.07 | 0.9 | 1.6 | 3.8 | <1 | 0.11 | 2.9 | 3.0 | <1 | 2.3 | <0.05 | <0.05 |
| S310 | NM224 | Riverside Drain at Rio Bravo | 4/22/1997 | 4. | 0.064 | 0.079 | 0.030 | 5 | <0.05 | 0.8 | 1.8 | 4.4 | <1 | <0.1 | 3.8 | 3.0 | <1 | 2.9 | <0.01 | 0.12 |
| S310 | NM385 | Riverside Drain at Rio Bravo | 10/21/1997 | 5. | 0.050 | 0.067 | 0.024 | 9 | <0.05 | 0.6 | 1.8 | 4.3 | <1 | 0.08 | 3.6 | 3.5 | <1 | 1.9 | <0.01 | 0.01 |
| S310 | NM552 | Riverside Drain at Rio Bravo | 9/22/1998 | 5. | 0.051 | 0.077 | 0.024 | 3 | <0.05 | 1.0 | 2.0 | 4.8 | <1 | 0.06 | 3.7 | 3.4 | <1 | 2.4 | <0.05 | <0.05 |
| S310 | NM432 | Riverside Drain at Rio Bravo | 3/31/1998 | 6. | 0.050 | 0.065 | 0.026 | 2 | 0.06 | 0.8 | 1.7 | 4.1 | <1 | 0.12 | 3.9 | 3.2 | <1 | 3.3 | <0.01 | <0.01 |
| S310 | NM374 | Riverside Drain at Rio Bravo | 9/16/1997 | 6. | 0.050 | 0.079 | 0.026 | 6 | <0.05 | 0.7 | 1.9 | 5.1 | <1 | <0.1 | 4.1 | 3.5 | <1 | 2.4 | <0.01 | 0.03 |
| S310 | NM394 | Riverside Drain at Rio Bravo | 11/20/1997 | 8. | 0.054 | 0.086 | 0.033 | 2 | <0.05 | 0.6 | 2.0 | 3.0 | <1 | 0.11 | 4.3 | 5.0 | <1 | 1.8 | <0.01 | 0.02 |
| S310 | NM403 | Riverside Drain at Rio Bravo | 1/8/1998 | 22. | 0.072 | 0.090 | 0.035 | 4 | <0.05 | 0.4 | 1.8 | 3.4 | <1 | 0.10 | 4.2 | 4.8 | <1 | 1.8 | <0.01 | <0.01 |
| S310 | NM588 | Riverside Drain at Rio Bravo | 1/5/1999 | <1. | 0.052 | 0.089 | 0.036 | 1 | <0.05 | 0.4 | 1.7 | 3.0 | <1 | 0.10 | 3.4 | 4.0 | <1 | 2.2 | <0.05 | <0.05 |
| S310 | NM576 | Riverside Drain at Rio Bravo | 12/1/1998 | <1. | 0.053 | 0.082 | 0.037 | 1 | <0.05 | 0.4 | 1.8 | 3.1 | <1 | 0.09 | 3.6 | 4.4 | <1 | 2.0 | <0.05 | <0.05 |
| S311 | NM243 | Stream in Monte Largo Canyon | 5/28/1997 | 4. | 0.013 | 0.015 | 0.004 | 1 | <0.05 | 1.0 | 0.1 | 0.4 | <1 | <0.1 | 0.8 | 0.2 | <1 | <0.1 | <0.05 | <0.05 |
| S312 | NM590 | Tijeras Arroyo at Four Hills | 1/5/1999 | 1. | 0.003 | 0.106 | 0.026 | 3 | <0.05 | 1.0 | 0.7 | 1.0 | <1 | 0.19 | 1.3 | 0.7 | 3 | 6.4 | <0.01 | <0.05 |
| S312 | NM601 | Tijeras Arroyo at Four Hills | 2/2/1999 | 1. | 0.005 | 0.103 | 0.023 | 3 | <0.05 | 1.2 | 0.8 | 1.2 | <1 | 0.19 | 1.4 | 0.8 | 3 | 6.9 | <0.01 | <0.05 |
| S312 | NM363 | Tijeras Arroyo at Four Hills | 7/9/1997 | 2. | 0.016 | 0.045 | 0.010 | 2 | <0.05 | 0.2 | 0.5 | 1.1 | <1 | <0.1 | 0.6 | 0.5 | 2 | 2.6 | <0.01 | <0.05 |
| S312 | NM614 | Tijeras Arroyo at Four Hills | 3/30/1999 | 2. | <0.02 | 0.109 | 0.021 | 4 | <0.05 | 0.6 | 1.0 | 1.6 | <1 | 0.13 | 1.3 | 0.8 | <1 | 6.8 | <0.01 | <0.05 |
| S312 | NM566 | Tijeras Arroyo at Four Hills | 10/23/1998 | 3. | 0.016 | 0.126 | 0.028 | 5 | <0.05 | 0.7 | 0.9 | 2.0 | 3. | 0.15 | 1.5 | 0.9 | 3 | 5.8 | <0.01 | <0.05 |
| S312 | NM477 | Tijeras Arroyo at Four Hills | 7/23/1998 | 3. | 0.021 | 0.102 | 0.023 | 4 | <0.05 | 1.7 | 1.0 | 1.8 | 2. | 0.16 | 1.4 | 0.9 | 3 | 5.6 | <0.01 | <0.05 |
| S312 | NM554 | Tijeras Arroyo at Four Hills | 9/22/1998 | 3. | <0.005 | 0.114 | 0.029 | 3 | 0.05 | 1.2 | 1.2 | 1.8 | <1 | 0.18 | 1.6 | 1.3 | 3 | 5.8 | <0.01 | <0.05 |
| S312 | NM540 | Tijeras Arroyo at Four Hills | 8/18/1998 | 4. | 0.005 | 0.114 | 0.026 | 2 | 0.14 | 1.7 | 1.2 | 1.9 | <1 | 0.18 | 1.4 | 1.0 | 3 | 5.4 | 0.01 | <0.05 |
| S312 | NM420 | Tijeras Arroyo at Four Hills | 2/20/1998 | 4. | 0.006 | 0.120 | 0.025 | 3 | <0.05 | 0.8 | 0.9 | 1.2 | 2. | 0.15 | 1.3 | 0.6 | 2 | 8.1 | <0.01 | <0.05 |
| S312 | NM434 | Tijeras Arroyo at Four Hills | 3/31/1998 | 4. | 0.011 | 0.127 | 0.023 | 2 | 0.49 | 1.1 | 0.8 | 1.6 | 5. | 0.21 | 1.5 | 0.8 | 3 | 6.2 | 0.02 | <0.05 |
| S312 | NM449 | Tijeras Arroyo at Four Hills | 5/5/1998 | 4. | 0.017 | 0.124 | 0.025 | 4 | 0.05 | 1.0 | 0.9 | 1.3 | 6. | 0.20 | 1.5 | 0.9 | 4 | 6.0 | <0.01 | <0.05 |
| S312 | NM463 | Tijeras Arroyo at Four Hills | 6/11/1998 | 4. | 0.020 | 0.122 | 0.024 | 16 | <0.05 | 1.1 | 1.0 | 1.6 | 4. | 0.20 | 1.2 | 0.9 | 4 | 5.8 | <0.01 | <0.05 |
| S312 | NM238 | Tijeras Arroyo at Four Hills | 5/27/1997 | 4. | 0.055 | 0.119 | 0.026 | 3 | <0.05 | 0.7 | 0.9 | 1.6 | <1 | 0.40 | 1.4 | 0.8 | 3 | 6.6 | <0.01 | <0.05 |
| S312 | NM193 | Tijeras Arroyo at Four Hills | 1/15/1997 | 4. | 0.057 | 0.125 | 0.027 | 7 | <0.05 | 0.8 | 1.1 | 1.6 | <1 | 0.30 | 1.4 | 1.0 | 2 | 8.6 | <0.05 | <0.05 |
| S312 | NM212 | Tijeras Arroyo at Four Hills | 3/19/1997 | 4. | 0.057 | 0.129 | 0.026 | 6 | <0.05 | 0.6 | 0.9 | 1.8 | <1 | 0.10 | 1.4 | 0.9 | 3 | 7.8 | <0.05 | <0.05 |
| S312 | NM226 | Tijeras Arroyo at Four Hills | 4/23/1997 | 4. | 0.061 | 0.128 | 0.027 | 13 | 0.06 | 0.8 | 1.0 | 1.9 | <1 | 0.20 | 1.8 | 0.9 | 3 | 7.0 | <0.01 | <0.05 |
| S312 | NM201 | Tijeras Arroyo at Four Hills | 2/11/1997 | 6. | 0.056 | 0.126 | 0.026 | 7 | <0.05 | 0.7 | 1.0 | 1.7 | <1 | 0.30 | 1.4 | 0.9 | 2 | 8.0 | <0.05 | <0.05 |

**Table B4.** Summary of trace-element chemistry in surface water-- Continued

| Site no. | Sample no. | Site name | Date | Al (µg/L) | B (mg/L) | Ba (mg/L) | Li (mg/L) | Zn (µg/L) | Pb (µg/L) | Cu (µg/L) | Rb (µg/L) | V (µg/L) | Cr (µg/L) | Co (µg/L) | Mo (µg/L) | As (µg/L) | Se (µg/L) | U (µg/L) | Ag (µg/L) | Cd (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S312 | NM387 | Tijeras Arroyo at Four Hills | 10/23/1997 | 12. | 0.110 | 0.222 | 0.051 | 35 | 0.26 | 1.9 | 2.1 | 3.9 | 3. | 0.35 | 3.4 | 1.2 | 4 | 13 | <0.01 | <0.05 |
| S312 | NM376 | Tijeras Arroyo at Four Hills | 9/18/1997 | 13. | 0.125 | 0.225 | 0.054 | 23 | 0.38 | 2.5 | 2.4 | 5.1 | <1 | 0.30 | 3.7 | 1.8 | 4 | 12 | <0.01 | <0.05 |
| S312 | NM405 | Tijeras Arroyo at Four Hills | 1/9/1998 | 58. | 0.055 | 0.115 | 0.024 | 6 | <0.05 | 0.8 | 0.7 | 1.2 | <1 | 0.17 | 1.4 | 0.8 | 3 | 7.1 | <0.01 | <0.05 |
| S312 | NM396 | Tijeras Arroyo at Four Hills | 11/18/1997 | 155. | 0.063 | 0.121 | 0.027 | 4 | 0.09 | 1.0 | 0.9 | 1.3 | <1 | 0.19 | 2.0 | 1.4 | 2 | 6.7 | <0.01 | <0.05 |
| S312 | NM578 | Tijeras Arroyo at Four Hills | 12/1/1998 | <1. | 0.007 | 0.044 | 0.026 | 2 | <0.05 | 0.8 | 0.8 | 1.2 | <1 | 0.22 | 1.4 | 0.9 | 3 | 6.2 | <0.01 | <0.05 |
| S313 | NM577 | West Riverside drain at Rio Bravo | 12/1/1998 | 1. | 0.044 | 0.113 | 0.041 | 2 | <0.05 | 0.5 | 2.4 | 2.7 | <1 | 0.10 | 3.6 | 5.4 | <1 | 2.2 | <0.01 | <0.05 |
| S313 | NM613 | West Riverside drain at Rio Bravo | 3/30/1999 | 1. | 0.045 | 0.077 | 0.032 | 2 | <0.05 | 0.5 | 2.1 | 3.0 | <1 | 0.08 | 4.1 | 4.2 | <1 | 3.4 | nd | nd |
| S313 | NM600 | West Riverside drain at Rio Bravo | 2/2/1999 | 2. | 0.040 | 0.079 | 0.037 | 1 | <0.05 | 0.6 | 2.4 | 2.4 | <1 | 0.07 | 3.8 | 4.9 | <1 | 3.2 | nd | nd |
| S313 | NM589 | West Riverside drain at Rio Bravo | 1/5/1999 | 2. | 0.040 | 0.080 | 0.040 | 1 | <0.05 | 0.4 | 2.2 | 2.3 | <1 | 0.14 | 3.5 | 4.9 | <1 | 2.6 | <0.05 | <0.25 |
| S313 | NM362 | West Riverside drain at Rio Bravo | 7/9/1997 | 3. | 0.053 | 0.060 | 0.032 | 2 | <0.05 | 0.6 | 1.9 | 4.1 | <1 | <0.1 | 4.0 | 4.7 | <1 | 2.3 | <0.01 | <0.05 |
| S313 | NM205 | West Riverside drain at Rio Bravo | 3/18/1997 | 3. | 0.063 | 0.092 | 0.034 | 5 | <0.05 | 0.5 | 2.2 | 3.5 | <1 | 0.20 | 4.6 | 4.0 | <1 | 4.0 | <0.01 | <0.05 |
| S313 | NM419 | West Riverside drain at Rio Bravo | 2/19/1998 | 4. | 0.036 | 0.073 | 0.035 | 2 | 0.05 | 0.6 | 2.2 | 2.9 | <1 | 0.11 | 3.8 | 5.4 | <1 | 3.1 | <0.01 | <0.05 |
| S313 | NM565 | West Riverside drain at Rio Bravo | 10/20/1998 | 4. | 0.057 | 0.089 | 0.034 | 4 | <0.05 | 0.4 | 2.4 | 3.4 | <1 | 0.08 | 3.9 | 5.2 | <1 | 2.1 | <0.01 | <0.05 |
| S313 | NM448 | West Riverside drain at Rio Bravo | 5/5/1998 | 4. | 0.058 | 0.069 | 0.041 | 4 | <0.05 | 0.6 | 1.9 | 3.1 | <1 | 0.10 | 3.7 | 4.5 | <1 | 3.3 | <0.01 | <0.05 |
| S313 | NM237 | West Riverside drain at Rio Bravo | 5/21/1997 | 4. | 0.079 | 0.080 | 0.044 | 1 | <0.05 | 0.6 | 2.0 | 2.8 | <1 | 0.10 | 4.0 | 4.2 | <1 | 3.0 | <0.01 | <0.05 |
| S313 | NM433 | West Riverside drain at Rio Bravo | 3/31/1998 | 5. | 0.046 | 0.068 | 0.032 | <1 | 0.06 | 0.6 | 1.9 | 3.3 | <1 | 0.09 | 3.8 | 4.2 | <1 | 3.2 | <0.01 | <0.05 |
| S313 | NM395 | West Riverside drain at Rio Bravo | 11/20/1997 | 5. | 0.051 | 0.067 | 0.032 | 2 | <0.05 | 0.5 | 2.2 | 3.2 | <1 | 0.08 | 4.2 | 6.2 | <1 | 1.7 | <0.01 | <0.05 |
| S313 | NM476 | West Riverside drain at Rio Bravo | 7/22/1998 | 5. | 0.054 | 0.063 | 0.034 | 3 | <0.05 | 0.6 | 1.8 | 4.4 | <1 | 0.10 | 3.6 | 5.2 | <1 | 2.4 | <0.01 | <0.05 |
| S313 | NM375 | West Riverside drain at Rio Bravo | 9/16/1997 | 5. | 0.058 | 0.072 | 0.033 | 3 | <0.05 | 0.5 | 2.1 | 4.1 | <1 | 0.10 | 4.4 | 5.3 | <1 | 2.0 | <0.01 | <0.05 |
| S313 | NM386 | West Riverside drain at Rio Bravo | 10/21/1997 | 5. | 0.065 | 0.070 | 0.034 | 4 | <0.05 | 0.4 | 2.3 | 3.7 | <1 | 0.10 | 4.5 | 6.1 | <1 | 1.7 | <0.01 | <0.05 |
| S313 | NM225 | West Riverside drain at Rio Bravo | 4/22/1997 | 5. | 0.079 | 0.093 | 0.039 | 9 | <0.05 | 0.5 | 2.2 | 3.8 | <1 | 0.10 | 4.9 | 4.2 | <1 | 3.7 | <0.01 | <0.05 |
| S313 | NM553 | West Riverside drain at Rio Bravo | 9/22/1998 | 6. | 0.045 | 0.088 | 0.035 | 4 | <0.05 | 0.5 | 2.4 | 4.9 | <1 | 0.11 | 4.6 | 5.6 | <1 | 2.8 | <0.01 | <0.05 |
| S313 | NM462 | West Riverside drain at Rio Bravo | 6/11/1998 | 8. | 0.058 | 0.066 | 0.039 | 3 | <0.05 | 0.6 | 1.8 | 3.4 | <1 | 0.08 | 3.4 | 4.4 | <1 | 2.7 | <0.01 | <0.05 |
| S313 | NM539 | West Riverside drain at Rio Bravo | 8/18/1998 | 14. | 0.039 | 0.069 | 0.035 | 2 | <0.05 | 0.6 | 2.0 | 3.6 | <1 | 0.10 | 3.6 | 4.9 | <1 | 2.2 | <0.01 | <0.05 |
| S313 | NM404 | West Riverside drain at Rio Bravo | 1/8/1998 | 18. | 0.071 | 0.074 | 0.034 | 3 | <0.05 | 0.5 | 2.0 | 3.2 | <1 | 0.09 | 4.0 | 5.5 | <1 | 2.1 | <0.01 | <0.05 |
| S314 | NM125 | Rio Grande at Arroyo de la Baranca | 7/1/1996 | 12. | 0.051 | 0.080 | 0.018 | nd | <0.1 | <0.1 | nd | 4.8 | <1 | nd | 3.7 | 2.0 | nd | 1.8 | nd | nd |

**Table B5.** Summary of chlorofluorocarbon concentrations in surface water

[CFC-11, trichlorofluoromethane ($CFCl_3$); CFC-12, dichlorodifluoromethane ($CF_2Cl_2$); CFC-113, trichlorotrifluoroethane ($C_2F_3Cl_3$); pg/kg, picograms per kilogram; °C, degrees Celsius; pptv, parts per trillion by volume; nd, not determined; Modern concentrations of CFC-11, CFC-12, and CFC-113 assumed to be 270, 543, and 84 pptv, respectively]

| Site no. | Sample no. | Site name | Date | Recharge temp-erature (°C) | Recharge altitude (feet) | CFC-11 (pg/kg) | CFC-12 (pg/kg) | CFC-113 (pg/kg) | Calculated atmospheric partial pressure of CFC-11 (pptv) | Calculated atmospheric partial pressure of CFC-12 (pptv) | Calculated atmospheric partial pressure of CFC-113 (pptv) | Percent modern CFC-11 | Percent modern CFC-12 | Percent modern CFC-113 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S290 | NM194 | Abo Arroyo at US 60 | 1/16/1997 | 0.4 | 5,730 | 878 | 504 | 151 | 210 | 561 | 82 | 78 | 103 | 99 |
| S290 | NM202 | Abo Arroyo at US 60 | 3/12/1997 | 7.9 | 5,730 | 766 | 673 | 119 | 292 | 1135 | 107 | 108 | 209 | 129 |
| S291 | NM220 | Alameda Drain at Alameda | 4/22/1997 | 13.4 | 4,995 | 738 | 380 | 87 | 369 | 816 | 107 | 137 | 150 | 129 |
| S291 | NM381 | Alameda Drain at Alameda | 10/21/1997 | 13.8 | 4,995 | 586 | 331 | 76 | 296 | 716 | 93 | 110 | 132 | 112 |
| S291 | NM370 | Alameda Drain at Alameda | 9/16/1997 | 20.8 | 4,995 | 464 | 276 | 53 | 329 | 810 | 95 | 122 | 149 | 114 |
| S291 | NM366 | Alameda Drain at Alameda | 7/9/1997 | 20.8 | 4,995 | 487 | 240 | 50 | 345 | 702 | 89 | 128 | 129 | 108 |
| S292 | NM406 | Bear Canyon Arroyo | 1/9/1998 | 4.3 | 6,640 | 801 | 412 | 115 | 254 | 592 | 84 | 94 | 109 | 101 |
| S292 | NM203 | Bear Canyon Arroyo | 3/19/1997 | 6.6 | 6,640 | 753 | 556 | 98 | 275 | 906 | 85 | 102 | 167 | 102 |
| S292 | NM421 | Bear Canyon Arroyo | 2/20/1998 | 6.9 | 6,640 | 565 | 270 | 82 | 210 | 448 | 72 | 78 | 83 | 86 |
| S292 | NM216 | Bear Canyon Arroyo | 4/23/1997 | 9.0 | 6,640 | 660 | 376 | 105 | 276 | 694 | 105 | 102 | 128 | 126 |
| S292 | NM229 | Bear Canyon Arroyo | 5/28/1997 | 9.0 | 6,640 | 674 | 502 | 91 | 283 | 926 | 91 | 105 | 171 | 110 |
| S292 | NM397 | Bear Canyon Arroyo | 11/18/1997 | 9.9 | 6,640 | 545 | 291 | 88 | 237 | 555 | 91 | 88 | 102 | 110 |
| S292 | NM388 | Bear Canyon Arroyo | 10/23/1997 | 11.9 | 6,640 | 566 | 342 | 68 | 278 | 727 | 80 | 103 | 134 | 96 |
| S292 | NM354 | Bear Canyon Arroyo | 7/9/1997 | 14.9 | 6,640 | 477 | 233 | 65 | 271 | 564 | 90 | 101 | 104 | 108 |
| S292 | NM377 | Bear Canyon Arroyo | 9/18/1997 | 15.0 | 6,640 | 445 | 300 | 70 | 255 | 731 | 97 | 94 | 135 | 117 |
| S293 | NM244 | Canyon del Trigo Stream | 5/29/1997 | 12.5 | 6,250 | 554 | 287 | 78 | 277 | 619 | 95 | 103 | 114 | 114 |
| S294 | NM204 | Chamizal Lateral at Alameda | 3/18/1997 | 10.0 | 4,995 | 639 | 406 | 89 | 266 | 741 | 89 | 99 | 137 | 108 |
| S294 | NM217 | Chamizal Lateral at Alameda | 4/22/1997 | 13.4 | 4,995 | 604 | 383 | 82 | 302 | 821 | 100 | 112 | 151 | 121 |
| S294 | NM380 | Chamizal Lateral at Alameda | 10/21/1997 | 13.7 | 4,995 | 601 | 321 | 72 | 302 | 691 | 88 | 112 | 127 | 106 |
| S294 | NM230 | Chamizal Lateral at Alameda | 5/21/1997 | 15.7 | 4,995 | 504 | 247 | 65 | 283 | 588 | 91 | 105 | 108 | 109 |
| S294 | NM355 | Chamizal Lateral at Alameda | 7/9/1997 | 19.8 | 4,995 | 433 | 221 | 50 | 293 | 622 | 84 | 109 | 115 | 101 |
| S294 | NM369 | Chamizal Lateral at Alameda | 9/16/1997 | 20.5 | 4,995 | 432 | 298 | 61 | 302 | 863 | 106 | 112 | 159 | 128 |
| S300 | NM187 | Rio Grande at Alameda | 1/14/1997 | 0.7 | 4,995 | 931 | 518 | 158 | 221 | 571 | 85 | 82 | 105 | 103 |
| S300 | NM398 | Rio Grande at Alameda | 1/8/1998 | 3.2 | 4,995 | 994 | 556 | 140 | 277 | 707 | 89 | 102 | 130 | 108 |
| S300 | NM413 | Rio Grande at Alameda | 2/19/1998 | 5.7 | 4,995 | 609 | 295 | 85 | 197 | 428 | 64 | 73 | 79 | 77 |
| S300 | NM389 | Rio Grande at Alameda | 11/20/1997 | 7.0 | 4,995 | 948 | 455 | 102 | 332 | 710 | 84 | 123 | 131 | 101 |
| S300 | NM195 | Rio Grande at Alameda | 2/11/1997 | 7.0 | 4,995 | 1179 | 632 | 118 | 415 | 990 | 98 | 154 | 182 | 118 |
| S300 | NM206 | Rio Grande at Alameda | 3/18/1997 | 8.6 | 4,995 | 728 | 664 | 103 | 281 | 1129 | 95 | 104 | 208 | 114 |
| S300 | NM218 | Rio Grande at Alameda | 4/22/1997 | 12.0 | 4,995 | 626 | 450 | 78 | 291 | 906 | 88 | 108 | 167 | 106 |
| S300 | NM378 | Rio Grande at Alameda | 10/21/1997 | 12.5 | 4,995 | 604 | 373 | 71 | 285 | 760 | 81 | 106 | 140 | 98 |
| S300 | NM231 | Rio Grande at Alameda | 5/21/1997 | 15.5 | 4,995 | 699 | 294 | 80 | 389 | 695 | 111 | 144 | 128 | 134 |
| S300 | NM118 | Rio Grande at Alameda | 6/29/1996 | 19.9 | 4,995 | 62 | 187 | nd | 33 | 531 | nd | 12 | 98 | nd |
| S300 | NM367 | Rio Grande at Alameda | 9/16/1997 | 19.9 | 4,995 | 457 | 334 | 58 | 311 | 943 | 98 | 115 | 174 | 119 |
| S300 | NM356 | Rio Grande at Alameda | 7/9/1997 | 20.7 | 4,995 | 444 | 249 | 52 | 313 | 728 | 91 | 116 | 134 | 110 |
| S300 | NM123 | Rio Grande at Alameda | 6/22/1996 | 26.6 | 4,995 | 415 | 206 | 130 | 378 | 757 | 314 | 140 | 139 | 379 |
| S301 | NM189 | Rio Grande at Campbell | 1/14/1997 | 0.4 | 4,960 | 957 | 516 | 163 | 222 | 559 | 86 | 82 | 103 | 104 |
| S301 | NM400 | Rio Grande at Campbell | 1/8/1998 | 2.5 | 4,960 | 1071 | 524 | 147 | 285 | 640 | 89 | 106 | 118 | 107 |
| S301 | NM197 | Rio Grande at Campbell | 2/11/1997 | 4.8 | 4,960 | 965 | 779 | 149 | 297 | 1084 | 107 | 110 | 200 | 129 |

**Table B5.** Summary of chlorofluorocarbon concentrations in surface water-- Continued

| Site no. | Sample no. | Site name | Date | Recharge temp-erature (°C) | Recharge altitude (feet) | CFC-11 (pg/kg) | CFC-12 (pg/kg) | CFC-113 (pg/kg) | Calculated atmospheric partial pressure of CFC-11 (pptv) | Calculated atmospheric partial pressure of CFC-12 (pptv) | Calculated atmospheric partial pressure of CFC-113 (pptv) | Percent modern CFC-11 | Percent modern CFC-12 | Percent modern CFC-113 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S301 | NM415 | Rio Grande at Campbell | 2/19/1998 | 6.2 | 4,960 | 627 | 301 | 95 | 209 | 450 | 74 | 77 | 83 | 89 |
| S301 | NM391 | Rio Grande at Campbell | 11/20/1997 | 7.2 | 4,960 | 858 | 466 | 119 | 304 | 735 | 98 | 113 | 135 | 118 |
| S301 | NM208 | Rio Grande at Campbell | 3/18/1997 | 11.0 | 4,960 | 655 | 389 | 104 | 288 | 744 | 110 | 107 | 137 | 133 |
| S301 | NM382 | Rio Grande at Campbell | 10/21/1997 | 13.8 | 4,960 | 555 | 289 | 74 | 281 | 626 | 90 | 104 | 115 | 109 |
| S301 | NM221 | Rio Grande at Campbell | 4/22/1997 | 15.3 | 4,960 | 551 | 299 | 75 | 303 | 699 | 103 | 112 | 129 | 124 |
| S301 | NM233 | Rio Grande at Campbell | 5/21/1997 | 15.8 | 4,960 | 506 | 243 | 65 | 285 | 582 | 92 | 106 | 107 | 110 |
| S301 | NM371 | Rio Grande at Campbell | 9/16/1997 | 22.3 | 4,960 | 396 | 221 | 55 | 300 | 685 | 105 | 111 | 126 | 126 |
| S301 | NM358 | Rio Grande at Campbell | 7/9/1997 | 23.0 | 4,960 | 388 | 192 | 47 | 302 | 610 | 94 | 112 | 112 | 113 |
| S302 | NM124 | Rio Grande at Isleta Below Diversion | 6/22/1996 | 26.3 | 4,905 | 328 | 1089 | 82 | 294 | 3939 | 194 | 109 | 725 | 233 |
| S303 | NM191 | Rio Grande at Rio Bravo | 1/15/1997 | 0.3 | 4,927 | 1032 | 1684 | 164 | 238 | 1810 | 86 | 88 | 333 | 103 |
| S303 | NM402 | Rio Grande at Rio Bravo | 1/8/1998 | 4.5 | 4,927 | 1070 | 484 | 149 | 323 | 662 | 104 | 120 | 122 | 125 |
| S303 | NM199 | Rio Grande at Rio Bravo | 2/11/1997 | 8.1 | 4,927 | 850 | 433 | 123 | 317 | 717 | 109 | 118 | 132 | 132 |
| S303 | NM393 | Rio Grande at Rio Bravo | 11/20/1997 | 8.5 | 4,927 | 960 | 449 | 117 | 367 | 757 | 105 | 136 | 139 | 127 |
| S303 | NM417 | Rio Grande at Rio Bravo | 2/19/1998 | 8.7 | 4,927 | 582 | 276 | 86 | 224 | 469 | 78 | 83 | 86 | 94 |
| S303 | NM210 | Rio Grande at Rio Bravo | 3/18/1997 | 13.2 | 4,927 | 600 | 296 | 91 | 296 | 628 | 110 | 110 | 116 | 132 |
| S303 | NM384 | Rio Grande at Rio Bravo | 10/21/1997 | 15.1 | 4,927 | 527 | 273 | 71 | 285 | 626 | 94 | 105 | 115 | 113 |
| S303 | NM235 | Rio Grande at Rio Bravo | 5/21/1997 | 16.4 | 4,927 | 487 | 233 | 76 | 282 | 572 | 111 | 105 | 105 | 134 |
| S303 | NM223 | Rio Grande at Rio Bravo | 4/22/1997 | 17.0 | 4,927 | 528 | 267 | 72 | 315 | 671 | 109 | 117 | 124 | 131 |
| S303 | NM121 | Rio Grande at Rio Bravo | 6/29/1996 | 21.5 | 4,927 | 131 | 193 | 99 | 96 | 583 | 186 | 36 | 107 | 224 |
| S303 | NM373 | Rio Grande at Rio Bravo | 9/16/1997 | 24.1 | 4,927 | 372 | 199 | 50 | 304 | 664 | 105 | 113 | 122 | 127 |
| S303 | NM360 | Rio Grande at Rio Bravo | 7/9/1997 | 25.8 | 4,927 | 365 | 189 | 43 | 319 | 667 | 96 | 118 | 123 | 116 |
| S304 | NM122 | Rio Grande at San Felipe | 6/22/1996 | 18.1 | 5,116 | 426 | 204 | nd | 270 | 541 | nd | 100 | 100 | nd |
| S305 | NM120 | Rio Grande at Central | 6/29/1996 | 20.6 | 4,946 | 49 | 177 | nd | 35 | 516 | nd | 13 | 95 | nd |
| S306 | NM119 | Rio Grande at Nature Center | 6/29/1996 | 20.3 | 4,960 | 45 | 184 | 100 | 31 | 532 | 177 | 12 | 98 | 213 |
| S308 | NM196 | Riverside Drain at Alameda | 2/11/1997 | 4.1 | 4,995 | 774 | 966 | 116 | 228 | 1295 | 79 | 85 | 238 | 96 |
| S308 | NM188 | Riverside Drain at Alameda | 1/14/1997 | 8.3 | 4,995 | 602 | 344 | 94 | 228 | 576 | 84 | 85 | 106 | 102 |
| S308 | NM414 | Riverside Drain at Alameda | 2/19/1998 | 8.5 | 4,995 | 533 | 263 | 77 | 203 | 443 | 69 | 75 | 82 | 83 |
| S308 | NM399 | Riverside Drain at Alameda | 1/8/1998 | 8.7 | 4,995 | 633 | 403 | 94 | 245 | 688 | 86 | 91 | 127 | 104 |
| S308 | NM207 | Riverside Drain at Alameda | 3/18/1997 | 9.2 | 4,995 | 692 | 608 | 93 | 276 | 1066 | 89 | 102 | 196 | 107 |
| S308 | NM219 | Riverside Drain at Alameda | 4/22/1997 | 12.2 | 4,995 | 1279 | 598 | 81 | 600 | 1214 | 93 | 222 | 224 | 112 |
| S308 | NM390 | Riverside Drain at Alameda | 11/20/1997 | 12.9 | 4,995 | 588 | 328 | 61 | 285 | 686 | 72 | 106 | 126 | 86 |
| S308 | NM232 | Riverside Drain at Alameda | 5/21/1997 | 14.7 | 4,995 | 537 | 267 | 63 | 287 | 608 | 83 | 106 | 112 | 100 |
| S308 | NM379 | Riverside Drain at Alameda | 10/21/1997 | 14.8 | 4,995 | 503 | 301 | 58 | 268 | 682 | 75 | 99 | 126 | 91 |
| S308 | NM357 | Riverside Drain at Alameda | 7/9/1997 | 18.8 | 4,995 | 453 | 247 | 50 | 293 | 666 | 80 | 109 | 123 | 96 |
| S308 | NM368 | Riverside Drain at Alameda | 9/16/1997 | 20.2 | 4,995 | 386 | 284 | 52 | 267 | 813 | 89 | 99 | 150 | 108 |
| S309 | NM198 | Riverside Drain at Campbell | 2/11/1997 | 4.8 | 4,960 | 674 | 446 | 95 | 207 | 621 | 68 | 77 | 114 | 82 |
| S309 | NM190 | Riverside Drain at Campbell | 1/14/1997 | 7.9 | 4,960 | 605 | 341 | 94 | 224 | 559 | 82 | 83 | 103 | 99 |
| S309 | NM416 | Riverside Drain at Campbell | 2/19/1998 | 9.0 | 4,960 | 564 | 275 | 81 | 221 | 474 | 75 | 82 | 87 | 91 |
| S309 | NM401 | Riverside Drain at Campbell | 1/8/1998 | 9.5 | 4,960 | 645 | 375 | 93 | 261 | 666 | 89 | 97 | 123 | 107 |
| S309 | NM209 | Riverside Drain at Campbell | 3/18/1997 | 10.6 | 4,960 | 663 | 395 | 105 | 285 | 741 | 109 | 106 | 136 | 132 |
| S309 | NM222 | Riverside Drain at Campbell | 4/22/1997 | 13.4 | 4,960 | 764 | 298 | 78 | 381 | 638 | 95 | 141 | 118 | 115 |
| S309 | NM392 | Riverside Drain at Campbell | 11/20/1997 | 14.0 | 4,960 | 521 | 297 | 66 | 268 | 652 | 82 | 99 | 120 | 99 |

**Table B5.** Summary of chlorofluorocarbon concentrations in surface water-- Continued

| Site no. | Sample no. | Site name | Date | Recharge temp-erature (°C) | Recharge altitude (feet) | CFC-11 (pg/kg) | CFC-12 (pg/kg) | CFC-113 (pg/kg) | Calculated atmospheric partial pressure of CFC-11 (pptv) | Calculated atmospheric partial pressure of CFC-12 (pptv) | Calculated atmospheric partial pressure of CFC-113 (pptv) | Percent modern CFC-11 | Percent modern CFC-12 | Percent modern CFC-113 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S309 | NM234 | Riverside Drain at Campbell | 5/21/1997 | 15.0 | 4,960 | 517 | 255 | 67 | 280 | 588 | 89 | 104 | 108 | 108 |
| S309 | NM383 | Riverside Drain at Campbell | 10/21/1997 | 16.2 | 4,960 | 464 | 247 | 54 | 265 | 595 | 75 | 98 | 110 | 90 |
| S309 | NM359 | Riverside Drain at Campbell | 7/9/1997 | 19.5 | 4,960 | 393 | 207 | 48 | 263 | 575 | 80 | 97 | 106 | 97 |
| S309 | NM372 | Riverside Drain at Campbell | 9/16/1997 | 22.4 | 4,960 | 360 | 211 | 43 | 274 | 660 | 83 | 101 | 122 | 100 |
| S310 | NM192 | Riverside Drain at Rio Bravo | 1/15/1997 | 7.7 | 4,927 | 653 | 1770 | 94 | 238 | 2868 | 81 | 88 | 528 | 98 |
| S310 | NM403 | Riverside Drain at Rio Bravo | 1/8/1998 | 11.3 | 4,927 | 626 | 367 | 84 | 280 | 712 | 89 | 104 | 131 | 108 |
| S310 | NM200 | Riverside Drain at Rio Bravo | 2/11/1997 | 12.4 | 4,927 | 570 | 337 | 73 | 270 | 689 | 85 | 100 | 127 | 102 |
| S310 | NM211 | Riverside Drain at Rio Bravo | 3/18/1997 | 12.9 | 4,927 | 639 | 337 | 97 | 311 | 705 | 115 | 115 | 130 | 139 |
| S310 | NM418 | Riverside Drain at Rio Bravo | 2/19/1998 | 13.0 | 4,927 | 462 | 234 | 55 | 225 | 491 | 64 | 83 | 90 | 77 |
| S310 | NM394 | Riverside Drain at Rio Bravo | 11/20/1997 | 14.2 | 4,927 | 612 | 359 | 65 | 318 | 796 | 81 | 118 | 147 | 98 |
| S310 | NM224 | Riverside Drain at Rio Bravo | 4/22/1997 | 15.4 | 4,927 | 622 | 302 | 74 | 344 | 708 | 102 | 127 | 130 | 123 |
| S310 | NM236 | Riverside Drain at Rio Bravo | 5/21/1997 | 16.1 | 4,927 | 497 | 244 | 62 | 284 | 589 | 89 | 105 | 109 | 107 |
| S310 | NM385 | Riverside Drain at Rio Bravo | 10/21/1997 | 16.1 | 4,927 | 524 | 184 | 66 | 297 | 442 | 91 | 110 | 81 | 110 |
| S310 | NM374 | Riverside Drain at Rio Bravo | 9/16/1997 | 21.4 | 4,927 | 396 | 232 | 49 | 289 | 697 | 90 | 107 | 128 | 108 |
| S310 | NM361 | Riverside Drain at Rio Bravo | 7/9/1997 | 25.8 | 4,927 | 431 | 221 | 45 | 377 | 782 | 101 | 140 | 144 | 121 |
| S311 | NM243 | Stream in Monte Largo Canyon | 5/28/1997 | 19.4 | 6,250 | 414 | 206 | 54 | 291 | 601 | 97 | 108 | 111 | 116 |
| S312 | NM405 | Tijeras Arroyo at Four Hills | 1/9/1998 | 3.1 | 5,550 | 1051 | 533 | 162 | 297 | 689 | 105 | 110 | 127 | 126 |
| S312 | NM396 | Tijeras Arroyo at Four Hills | 11/18/1997 | 5.3 | 5,550 | 829 | 446 | 117 | 265 | 643 | 87 | 98 | 118 | 104 |
| S312 | NM193 | Tijeras Arroyo at Four Hills | 1/15/1997 | 5.4 | 5,550 | 762 | 420 | 114 | 249 | 617 | 87 | 92 | 114 | 104 |
| S312 | NM212 | Tijeras Arroyo at Four Hills | 3/19/1997 | 5.5 | 5,550 | 1003 | 1138 | 135 | 329 | 1681 | 103 | 122 | 310 | 124 |
| S312 | NM420 | Tijeras Arroyo at Four Hills | 2/20/1998 | 9.3 | 5,550 | 651 | 251 | 77 | 266 | 451 | 75 | 99 | 83 | 90 |
| S312 | NM226 | Tijeras Arroyo at Four Hills | 4/23/1997 | 9.4 | 5,550 | 737 | 434 | 104 | 303 | 784 | 102 | 112 | 144 | 123 |
| S312 | NM238 | Tijeras Arroyo at Four Hills | 5/27/1997 | 11.2 | 5,550 | 606 | 542 | 84 | 275 | 1070 | 93 | 102 | 197 | 111 |
| S312 | NM387 | Tijeras Arroyo at Four Hills | 10/23/1997 | 11.5 | 5,550 | 756 | 411 | 81 | 350 | 825 | 90 | 129 | 152 | 108 |
| S312 | NM201 | Tijeras Arroyo at Four Hills | 2/11/1997 | 11.8 | 5,550 | 588 | 299 | 83 | 276 | 607 | 95 | 102 | 112 | 114 |
| S312 | NM376 | Tijeras Arroyo at Four Hills | 9/18/1997 | 18.0 | 5,550 | 541 | 446 | 63 | 345 | 1191 | 100 | 128 | 219 | 120 |
| S312 | NM363 | Tijeras Arroyo at Four Hills | 7/9/1997 | 27.4 | 5,550 | 299 | 141 | 35 | 285 | 540 | 86 | 106 | 99 | 103 |
| S313 | NM404 | West Riverside drain at Rio Bravo | 1/8/1998 | 13.7 | 4,927 | 512 | 313 | 69 | 260 | 680 | 84 | 96 | 125 | 102 |
| S313 | NM237 | West Riverside drain at Rio Bravo | 5/21/1997 | 14.8 | 4,927 | 467 | 265 | 59 | 250 | 605 | 79 | 93 | 111 | 95 |
| S313 | NM419 | West Riverside drain at Rio Bravo | 2/19/1998 | 15.2 | 4,927 | 397 | 247 | 60 | 216 | 572 | 80 | 80 | 105 | 96 |
| S313 | NM205 | West Riverside drain at Rio Bravo | 3/18/1997 | 16.2 | 4,927 | 504 | 288 | 76 | 290 | 700 | 110 | 107 | 129 | 132 |
| S313 | NM225 | West Riverside drain at Rio Bravo | 4/22/1997 | 17.6 | 4,927 | 495 | 260 | 56 | 304 | 670 | 87 | 113 | 123 | 104 |
| S313 | NM395 | West Riverside drain at Rio Bravo | 11/20/1997 | 17.7 | 4,927 | 493 | 272 | 51 | 304 | 705 | 77 | 113 | 130 | 93 |
| S313 | NM386 | West Riverside drain at Rio Bravo | 10/21/1997 | 20.5 | 4,927 | 351 | 198 | 34 | 245 | 572 | 59 | 91 | 105 | 71 |
| S313 | NM362 | West Riverside drain at Rio Bravo | 7/9/1997 | 21.2 | 4,927 | 400 | 236 | 41 | 288 | 702 | 74 | 107 | 129 | 89 |
| S313 | NM375 | West Riverside drain at Rio Bravo | 9/16/1997 | 23.0 | 4,927 | 308 | 193 | 35 | 240 | 616 | 70 | 89 | 113 | 84 |
| S314 | NM125 | Rio Grande at Arroyo de la Baranca | 7/1/1996 | 26.9 | 5,030 | 123 | 168 | 38 | 114 | 624 | 93 | 42 | 115 | 112 |

**Table B6.** Summary of hydrogen-2 and oxygen-18 isotopic composition of water, sulfur-34 of dissolved sulfate, and carbon-13 and carbon-14 of dissolved inorganic carbon in surface water

[$\delta^2H$, hydrogen-2; $\delta^{18}O$, oxygen-18; $\delta^{34}S$, sulfur-34; $\delta=((R_{sample}/R_{standard})-1)x1000$, where R is an isotope ratio; per mil, parts per thousand; pmC, percent modern carbon]

| Site no. | Sample no. | Site name | Date | $\delta^2H$ (per mil) | $\delta^{18}O$ (per mil) | $\delta^{34}S$ (per mil) | $\delta^{13}C$ (per mil) | $^{14}C$ (pmC) |
|---|---|---|---|---|---|---|---|---|
| S300 | NM118 | Rio Grande at Alameda | 6/29/1996 | -63.9 | -8.75 | | | |
| S306 | NM119 | Rio Grande at Nature Center | 6/29/1996 | -64.3 | -8.90 | | | |
| S305 | NM120 | Rio Grande at Central | 6/29/1996 | -65.5 | -9.04 | | | |
| S303 | NM121 | Rio Grande at Rio Bravo | 6/29/1996 | -79.0 | -10.6 | | | |
| S304 | NM122 | Rio Grande at San Felipe | 6/22/1996 | -90.0 | -11.7 | | - 8.3 | 96.05 |
| S300 | NM123 | Rio Grande at Alameda | 6/22/1996 | -88.7 | -11.4 | | - 10.3 | 97.13 |
| S302 | NM124 | Rio Grande at Isleta Below Diversion | 6/22/1996 | -88.8 | -11.2 | | | |
| S314 | NM125 | Rio Grande at Arroyo de la Baranca | 7/1/1996 | -86.1 | -11.2 | | | |
| S300 | NM187 | Rio Grande at Alameda | 1/14/1997 | -91.6 | -12.2 | -1.61 | | |
| S308 | NM188 | Riverside Drain at Alameda | 1/14/1997 | -89.8 | -11.7 | | | |
| S301 | NM189 | Rio Grande at Campbell | 1/14/1997 | -92.7 | -12.3 | | | |
| S309 | NM190 | Riverside Drain at Campbell | 1/14/1997 | -89.9 | -11.6 | | | |
| S303 | NM191 | Rio Grande at Rio Bravo | 1/15/1997 | -91.4 | -12.1 | | | |
| S310 | NM192 | Riverside Drain at Rio Bravo | 1/15/1997 | -87.9 | -11.4 | | | |
| S312 | NM193 | Tijeras Arroyo at Four Hills | 1/15/1997 | -69.9 | -9.65 | | | |
| S290 | NM194 | Abo Arroyo at US 60 | 1/16/1997 | -63.1 | -8.97 | | | |
| S300 | NM195 | Rio Grande at Alameda | 2/11/1997 | -94.1 | -12.5 | -1.23 | | |
| S308 | NM196 | Riverside Drain at Alameda | 2/11/1997 | -90.9 | -11.9 | | | |
| S301 | NM197 | Rio Grande at Campbell | 2/11/1997 | -93.4 | -12.5 | | | |
| S309 | NM198 | Riverside Drain at Campbell | 2/11/1997 | -90.6 | -12.0 | | | |
| S303 | NM199 | Rio Grande at Rio Bravo | 2/11/1997 | -92.9 | -12.5 | | | |
| S310 | NM200 | Riverside Drain at Rio Bravo | 2/11/1997 | -87.7 | -11.5 | | | |
| S312 | NM201 | Tijeras Arroyo at Four Hills | 2/11/1997 | -72.2 | -10.0 | | | |
| S290 | NM202 | Abo Arroyo at US 60 | 3/12/1997 | -55.3 | -7.60 | | | |
| S292 | NM203 | Bear Canyon Arroyo | 3/19/1997 | -84.9 | -11.7 | | | |
| S294 | NM204 | Chamizal Lateral at Alameda | 3/18/1997 | -92.7 | -12.5 | | | |
| S313 | NM205 | West Riverside drain at Rio Bravo | 3/18/1997 | -91.7 | -12.1 | | | |
| S300 | NM206 | Rio Grande at Alameda | 3/18/1997 | -92.4 | -12.2 | 1.29 | | |
| S308 | NM207 | Riverside Drain at Alameda | 3/18/1997 | -93.5 | -12.5 | | | |
| S301 | NM208 | Rio Grande at Campbell | 3/18/1997 | -91.5 | -12.1 | | | |
| S309 | NM209 | Riverside Drain at Campbell | 3/18/1997 | -93.4 | -12.5 | | | |
| S303 | NM210 | Rio Grande at Rio Bravo | 3/18/1997 | -91.6 | -12.1 | | | |
| S310 | NM211 | Riverside Drain at Rio Bravo | 3/18/1997 | -92.4 | -12.3 | | | |
| S312 | NM212 | Tijeras Arroyo at Four Hills | 3/19/1997 | -72.2 | -10.0 | | | |
| S292 | NM216 | Bear Canyon Arroyo | 4/23/1997 | -82.8 | -11.8 | | | |
| S294 | NM217 | Chamizal Lateral at Alameda | 4/22/1997 | -93.8 | -12.5 | | | |
| S300 | NM218 | Rio Grande at Alameda | 4/22/1997 | -92.5 | -12.2 | -0.40 | | |
| S308 | NM219 | Riverside Drain at Alameda | 4/22/1997 | -93.5 | -12.4 | | | |
| S291 | NM220 | Alameda Drain at Alameda | 4/22/1997 | -94.4 | -12.4 | | | |
| S301 | NM221 | Rio Grande at Campbell | 4/22/1997 | -91.2 | -12.2 | | | |
| S309 | NM222 | Riverside Drain at Campbell | 4/22/1997 | -93.1 | -12.4 | | | |
| S303 | NM223 | Rio Grande at Rio Bravo | 4/22/1997 | -90.2 | -12.1 | | | |
| S310 | NM224 | Riverside Drain at Rio Bravo | 4/22/1997 | -92.3 | -12.4 | | | |
| S313 | NM225 | West Riverside drain at Rio Bravo | 4/22/1997 | -91.3 | -12.2 | | | |
| S312 | NM226 | Tijeras Arroyo at Four Hills | 4/23/1997 | -72.4 | -10.2 | | | |
| S292 | NM229 | Bear Canyon Arroyo | 5/28/1997 | -84.1 | -12.0 | | | |
| S294 | NM230 | Chamizal Lateral at Alameda | 5/21/1997 | -94.5 | -12.5 | | | |
| S300 | NM231 | Rio Grande at Alameda | 5/21/1997 | -93.9 | -12.5 | -5.33 | | |

**Table B6.** Summary of hydrogen-2 and oxygen-18 isotopic composition of water, sulfur-34 of dissolved sulfate, and carbon-13 and carbon-14 of dissolved inorganic carbon in surface water-- Continued

| Site no. | Sample no. | Site name | Date | $\delta^2H$ (per mil) | $\delta^{18}O$ (per mil) | $\delta^{34}S$ (per mil) | $\delta^{13}C$ (per mil) | $^{14}C$ (pmC) |
|---|---|---|---|---|---|---|---|---|
| S308 | NM232 | Riverside Drain at Alameda | 5/21/1997 | -94.7 | -12.5 | | | |
| S301 | NM233 | Rio Grande at Campbell | 5/21/1997 | -93.8 | -12.5 | | | |
| S309 | NM234 | Riverside Drain at Campbell | 5/21/1997 | -93.6 | -12.4 | | | |
| S303 | NM235 | Rio Grande at Rio Bravo | 5/21/1997 | -95.1 | -12.5 | | | |
| S310 | NM236 | Riverside Drain at Rio Bravo | 5/21/1997 | -92.0 | -12.3 | | | |
| S313 | NM237 | West Riverside drain at Rio Bravo | 5/21/1997 | -91.0 | -12.1 | | | |
| S312 | NM238 | Tijeras Arroyo at Four Hills | 5/27/1997 | -76.8 | -10.5 | | | |
| S311 | NM243 | Stream in Monte Largo Canyon | 5/28/1997 | -74.9 | -10.9 | | | |
| S293 | NM244 | Canyon del Trigo Stream | 5/29/1997 | -73.7 | -10.8 | | | |
| S292 | NM354 | Bear Canyon Arroyo | 7/9/1997 | -83.5 | -11.9 | | | |
| S294 | NM355 | Chamizal Lateral at Alameda | 7/9/1997 | -94.1 | -12.7 | | | |
| S300 | NM356 | Rio Grande at Alameda | 7/9/1997 | -94.7 | -12.7 | -2.68 | | |
| S308 | NM357 | Riverside Drain at Alameda | 7/9/1997 | -93.0 | -12.6 | | | |
| S301 | NM358 | Rio Grande at Campbell | 7/9/1997 | -92.8 | -12.7 | | | |
| S309 | NM359 | Riverside Drain at Campbell | 7/9/1997 | -93.2 | -12.7 | | | |
| S303 | NM360 | Rio Grande at Rio Bravo | 7/9/1997 | -94.7 | -12.6 | | | |
| S310 | NM361 | Riverside Drain at Rio Bravo | 7/9/1997 | -95.0 | -12.6 | | | |
| S313 | NM362 | West Riverside drain at Rio Bravo | 7/9/1997 | -94.4 | -12.6 | | | |
| S312 | NM363 | Tijeras Arroyo at Four Hills | 7/9/1997 | -75.0 | -10.4 | | | |
| S291 | NM366 | Alameda Drain at Alameda | 7/9/1997 | -94.7 | -12.6 | | | |
| S300 | NM367 | Rio Grande at Alameda | 9/16/1997 | -85.8 | -11.7 | -4.00 | | |
| S308 | NM368 | Riverside Drain at Alameda | 9/16/1997 | -90.3 | -12.1 | | | |
| S294 | NM369 | Chamizal Lateral at Alameda | 9/16/1997 | -90.6 | -12.1 | | | |
| S291 | NM370 | Alameda Drain at Alameda | 9/16/1997 | -90.1 | -12.1 | | | |
| S301 | NM371 | Rio Grande at Campbell | 9/16/1997 | -88.3 | -11.7 | | | |
| S309 | NM372 | Riverside Drain at Campbell | 9/16/1997 | -89.2 | -12.0 | | | |
| S303 | NM373 | Rio Grande at Rio Bravo | 9/16/1997 | -87.7 | -11.7 | | | |
| S310 | NM374 | Riverside Drain at Rio Bravo | 9/16/1997 | -88.2 | -12.0 | | | |
| S313 | NM375 | West Riverside drain at Rio Bravo | 9/16/1997 | -90.4 | -12.0 | | | |
| S312 | NM376 | Tijeras Arroyo at Four Hills | 9/18/1997 | -73.1 | -9.95 | | | |
| S292 | NM377 | Bear Canyon Arroyo | 9/18/1997 | -82.3 | -11.8 | | | |
| S300 | NM378 | Rio Grande at Alameda | 10/21/1997 | -89.8 | -12.2 | -4.52 | | |
| S308 | NM379 | Riverside Drain at Alameda | 10/21/1997 | -87.7 | -12.1 | | | |
| S294 | NM380 | Chamizal Lateral at Alameda | 10/21/1997 | -89.3 | -12.1 | | | |
| S291 | NM381 | Alameda Drain at Alameda | 10/21/1997 | -90.5 | -12.1 | | | |
| S301 | NM382 | Rio Grande at Campbell | 10/21/1997 | -90.6 | -12.2 | | | |
| S309 | NM383 | Riverside Drain at Campbell | 10/21/1997 | -87.6 | -12.1 | | | |
| S303 | NM384 | Rio Grande at Rio Bravo | 10/21/1997 | -89.5 | -12.1 | | | |
| S310 | NM385 | Riverside Drain at Rio Bravo | 10/21/1997 | -90.8 | -12.0 | | | |
| S313 | NM386 | West Riverside drain at Rio Bravo | 10/21/1997 | -89.9 | -11.9 | | | |
| S312 | NM387 | Tijeras Arroyo at Four Hills | 10/23/1997 | -72.2 | -10.1 | | | |
| S292 | NM388 | Bear Canyon Arroyo | 10/23/1997 | -82.2 | -11.7 | | | |
| S300 | NM389 | Rio Grande at Alameda | 11/20/1997 | -92.4 | -12.7 | -1.12 | | |
| S308 | NM390 | Riverside Drain at Alameda | 11/20/1997 | -90.3 | -12.3 | | | |
| S301 | NM391 | Rio Grande at Campbell | 11/20/1997 | -94.5 | -12.7 | | | |
| S309 | NM392 | Riverside Drain at Campbell | 11/20/1997 | -89.2 | -12.2 | | | |
| S303 | NM393 | Rio Grande at Rio Bravo | 11/20/1997 | -93.7 | -12.6 | | | |
| S310 | NM394 | Riverside Drain at Rio Bravo | 11/20/1997 | -88.5 | -11.9 | | | |
| S313 | NM395 | West Riverside drain at Rio Bravo | 11/20/1997 | -90.0 | -12.1 | | | |
| S312 | NM396 | Tijeras Arroyo at Four Hills | 11/18/1997 | -75.1 | -10.4 | | | |
| S292 | NM397 | Bear Canyon Arroyo | 11/18/1997 | -84.3 | -11.7 | | | |

**Table B6.** Summary of hydrogen-2 and oxygen-18 isotopic composition of water, sulfur-34 of dissolved sulfate, and carbon-13 and carbon-14 of dissolved inorganic carbon in surface water-- Continued

| Site no. | Sample no. | Site name | Date | $\delta^2H$ (per mil) | $\delta^{18}O$ (per mil) | $\delta^{34}S$ (per mil) | $\delta^{13}C$ (per mil) | $^{14}C$ (pmC) |
|---|---|---|---|---|---|---|---|---|
| S300 | NM398 | Rio Grande at Alameda | 1/8/1998 | -94.1 | -12.7 | 0.65 | | |
| S308 | NM399 | Riverside Drain at Alameda | 1/8/1998 | -92.9 | -12.5 | | | |
| S301 | NM400 | Rio Grande at Campbell | 1/8/1998 | -93.7 | -12.7 | | | |
| S309 | NM401 | Riverside Drain at Campbell | 1/8/1998 | -92.6 | -12.6 | | | |
| S303 | NM402 | Rio Grande at Rio Bravo | 1/8/1998 | -94.1 | -12.6 | | | |
| S310 | NM403 | Riverside Drain at Rio Bravo | 1/8/1998 | -89.3 | -12.2 | | | |
| S313 | NM404 | West Riverside drain at Rio Bravo | 1/8/1998 | -92.5 | -12.3 | | | |
| S312 | NM405 | Tijeras Arroyo at Four Hills | 1/9/1998 | -76.7 | -10.6 | | | |
| S292 | NM406 | Bear Canyon Arroyo | 1/9/1998 | -82.9 | -11.8 | | | |
| S300 | NM413 | Rio Grande at Alameda | 2/19/1998 | -95.1 | -12.7 | -0.08 | | |
| S308 | NM414 | Riverside Drain at Alameda | 2/19/1998 | -94.4 | -12.6 | | | |
| S301 | NM415 | Rio Grande at Campbell | 2/19/1998 | -93.1 | -12.8 | | | |
| S309 | NM416 | Riverside Drain at Campbell | 2/19/1998 | -93.1 | -12.7 | | | |
| S303 | NM417 | Rio Grande at Rio Bravo | 2/19/1998 | -94.5 | -12.7 | | | |
| S310 | NM418 | Riverside Drain at Rio Bravo | 2/19/1998 | -91.6 | -12.3 | | | |
| S313 | NM419 | West Riverside drain at Rio Bravo | 2/19/1998 | -93.2 | -12.5 | | | |
| S312 | NM420 | Tijeras Arroyo at Four Hills | 2/20/1998 | -76.5 | -10.8 | | | |
| S292 | NM421 | Bear Canyon Arroyo | 2/20/1998 | -83.2 | -11.9 | | | |
| S297 | NM422 | Jemez River below Jemez Canyon Dam | 2/20/1998 | -66.8 | -8.51 | 7.05 | | |
| S298 | NM423 | Jemez River at Jemez | 2/20/1998 | -85.9 | -11.9 | | | |
| S307 | NM424 | Rio Puerco at Hwy 6 | 2/20/1998 | -60.2 | -7.87 | 5.53 | | |
| S300 | NM425 | Rio Grande at Alameda | 3/31/1998 | -93.8 | -12.7 | 0.80 | | |
| S308 | NM426 | Riverside Drain at Alameda | 3/31/1998 | -93.2 | -12.7 | | | |
| S294 | NM427 | Chamizal Lateral at Alameda | 3/31/1998 | -94.1 | -12.7 | 8.25 | | |
| S291 | NM428 | Alameda Drain at Alameda | 3/31/1998 | -92.9 | -12.6 | | | |
| S301 | NM429 | Rio Grande at Campbell | 3/31/1998 | -91.4 | -12.5 | | | |
| S309 | NM430 | Riverside Drain at Campbell | 3/31/1998 | -94.4 | -12.7 | | | |
| S303 | NM431 | Rio Grande at Rio Bravo | 3/31/1998 | -92.4 | -12.5 | | | |
| S310 | NM432 | Riverside Drain at Rio Bravo | 3/31/1998 | -93.9 | -12.7 | | | |
| S313 | NM433 | West Riverside drain at Rio Bravo | 3/31/1998 | -93.7 | -12.7 | | | |
| S312 | NM434 | Tijeras Arroyo at Four Hills | 3/31/1998 | -78.8 | -10.8 | | | |
| S292 | NM435 | Bear Canyon Arroyo | 3/31/1998 | -84.1 | -12.0 | | | |
| S292 | NM436 | Bear Canyon Arroyo | 3/31/1998 | -83.5 | -12.0 | | | |
| S297 | NM437 | Jemez River below Jemez Canyon Dam | 4/7/1998 | -72.7 | -9.57 | | | |
| S298 | NM438 | Jemez River at Jemez | 4/7/1998 | -84.4 | -11.9 | | | |
| S307 | NM439 | Rio Puerco at Hwy 6 | 4/7/1998 | -60.2 | -7.30 | 3.45 | | |
| S300 | NM440 | Rio Grande at Alameda | 5/5/1998 | -90.6 | -11.9 | -1.39 | | |
| S308 | NM441 | Riverside Drain at Alameda | 5/5/1998 | -90.7 | -12.2 | | | |
| S294 | NM442 | Chamizal Lateral at Alameda | 5/5/1998 | -90.1 | -12.2 | | | |
| S291 | NM443 | Alameda Drain at Alameda | 5/5/1998 | -90.7 | -12.2 | | | |
| S301 | NM444 | Rio Grande at Campbell | 5/5/1998 | -90.5 | -12.0 | | | |
| S309 | NM445 | Riverside Drain at Campbell | 5/5/1998 | -92.2 | -12.2 | | | |
| S303 | NM446 | Rio Grande at Rio Bravo | 5/5/1998 | -90.5 | -11.9 | | | |
| S310 | NM447 | Riverside Drain at Rio Bravo | 5/5/1998 | -91.4 | -12.2 | | | |
| S313 | NM448 | West Riverside drain at Rio Bravo | 5/5/1998 | -92.5 | -12.3 | | | |
| S312 | NM449 | Tijeras Arroyo at Four Hills | 5/5/1998 | -77.6 | -10.9 | | | |
| S292 | NM450 | Bear Canyon Arroyo | 5/5/1998 | -83.8 | -12.0 | | | |
| S297 | NM451 | Jemez River below Jemez Canyon Dam | 5/7/1998 | -74.2 | -9.99 | 7.72 | | |
| S298 | NM452 | Jemez River at Jemez | 5/7/1998 | -87.0 | -12.2 | | | |
| S307 | NM453 | Rio Puerco at Hwy 6 | 5/7/1998 | -57.1 | -5.84 | -8.33 | | |
| S300 | NM454 | Rio Grande at Alameda | 6/11/1998 | -89.3 | -12.1 | -4.88 | | |

**Table B6.** Summary of hydrogen-2 and oxygen-18 isotopic composition of water, sulfur-34 of dissolved sulfate, and carbon-13 and carbon-14 of dissolved inorganic carbon in surface water-- Continued

| Site no. | Sample no. | Site name | Date | $\delta^2H$ (per mil) | $\delta^{18}O$ (per mil) | $\delta^{34}S$ (per mil) | $\delta^{13}C$ (per mil) | $^{14}C$ (pmC) |
|---|---|---|---|---|---|---|---|---|
| S308 | NM455 | Riverside Drain at Alameda | 6/11/1998 | -90.6 | -12.3 | | | |
| S294 | NM456 | Chamizal Lateral at Alameda | 6/11/1998 | -89.8 | -12.2 | | | |
| S291 | NM457 | Alameda Drain at Alameda | 6/11/1998 | -89.8 | -12.2 | | | |
| S301 | NM458 | Rio Grande at Campbell | 6/11/1998 | -89.9 | -12.0 | | | |
| S309 | NM459 | Riverside Drain at Campbell | 6/11/1998 | -91.6 | -12.2 | | | |
| S303 | NM460 | Rio Grande at Rio Bravo | 6/11/1998 | -90.5 | -12.1 | | | |
| S310 | NM461 | Riverside Drain at Rio Bravo | 6/11/1998 | -90.8 | -12.1 | | | |
| S313 | NM462 | West Riverside drain at Rio Bravo | 6/11/1998 | -90.1 | -12.2 | | | |
| S312 | NM463 | Tijeras Arroyo at Four Hills | 6/11/1998 | -79.1 | -10.9 | | | |
| S292 | NM464 | Bear Canyon Arroyo | 6/11/1998 | -84.1 | -11.9 | | | |
| S297 | NM465 | Jemez River below Jemez Canyon Dam | 6/12/1998 | -76.8 | -10.3 | 8.60 | | |
| S298 | NM466 | Jemez River at Jemez | 6/12/1998 | -83.5 | -11.5 | | | |
| S307 | NM467 | Rio Puerco at Hwy 6 | 6/12/1998 | -44.8 | -2.36 | -3.58 | | |
| S300 | NM468 | Rio Grande at Alameda | 7/22/1998 | -86.7 | -11.5 | | | |
| S308 | NM469 | Riverside Drain at Alameda | 7/22/1998 | -87.9 | -11.7 | | | |
| S294 | NM470 | Chamizal Lateral at Alameda | 7/22/1998 | -89.5 | -11.7 | | | |
| S291 | NM471 | Alameda Drain at Alameda | 7/22/1998 | -87.6 | -11.7 | | | |
| S301 | NM472 | Rio Grande at Campbell | 7/22/1998 | -86.0 | -11.4 | | | |
| S309 | NM473 | Riverside Drain at Campbell | 7/22/1998 | -87.8 | -11.8 | | | |
| S303 | NM474 | Rio Grande at Rio Bravo | 7/22/1998 | -84.1 | -11.4 | | | |
| S310 | NM475 | Riverside Drain at Rio Bravo | 7/22/1998 | -87.6 | -11.7 | | | |
| S313 | NM476 | West Riverside drain at Rio Bravo | 7/22/1998 | -89.2 | -11.9 | | | |
| S312 | NM477 | Tijeras Arroyo at Four Hills | 7/23/1998 | -78.2 | -10.9 | | | |
| S292 | NM478 | Bear Canyon Arroyo | 7/23/1998 | -83.7 | -11.8 | | | |
| S297 | NM479 | Jemez River below Jemez Canyon Dam | 7/23/1998 | -74.1 | -9.70 | | | |
| S298 | NM480 | Jemez River at Jemez | 7/23/1998 | -80.1 | -10.8 | | | |
| S300 | NM531 | Rio Grande at Alameda | 8/18/1998 | -84.5 | -11.1 | | | |
| S308 | NM532 | Riverside Drain at Alameda | 8/18/1998 | -86.3 | -11.5 | | | |
| S294 | NM533 | Chamizal Lateral at Alameda | 8/18/1998 | -85.6 | -11.5 | | | |
| S291 | NM534 | Alameda Drain at Alameda | 8/18/1998 | -86.2 | -11.4 | | | |
| S301 | NM535 | Rio Grande at Campbell | 8/18/1998 | -84.8 | -11.3 | | | |
| S309 | NM536 | Riverside Drain at Campbell | 8/18/1998 | -87.4 | -11.5 | | | |
| S303 | NM537 | Rio Grande at Rio Bravo | 8/18/1998 | -84.0 | -11.2 | | | |
| S310 | NM538 | Riverside Drain at Rio Bravo | 8/18/1998 | -85.3 | -11.6 | | | |
| S313 | NM539 | West Riverside drain at Rio Bravo | 8/18/1998 | -88.6 | -11.7 | | | |
| S312 | NM540 | Tijeras Arroyo at Four Hills | 8/18/1998 | -76.2 | -10.7 | | | |
| S292 | NM541 | Bear Canyon Arroyo | 8/18/1998 | -83.6 | -11.9 | | | |
| S297 | NM542 | Jemez River below Jemez Canyon Dam | 8/19/1998 | -74.4 | -9.53 | | | |
| S298 | NM543 | Jemez River at Jemez | 8/19/1998 | -79.1 | -10.9 | | | |
| S307 | NM544 | Rio Puerco at Hwy 6 | 8/19/1998 | -39.3 | -4.83 | -0.79 | | |
| S300 | NM545 | Rio Grande at Alameda | 9/22/1998 | -84.7 | -11.4 | | | |
| S308 | NM546 | Riverside Drain at Alameda | 9/22/1998 | -85.1 | -11.5 | | | |
| S294 | NM547 | Chamizal Lateral at Alameda | 9/22/1998 | -85.3 | -11.5 | | | |
| S291 | NM548 | Alameda Drain at Alameda | 9/22/1998 | -85.1 | -11.5 | | | |
| S301 | NM549 | Rio Grande at Campbell | 9/22/1998 | -84.7 | -11.3 | | | |
| S309 | NM550 | Riverside Drain at Campbell | 9/22/1998 | -85.1 | -11.4 | | | |
| S303 | NM551 | Rio Grande at Rio Bravo | 9/22/1998 | -84.0 | -11.3 | | | |
| S310 | NM552 | Riverside Drain at Rio Bravo | 9/22/1998 | -84.8 | -11.5 | | | |
| S313 | NM553 | West Riverside drain at Rio Bravo | 9/22/1998 | -85.4 | -11.4 | | | |
| S312 | NM554 | Tijeras Arroyo at Four Hills | 9/22/1998 | -74.7 | -10.5 | | | |
| S292 | NM555 | Bear Canyon Arroyo | 9/29/1998 | -82.5 | -11.8 | | | |

**Table B6.** Summary of hydrogen-2 and oxygen-18 isotopic composition of water, sulfur-34 of dissolved sulfate, and carbon-13 and carbon-14 of dissolved inorganic carbon in surface water-- Continued

| Site no. | Sample no. | Site name | Date | $\delta^{2}H$ (per mil) | $\delta^{18}O$ (per mil) | $\delta^{34}S$ (per mil) | $\delta^{13}C$ (per mil) | $^{14}C$ (pmC) |
|---|---|---|---|---|---|---|---|---|
| S297 | NM556 | Jemez River below Jemez Canyon Dam | 9/24/1998 | -69.6 | -8.41 | | | |
| S298 | NM557 | Jemez River at Jemez | 9/24/1998 | -81.0 | -11.0 | | | |
| S300 | NM558 | Rio Grande at Alameda | 10/20/1998 | -84.0 | -11.1 | | | |
| S308 | NM559 | Riverside Drain at Alameda | 10/20/1998 | -86.3 | -11.4 | | | |
| S294 | NM560 | Chamizal Lateral at Alameda | 10/20/1998 | -86.7 | -11.5 | | | |
| S301 | NM561 | Rio Grande at Campbell | 10/20/1998 | -84.8 | -11.3 | | | |
| S309 | NM562 | Riverside Drain at Campbell | 10/20/1998 | -84.7 | -11.4 | | | |
| S303 | NM563 | Rio Grande at Rio Bravo | 10/20/1998 | -88.7 | -12.1 | | | |
| S310 | NM564 | Riverside Drain at Rio Bravo | 10/20/1998 | -86.2 | -11.7 | | | |
| S313 | NM565 | West Riverside drain at Rio Bravo | 10/20/1998 | -86.7 | -11.5 | | | |
| S312 | NM566 | Tijeras Arroyo at Four Hills | 10/23/1998 | -76.1 | -10.8 | | | |
| S292 | NM567 | Bear Canyon Arroyo | 10/23/1998 | -84.7 | -11.8 | | | |
| S297 | NM568 | Jemez River below Jemez Canyon Dam | 10/27/1998 | -66.4 | -8.07 | | | |
| S298 | NM569 | Jemez River at Jemez | 10/27/1998 | -81.7 | -11.9 | | | |
| S307 | NM570 | Rio Puerco at Hwy 6 | 10/23/1998 | -86.7 | -12.2 | 2.27 | | |
| S300 | NM571 | Rio Grande at Alameda | 12/1/1998 | -89.1 | -12.0 | | | |
| S308 | NM572 | Riverside Drain at Alameda | 12/1/1998 | -88.5 | -11.7 | | | |
| S301 | NM573 | Rio Grande at Campbell | 12/1/1998 | -90.2 | -12.0 | | | |
| S309 | NM574 | Riverside Drain at Campbell | 12/1/1998 | -86.9 | -11.6 | | | |
| S303 | NM575 | Rio Grande at Rio Bravo | 12/1/1998 | -88.5 | -12.0 | | | |
| S310 | NM576 | Riverside Drain at Rio Bravo | 12/1/1998 | -84.7 | -11.6 | | | |
| S313 | NM577 | West Riverside drain at Rio Bravo | 12/1/1998 | -84.7 | -11.6 | | | |
| S312 | NM578 | Tijeras Arroyo at Four Hills | 12/1/1998 | -78.4 | -10.8 | | | |
| S292 | NM579 | Bear Canyon Arroyo | 12/1/1998 | -82.9 | -11.8 | | | |
| S297 | NM580 | Jemez River below Jemez Canyon Dam | 12/3/1998 | -66.6 | -8.34 | | | |
| S298 | NM581 | Jemez River at Jemez | 12/3/1998 | -85.6 | -12.0 | | | |
| S307 | NM582 | Rio Puerco at Hwy 6 | 12/3/1998 | -64.3 | -8.52 | 5.86 | | |
| S300 | NM583 | Rio Grande at Alameda | 1/5/1999 | -90.5 | -12.1 | | | |
| S308 | NM584 | Riverside Drain at Alameda | 1/5/1999 | -89.2 | -11.9 | | | |
| S301 | NM585 | Rio Grande at Campbell | 1/5/1999 | -90.8 | -12.2 | | | |
| S309 | NM586 | Riverside Drain at Campbell | 1/5/1999 | -89.2 | -11.8 | | | |
| S303 | NM587 | Rio Grande at Rio Bravo | 1/5/1999 | -91.0 | -12.1 | | | |
| S310 | NM588 | Riverside Drain at Rio Bravo | 1/5/1999 | -87.2 | -11.6 | | | |
| S313 | NM589 | West Riverside drain at Rio Bravo | 1/5/1999 | -87.4 | -11.7 | | | |
| S312 | NM590 | Tijeras Arroyo at Four Hills | 1/5/1999 | -77.3 | -10.8 | | | |
| S292 | NM591 | Bear Canyon Arroyo | 1/5/1999 | -84.9 | -11.9 | | | |
| S297 | NM592 | Jemez River below Jemez Canyon Dam | 1/6/1999 | -66.4 | -8.45 | | | |
| S298 | NM593 | Jemez River at Jemez | 1/6/1999 | -87.8 | -12.0 | | | |
| S300 | NM594 | Rio Grande at Alameda | 2/2/1999 | -93.3 | -12.4 | | | |
| S308 | NM595 | Riverside Drain at Alameda | 2/2/1999 | -89.6 | -12.1 | | | |
| S301 | NM596 | Rio Grande at Campbell | 2/2/1999 | -92.3 | -12.4 | | | |
| S309 | NM597 | Riverside Drain at Campbell | 2/2/1999 | -89.5 | -12.1 | | | |
| S303 | NM598 | Rio Grande at Rio Bravo | 2/2/1999 | -91.7 | -12.2 | | | |
| S310 | NM599 | Riverside Drain at Rio Bravo | 2/2/1999 | -87.3 | -11.8 | | | |
| S313 | NM600 | West Riverside drain at Rio Bravo | 2/2/1999 | -88.8 | -11.9 | | | |
| S312 | NM601 | Tijeras Arroyo at Four Hills | 2/2/1999 | -78.5 | -10.8 | | | |
| S292 | NM602 | Bear Canyon Arroyo | 2/3/1999 | -84.0 | -11.8 | | | |
| S297 | NM603 | Jemez River below Jemez Canyon Dam | 2/3/1999 | -68.5 | -8.57 | | | |
| S298 | NM604 | Jemez River at Jemez | 2/3/1999 | -87.0 | -11.9 | | | |
| S307 | NM605 | Rio Puerco at Hwy 6 | 2/3/1999 | -61.1 | -7.30 | 6.25 | | |
| S300 | NM606 | Rio Grande at Alameda | 3/30/1999 | -91.2 | -12.1 | | -6.4 | 88.23 |

**Table B6.** Summary of hydrogen-2 and oxygen-18 isotopic composition of water, sulfur-34 of dissolved sulfate, and carbon-13 and carbon-14 of dissolved inorganic carbon in surface water-- Continued

| Site no. | Sample no. | Site name | Date | $\delta^{2}H$ (per mil) | $\delta^{18}O$ (per mil) | $\delta^{34}S$ (per mil) | $\delta^{13}C$ (per mil) | $^{14}C$ (pmC) |
|---|---|---|---|---|---|---|---|---|
| S308 | NM607 | Riverside Drain at Alameda | 3/30/1999 | -92.7 | -12.5 | | | |
| S294 | NM608 | Chamizal Lateral at Alameda | 3/30/1999 | -94.0 | -12.5 | | | |
| S301 | NM609 | Rio Grande at Campbell | 3/30/1999 | -91.0 | -12.1 | | -6.1 | 88.86 |
| S309 | NM610 | Riverside Drain at Campbell | 3/30/1999 | -92.6 | -12.5 | | | |
| S303 | NM611 | Rio Grande at Rio Bravo | 3/30/1999 | -91.3 | -12.2 | | -6.4 | 82.92 |
| S310 | NM612 | Riverside Drain at Rio Bravo | 3/30/1999 | -94.2 | -12.5 | | | |
| S313 | NM613 | West Riverside drain at Rio Bravo | 3/30/1999 | -92.0 | -12.3 | | | |
| S312 | NM614 | Tijeras Arroyo at Four Hills | 3/30/1999 | -77.9 | -10.6 | | -7.1 | 87.18 |
| S292 | NM615 | Bear Canyon Arroyo | 4/2/1999 | -84.0 | -11.9 | | -10.9 | 112.7 |
| S297 | NM616 | Jemez River below Jemez Canyon Dam | 4/1/1999 | -69.7 | -8.54 | | -2.9 | 83.11 |
| S298 | NM617 | Jemez River at Jemez | 4/2/1999 | -86.1 | -11.9 | | -3.7 | 71.19 |
| S307 | NM618 | Rio Puerco at Hwy 6 | 4/2/1999 | -53.9 | -5.89 | 5.44 | -0.11 | 63.87 |

**Table B7.** Summary of hydrogen-2 and oxygen-18 isotopic composition of water in archived precipitation samples, Albuquerque

[RWS, raw water sample number of C. Yapp; dms, degrees-minutes-seconds; $\delta^2H$, hydrogen-2; $\delta^{18}O$, oxygen-18; $\delta=((R_{sample}/R_{standard})-1)x1000$, where R is an isotope ratio; per mil, parts per thousand; nd, not determined]

| RWS No. | Site Name | End date | Latitude (dms) | Longitude (dms) | Collector | $\delta^2H$ (per mil) | $\delta^{18}O$ (per mil) |
|---|---|---|---|---|---|---|---|
| 179 | Precip collected atop Northrop Hall UNM | 10/81 | 350458 | 1063720 | C. Yapp | - 61.1 | - 9.3 |
| 283 | Precip collected atop Northrop Hall UNM | 11/82 | 350458 | 1063720 | C. Yapp | - 96.6 | - 13.2 |
| 286 | Precip collected atop Northrop Hall UNM | 2/83 | 350458 | 1063720 | C. Yapp | -130.5 | - 17.8 |
| 287 | Precip collected atop Northrop Hall UNM | 3/83 | 350458 | 1063720 | C. Yapp | - 87.3 | - 11.7 |
| 290 | Precip collected atop Northrop Hall UNM | 5/83 | 350458 | 1063720 | C. Yapp | - 52.4 | - 6.2 |
| 292 | Precip collected atop Northrop Hall UNM | 6/83 | 350458 | 1063720 | C. Yapp | - 21.4 | - 3.2 |
| 293 | Precip collected atop Northrop Hall UNM | 7/83 | 350458 | 1063720 | C. Yapp | - 22.2 | - 2.9 |
| 295 | precip collected atop Northrop Hall UNM | 9/83 | 350458 | 1063720 | C. Yapp | - 50.1 | - 7.7 |
| 296 | Precip collected atop Northrop Hall UNM | 10/11/83 | 350458 | 1063720 | C. Yapp | -108.4 | - 14.4 |
| 300 | Precip collected atop Northrop Hall UNM | 1/19/84 | 350458 | 1063720 | C. Yapp | - 66.4 | - 10.3 |
| 301 | Precip collected atop Northrop Hall UNM | 3/84 | 350458 | 1063720 | C. Yapp | -102.5 | - 13.6 |
| 41 | Cross sectional core of snow collected at Crest of Sandia Mts near T.V. towers | 11/22/80 | nd | nd | C. Yapp | -159.2 | - 21.2 |
| 284 | Snow from 8000 ft level east side of Sandia Mts. | 11/30/82 | nd | nd | C. Yapp | - 83.1 | - 12.0 |

| Sample No. | Name | Begin date | End date | Latitude (dms) | Longitude (dms) | Collector | $\delta^2H$ (per mil) | $\delta^{18}O$ (per mil) |
|---|---|---|---|---|---|---|---|---|
| 1 | Precipitation | 5/6/1987 | 5/24/1987 | 350709 | 1062943 | R. Hejl | - 58.9 | - 6.3 |
| 2 | Precipitation | 6/7/1987 | 6/8/1987 | 350709 | 1062943 | R. Hejl | - 75.9 | - 10.6 |
| 3 | Precipitation | 7/20/1987 | 7/21/1987 | 350709 | 1062943 | R. Hejl | - 55.4 | - 8.2 |
| 4 | Precipitation | 7/24/1987 | 7/30/1987 | 350709 | 1062943 | R. Hejl | - 41.8 | - 5.4 |
| 5 | Precipitation | 8/2/1987 | 8/22/1987 | 350709 | 1062943 | R. Hejl | - 28.6 | - 4.2 |
| 6 | Precipitation | 8/22/1987 | 8/27/1987 | 350709 | 1062943 | R. Hejl | - 18.7 | - 3.7 |
| 7 | Precipitation | 10/13/1987 | 10/31/1987 | 350709 | 1062943 | R. Hejl | - 68.6 | - 9.7 |
| 8 | Precipitation | 11/1/1987 | 11/16/1987 | 350709 | 1062943 | R. Hejl | - 92.9 | - 12.1 |
| 9 | Precipitation | 12/17/1987 | 12/18/1987 | 350709 | 1062943 | R. Hejl | - 96.3 | - 13.6 |
| 10 | Precipitation | 1/17/1988 | 1/21/1988 | 350709 | 1062943 | R. Hejl | -132.4 | - 16.9 |
| 11 | Precipitation | 2/1/1988 | 2/3/1988 | 350709 | 1062943 | R. Hejl | -150.0 | - 18.4 |
| 12 | Precipitation | 3/2/1988 | 4/1/1988 | 350709 | 1062943 | R. Hejl | - 78.6 | - 11.4 |
| 13 | Precipitation | 4/14/1988 | 4/30/1988 | 350709 | 1062943 | R. Hejl | - 56.8 | - 7.8 |
| 14 | Precipitation | 5/17/1988 | 5/25/1988 | 350709 | 1062943 | R. Hejl | - 63.6 | - 9.2 |
| 15 | Precipitation | 6/4/1988 | 6/28/1988 | 350709 | 1062943 | R. Hejl | - 46.4 | - 6.5 |
| 16 | Precipitation | 7/1/1988 | 7/9/1988 | 350709 | 1062943 | R. Hejl | - 53.5 | - 8.0 |
| 17 | Precipitation | 7/17/1988 | 7/28/1988 | 350709 | 1062943 | R. Hejl | - 33.3 | - 5.2 |

**Table B8.** Summary of hydrogen-2 and oxygen-18 isotopic composition of water in archived surface-water samples from the early 1980s

[RWS, raw water sample number of C. Yapp; dms, degrees-minutes-seconds; $\delta^2H$, hydrogen-2; $\delta^{18}O$, oxygen-18; $\delta=((R_{sample}/R_{standard})-1)x1000$, where R is an isotope ratio; per mil, parts per thousand]

| RWS No. | Name | Latitude (dms) | Longitude (dms) | Date | Collector | $\delta^2H$ (per mil) | $\delta^{18}O$ (per mil) |
|---|---|---|---|---|---|---|---|
| 49 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 02/16/80 | C. Yapp | - 94.6 | - 12.7 |
| 9 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 10/09/80 | C. Yapp | - 94.8 | - 12.5 |
| 33 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 11/06/80 | C. Yapp | - 97.2 | - 12.5 |
| 56 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 01/14/81 | C. Yapp | - 96.5 | - 12.7 |
| 63 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 02/10/81 | C. Yapp | - 98.6 | - 12.9 |
| 71 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 04/08/81 | C. Yapp | - 94.1 | - 12.3 |
| 79 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 05/28/81 | C. Yapp | - 88.5 | - 11.4 |
| 106 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 06/27/81 | C. Yapp | - 90.0 | - 11.6 |
| 116 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 06/29/81 | C. Yapp | - 90.6 | - 11.6 |
| 125 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 07/23/81 | C. Yapp | - 91.0 | - 11.9 |
| 148 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 08/18/81 | C. Yapp | - 88.2 | - 11.2 |
| 174 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 10/30/81 | C. Yapp | - 83.1 | - 10.8 |
| 189 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 11/26/81 | C. Yapp | - 90.9 | - 12.0 |
| 218 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 03/14/82 | C. Yapp | - 96.2 | - 12.8 |
| 250 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 03/15/82 | C. Yapp | - 97.0 | - 12.8 |
| 254 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 04/10/82 | C. Yapp | - 93.5 | - 12.4 |
| 256 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 05/09/82 | C. Yapp | -101.6 | - 13.5 |
| 260 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 05/16/82 | C. Yapp | -103.3 | - 13.7 |
| 261 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 05/23/82 | C. Yapp | -102.6 | - 13.8 |
| 262 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 05/30/82 | C. Yapp | -103.5 | - 13.9 |
| 264 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 06/06/82 | C. Yapp | -105.0 | - 14.1 |
| 273 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 06/14/82 | C. Yapp | -104.8 | - 14.1 |
| 274 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 06/21/82 | C. Yapp | -105.3 | - 14.2 |
| 277 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 08/18/82 | C. Yapp | - 94.9 | - 12.6 |
| 279 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 09/21/82 | C. Yapp | - 82.6 | - 11.3 |
| 281 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 10/21/82 | C. Yapp | - 93.1 | - 12.5 |
| 289 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 05/15/83 | C. Yapp | - 96.5 | - 13.1 |
| 291 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 06/15/83 | C. Yapp | - 97.9 | - 13.6 |
| 216 | Rio Grande at Corrales Rd Brg Hwy 46 | 351150 | 1063829 | 02/02/82 | C. Yapp | - 94.2 | - 12.7 |
| 107 | Water from outlet below Cochiti dam | 353705 | 1061924 | 06/27/81 | C. Yapp | - 92.5 | - 12.1 |
| 176 | Rio Grande at NM Hwy 6 bridge, Belen, NM | 343909 | 1064414 | 11/01/81 | C. Yapp | - 86.8 | - 11.2 |
| 2 | Water Collected just above waterfall about 150 yards upstream from Simms well, Bear Canyon | 350902 | 1062729 | 09/26/80 | C. Yapp | - 81.8 | - 11.4 |
| 285A | Embudito Spr. | 350547 | 1062744 | 01/12/83 | C. Yapp | - 81.3 | - 11.3 |
| 285B | Embudito Spr. | 350547 | 1062744 | 01/12/83 | C. Yapp | - 82.8 | - 11.4 |
| 297 | Alamosa River at Dolores Canyon Road Br | 372138 | 1063559 | 08/10/83 | C. Yapp | - 98.2 | - 14.3 |
| 298 | Alamosa River at Alum Creek | 372305 | 1063352 | 08/10/83 | C. Yapp | -109.2 | - 14.9 |
| 299 | Alamosa River at Silver lakes Road Br over Alamosa River | 372327 | 1062240 | 08/10/83 | C. Yapp | - 99.9 | - 14.1 |
| 259 | Three Gun Spring | 350557 | 1062618 | 05/12/82 | C. Yapp | - 83.6 | - 11.7 |
| 126 | Cienega Springs,Sandia Mts | 351012 | 1062304 | 07/27/81 | C. Yapp | - 89.4 | - 12.6 |
| 227 | Lake Carlsbad at bridge on Hwy 62 & 180 in Carlsbad | 322505 | 1041325 | 03/14/82 | C. Yapp | - 42.3 | - 5.8 |
| 221 | Rio Hondo, near Hondo, at bridge on Hwy 395 | 332200 | 1051435 | 03/14/82 | C. Yapp | - 58.8 | - 8.4 |
| 154 | Stream at Indian Head nest area, Santa Fe National Forest, Hwy 4, Jemez River | 354942 | 1063839 | 09/26/81 | C. Yapp | - 79.9 | - 11.0 |

**Table B9.** Tritium concentrations in surface water

[TU, Tritium Unit, 1 TU=1 atom of $^3H$ in $10^{18}$ atoms of H; 1 σ, one standard deviation]

| Site no. | Sample no. | Site name | Date | Tritium (TU) | ± 1σ (TU) |
|---|---|---|---|---|---|
| S290 | NM194 | Abo Arroyo at US 60 | 1/16/1997 | 6.2 | 0.3 |
| S290 | NM202 | Abo Arroyo at US 60 | 3/12/1997 | 6.6 | 0.4 |
| S291 | NM220 | Alameda Drain at Alameda | 4/22/1997 | 8.3 | 0.4 |
| S291 | NM366 | Alameda Drain at Alameda | 7/9/1997 | 9.3 | 0.4 |
| S291 | NM370 | Alameda Drain at Alameda | 9/16/1997 | 9.6 | 0.4 |
| S291 | NM381 | Alameda Drain at Alameda | 10/21/1997 | 9.6 | 0.4 |
| S292 | NM421 | Bear Canyon Arroyo | 2/20/1998 | 8.9 | 0.4 |
| S292 | NM397 | Bear Canyon Arroyo | 11/18/1997 | 9.1 | 0.4 |
| S292 | NM388 | Bear Canyon Arroyo | 10/23/1997 | 9.2 | 0.5 |
| S292 | NM203 | Bear Canyon Arroyo | 3/19/1997 | 9.4 | 0.4 |
| S292 | NM406 | Bear Canyon Arroyo | 1/9/1998 | 9.7 | 0.5 |
| S292 | NM216 | Bear Canyon Arroyo | 4/23/1997 | 9.8 | 0.5 |
| S292 | NM354 | Bear Canyon Arroyo | 7/9/1997 | 10. | 0.5 |
| S292 | NM229 | Bear Canyon Arroyo | 5/28/1997 | 11. | 0.5 |
| S294 | NM204 | Chamizal Lateral at Alameda | 3/18/1997 | 8.7 | 0.4 |
| S294 | NM369 | Chamizal Lateral at Alameda | 9/16/1997 | 9.2 | 0.5 |
| S294 | NM217 | Chamizal Lateral at Alameda | 4/22/1997 | 9.3 | 0.5 |
| S294 | NM380 | Chamizal Lateral at Alameda | 10/21/1997 | 9.6 | 0.5 |
| S294 | NM230 | Chamizal Lateral at Alameda | 5/21/1997 | 10. | 0.5 |
| S294 | NM355 | Chamizal Lateral at Alameda | 7/9/1997 | 11. | 0.5 |
| S297 | NM422 | Jemez River below Jemez Canyon Dam | 2/20/1998 | 6.5 | 0.4 |
| S298 | NM423 | Jemez River at Jemez | 2/20/1998 | 3.5 | 0.3 |
| S300 | NM118 | Rio Grande at Alameda | 6/29/1996 | 7.2 | 0.5 |
| S300 | NM195 | Rio Grande at Alameda | 2/11/1997 | 7.9 | 0.4 |
| S300 | NM206 | Rio Grande at Alameda | 3/18/1997 | 8.1 | 0.4 |
| S300 | NM413 | Rio Grande at Alameda | 2/19/1998 | 8.7 | 0.4 |
| S300 | NM187 | Rio Grande at Alameda | 1/14/1997 | 8.8 | 0.5 |
| S300 | NM218 | Rio Grande at Alameda | 4/22/1997 | 8.9 | 0.5 |
| S300 | NM398 | Rio Grande at Alameda | 1/8/1998 | 9.0 | 0.4 |
| S300 | NM123 | Rio Grande at Alameda | 6/22/1996 | 9.6 | 0.5 |
| S300 | NM378 | Rio Grande at Alameda | 10/21/1997 | 9.8 | 0.5 |
| S300 | NM389 | Rio Grande at Alameda | 11/20/1997 | 9.9 | 0.4 |
| S300 | NM367 | Rio Grande at Alameda | 9/16/1997 | 9.9 | 0.5 |
| S300 | NM231 | Rio Grande at Alameda | 5/21/1997 | 11. | 0.5 |
| S300 | NM356 | Rio Grande at Alameda | 7/9/1997 | 11. | 0.5 |
| S301 | NM189 | Rio Grande at Campbell | 1/14/1997 | 8.0 | 0.4 |
| S301 | NM197 | Rio Grande at Campbell | 2/11/1997 | 8.0 | 0.4 |
| S301 | NM400 | Rio Grande at Campbell | 1/8/1998 | 8.8 | 0.4 |
| S301 | NM415 | Rio Grande at Campbell | 2/19/1998 | 8.8 | 0.5 |
| S301 | NM208 | Rio Grande at Campbell | 3/18/1997 | 8.9 | 0.4 |
| S301 | NM221 | Rio Grande at Campbell | 4/22/1997 | 9.3 | 0.5 |
| S301 | NM371 | Rio Grande at Campbell | 9/16/1997 | 9.4 | 0.5 |
| S301 | NM382 | Rio Grande at Campbell | 10/21/1997 | 9.8 | 0.5 |
| S301 | NM233 | Rio Grande at Campbell | 5/21/1997 | 9.9 | 0.4 |
| S301 | NM391 | Rio Grande at Campbell | 11/20/1997 | 10. | 0.4 |
| S301 | NM358 | Rio Grande at Campbell | 7/9/1997 | 11. | 0.5 |

**Table B9.** Tritium concentrations in surface water-- Continued

| Site no. | Sample no. | Site name | Date | Tritium (TU) | ± 1σ (TU) |
|---|---|---|---|---|---|
| S302 | NM124 | Rio Grande at Isleta Below Diversion | 6/22/1996 | 8.4 | 0.4 |
| S303 | NM402 | Rio Grande at Rio Bravo | 1/8/1998 | 7.4 | 0.4 |
| S303 | NM199 | Rio Grande at Rio Bravo | 2/11/1997 | 7.8 | 0.4 |
| S303 | NM191 | Rio Grande at Rio Bravo | 1/15/1997 | 8.2 | 0.4 |
| S303 | NM210 | Rio Grande at Rio Bravo | 3/18/1997 | 8.3 | 0.4 |
| S303 | NM417 | Rio Grande at Rio Bravo | 2/19/1998 | 8.6 | 0.4 |
| S303 | NM384 | Rio Grande at Rio Bravo | 10/21/1997 | 9.2 | 0.5 |
| S303 | NM223 | Rio Grande at Rio Bravo | 4/22/1997 | 9.3 | 0.5 |
| S303 | NM121 | Rio Grande at Rio Bravo | 6/29/1996 | 9.4 | 0.4 |
| S303 | NM373 | Rio Grande at Rio Bravo | 9/16/1997 | 9.5 | 0.5 |
| S303 | NM393 | Rio Grande at Rio Bravo | 11/20/1997 | 10. | 0.4 |
| S303 | NM235 | Rio Grande at Rio Bravo | 5/21/1997 | 11. | 0.4 |
| S303 | NM360 | Rio Grande at Rio Bravo | 7/9/1997 | 11. | 0.5 |
| S304 | NM122 | Rio Grande at San Felipe | 6/22/1996 | 10. | 0.4 |
| S305 | NM120 | Rio Grande nr Central | 6/29/1996 | 7.4 | 0.4 |
| S306 | NM119 | Rio Grande nr I-40 | 6/29/1996 | 7.5 | 0.4 |
| S307 | NM424 | Rio Puerco at Hwy 6 | 2/20/1998 | 1.9 | 0.3 |
| S308 | NM196 | Riverside Drain at Alameda | 2/11/1997 | 8.3 | 0.4 |
| S308 | NM188 | Riverside Drain at Alameda | 1/14/1997 | 8.4 | 0.4 |
| S308 | NM207 | Riverside Drain at Alameda | 3/18/1997 | 8.4 | 0.4 |
| S308 | NM414 | Riverside Drain at Alameda | 2/19/1998 | 8.5 | 0.4 |
| S308 | NM379 | Riverside Drain at Alameda | 10/21/1997 | 8.8 | 0.4 |
| S308 | NM219 | Riverside Drain at Alameda | 4/22/1997 | 9.0 | 0.5 |
| S308 | NM368 | Riverside Drain at Alameda | 9/16/1997 | 9.3 | 0.4 |
| S308 | NM232 | Riverside Drain at Alameda | 5/21/1997 | 9.5 | 0.4 |
| S308 | NM390 | Riverside Drain at Alameda | 11/20/1997 | 9.5 | 0.4 |
| S308 | NM357 | Riverside Drain at Alameda | 7/9/1997 | 9.6 | 0.4 |
| S308 | NM399 | Riverside Drain at Alameda | 1/8/1998 | 9.6 | 0.5 |
| S309 | NM416 | Riverside Drain at Campbell | 2/19/1998 | 8.1 | 0.4 |
| S309 | NM190 | Riverside Drain at Campbell | 1/14/1997 | 8.4 | 0.4 |
| S309 | NM198 | Riverside Drain at Campbell | 2/11/1997 | 8.9 | 0.4 |
| S309 | NM383 | Riverside Drain at Campbell | 10/21/1997 | 9.0 | 0.4 |
| S309 | NM209 | Riverside Drain at Campbell | 3/18/1997 | 9.1 | 0.4 |
| S309 | NM401 | Riverside Drain at Campbell | 1/8/1998 | 9.2 | 0.4 |
| S309 | NM392 | Riverside Drain at Campbell | 11/20/1997 | 9.4 | 0.4 |
| S309 | NM234 | Riverside Drain at Campbell | 5/21/1997 | 9.8 | 0.5 |
| S309 | NM372 | Riverside Drain at Campbell | 9/16/1997 | 9.9 | 0.5 |
| S309 | NM222 | Riverside Drain at Campbell | 4/22/1997 | 10. | 0.4 |
| S309 | NM359 | Riverside Drain at Campbell | 7/9/1997 | 11. | 0.5 |
| S310 | NM211 | Riverside Drain at Rio Bravo | 3/18/1997 | 8.4 | 0.4 |
| S310 | NM200 | Riverside Drain at Rio Bravo | 2/11/1997 | 8.7 | 0.4 |
| S310 | NM394 | Riverside Drain at Rio Bravo | 11/20/1997 | 8.7 | 0.4 |
| S310 | NM385 | Riverside Drain at Rio Bravo | 10/21/1997 | 9.0 | 0.4 |
| S310 | NM403 | Riverside Drain at Rio Bravo | 1/8/1998 | 9.0 | 0.4 |
| S310 | NM192 | Riverside Drain at Rio Bravo | 1/15/1997 | 9.1 | 0.4 |
| S310 | NM374 | Riverside Drain at Rio Bravo | 9/16/1997 | 9.2 | 0.5 |
| S310 | NM418 | Riverside Drain at Rio Bravo | 2/19/1998 | 9.2 | 0.5 |
| S310 | NM224 | Riverside Drain at Rio Bravo | 4/22/1997 | 9.4 | 0.5 |

**Table B9.** Tritium concentrations in surface water-- Continued

| Site no. | Sample no. | Site name | Date | Tritium (TU) | ± 1σ (TU) |
|---|---|---|---|---|---|
| S310 | NM236 | Riverside Drain at Rio Bravo | 5/21/1997 | 9.5 | 0.4 |
| S310 | NM361 | Riverside Drain at Rio Bravo | 7/9/1997 | 10. | 0.5 |
| S312 | NM420 | Tijeras Arroyo at Four Hills | 2/20/1998 | 5.0 | 0.4 |
| S312 | NM226 | Tijeras Arroyo at Four Hills | 4/23/1997 | 5.2 | 0.4 |
| S312 | NM212 | Tijeras Arroyo at Four Hills | 3/19/1997 | 5.4 | 0.3 |
| S312 | NM376 | Tijeras Arroyo at Four Hills | 9/18/1997 | 5.5 | 0.4 |
| S312 | NM396 | Tijeras Arroyo at Four Hills | 11/18/1997 | 5.7 | 0.3 |
| S312 | NM238 | Tijeras Arroyo at Four Hills | 5/27/1997 | 5.7 | 0.4 |
| S312 | NM387 | Tijeras Arroyo at Four Hills | 10/23/1997 | 5.7 | 0.4 |
| S312 | NM201 | Tijeras Arroyo at Four Hills | 2/11/1997 | 5.8 | 0.3 |
| S312 | NM405 | Tijeras Arroyo at Four Hills | 1/9/1998 | 5.8 | 0.4 |
| S312 | NM193 | Tijeras Arroyo at Four Hills | 1/15/1997 | 5.9 | 0.4 |
| S312 | NM363 | Tijeras Arroyo at Four Hills | 7/9/1997 | 6.2 | 0.4 |
| S313 | NM237 | West Riverside drain at Rio Bravo | 5/21/1997 | 8.9 | 0.4 |
| S313 | NM205 | West Riverside drain at Rio Bravo | 3/18/1997 | 9.1 | 0.4 |
| S313 | NM419 | West Riverside drain at Rio Bravo | 2/19/1998 | 9.1 | 0.5 |
| S313 | NM375 | West Riverside drain at Rio Bravo | 9/16/1997 | 9.3 | 0.5 |
| S313 | NM386 | West Riverside drain at Rio Bravo | 10/21/1997 | 9.3 | 0.5 |
| S313 | NM404 | West Riverside drain at Rio Bravo | 1/8/1998 | 9.6 | 0.4 |
| S313 | NM225 | West Riverside drain at Rio Bravo | 4/22/1997 | 9.7 | 0.5 |
| S313 | NM395 | West Riverside drain at Rio Bravo | 11/20/1997 | 10. | 0.4 |
| S313 | NM362 | West Riverside drain at Rio Bravo | 7/9/1997 | 10. | 0.5 |
| S314 | NM125 | Rio Grande at Arroyo de la Baranca | 7/1/1996 | 8.0 | 0.4 |

# Appendix C. Chemical and isotopic compositions of air, rocks, and plants, and saturation indices for selected minerals in ground water from the Middle Rio Grande Basin

**Table C1.** Selected data on the chemical and isotopic composition of air and shallow unsaturated zone

[CFC-11, trichlorofluoromethane ($CFCl_3$); CFC-12, dichlorodifluoromethane ($CF_2Cl_2$); CFC-113, trichlorotrifluoroethane ($C_2F_3Cl_3$); $SF_6$, sulfur hexafluoride; pptv, parts per trillion by volume; $\delta=((R_{sample}/R_{standard})-1)x1000$, where R is an isotope ratio; $\delta^{13}C$, carbon-13; $\delta^{18}O$, oxygen-18; UZ, Unsaturated Zone, samples taken three feet below land surface; Fraction of gas by volume; nd, not determined; Air samples taken six feet above land surface]

| Location | Date | CFC-12 (pptv) | CFC-11 (pptv) | CFC-113 (pptv) | $SF_6$ (pptv) | Fraction of $CO_2$ gas | Fraction of $N_2$ gas | Fraction of $O_2$ gas | Fraction of Ar gas | Fraction of $CH_4$ gas | $\delta^{13}C$ of $CO_2$ (per mil) | $\delta^{18}O$ of $CO_2$ (per mil) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Air** | | | | | | | | | | | | |
| Abo Arroyo @ Hwy 47 | 1/16/97 | 559.7 | 268.3 | 80.5 | nd | 0.000320 | nd | nd | nd | nd | -8.94 | nd |
| Bear Canyon | 6/21/96 | 548.6 | 269.9 | 88.7 | 15.05 | nd | nd | nd | nd | nd | -8.39 | 41.22 |
| Bear Canyon | 1/15/97 | 538.8 | 259.9 | 82.3 | nd | nd | nd | nd | nd | nd | nd | nd |
| Bear Canyon Ridge | 5/8/97 | 565.7 | 262.3 | 81.7 | nd | nd | nd | nd | nd | nd | nd | nd |
| Burn Site Kirtland AFB | 6/25/96 | 526.6 | 261.4 | 81.0 | 3.73 | nd | nd | nd | nd | nd | -8.28 | 41.10 |
| Cochiti Windmill 170T | 8/29/96 | 529.7 | 258.1 | 82.5 | 4.98 | nd | nd | nd | nd | nd | nd | nd |
| Kirtland AFB | 6/28/96 | 560.5 | 266.2 | 79.2 | 4.20 | nd | nd | nd | nd | nd | nd | nd |
| Kirtland South | 5/8/97 | 529.5 | 256.2 | 81.7 | nd | 0.000358 | 0.78398 | 0.20740 | 0.00923 | 0 | -8.44 | nd |
| Lincoln Middle School well | 7/24/98 | nd | nd | nd | 4.30 | nd | nd | nd | nd | nd | nd | nd |
| Mesa del Sol | 7/25/98 | nd | nd | nd | 4.15 | nd | nd | nd | nd | nd | nd | nd |
| Mesa del Sol | 8/2/98 | nd | nd | nd | 4.73 | nd | nd | nd | nd | nd | nd | nd |
| Mesa del Sol | 6/28/97 | nd | nd | nd | 3.98 | nd | nd | nd | nd | nd | nd | nd |
| Private Production Well #10 | 7/2/96 | 530.8 | 261.6 | 79.3 | 3.96 | nd | nd | nd | nd | nd | nd | nd |
| Rio Grande @ Campbell Rd. | 10/22/97 | nd | nd | nd | 4.58 | nd | nd | nd | nd | nd | nd | nd |
| Rio Grande @ Rio Bravo | 6/29/96 | 570.2 | 265.2 | 85.1 | 5.61 | nd | nd | nd | nd | nd | nd | nd |
| Rio Grande @ Rio Bravo | 1/15/97 | 544.6 | 264.4 | 82.4 | nd | 0.000320 | nd | nd | nd | nd | -9.01 | nd |
| Rio Rancho 13 | 8/13/96 | 550.7 | 267.8 | 88.7 | 6.10 | nd | nd | nd | nd | nd | nd | nd |
| Sandia Well | 7/30/98 | nd | nd | nd | 7.07 | nd | nd | nd | nd | nd | nd | nd |
| Santa Ana 6T | 8/27/96 | 529.3 | 260.4 | 83.8 | 3.72 | nd | nd | nd | nd | nd | nd | nd |
| Tijeras Arroyo @ Four Hills Rd | 10/22/97 | nd | nd | nd | 104 | nd | nd | nd | nd | nd | nd | nd |
| Tio Pedro Windmill | 8/28/96 | 530.2 | 258.9 | 78.4 | 4.60 | nd | nd | nd | nd | nd | nd | nd |
| Tome | 8/6/98 | nd | nd | nd | 4.91 | nd | nd | nd | nd | nd | nd | nd |
| Tunnel Spring | 6/18/96 | 543.0 | 263.7 | 80.8 | 4.27 | nd | nd | nd | nd | nd | nd | nd |
| **Unsaturated Zone Air** | | | | | | | | | | | | |
| Abo Arroyo | 1/16/97 | 554.5 | 256.0 | 76.5 | nd | 0.000683 | 0.78026 | 0.20639 | 0.00933 | <0.001 | -12.50 | nd |
| Bear Canyon Arroyo | 1/15/97 | 536.3 | 260.3 | 80.5 | nd | 0.000764 | 0.78084 | 0.20596 | 0.00928 | <0.001 | -16.68 | nd |
| Bear Canyon Arroyo | 2/20/97 | 546.3 | 349.3 | 81.9 | nd | 0.003053 | 0.77450 | 0.20091 | 0.00934 | <0.001 | -21.41 | nd |
| Bear Canyon Arroyo | 10/22/97 | 526.1 | 282.2 | 79.2 | nd | 0.006220 | 0.78201 | 0.20129 | 0.00924 | <0.001 | -20.05 | nd |
| Bear Canyon Arroyo Ridge | 1/15/97 | nd | nd | nd | nd | 0.001253 | 0.78043 | 0.20392 | 0.00944 | <0.001 | -14.62 | nd |
| Bear Canyon Arroyo Ridge | 2/20/97 | 544.5 | 265.7 | 83.5 | nd | 0.002994 | 0.77819 | 0.20363 | 0.00933 | <0.001 | -16.10 | nd |
| Bear Canyon Arroyo Ridge | 5/8/97 | 528.3 | 263.6 | 84.8 | nd | 0.006104 | 0.78192 | 0.20131 | 0.00936 | <0.001 | -14.83 | nd |
| Bear Canyon Arroyo Ridge | 10/22/97 | 524.4 | 228.1 | 77.6 | nd | 0.004310 | 0.78266 | 0.20295 | 0.00926 | <0.001 | -14.30 | nd |
| Burn Site Kirtland AFB | 6/25/96 | nd | nd | nd | nd | nd | nd | nd | nd | nd | -11.53 | 30.02 |
| Burn Site Kirtland AFB | 6/25/96 | nd | nd | nd | nd | nd | nd | nd | nd | nd | -11.77 | 32.14 |
| Kirtland North | 6/29/96 | nd | nd | nd | nd | nd | nd | nd | nd | nd | -12.11 | 32.39 |
| Kirtland North | 2/20/97 | 555.3 | 262.3 | 79.8 | nd | 0.001696 | 0.77526 | 0.20409 | 0.00927 | <0.001 | -15.96 | nd |
| Kirtland North | 5/8/97 | 523.6 | 254.2 | 81.6 | nd | 0.002523 | 0.78294 | 0.20568 | 0.00930 | <0.001 | -16.23 | nd |
| Kirtland North | 10/22/97 | 522.6 | 249.8 | 82.8 | nd | 0.003040 | 0.78612 | 0.20508 | 0.00923 | <0.001 | nd | nd |
| Kirtland South | 2/20/97 | 523.1 | 260.2 | 79.8 | nd | 0.000926 | 0.77493 | 0.20358 | 0.00935 | <0.001 | -14.42 | nd |
| Kirtland South | 5/8/97 | 518.2 | 257.3 | 79.9 | nd | 0.002266 | 0.78469 | 0.20249 | 0.00932 | <0.001 | -13.39 | nd |
| Kirtland South | 10/22/97 | 518.8 | 219.4 | 71.7 | nd | 0.002760 | 0.78880 | 0.20771 | 0.00934 | <0.001 | -13.25 | nd |
| Private Production Well #10 | 7/2/96 | nd | nd | nd | nd | nd | nd | nd | nd | nd | -14.71 | 28.84 |
| Tijeras Arroyo @ 4-Hills | 5/8/97 | 816.4 | 305.2 | 74.3 | nd | 0.077083 | 0.77406 | 0.14110 | 0.00932 | <0.001 | -17.27 | nd |
| Tijeras Arroyo @ 4-Hills | 2/20/97 | 1,142. | 265.8 | 64.7 | nd | 0.062678 | 0.77977 | 0.13695 | 0.00949 | <0.001 | -18.39 | nd |
| Tijeras Arroyo @ 4-Hills | 1/15/97 | 576.7 | 321.7 | 82.2 | nd | 0.001555 | 0.78204 | 0.20624 | 0.00940 | <0.001 | -18.29 | nd |

**Table C2.** Solid carbonates, limestone, and caliche samples analyzed for $\delta^{13}C$ and $^{14}C$ activity

[RSIL, Reston Stable Isotope Laboratory, USGS; RRL, Rafter Radiocarbon Laboratory; $\delta=((R_{sample}/R_{standard})-1)x1000$, where R is an isotope ratio; $\delta^{13}C$, carbon-13; Carbonate rock samples from Middle Rio Grande Basin.The samples are of drill cuttings and carbonate float. Drill cuttings containing carbonates were identified at the drill site by acid addition while the cuttings were still wet. In the lab, the sample was washed to remove drilling mud, and carbonate fragments were identified with acid. Each drill-cutting sample is a single fragment of carbonate from the sample bag. Each sample was ground and seived through 60-mesh sieve, separately. Other samples are caliche removed from the surface of limestone from various sites, or caliche from soils and drill cuttings. Samples collected summer 1996- winter 1997. pmC, percent modern carbon; 1s, one standard deviation, per mil; parts per thousand.]

| ID No. | Sample Number | Description | RSIL $\delta^{13}C$ (per mil) [1] | RRL $\delta^{13}C$ (per mil) [1] | $^{14}C$ Activity (pmC) | $^{14}C$ error ± 1σ (pmC) | Conventional $^{14}C$ age (years) | $^{14}C$ age error ± 1σ (years) |
|---|---|---|---|---|---|---|---|---|
| NP-1 | 1 | gray limestone @ Domestic Well #01 | 0.1 | | | | | |
| NP-2 | 2a | limestone from Sandia Crest near Tram | -0.1 | | | | | |
| NP-3 | 2b | limestone from Sandia Crest near Tram | 2.8 | | | | | |
| NP-4 | 2c | limestone from Sandia Crest near Tram | -3.7 | | | | | |
| NP-5 | 2d | limestone from Sandia Crest near Tram | -2.8 | | | | | |
| NP-6 | 3 | limestone @ Burn Site Well | -0.8 | | | | | |
| NP-7 | 4a | Caliche from limestone surface @ Burn Site | -4.3 | | | | | |
| NP-8 | 4b | limestone from Burn Site--no caliche | -1.8 | | | | | |
| NP-9 | 4c | limestone from Burn Site--no caliche (chert) | | | | | | |
| NP-10 | 4d | Caliche from 4c | -3.8 | -3.3 | 40.57 | 0.29 | 7,197 | 60 |
| NP-11 | 5a | Caliche from Domestic Well #06 | -3.0 | | | | | |
| NP-12 | 5b | Caliche from Domestic Well #06 | -3.8 | | | | | |
| NP-13 | 1 | Del Sol 305'-310' carbonate hand picked from drill cuttings, single samples | -3.3 | | | | | |
| NP-14 | 2 | Del Sol 305'-310' carbonate hand picked from drill cuttings, single samples | -4.3 | | | | | |
| NP-15 | 3 | Del Sol 305'-310' carbonate hand picked from drill cuttings, single samples | -6.5 | | | | | |
| NP-16 | 1 | Del Sol 310'-315' carbonate hand picked from drill cuttings, single samples | -4.2 | | | | | |
| NP-17 | 2 | Del Sol 310'-315' carbonate hand picked from drill cuttings, single samples | -4.8 | | | | | |
| NP-18 | 1 | Del Sol 265'-270' carbonate hand picked from drill cuttings, single samples | -4.9 | | | | | |
| NP-19 | 1 | West Bluff 925'-930' carbonate hand picked from drill cuttings, single samples | -5.2 | -4.7 | 0.92 | 0.06 | 37,630 | 490 |
| NP-20 | 1 | Del Sol 320'-325' carbonate hand picked from drill cuttings, single samples | -1.1 | | | | | |
| NP-21 | 2 | Del Sol 320'-325' carbonate hand picked from drill cuttings, single samples | -1.5 | | | | | |
| NP-22 | 3 | Del Sol 320'-325' carbonate hand picked from drill cuttings, single samples | -2.8 | | | | | |
| NP-23 | 4 | Del Sol 320'-325' carbonate hand picked from drill cuttings, single samples | -4.9 | | | | | |
| NP-24 | 1 | Hunter Ridge 995'-1005' carbonate hand picked from drill cuttings, single samples | -5.4 | | | | | |
| NP-25 | 1 | Del Sol 260'-265' carbonate hand picked from drill cuttings, single samples | -5.3 | | | | | |
| NP-26 | 1 | West Bluff 285'-305' carbonate hand picked from drill cuttings, single samples | -5.8 | | | | | |
| NP-27 | 1 | Del Sol 965'-970' carbonate hand picked from drill cuttings, single samples | -4.9 | -4.0 | 0.76 | 0.06 | 39,120 | 610 |
| NP-28 | 1 | Domestic Well #06 cuttings, caliche | -2.9 | -3.2 | 3.32 | 0.08 | 27,290 | 190 |

**Table C2.** Solid carbonates, limestone, and caliche samples analyzed for $\delta^{13}C$ and $^{14}C$ activity-- Continued

| ID No. | Sample Number | Description | RSIL $\delta^{13}C$ (per mil) [1] | RRL $\delta^{13}C$ (per mil) [1] | $^{14}C$ Activity (pmC) | $^{14}C$ error ± 1σ (pmC) | Conventional $^{14}C$ age (years) | $^{14}C$ age error ± 1σ (years) |
|---|---|---|---|---|---|---|---|---|
| NP-29 | 1 | 310'-320' Garfield | -5.0 | | | | | |
| NP-30 | 1 | 250'-260' Garfield | -5.2 | | | | | |
| NP-31 | 2 | 250'-260' Garfield | -4.9 | | | | | |
| NP-32 | 1 | Bear Canyon caliche | -3.6 | | | | | |
| NP-33 | 2 | Bear Canyon caliche | -5.7 | | | | | |
| NP-34 | 3 | Bear Canyon caliche | -5.3 | | | | | |
| NP-35 | 4 | Bear Canyon caliche | -4.4 | | | | | |
| NP-37 | 6 | Bear Canyon caliche | -4.7 | | | | | |
| NP-38 | 1 | limestone, misc. carbonate float from Abo Arroyo | 1.4 | | | | | |
| NP-39 | 2 | limestone, misc. carbonate float from Abo Arroyo | -1.2 | | | | | |
| NP-40 | 3 | limestone, misc. carbonate float from Abo Arroyo | -2.6 | | | | | |

[1] Differences in $\delta^{13}C$ values due mostly to inhomogenities in sample

**Table C3.** Stable carbon isotopic composition of plants, $\delta^{13}C$

[$\delta=((R_{sample}/R_{standard})-1)x1000$, where R is an isotope ratio; δ13C, carbon-13; per mil, parts per thousand; 1s, one standard deviation; nd, not determined]

| Sample ID | Location | Date | Name | Selected part of plant for analysis | Comment | $\delta^{13}C$ (per mil) | ± 1 σ of separate samples |
|---|---|---|---|---|---|---|---|
| p-01 | Kirtland North | 5/8/97 | grass | flower part only | 1-2 same specimen | -26.28 | nd |
| p-02 | Kirtland North | 5/8/97 | grass | stem of p-1 | | -27.27 | 0.50 |
| p-03 | Kirtland North | 5/8/97 | Chamisa | foliage | 3-4 same specimen | -26.48 | 0.36 |
| p-04 | Kirtland North | 5/8/97 | Chamisa | stem | | -27.70 | 0.08 |
| p-05 | Kirtland North | 5/8/97 | Apache Plume | foliage | 5-6 same specimen | -25.37 | 0.03 |
| p-06 | Kirtland North | 5/8/97 | Apache Plume | stem | | -26.42 | 0.29 |
| p-07 | Kirtland South | 5/8/97 | Juniper | foliage | 7-8 same specimen | -23.81 | 0.40 |
| p-08 | Kirtland South | 5/8/97 | Juniper | wood stem | | -23.15 | 0.08 |
| p-09 | Kirtland South | 5/8/97 | Chamisa | foliage | 9-10 same specimen | -14.82 | 0.03 |
| p-10 | Kirtland South | 5/8/97 | Chamisa | woody stem | | -13.47 | 0.08 |
| p-11 | Kirtland South | 5/8/97 | Apache Plume | foliage | 11-12 same specimen | -23.70 | 0.13 |
| p-12 | Kirtland South | 5/8/97 | Apache Plume | woody stem | | -23.90 | 0.04 |
| p-13 | Kirtland South | 5/8/97 | grass | root | 13-15 same specimen | -14.47 | nd |
| p-14 | Kirtland South | 5/8/97 | grass | stem at base of plant | | -14.48 | 0.11 |
| p-15 | Kirtland South | 5/8/97 | grass | foliage (blades of grass) | | -14.45 | 0.18 |
| p-16 | Embudito Arroyo | 4/29/97 | Chamisa | woody stem | | -27.65 | 0.12 |
| p-17 | Embudo Arroyo | 4/29/97 | Willow | budding foliage | 17-18 same specimen | -26.72 | 0.34 |
| p-18 | Embudo Arroyo | 4/29/97 | Willow | wood branch | | -27.21 | 0.32 |
| p-19 | Embudo Arroyo | 4/29/97 | Chamisa | foliage | | -29.91 | 0.05 |
| p-20 | Embudo Arroyo | 4/29/97 | grass | foliage (blades) | | -30.02 | 0.01 |
| p-21 | Embudito Arroyo | 4/29/97 | unknown plant | leaves | 21-22 same specimen | -25.18 | 0.12 |
| p-22 | Embudito Arroyo | 4/29/97 | unknown plant | stem | | -24.77 | 0.07 |
| p-23 | Embudito Arroyo | 4/29/97 | Apache Plume | foliage | 23-24 same specimen | -23.99 | 0.16 |
| p-24 | Embudito Arroyo | 4/29/97 | Apache Plume | stem | | -24.68 | 0.12 |
| p-25 | Embudito Arroyo | 4/29/97 | Chamisa | foliage | 25-26 same specimen | -27.36 | 0.36 |
| p-26 | Embudito Arroyo | 4/29/97 | Chamisa | stem | | -26.43 | nd |

**Table C4.** Summary statistics of saturation indices for selected minerals by hydrochemical zone

[All calculations based on the PHREEQC thermochemical data base (Parkhurst, 1995)]

| Hydrochemical zone | | Albite ($NaAlSi_3O_8$) | Ca-Mont-morillonite ($Ca_{0.165}Al_{2.33}Si_{3.67}O_{10}(OH)_2$) | Calcite ($CaCO_3$) | Chalced-ony ($SiO_2$) | Chlorite ($Mg_5Al_2Si_3O_{10}(OH)_8$) | Carbon dioxide ($CO_{2(g)}$)[1] | Dolomite ($CaMg(CO_3)_2$) | Fluorite ($CaF_2$) | Gibbsite ($Al(OH)_3$) | Gypsum ($CaSO_4$: $2H_2O$) | Illite ($K_{0.6}Mg_{0.25}Al_{2.3}Si_{3.5}O_{10}(OH)_2$) | Potassium feldspar ($KAlSi_3O_8$) | Mica ($KAl_3Si_3O_{10}(OH)_2$) | Kaolinite ($Al_2Si_2O_5(OH)_4$) | Quartz ($SiO_2$) | Amorphous silica ($SiO_{2(a)}$) | Talc ($Mg_3Si_4O_{10}(OH)_2$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Northern Mountain Front | Number | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 |
| | Minimum | -1.68 | 0.17 | -1.15 | 0.24 | -13.81 | -2.84 | -2.75 | -2.72 | -0.37 | -3.13 | -0.35 | -0.28 | 4.59 | 1.41 | 0.66 | -0.61 | -6.28 |
| | Median | -1.04 | 3.34 | -0.23 | 0.56 | -6.52 | -2.37 | -1.03 | -2.05 | 0.52 | -2.44 | 2.29 | 0.91 | 7.65 | 3.82 | 1.00 | -0.29 | -1.09 |
| | Maximum | -0.29 | 4.13 | 0.17 | 0.66 | -0.22 | -1.17 | 0.17 | -1.01 | 0.96 | -1.64 | 3.04 | 1.53 | 8.58 | 4.72 | 1.11 | -0.18 | 3.42 |
| Northwestern | Number | 11 | 11 | 13 | 13 | 11 | 13 | 13.0 | 13.0 | 11.0 | 13.0 | 11.0 | 11.0 | 11.0 | 11.0 | 13.0 | 13.0 | 13.0 |
| | Minimum | -1.93 | -0.28 | -0.53 | 0.06 | -7.07 | -3.17 | -1.65 | -2.83 | -0.28 | -2.73 | -0.67 | -0.74 | 4.32 | 1.24 | 0.48 | -0.78 | -1.64 |
| | Median | -1.43 | 1.27 | -0.06 | 0.28 | -4.51 | -2.61 | -0.62 | -1.68 | 0.01 | -2.28 | 0.66 | 0.17 | 5.95 | 2.45 | 0.72 | -0.58 | -0.21 |
| | Maximum | -0.11 | 3.52 | 0.36 | 0.66 | -1.61 | -2.18 | -0.30 | -1.24 | 0.65 | -1.86 | 2.64 | 1.41 | 8.20 | 4.12 | 1.10 | -0.19 | 2.59 |
| West Central | Number | 58 | 58 | 66 | 66 | 58 | 66 | 66 | 66 | 58 | 66 | 58 | 58 | 58 | 58 | 66 | 66 | 66 |
| | Minimum | -2.18 | -2.40 | -0.61 | -0.11 | -8.12 | -3.89 | -1.86 | -2.70 | -1.15 | -3.28 | -2.31 | -1.22 | 2.20 | -0.51 | 0.33 | -0.97 | -3.17 |
| | Median | -0.83 | 0.60 | 0.07 | 0.25 | -1.40 | -3.06 | -0.40 | -1.78 | -0.26 | -2.41 | 0.04 | -0.05 | 5.15 | 1.79 | 0.67 | -0.59 | 2.27 |
| | Maximum | 0.77 | 4.30 | 0.65 | 0.70 | 4.48 | -1.74 | 0.75 | -0.10 | 0.81 | -1.39 | 3.86 | 2.20 | 9.42 | 4.56 | 1.14 | -0.16 | 5.84 |
| Western Boundary | Number | 8 | 8 | 15 | 15 | 8 | 15 | 15 | 15 | 8 | 15 | 8 | 8 | 8 | 8 | 15 | 15 | 15 |
| | Minimum | -1.85 | -1.17 | -0.09 | 0.01 | -5.83 | -3.13 | -0.32 | -3.37 | -0.64 | -1.56 | -1.40 | -0.91 | 3.40 | 0.54 | 0.34 | -0.80 | -2.49 |
| | Median | -0.73 | 1.16 | 0.40 | 0.14 | -1.92 | -2.27 | 0.63 | -0.74 | 0.18 | -0.99 | 0.73 | 0.08 | 5.90 | 2.38 | 0.56 | -0.70 | 0.97 |
| | Maximum | 1.18 | 3.30 | 1.35 | 0.65 | -0.22 | -0.42 | 2.33 | 0.23 | 0.79 | -0.01 | 3.06 | 2.16 | 8.56 | 3.81 | 1.09 | -0.21 | 4.08 |
| Rio Puerco | Number | 11 | 11 | 21 | 20 | 11 | 21 | 21 | 21 | 11 | 21 | 11 | 11 | 11 | 11 | 20 | 20 | 20 |
| | Minimum | -1.57 | 0.66 | 0.05 | -0.11 | -5.03 | -3.41 | -1.24 | -1.99 | -0.23 | -1.93 | 0.26 | -0.40 | 5.37 | 1.75 | 0.31 | -0.95 | -2.87 |
| | Median | -0.61 | 2.15 | 0.17 | 0.20 | -2.65 | -2.29 | 0.19 | -1.21 | 0.57 | -0.81 | 1.60 | 0.24 | 7.01 | 3.33 | 0.63 | -0.65 | 0.89 |
| | Maximum | -0.21 | 3.00 | 0.89 | 0.30 | 2.10 | -1.56 | 1.64 | -0.47 | 1.02 | -0.16 | 2.24 | 0.83 | 8.08 | 4.12 | 0.75 | -0.55 | 4.25 |
| Southwestern Mountain Front | Number | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| | Minimum | -3.67 | -3.28 | 0.43 | -0.34 | 1.39 | -3.18 | 0.27 | -1.62 | -1.01 | -2.01 | -3.36 | -2.57 | 1.05 | -1.04 | 0.07 | -1.17 | 0.26 |
| | Median | -3.67 | -3.28 | 0.51 | 0.03 | 1.39 | -2.88 | 0.69 | -1.08 | -1.01 | -2.00 | -3.36 | -2.57 | 1.05 | -1.04 | 0.48 | -0.83 | 1.77 |
| | Maximum | -3.67 | -3.28 | 0.59 | 0.40 | 1.39 | -2.59 | 1.11 | -0.54 | -1.01 | -1.98 | -3.36 | -2.57 | 1.05 | -1.04 | 0.89 | -0.50 | 3.28 |
| Abo Arroyo | Number | 4 | 4 | 5 | 5 | 4 | 5 | 5 | 5 | 4 | 5 | 4 | 4 | 4 | 4 | 5 | 5 | 5 |
| | Minimum | -2.05 | 0.58 | -0.27 | 0.06 | -6.23 | -2.92 | -0.68 | -1.87 | -0.15 | -1.96 | -0.21 | -0.85 | 4.71 | 1.97 | 0.51 | -0.80 | -2.05 |
| | Median | -1.70 | 1.58 | 0.02 | 0.16 | -4.04 | -2.32 | -0.17 | -1.04 | 0.31 | -1.14 | 0.84 | -0.71 | 6.03 | 2.71 | 0.59 | -0.68 | 0.06 |
| | Maximum | -0.98 | 1.95 | 0.33 | 0.42 | -1.91 | -1.96 | 0.50 | -0.82 | 0.69 | -0.67 | 0.95 | 0.58 | 6.23 | 3.26 | 0.86 | -0.42 | 2.20 |
| Eastern Mountain Front | Number | 64 | 64 | 80 | 80 | 64 | 80 | 80 | 80 | 64 | 80 | 64 | 64 | 64 | 64 | 80 | 80 | 80 |
| | Minimum | -8.49 | -10.28 | -0.68 | -1.95 | -11.81 | -5.32 | -2.46 | -3.55 | -1.59 | -3.34 | -9.20 | -6.94 | -4.55 | -5.38 | -1.50 | -2.81 | -5.19 |
| | Median | -1.29 | 2.36 | 0.05 | 0.26 | -4.10 | -2.45 | -0.60 | -1.62 | 0.61 | -2.25 | 1.27 | 0.22 | 6.68 | 3.42 | 0.69 | -0.59 | -0.87 |
| | Maximum | 0.30 | 5.30 | 0.58 | 0.65 | 4.67 | -1.67 | 1.29 | -0.25 | 1.84 | -1.47 | 4.30 | 1.76 | 10.54 | 5.99 | 1.09 | -0.22 | 5.14 |
| Tijeras Fault Zone | Number | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| | Minimum | -2.02 | -1.53 | -0.02 | -0.09 | -11.97 | -2.82 | -0.39 | -1.43 | -0.58 | -1.73 | -1.74 | -1.48 | 2.94 | 0.36 | 0.36 | -0.94 | -6.43 |
| | Median | -1.24 | 2.05 | 0.19 | 0.20 | -6.65 | -1.67 | 0.09 | -0.52 | 0.55 | -1.39 | 1.22 | -0.14 | 6.59 | 3.22 | 0.65 | -0.66 | -2.37 |
| | Maximum | -0.67 | 4.26 | 0.29 | 0.30 | -1.64 | -0.46 | 0.61 | 0.20 | 1.80 | -0.99 | 3.26 | 0.82 | 9.98 | 5.49 | 0.75 | -0.56 | 1.69 |
| Tijeras Arroyo | Number | 5 | 5 | 9 | 9 | 5 | 9 | 9 | 9 | 5 | 9 | 5 | 5 | 5 | 5 | 9 | 9 | 9 |
| | Minimum | -2.51 | 0.29 | -0.13 | 0.11 | -7.46 | -2.54 | -0.64 | -1.84 | -0.13 | -1.72 | -0.64 | -1.01 | 4.33 | 1.77 | 0.57 | -0.76 | -2.53 |
| | Median | -1.76 | 1.73 | 0.13 | 0.16 | -5.44 | -2.10 | -0.07 | -1.24 | 0.38 | -1.42 | 0.76 | -0.35 | 6.02 | 2.90 | 0.62 | -0.71 | -1.23 |
| | Maximum | -1.56 | 2.52 | 0.29 | 0.23 | -4.13 | -1.85 | 0.19 | -0.78 | 0.89 | -1.02 | 1.62 | -0.08 | 7.26 | 3.76 | 0.66 | -0.62 | -0.33 |
| Northeastern | Number | 8 | 8 | 10 | 10 | 8 | 10 | 10 | 10 | 8 | 10 | 8 | 8 | 8 | 8 | 10 | 10 | 10 |
| | Minimum | -1.72 | -0.18 | -0.32 | 0.05 | -6.64 | -3.04 | -1.00 | -1.78 | -0.27 | -1.94 | -0.73 | -0.94 | 4.18 | 1.34 | 0.50 | -0.81 | -4.12 |
| | Median | -0.76 | 2.04 | 0.10 | 0.44 | -4.27 | -2.12 | -0.17 | -1.42 | 0.28 | -0.95 | 1.27 | 0.47 | 6.42 | 3.00 | 0.88 | -0.42 | -0.36 |
| | Maximum | 0.03 | 3.80 | 0.50 | 0.71 | -0.53 | -0.76 | 0.53 | -0.86 | 0.96 | -0.44 | 2.84 | 1.38 | 8.37 | 4.54 | 1.15 | -0.14 | 3.17 |
| Central | Number | 174 | 174 | 217 | 216 | 174 | 217 | 217 | 213 | 174 | 217 | 174 | 174 | 174 | 174 | 216 | 216 | 216 |
| | Minimum | -1.91 | 0.28 | -1.08 | -2.23 | -11.56 | -4.00 | -2.57 | -3.17 | -0.55 | -3.22 | 0.27 | -0.32 | 5.11 | 1.28 | -1.80 | -3.07 | -9.30 |
| | Median | -0.38 | 3.05 | 0.05 | 0.52 | -2.99 | -2.57 | -0.41 | -1.76 | 0.49 | -1.94 | 2.43 | 1.24 | 7.72 | 3.66 | 0.97 | -0.33 | 0.83 |
| | Maximum | 1.09 | 6.23 | 1.06 | 0.77 | 6.51 | -1.02 | 1.59 | -1.07 | 1.62 | -0.89 | 5.40 | 2.69 | 11.49 | 6.31 | 1.23 | -0.07 | 8.08 |
| Discharge | Number | 4 | 4 | 7 | 7 | 4 | 7 | 7 | 7 | 4 | 7 | 4 | 4 | 4 | 4 | 7 | 7 | 7 |
| | Minimum | -0.62 | 1.61 | 0.03 | 0.21 | -2.09 | -3.30 | -0.18 | -1.23 | 0.03 | -1.59 | 1.43 | 0.43 | 6.58 | 2.52 | 0.65 | -0.64 | 0.36 |
| | Median | -0.39 | 2.04 | 0.18 | 0.39 | -1.56 | -2.51 | 0.36 | -0.75 | 0.37 | -1.27 | 1.60 | 0.71 | 6.93 | 3.08 | 0.83 | -0.45 | 1.52 |
| | Maximum | -0.10 | 2.61 | 0.65 | 0.54 | -0.81 | -2.45 | 1.13 | -0.14 | 0.51 | -0.94 | 2.11 | 1.01 | 7.32 | 3.36 | 0.98 | -0.31 | 6.24 |

[1] Log $CO_2$ partial pressure.

# Appendix D. Summary of quality-assurance and quality-control data

**Table D1.** Concentrations of major elements and selected trace elements in standard reference water samples

[NIST, National Institute of Standards and Technology; NRCC, National Research Council of Canada; mg/L, milligrams per liter; (2.7), provisional concentrations; nd, not determined]

| Element | High Purity standard TWDW (mg/L) | NIST standard reference material 1643D (mg/L) | NRCC standard reference SLRS-3 (mg/L) |
|---|---|---|---|
| Calcium | 35.0 | 31.04 ± 0.5 | 6 ± 0.4 |
| Magnesium | 9.0 | 7.989 ± 0.035 | 1.6 ± 0.2 |
| Potassium | 2.5 | 2.356 ± 0.035 | 0.70 ± 0.1 |
| Sodium | 6.0 | 22.07 ± 0.64 | 2.3 ± 0.2 |
| Silicon | nd | (2.7) | nd |
| Aluminum[1] | 120* | 127.6* ± 3.5 | 31* ± 3 |
| Iron[1] | 100* | 91.2* ± 3.9 | 100* ± 2 |
| Manganese[1] | 40* | 37.66* ± 0.83 | 3.9* ± 0.3 |
| Strontium[1] | 250* | 294.8* ± 3.4 | (28.1*) |

[1]Aluminum, iron, manganese, and strontium concentrations are in ug/L (micrograms per liter).

**Table D2.** Standard reference materials, recommended concentrations, measured concentrations by direct-current plasma spectroscopy, and measured standard deviations

[(35), provisional concentrations; mg/L, milligrams per liter; nd, not determined]

| Chemical or atomic symbol | Ca (mg/L) | Mg (mg/L) | Sr (mg/L) | Si (mg/L) | Na (mg/L) | K (mg/L) | Fe (mg/L) | Mn (mg/L) | Al (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| **1643D** | 31.0 | 8.0 | 0.29 | (2.7) | 22.1 | 2.4 | 0.10 | 0.04 | 0.12 |
| **Average of 5 analyses** | 30.3 | 8.2 | 0.32 | 2.8 | 21.3 | 2.5 | 0.12 | 0.04 | 0.12 |
| **Standard deviation** | 0.8 | 0.3 | 0.03 | 0.1 | 0.5 | 0.1 | 0.00 | 0.00 | 0.01 |
| **SLRS-3** | 6.0 | 1.6 | (0.028) | nd | 2.3 | 0.7 | 0.10 | 0.00 | 0.03 |
| **Average of 7 analyses** | 6.2 | 1.6 | 0.029 | 1.7 | 2.4 | 0.7 | 0.10 | 0.00 | 0.02 |
| **Standard deviation** | 0.1 | 0.0 | 0.001 | 0.0 | 0.1 | 0.1 | 0.00 | 0.00 | 0.00 |
| **TMDW** | 35.0 | 9.0 | 0.25 | nd | 6.0 | 2.5 | 0.10 | 0.04 | 0.12 |
| **Average of 5 analyses** | 34.7 | 9.1 | 0.25 | nd | 6.1 | 2.6 | 0.13 | 0.04 | 0.10 |
| **Standard deviation** | 0.4 | 0.4 | 0.02 | nd | 0.3 | 0.1 | 0.01 | 0.00 | 0.02 |
| **High Ca standard** | 50.0 | 20.0 | 2.0 | 20.0 | 10.0 | 10.0 | 2.00 | 2.00 | 0.50 |
| **Average of 24 analyses** | 50.3 | 20.0 | 2.0 | 19.7 | 9.8 | 9.9 | 1.98 | 1.99 | 0.49 |
| **Standard deviation** | 0.9 | 0.2 | 0.1 | 0.5 | 0.3 | 0.3 | 0.05 | 0.04 | 0.02 |
| **Low Ca high standard** | 20.0 | 5.0 | 0.5 | 10.0 | 5.0 | 2.0 | 0.50 | 0.50 | 0.10 |
| **Average of 6 analyses** | 20.3 | 5.1 | 0.5 | 9.8 | 4.9 | 2.0 | 0.47 | 0.51 | 0.10 |
| **Standard deviation** | 0.5 | 0.1 | 0.0 | 0.2 | 0.2 | 0.0 | 0.02 | 0.01 | 0.01 |
| **Low Ca standard** | 10.0 | nd | nd | nd | nd | nd | nd | nd | nd |
| **Average of 6 analyses** | 10.1 | nd | nd | nd | nd | nd | nd | nd | nd |
| **Standard deviation** | 0.2 | nd | nd | nd | nd | nd | nd | nd | nd |

**Table D3.** Standard reference materials, recommended concentrations, measured concentrations by ion chromatography, and measured standard deviations

[First row is the recommended concentration and accuracy; mg/L, milligrams per liter]

| Chemical or atomic symbol | Fluoride (mg/L) | | Chloride (mg/L) | | Nitrate (mg/L) | | Sulfate (mg/L) | |
|---|---|---|---|---|---|---|---|---|
| **High Purity Simulated rainwater** | 0.1 | ±0.01 | 0.98 | ±0.01 | 7.0 | ±0.2 | 10.1 | ±0.3 |
| **Average of 4 analyses** | 0.11 | | 1.0 | | 6.92 | | 10.3 | |
| **Standard deviation** | 0.0 | | 0.0 | | 0.04 | | 0.0 | |

**Table D4a.** Concentrations of trace elements in standard reference water samples and high purity working standards

[Concentrations are in ug/L (micrograms per liter); NIST, National Institute of Standards and Technology; NRCC, National Research Council of Canada; ERA, Environmental Research Associates; SRM, standard reference material; (35), provisional concentration; nd, not determined]

| Symbol of element | NIST water SRM 1643D | NRCC standard SLRS-3 | ERA standard WW-11 | ERA standard PW-34 | High Purity standard TMDW |
|---|---|---|---|---|---|
| Ag | 1.27 ±0.05 | nd | 108. | 106. | 2 ±0.01 |
| Al | 127.6 ±3.5 | 31 ±3 | 762. | 375. | 120 ±0.6 |
| As | 56.02 ±0.73 | 0.72 ±0.05 | 32.4 | 81.3 | 80 ±0.4 |
| B | 144.8 ±5.2 | nd | 431. | 156. | nd |
| Ba | 506.5 ±8.9 | 13.4 ±0.6 | 649. | 1130. | 50 ±0.25 |
| Be | 12.53 ±0.28 | 0.005 ±0.00 | 75.7 | 77.5 | 20 ±0.1 |
| Bi | (13) | nd | nd | nd | 10 ±0.05 |
| Cd | 6.47 ±0.37 | 0.013 ±0.00 | 59.5 | 56.3 | 10 ±0.05 |
| Co | 25.00 ±0.59 | 0.027 ±0.00 | 184. | nd | 25 ±0.13 |
| Cr | 18.53 ±0.2 | 0.30 ±0.04 | 119. | 375. | 20 ±0.1 |
| Cu | 20.5 ±3.8 | 1.35 ±0.07 | 238. | 688. | 20 ±0.1 |
| Fe | 91.2 ±3.9 | 100 ±2 | 276. | 225. | 100 ±0.5 |
| Li | 16.50 ±0.55 | nd | nd | nd | 20 ±0.1 |
| Mn | 37.66 ±0.83 | 3.9 ±0.3 | 432. | 125. | 40 ±0.2 |
| Mo | 112.9 ±1.7 | 0.19 ±0.01 | 541. | 313. | 100 ±0.5 |
| Ni | 58.1 ±2.7 | 0.83 ±0.08 | 324. | 225. | 60 ±0.3 |
| Pb | 18.15 ±0.64 | 0.068 ±0.00 | 297. | 56.3 | 40 ±0.2 |
| Rb | (13) | nd | nd | nd | 10 ±0.05 |
| Sb | 54.1 ±1.1 | 0.12 ±0.01 | 86.5 | 43.8 | 10 ±0.05 |
| Se | 11.43 ±0.17 | nd | 81.1 | 56.3 | 10 ±0.05 |
| Sr | 294.8 ±3.4 | (28.1) | 551. | nd | 250 ±1.25 |
| Te | (1) | nd | nd | nd | 3 ±0.02 |
| Tl | 7.28 ±0.25 | nd | 83.8 | 81.3 | 10 ±0.05 |
| U | nd | (0.045) | nd | nd | 10 ±0.05 |
| V | 35.1 ±1.4 | 0.30 ±0.02 | 314. | nd | 30 ±0.15 |
| Zn | 72.48 ±0.65 | 1.04 ±0.09 | 119. | 688. | 70 ±0.35 |

**Table D4b.** Concentrations of trace elements in standard reference water samples and high purity working standards-- Continued

| Symbol of Element | High Purity standards CWW-TM-A | High Purity standards CWW-TM-B | VHG Labs standards QCTM #1 | VHG Labs standards QCTM #2 |
|---|---|---|---|---|
| Ag | 10 ±0.1 | 50 ±0.3 | 69.0 | nd |
| Al | 50 ±0.3 | 200 ±1.0 | 68.48 | nd |
| As | 10 ±0.1 | 50 ±0.3 | 180.2 | nd |
| B | 50 ±0.3 | 200 ±1.0 | nd | 99.4 |
| Ba | 50 ±0.3 | 200 ±1.0 | 126.2 | nd |
| Be | 10 ±0.1 | 50 ±0.3 | 66.7 | nd |
| Cd | 10 ±0.1 | 50 ±0.3 | 79.3 | nd |
| Co | 50 ±0.3 | 200 ±1.0 | 397.9 | nd |
| Cr | 50 ±0.3 | 200 ±1.0 | 64.9 | nd |
| Cu | 50 ±0.3 | 200 ±1.0 | 342.1 | nd |
| Fe | 50 ±0.3 | 200 ±1.0 | 425.5 | nd |
| Mn | 50 ±0.3 | 200 ±1.0 | 412.1 | nd |
| Mo | 50 ±0.3 | 200 ±1.0 | nd | 294.3 |
| Ni | 50 ±0.3 | 200 ±1.0 | 72.7 | nd |
| Pb | 50 ±0.3 | 200 ±1.0 | 112.3 | nd |
| Sb | 10 ±0.1 | 50 ±0.3 | nd | 179.1 |
| Se | 10 ±0.1 | 50 ±0.3 | 50.4 | nd |
| Sr | 50 ±0.3 | 200 ±1.0 | nd | nd |
| Tl | 10 ±0.1 | 50 ±0.3 | 224.5 | nd |
| V | 50 ±0.3 | 200 ±1.0 | 65.2 | nd |
| Zn | 50 ±0.3 | 200 ±1.0 | 210.2 | nd |

**Table D5a.** Standard reference materials, recommended concentrations, measured concentrations by inductively-coupled plasma-mass spectroscopy, and measured standard deviations for the 1997 samples

[Concentrations are in µg/L (micrograms per liter); (3), number of analyses; <, less than; nd, not determined]

| Symbol of Element<br>Mass Number | Al<br>27 | As<br>75 | B<br>11 | Ba<br>135;137;138 | Cr<br>52 | Cu<br>63 | Li<br>7 | Mn<br>55 | Mo<br>95;97;98 | Pb<br>208 | Rb<br>85 | U<br>238 | V<br>51 | Zn<br>66;68 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1643D | 127.6 | 56 | 144 | 506 | 18.5 | 20.5 | 16.5 | 37.7 | 112.9 | 18.2 | (13) | nd | 35.1 | 72.5 |
| average (4) | 120.6 | 51.9 | 139.1 | 507 | 18.9 | 19.6 | 16.6 | 37.5 | 111.6 | 19.5 | 11.7 | nd | 35.9 | 69 |
| standard deviation | 3.8 | 0.4 | 3.4 | 12.2 | 0.6 | 0.6 | 1.2 | 1 | 0.9 | 0.3 | 0.1 | nd | 0.9 | 6.2 |
| CWW-TM-A | 50 | 10 | 50 | 50 | 50 | 50 | nd | 50 | 50 | 50 | nd | nd | 50 | 50 |
| average (5) | 51.1 | 10.4 | 48.9 | 49.4 | 49.4 | 48.6 | nd | 49.7 | 48.9 | 48.7 | nd | nd | 49.4 | 53.7 |
| standard deviation | 2.2 | 0.4 | 7.6 | 1.2 | 2.3 | 2.2 | nd | 3.4 | 1.5 | 4.3 | nd | nd | 3.4 | 1.9 |
| CWW-TM-B | 200 | 50 | 200 | 200 | 200 | 200 | nd | 200 | 200 | 200 | nd | nd | 200 | 200 |
| Average (5) | 193.1 | 50.6 | 186.5 | 201.1 | 196 | 187.8 | nd | 200 | 189.8 | 214.9 | nd | nd | 197.9 | 211.3 |
| standard deviation | 9.3 | 0.8 | 8.1 | 10.3 | 10.1 | 4.1 | nd | 9.9 | 1.5 | 5.8 | nd | nd | 7.4 | 4.7 |
| CWW-TM-E | 25 | 5 | 25 | 25 | 25 | 25 | nd | 25 | 25 | 25 | nd | nd | 25 | 25 |
| Average (6) | 26.1 | 5.1 | 24.9 | 24.2 | 25.3 | 25.2 | nd | 25.1 | 24.4 | 25 | nd | nd | 25.4 | 27.2 |
| Standard deviation | 2 | 0.1 | 1.5 | 1.3 | 1.4 | 0.9 | nd | 0.9 | 0.3 | 1.9 | nd | nd | 1.3 | 0.7 |
| PW-34 | 375 | 81.3 | 156 | 1130 | 375 | 688 | nd | 125 | 313 | 56.3 | nd | nd | nd | 688 |
| Average (5) | 372 | 82 | 171.6 | 1140.3 | 374 | 648 | nd | 123 | 309 | 58.9 | nd | nd | nd | 644 |
| Standard deviation | 13.8 | 1.4 | 5.2 | 45.2 | 16.1 | 37.9 | nd | 3.1 | 9.7 | 1.5 | nd | nd | nd | 27.5 |
| QCTM #1 | 68.5 | 180.2 | nd | 126.2 | 64.9 | 342 | nd | 412 | nd | 112.3 | nd | nd | 65.2 | 210.2 |
| Average (9) | 72 | 179 | nd | 134.6 | 64.8 | 334 | nd | 438 | nd | 112.5 | nd | nd | 65.9 | 204.1 |
| Standard deviation | 2.7 | 4.3 | nd | 9.8 | 1.3 | 12.4 | nd | 17 | nd | 11 | nd | nd | 1.4 | 4 |
| QCTM #2 | nd | nd | 99.4 | nd | nd | nd | nd | nd | 294 | nd | nd | nd | nd | nd |
| Average (8) | nd | nd | 94.9 | nd | nd | nd | nd | nd | 284 | nd | nd | nd | nd | nd |
| Standard deviation | nd | nd | 34.7 | nd | nd | nd | nd | nd | 7.8 | nd | nd | nd | nd | nd |
| SLRS-3 | 31 | 0.7 | nd | 13.4 | nd | 1.4 | nd | 3.9 | nd | 0.1 | nd | nd | 0.3 | 1 |
| Average (6) | 30.7 | 0.8 | nd | 13.5 | nd | 1.5 | nd | 3.8 | nd | 0.1 | nd | nd | 0.5 | 1.7 |
| Standard deviation | 1.2 | 0 | nd | 0.4 | nd | 0.1 | nd | 0.1 | nd | 0 | nd | nd | 0.2 | 0.1 |
| TMDW | 120 | 80 | nd | 50 | 20 | 20 | nd | 40 | 100 | 40 | 10 | 10 | 30 | 70 |
| Average (6) | 110.4 | 66.2 | nd | 46.9 | 19.6 | 17.3 | nd | 37.8 | 94.5 | 39.3 | 9.7 | 10.7 | 29.7 | 49.7 |
| Standard deviation | 4 | 1.2 | nd | 1.3 | 0.8 | 0.5 | nd | 0.6 | 1.2 | 1 | 0.2 | 0.6 | 0.9 | 1.8 |
| WW-11 | 762 | 32.4 | 431 | 649 | 119 | 238 | nd | 432 | 541 | 297 | nd | nd | 314 | 119 |
| Average (6) | 745 | 33.6 | 430 | 675 | 116 | 224 | nd | 423 | 559 | 311 | nd | nd | 318 | 127 |
| Standard deviation | 46.4 | 0.4 | 9.8 | 31.3 | 6.8 | 5.2 | nd | 22.3 | 13.7 | 3.9 | nd | nd | 17.8 | 6.4 |
| Blank(H2O+HNO3) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Average (11) | 1.7 | 0 | <10 | 0 | 0.4 | 0.1 | 0.1 | 0 | 0.7 | 0 | 0 | 0 | 0.1 | 0.3 |
| Standard deviation | 2.3 | 0.1 | nd | 0 | 1 | 0.1 | 0.5 | 0.1 | 0.5 | 0 | 0 | 0 | 0.1 | 0.2 |
| 1 ppb | 1 | 1 | nd | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Average (11) | 0.9 | 0.9 | nd | 0.9 | 1.3 | 1.3 | 1.1 | 1 | 1 | 1 | 1 | 1 | 1 | 1.8 |
| Standard deviation | 0.7 | 0.1 | nd | 0.2 | 1.3 | 0.6 | 0.6 | 0.1 | 0.2 | 0.1 | 0 | 0.2 | 0.1 | 0.6 |
| 10 ppb | 10 | 10 | nd | 10 | 10 | 10 | 10 | 10 | nd | 10 | 10 | 10 | 10 | 10 |
| Average (11) | 9.7 | 10.2 | nd | 11 | 10 | 10.4 | 9.1 | 10.2 | nd | 10.5 | 10.4 | 10.4 | 10.3 | 10.6 |
| Standard deviation | 0.7 | 0.1 | nd | 0.7 | 0.4 | 0.1 | 1.8 | 0.4 | nd | 0.3 | 0 | 1 | 0.3 | 0.2 |
| 20 ppb | 20 | 20 | nd | 20 | 20 | 20 | 20 | 20 | nd | 20 | 20 | 20 | 20 | 20 |
| Average (6) | 19.2 | 20 | nd | 21.1 | 20.3 | 19.7 | 19.2 | 20.2 | nd | 21 | 20.4 | 21.3 | 20.2 | 20.3 |
| Standard deviation | 0.8 | 0.5 | nd | 0.9 | 0.5 | 0.5 | 1.7 | 0.3 | nd | 1.3 | 0.2 | 1.6 | 0.6 | 0.6 |
| 100 ppb | 100 | 100 | nd | 100 | 100 | 100 | 100 | 100 | nd | 100 | 100 | 100 | 100 | 100 |
| Average (3) | 99.3 | 102.4 | nd | 104.4 | 101 | 98.3 | 100 | 98.4 | nd | 96.9 | 110.4 | 111 | 102.5 | 100.4 |
| Standard deviation | 1.5 | 2.9 | nd | 1.2 | 1.8 | 2.1 | 6.6 | 3 | nd | 5.6 | 8.7 | 6.9 | 1 | 2.8 |

**Table D5b.** Standard reference materials, recommended concentrations, measured concentrations by inductively-coupled plasma-mass spectroscopy, and measured standard deviations

| Symbol of element | Se | Rb | Sr | Mo | Mo | Mo | Cd | Cs | Ba | Ba | Ba | Tl | Pb | U |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mass number** | 82 | 85 | 88 | 95 | 97 | 98 | 111 | 133 | 135 | 137 | 138 | 205 | 208 | 238 |
| CWW-TM-A | 10 | nd | 50 | 50 | 50 | 50 | 10 | nd | 50 | 50 | 50 | 10 | 50 | nd |
| Average (3) | 12.0 | 0.0 | 49.9 | 49.1 | 49.3 | 49.2 | 10.4 | 0.4 | 49.4 | 49.5 | 50.6 | 10.1 | 50.9 | 0.00 |
| STD | 0.00 | 0.00 | 0.33 | 0.7 | 0.62 | 0.71 | 0.36 | 0.02 | 1.61 | 1.7 | 2.31 | 0.16 | 0.93 | 0.00 |
| CWW-TM-B | 50 | nd | 200 | 200 | 200 | 200 | 50 | nd | 200 | 200 | 200 | 50 | 200 | nd |
| Average (5) | 56 | 0.0 | 201 | 197 | 196 | 197 | 52 | 0 | 198 | 199 | 203 | 51 | 206 | 0 |
| STD | 1.7 | 0.0 | 2.5 | 2.8 | 2.6 | 2.4 | 0.8 | 0.0 | 5.0 | 5.2 | 6.1 | 1.0 | 0.5 | 0.0 |
| CWW-TM-E | 5 | nd | 25 | 25 | 25 | 25 | 25 | nd | 25 | 25 | 25 | 5 | 25 | nd |
| Average (3) | 6 | 0.0 | 25 | 24 | 25 | 24 | 26 | 0.0 | 25 | 25 | 25 | 5 | 26 | 0 |
| STD | 0.0 | 0.0 | 0.2 | 0.4 | 0.4 | 0.4 | 0.6 | 0.0 | 0.8 | 0.8 | 1.1 | 0.1 | 0.3 | 0 |
| 1643d | 11 | 13 | 295 | 113 | 113 | 113 | 6.47 | nd | 506 | 506 | 506 | 7.28 | 18.2 | nd |
| Average (6) | 10 | 11 | 295 | 114 | 114 | 113 | 6.00 | 4.5 | 497 | 520 | 506 | 7.34 | 18.0 | 0 |
| STD | 0.5 | 0.1 | 3.0 | 0.9 | 0.8 | 0.7 | 0.08 | 0.2 | 11.0 | 9.1 | 11.5 | 0.19 | 0.3 | 0 |
| SLRS-3 | nd | nd | 28.1 | 0.19 | 0.19 | 0.19 | 0.013 | nd | 13.4 | 13.4 | 13.4 | nd | 0.068 | 0.05 |
| Average (4) | 0.35 | 1.65 | 32.0 | 0.28 | 0.28 | 0.3 | 0.015 | 0.02 | 13.9 | 13.9 | 14.0 | 0.02 | 0.070 | 0.05 |
| STD | 0.11 | 0.05 | 0.5 | 0.04 | 0.04 | 0 | 0.004 | 0.01 | 0.2 | 0.2 | 0.4 | 0.00 | 0.000 | 0.00 |
| QCTM #1 | 50 | nd | nd | nd | nd | nd | 79.3 | nd | 126.2 | 126.2 | 126.2 | 224.5 | 112.3 | nd |
| Average (6) | 55.5 | 0.01 | 106.5 | 0.10 | 0.08 | 0.10 | 80.1 | 0.001 | 123.7 | 124.5 | 127.5 | 231.8 | 115 | 0.00 |
| STD | 1.3 | 0.00 | 1.0 | 0.06 | 0.07 | 0.06 | 1.5 | 0.004 | 2.6 | 2.9 | 2.2 | 4.8 | 2.1 | 0.00 |
| QCTM #2 | nd | nd | nd | 294.3 | 294.3 | 294.3 | nd | nd | nd | nd | nd | nd | nd | nd |
| Average (4) | 0.25 | 0.01 | 0.00 | 290.5 | 289 | 307.7 | 0.81 | 0.01 | 0.00 | 0.20 | 0.00 | 0.06 | 0.29 | 0.00 |
| STD | 0.11 | 0.00 | 0.00 | 2.2 | 2.9 | 14.2 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.02 | 0.00 |
| 1 ppb | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Average (8) | 1.15 | 0.96 | 0.95 | 0.98 | 0.95 | 0.96 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.99 | 0.97 | 1.00 |
| STD | 0.15 | 0.01 | 0.05 | 0.04 | 0.05 | 0.05 | 0.02 | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 0.02 | 0.04 |
| 5 ppb | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| Average (8) | 5.24 | 4.85 | 4.86 | 4.74 | 4.75 | 4.74 | 4.94 | 4.93 | 4.86 | 4.85 | 4.91 | 4.96 | 4.94 | 5.05 |
| STD | 0.14 | 0.07 | 0.10 | 0.05 | 0.05 | 0.05 | 0.09 | 0.19 | 0.14 | 0.13 | 0.19 | 0.14 | 0.10 | 0.17 |
| 10 ppb | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| Average (9) | 10.9 | 10.0 | 10.1 | 0.2 | 0.1 | 0.2 | 10.2 | 10.1 | 10.1 | 10.1 | 10.1 | 10.3 | 10.2 | 10.5 |
| STD | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.1 | 0.3 | 0.2 | 0.2 | 0.3 | 0.2 | 0.2 | 0.3 |
| 50 ppb | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| Average (7) | 52.4 | 50.7 | 50.9 | 49.7 | 49.8 | 49.8 | 51.5 | 52.7 | 50.5 | 50.8 | 51.3 | 52.5 | 51.4 | 54.1 |
| STD | 0.5 | 0.5 | 0.5 | 0.3 | 0.3 | 0.3 | 0.9 | 0.8 | 1.1 | 1.1 | 1.5 | 1.3 | 0.9 | 1.6 |
| 20 ppb | 20.0 | 20.0 | 20.0 | nd | nd | nd | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |
| Average (5) | 21.2 | 20.0 | 20.2 | nd | nd | nd | 20.4 | 20.3 | 20.0 | 20.1 | 20.3 | 20.8 | 20.6 | 21.3 |
| STD | 0.4 | 0.2 | 0.3 | nd | nd | nd | 0.5 | 0.7 | 0.5 | 0.5 | 0.7 | 0.5 | 0.4 | 0.7 |
| 100 ppb (1) | 104 | 103 | 103 | 98.7 | 98.5 | 98.8 | 101 | 102 | 102 | 102 | 104 | 104 | 102 | 104 |
| HNO3 blank (5) | 0.08 | 0.00 | 0.00 | 0.08 | 0.08 | 0.08 | 0.00 | 0.00 | 0.00 | -0.01 | -0.01 | -0.01 | 0.00 | 0.00 |
| STD | 0.07 | 0.00 | 0.00 | 0.04 | 0.04 | 0.04 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.02 | 0.01 | 0.00 |
| 100 ppm Ca (3) | 0.30 | 0.00 | 2.00 | 0.20 | 0.20 | 0.20 | 0.00 | 0.00 | 0.17 | 0.20 | 0.20 | 0.00 | 0.04 | 0.00 |
| STD | 0.08 | 0.00 | 0.08 | 0.28 | 0.28 | 0.28 | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| 200 ppm Cl (3) | 0.30 | 0.00 | 0.00 | 0.03 | 0.03 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| STD | 0.00 | 0.00 | 0.00 | 0.05 | 0.05 | 0.05 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**Table D6a.** Concentrations of major and trace metals by ICP-MS in blank water acidified with reagent grade and Baker Chemical Co. Ultrex nitric acid.

[µg/L, micrograms per liter; mg/L, milligrams per liter]

| Symbol of element | Al (µg/L) | As (µg/L) | B (µg/L) | Be (µg/L) | Cd (µg/L) | Co (µg/L) | Cr (µg/L) | Cs (µg/L) | Cu (µg/L) | Fe (µg/L) | Li (µg/L) | Mn (µg/L) | Mo (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reagent grade nitric | 3 | <0.1 | 5 | <0.1 | <0.1 | <0.1 | <1 | <0.1 | <0.1 | <10 | <0.1 | <0.1 | <0.1 |
| Ultrex nitric | 4 | <0.1 | 5 | <0.1 | <0.1 | <0.1 | <1 | <0.1 | <0.1 | <10 | <0.1 | <0.1 | <0.1 |

| Symbol of element | Ni (µg/L) | Pb (µg/L) | Rb (µg/L) | Se (µg/L) | Sr (µg/L) | Tl (µg/L) | U (µg/L) | V (µg/L) | Zn (µg/L) | Ca (mg/L) | Mg (mg/L) | K (mg/L) | Na (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reagent grade nitric | 1.1 | <0.1 | <0.1 | <1 | <0.1 | <0.1 | <1 | <0.1 | <1 | <0.1 | <0.05 | <0.1 | <0.05 |
| Ultrex nitric | 0.1 | <0.1 | <0.1 | <1 | <0.1 | <0.1 | <1 | <0.1 | <1 | <0.1 | <0.05 | <0.1 | <0.05 |

**Table D6b.** Concentration of major elements by DCP in a blank water-sample (lot 95171) acidified in the field. The water sample was obtained from the U.S. Geological Survey Water Quality Laboratory, Ocala, Florida.

[mg/L, milligrams per liter]

| Symbol of element | Ca (mg/L) | Mg (mg/L) | Sr (mg/L) | Si (mg/L) | Na (mg/L) | K (mg/L) | Fe (mg/L) | Mn (mg/L) | Al (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| Concentration | <0.3 | <0.05 | <0.01 | <0.05 | <0.05 | <0.1 | <0.01 | <0.003 | <0.005 |

**Table D7a.** Concentrations of selected major and trace metals in 9 ground-water samples passed through different pore-sized filters

[mg/L, milligrams per liter; µg/L, micrograms per liter; µ, microns; d, daltons, 1 dalton=1.66x10$^{24}$ grams; all samples were filtered during field collection]

| Site no. | Sample no. | Site name | Type of filter | Filter size | Ca (mg/L) | Mg (mg/L) | Sr (mg/L) | SiO2 (mg/L) | Na (mg/L) | K (mg/L) | Fe (mg/L) | Mn (mg/L) | Al (mg/L) | B (mg/L) | Ba (mg/L) | Li (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S003 | NM481 | 98th St D | cartridge | 0.45 µ | 5.6 | 1.09 | 0.53 | 27.4 | 360 | 3.5 | 0.02 | 0.005 | 0.008 | 0.843 | 0.035 | 0.264 |
| | | | tangential | 0.1 µ | 5.6 | 1.09 | 0.53 | 27.4 | 373 | 3.5 | 0.03 | 0.005 | 0.008 | 0.832 | 0.034 | 0.264 |
| | | | tangential | 30,000 d | 5.4 | 1.05 | 0.51 | 26.7 | 360 | 3.5 | 0.02 | 0.005 | 0.012 | 0.832 | 0.034 | 0.273 |
| S004 | NM482 | 98th St MD | cartridge | 0.45 µ | 1.8 | 0.09 | 0.07 | 20.2 | 140 | 1.2 | 0.01 | 0.009 | 0.032 | 0.296 | 0.012 | 0.078 |
| | | | membrane | 0.2 µ | 2.1 | 0.21 | 0.07 | 22.4 | 139 | 1.3 | 0.15 | 0.013 | 0.313 | 0.293 | 0.016 | 0.079 |
| | | | tangential | 0.1 µ | 1.7 | 0.09 | 0.06 | 20.3 | 140 | 1.2 | 0.02 | 0.009 | 0.034 | 0.291 | 0.012 | 0.077 |
| S005 | NM483 | 98th St MS | cartridge | 0.45 µ | 5.3 | 0.72 | 0.20 | 16.5 | 162 | 2.8 | 0.02 | 0.039 | 0.010 | 0.368 | 0.037 | 0.048 |
| | | | tangential | 0.1 µ | 5.3 | 0.72 | 0.20 | 16.2 | 165 | 2.8 | 0.02 | 0.038 | 0.014 | 0.365 | 0.037 | 0.048 |
| | | | tangential | 30,000 d | 5.2 | 0.73 | 0.20 | 16.2 | 157 | 2.9 | 0.02 | 0.037 | 0.014 | 0.368 | 0.037 | 0.060 |
| S088 | NM494 | Isleta MS | cartridge | 0.45 µ | 30.2 | 4.68 | 0.29 | 37.9 | 22.0 | 5.1 | 0.03 | 0.074 | 0.005 | 0.056 | 0.058 | 0.030 |
| | | | tangential | 0.1 µ | 30.4 | 4.68 | 0.28 | 38.1 | 21.4 | 5.2 | 0.04 | 0.074 | 0.007 | 0.054 | 0.058 | 0.030 |
| S089 | NM495 | Isleta S | cartridge | 0.45 µ | 119 | 16.10 | 0.91 | 38.7 | 59.2 | 7.5 | 0.43 | 1.260 | 0.004 | 0.126 | 0.169 | 0.069 |
| | | | tangential | 0.1 µ | 118 | 16.10 | 0.90 | 38.5 | 58.4 | 7.4 | 0.43 | 1.260 | 0.004 | 0.122 | 0.167 | 0.067 |
| S210 | NM511 | Sandia D | cartridge | 0.45 µ | 24.1 | 6.78 | 0.31 | 55.0 | 92.9 | 7.4 | 0.03 | 0.104 | 0.016 | 0.150 | 0.064 | 0.119 |
| | | | membrane | 0.2 µ | 25.3 | 7.09 | 0.33 | 55.8 | 91.0 | 7.7 | 0.09 | 0.104 | 0.093 | 0.154 | 0.067 | 0.117 |
| | | | tangential | 0.1 µ | 24.4 | 6.62 | 0.30 | 56.5 | 89.6 | 7.5 | 0.03 | 0.101 | 0.020 | 0.145 | 0.065 | 0.115 |
| S211 | NM512 | Sandia M | cartridge | 0.45 µ | 24.3 | 4.83 | 0.26 | 61.0 | 122 | 8.5 | 0.02 | 0.023 | 0.009 | 0.263 | 0.058 | 0.217 |
| | | | membrane | 0.2 µ | 24.3 | 4.90 | 0.27 | 60.8 | 126 | 8.6 | 0.04 | 0.023 | 0.056 | 0.255 | 0.059 | 0.215 |
| | | | tangential | 0.1 µ | 24.4 | 4.84 | 0.26 | 62.5 | 123 | 8.6 | 0.03 | 0.020 | 0.008 | 0.256 | 0.059 | 0.213 |
| S229 | NM515 | SH03 UNM | cartridge | 0.45 µ | 67.0 | 8.04 | 0.17 | 19.8 | 13.1 | 1.6 | 0.03 | <0.001 | 0.004 | 0.020 | 0.055 | 0.009 |
| | | | tangential | 0.1 µ | 67.9 | 7.87 | 0.16 | 19.5 | 13.5 | 1.8 | 0.04 | <0.001 | 0.014 | 0.020 | 0.056 | 0.009 |
| S230 | NM516 | Sierra Vista D | cartridge | 0.45 µ | 6.2 | 0.50 | 0.14 | 18.5 | 172 | 1.6 | 0.02 | 0.008 | 0.022 | 0.464 | 0.024 | 0.099 |
| | | | membrane | 0.2 µ | 6.3 | 0.61 | 0.14 | 22.7 | 169 | 1.6 | 0.22 | 0.010 | 0.399 | 0.465 | 0.027 | 0.098 |
| | | | tangential | 0.1 µ | 6.2 | 0.51 | 0.14 | 18.5 | 171 | 1.6 | 0.01 | <0.01 | 0.021 | 0.452 | 0.024 | 0.097 |

**Table D7b.** Concentrations of selected major and trace metals in 9 ground-water samples passed through different pore-sized filters--Continued

| Site no. | Sample no. | Site name | Type of filter | Filter size | V (µg/L) | Cr (µg/L) | Co (µg/L) | Cu (µg/L) | Rb (µg/L) | Mo (µg/L) | Zn (µg/L) | As (µg/L) | Se (µg/L) | Pb (µg/L) | U (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S003 | NM481 | 98th St D | cartridge | 0.45 µ | 53.0 | 10 | <0.05 | 0.4 | 2.2 | 15 | <1 | 39 | 1 | <0.05 | 15 |
| | | | tangential | 0.1 µ | 53.7 | 9 | <0.05 | 0.5 | 2.2 | 15 | <1 | 38 | <1 | <0.05 | 15 |
| | | | tangential | 30,000 d | 52.7 | 9 | <0.05 | 1.5 | 2.2 | 15 | <1 | 38 | <1 | 0.3 | 15 |
| S004 | NM482 | 98th St MD | cartridge | 0.45 µ | 12.0 | 4 | <0.05 | <0.1 | 0.6 | 5.8 | <1 | 52 | <1 | <0.05 | 86 |
| | | | membrane | 0.2 µ | 13.7 | 6 | <0.05 | 1.2 | 0.9 | 5.9 | 8 | 52 | <1 | 0.3 | 88 |
| | | | tangential | 0.1 µ | 13.1 | 4 | 0.20 | 0.2 | 0.6 | 5.8 | <1 | 52 | <1 | 0.1 | 85 |
| S005 | NM483 | 98th St MS | cartridge | 0.45 µ | <0.1 | <1 | <0.05 | 0.1 | 5.3 | 10 | <1 | 12 | <1 | <0.05 | 6.0 |
| | | | tangential | 0.1 µ | <0.1 | 2 | <0.05 | 0.2 | 4.9 | 10 | <1 | 12 | <1 | 0.1 | 6.0 |
| | | | tangential | 30,000 d | 0.2 | <1 | <0.05 | 0.4 | 4.4 | 9.7 | <1 | 12 | <1 | 0.2 | 5.9 |
| S088 | NM494 | Isleta MS | cartridge | 0.45 µ | 4.9 | <1 | 0.13 | 0.2 | 6.6 | 4.6 | 2 | 6 | <1 | <0.05 | 1.5 |
| | | | tangential | 0.1 µ | 4.9 | <1 | 0.13 | 0.8 | 6.7 | 4.5 | 3 | 6 | <1 | <0.05 | 1.5 |
| S089 | NM495 | Isleta S | cartridge | 0.45 µ | <0.1 | <1 | 0.21 | 0.7 | 5.2 | 7.6 | 3 | 3 | <1 | <0.05 | 1.9 |
| | | | tangential | 0.1 µ | <0.1 | <1 | 0.21 | 0.7 | 5.2 | 7.6 | 3 | 3 | <1 | <0.05 | 1.9 |
| S210 | NM511 | Sandia D | cartridge | 0.45 µ | 13.9 | 2 | 0.24 | 0.4 | 7.1 | 20 | 3 | 27 | 2 | <0.05 | 5.3 |
| | | | membrane | 0.2 µ | 13.9 | 2 | 0.24 | 1.5 | 7.1 | 19 | 9 | 26 | 2 | 0.2 | 5.2 |
| | | | tangential | 0.1 µ | 14.2 | 2 | 0.18 | 0.5 | 7.2 | 18 | 3 | 27 | 2 | 0.1 | 5.3 |
| S211 | NM512 | Sandia M | cartridge | 0.45 µ | 20.1 | 2 | 0.13 | 0.2 | 11 | 8.2 | 3 | 47 | 2 | <0.05 | 2.8 |
| | | | membrane | 0.2 µ | 19.9 | 2 | 0.05 | 0.5 | 11 | 8.1 | 6 | 47 | 2 | 0.1 | 2.8 |
| | | | tangential | 0.1 µ | 20.0 | 1 | <0.05 | 0.2 | 11 | 8.0 | 3 | 47 | 3 | <0.05 | 2.7 |
| S229 | NM515 | SH03 UNM | cartridge | 0.45 µ | 1.2 | <1 | 0.09 | 0.4 | 0.5 | 2.0 | 3 | 1 | 1 | 0.1 | 15 |
| | | | tangential | 0.1 µ | 1.2 | <1 | 0.09 | 2.6 | 0.5 | 2.0 | 5 | <1 | 1 | 0.2 | 15 |
| S230 | NM516 | Sierra Vista D | cartridge | 0.45 µ | <0.1 | <1 | <0.05 | 0.9 | 0.9 | 8.2 | 2 | 24 | <1 | <0.05 | 2.3 |
| | | | membrane | 0.2 µ | 0.3 | <1 | 0.13 | 1.4 | 1.2 | 7.9 | 31 | 23 | <1 | 0.5 | 2.4 |
| | | | tangential | 0.1 µ | <0.1 | <1 | <0.05 | 1.0 | 0.9 | 8.1 | 3 | 23 | 1 | 0.1 | 2.3 |

**Table D8.** Concentrations of selected trace metals in 5 ground-water samples filtered through 0.45-micron cartridge filters in the field and then through 0.2- or 0.1-micron membrane filters in the laboratory

[µg/L, micrograms per liter; µ, microns]

| Site no. | Sample no. | Site name | Filter size (µ) | Ba (µg/L) | V (µg/L) | Cr (µg/L) | Co (µg/L) | Cu (µg/L) | Rb (µg/L) | Mo (µg/L) | Zn (µg/L) | As (µg/L) | Se (µg/L) | Pb (µg/L) | U (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S003 | NM481 | 98th St. D | 0.45 | 41 | 55 | 14 | <0.1 | 0.3 | 2.3 | 15 | 5 | 40 | 3 | 0.2 | 16 |
| | | | 0.2 | 37 | 60 | 5 | <0.1 | 0.7 | 2.2 | 15 | 3 | 39 | 1 | 0.1 | 15 |
| | | | 0.1 | 43 | 64 | 6 | <0.1 | 0.9 | 2.2 | 17 | 5 | 43 | 2 | 0.2 | 13 |
| S016 | NM258 | Windmill #15 | 0.45 | 13 | 60 | 16 | <0.1 | 4.6 | 4.1 | 31 | 259 | 155 | 14 | 0.3 | 8.5 |
| | | | 0.2 | 12 | 31 | 4 | <0.1 | 2.1 | 3.8 | 33 | 134 | 157 | 13 | 0.1 | 8.3 |
| | | | 0.1 | 12 | 34 | 6 | <0.1 | 2.1 | 4.0 | 36 | 131 | 160 | 14 | 0.1 | 7.5 |
| S060 | NM279 | Garfield D | 0.45 | 40 | 37 | 2 | <0.1 | 0.1 | 4.4 | 3.0 | 2 | 51 | <1 | <0.1 | 3.6 |
| | | | 0.2 | 36 | 40 | 3 | <0.1 | 0.6 | 4.0 | 2.9 | 2 | 48 | <1 | <0.1 | 4.0 |
| | | | 0.1 | 38 | 43 | 5 | <0.1 | 0.5 | 4.1 | 3.1 | 4 | 54 | <1 | 0.1 | 3.4 |
| S149 | NM312 | Nor Este D | 0.45 | 56 | 35 | <1 | <0.1 | 0.4 | 9.9 | 8.6 | 5 | 54 | 1 | <0.1 | 2.0 |
| | | | 0.2 | 49 | 38 | 5 | <0.1 | 0.4 | 9.0 | 8.6 | 3 | 53 | 1 | <0.1 | 2.0 |
| | | | 0.1 | 53 | 41 | 4 | <0.1 | 0.2 | 9.5 | 9.4 | 3 | 60 | 2 | <0.1 | 1.6 |
| S173 | NM323 | Rio Bravo 5M | 0.45 | 38 | 15 | <1 | <0.1 | 0.6 | 5.9 | 9.9 | 5 | 21 | <1 | <0.1 | 4.3 |
| | | | 0.2 | 33 | 17 | 3 | <0.1 | 0.8 | 5.4 | 9.6 | 4 | 20 | <1 | <0.1 | 4.0 |
| | | | 0.1 | 83 | 18 | 3 | <0.1 | 2.0 | 5.7 | 11 | 10 | 23 | <1 | 0.2 | 3.5 |

**Table D9.** Comparison of water temperature and excess air calculated from dissolved gas analyses of laboratory water samples equilibrated with air and analyzed with the MRGB samples, 1996 through 1998

[ºC, degrees Celsius; cc/kg $H_2O$, cubic centimeters of dry excess air at 0 degrees Celsius and one atmosphere pressure per kilogram of water]

| Sampling year | Number of water standards | Average bath (ºC) | Calculated temperature (ºC) | Observed minus calculated (ºC) | Standard deviation | Calculated excess air (cc/kg of H2O) | Standard deviation |
|---|---|---|---|---|---|---|---|
| 1996 | 3 | 5.7 | 6.0 | -0.3 | 0.8 | 0.3 | 0.3 |
| 1996 | 30 | 24.23 | 24.4 | -0.1 | 0.8 | 0.0 | 0.3 |
| 1997 | 6 | 8.98 | 9.0 | -0.1 | 0.3 | 0.4 | 0.5 |
| 1997 | 5 | 16.0 | 16.1 | -0.1 | 0.4 | 0.1 | 0.1 |
| 1997 | 9 | 24.54 | 24.4 | 0.1 | 0.5 | 0.0 | 0.2 |
| 1998 | 6 | 9.2 | 9.1 | 0.1 | 0.3 | -0.2 | 0.3 |
| 1998 | 6 | 16.05 | 16.5 | -0.5 | 0.3 | -0.2 | 0.1 |
| 1998 | 6 | 25.53 | 25.8 | -0.2 | 0.6 | -0.1 | 0.1 |

## **Table D10.** Summary of QA/QC data for radiocarbon activity measurements

[δ=(($R_{sample}$/$R_{standard}$) –1)x1000, where R is an isotope ratio; $^{o}/_{oo}$, per mil; $\delta^{13}C$, carbon-13; pmC, percent modern carbon; S, analyzed from a water sample in a septum bottle; P, analyzed from a powder of $BaCO_3$; Group: 1, compare original powder determination to septum bottle collected at same time but stored about 1 year; 2, re-run $BaCO_3$ powder about 1 year after initial sample run; 3, re-sample the well a year later and run a new septum bottle (both samples from septum bottles); 4, re-run archived duplicate septum bottle; 5, extract second aliquot of $CO_2$ from original powder; Libby half-life, 5,568 years]

| | | | First Analysis | | | | | | Repeated Analysis | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site no. | Sample no. | Site name | $\delta^{13}C$ ($^{o}/_{oo}$) | $^{14}C$ activity (pmC) | ± (pmC) | S or P | $^{14}C$ age Libby half-life (years) | $^{14}C$ age 5,730 half-life (years) | $\delta^{13}C$ ($^{o}/_{oo}$) | $^{14}C$ activity (pmC) | ± (pmC) | S or P | $^{14}C$ age Libby half-life (years) | $^{14}C$ age 5,730 half-life (years) | Group |
| S007 | NM002 | Domestic Well #01 | -11.8 | 113.40 | 0.96 | P | -1,010 | -1,040 | -12.1 | 113.56 | 0.94 | S | -1,021 | -1,051 | 1 |
| S133 | NM091 | Montaňo 6D | -9.6 | 25.19 | 0.23 | P | 11,075 | 11,397 | -9.9 | 21.96 | 0.21 | S | 12,177 | 12,532 | 1 |
| S254 | NM168 | Private Production Well #12 | -10.8 | 92.03 | 0.81 | P | 667 | 687 | -10.0 | 92.11 | 0.79 | S | 660 | 679 | 1 |
| S247 | NM161 | Domestic Well #19 | -8.4 | 4.86 | 0.14 | P | 24,293 | 24,999 | -8.8 | 4.71 | 0.12 | S | 24,544 | 25,259 | 1 |
| S245 | NM159 | SWAB 3-980 | -9.1 | 44.08 | 0.37 | P | 6,580 | 6,772 | -12.5 | 39.47 | 0.33 | S | 7,468 | 7,685 | 1 |
| S071 | NM060 | Domestic Well #07 | -8.7 | 97.48 | 0.80 | P | 205 | 211 | -10.2 | 94.58 | 1.10 | S | 448 | 461 | 1 |
| S026 | NM013 | Burton 5 | -9.3 | 44.66 | 0.37 | P | 6,475 | 6,664 | -9.0 | 42.41 | 0.39 | S | 6,891 | 7,091 | 1 |
| S111 | NM079 | Domestic Well #10 | -6.7 | 54.73 | 0.46 | P | 4,842 | 4,983 | -5.1 | 61.42 | 0.51 | P | 3,916 | 4,029 | 2 |
| S239 | NM156 | Domestic Well #17 | -8.7 | 22.00 | 0.26 | P | 12,163 | 12,517 | -8.6 | 22.92 | 0.23 | P | 11,834 | 12,178 | 2 |
| S283 | NM181 | Zia Ball Park D | -6.1 | 18.34 | 0.23 | P | 13,625 | 14,021 | -6.4 | 23.29 | 0.22 | P | 11,705 | 12,046 | 2 |
| S054 | NM041 | Domestic Well #04 | -7.6 | 29.28 | 0.30 | P | 9,867 | 10,154 | -7.0 | 32.94 | 0.30 | P | 8,920 | 9,180 | 2 |
| S008 | NM003 | Private Production Well #01 | -7.9 | 5.47 | 0.10 | P | 23,343 | 24,022 | -8.5 | 6.92 | 0.14 | P | 21,454 | 22,078 | 2 |
| S276 | NM179 | Windmill #12 | -7.7 | 38.08 | 0.38 | P | 7,756 | 7,981 | -7.1 | 39.68 | 0.33 | P | 7,425 | 7,641 | 2 |
| S218 | NM145 | Santa Ana Boundary M | -7.0 | 8.24 | 0.12 | P | 20,052 | 20,635 | -7.7 | 10.45 | 0.13 | P | 18,143 | 18,671 | 2 |
| S170 | NM108 | Ridgecrest 3 | -12.2 | 70.25 | 0.72 | P | 2,837 | 2,919 | -11.9 | 69.43 | 0.66 | P | 2,931 | 3,016 | 2 |
| S198 | NM137 | Windmill #07 | -4.7 | 84.49 | 0.71 | P | 1,354 | 1,393 | -3.8 | 87.76 | 0.73 | P | 1,049 | 1,079 | 2 |
| S193 | NM129 | Rio Rancho 9 | -7.9 | 7.72 | 0.12 | P | 20,575 | 21,174 | -8.6 | 8.34 | 0.13 | P | 19,955 | 20,535 | 2 |
| S187 | NM131 | Rio Rancho 12 | -9.6 | 24.84 | 0.23 | S | 11,188 | 11,513 | -8.9 | 32.54 | 0.26 | P | 9,019 | 9,281 | 2 |
| S188 | NM132 | Rio Rancho 13 | -7.2 | 3.00 | 0.09 | P | 28,168 | 28,987 | -7.9 | 4.16 | 0.10 | P | 25,542 | 26,285 | 2 |
| S120 | NM304 | Mesa Del Sol D | -10.8 | 19.27 | 0.15 | S | 13,227 | 13,612 | -10.7 | 17.84 | 0.15 | S | 13,847 | 14,249 | 3 |
| S153 | NM315 | Open Space | -8.3 | 55.15 | 0.51 | S | 4,781 | 4,920 | -7.8 | 54.39 | 0.38 | S | 4,892 | 5,034 | 3 |
| S150 | NM313 | Nor Este M | -8.6 | 17.12 | 0.19 | S | 14,177 | 14,590 | -8.4 | 17.18 | 0.16 | S | 14,149 | 14,561 | 3 |
| S149 | NM312 | Nor Este D | -8.7 | 7.96 | 0.11 | S | 20,329 | 20,921 | -8.8 | 8.01 | 0.10 | S | 20,279 | 20,869 | 3 |
| S044 | NM268 | Del Sol M | -8.0 | 14.48 | 0.16 | S | 15,523 | 15,974 | -7.9 | 13.90 | 0.19 | S | 15,851 | 16,312 | 3 |
| S121 | NM302 | Mesa Del Sol M | -8.5 | 8.32 | 0.09 | S | 19,974 | 20,555 | -9.1 | 8.52 | 0.10 | S | 19,783 | 20,359 | 3 |
| S043 | NM267 | Del Sol D | -8.0 | 6.37 | 0.09 | S | 22,119 | 22,763 | -8.0 | 6.92 | 0.16 | S | 21,454 | 22,078 | 3 |
| S003 | NM251 | 98th St. D | -7.4 | 0.62 | 0.05 | S | 40,833 | 42,021 | -7.2 | 1.08 | 0.06 | S | 36,375 | 37,433 | 3 |
| S117 | NM298 | Domestic Well #25 | -9.0 | 95.07 | 0.67 | S | 406 | 418 | -9.0 | 96.28 | 0.67 | S | 305 | 313 | 4 |
| S078 | NM289 | Hunter Ridge Nest 2 Well 1 | -9.0 | 73.80 | 0.62 | S | 2,440 | 2,512 | -9.0 | 73.50 | 0.51 | S | 2,473 | 2,545 | 4 |
| S186 | NM130 | Rio Rancho 10 | -6.8 | 11.66 | 0.16 | P | 17,263 | 17,765 | -7.0 | 12.18 | 0.23 | P | 16,912 | 17,404 | 5 |

# Appendix E. Supplementary water-quality data from the USGS NWIS database

**Table E1.** Location and well-construction information for ground-water sites selected from the U.S. Geological Survey National Water Information System, by hydrochemical zone

[nd, not determined; <, less than; na, not applicable; dms, degrees-minutes-seconds]

| Sample reference number | Well number | Station number | Latitude (dms) | Longitude (dms) | Sample date | Altitude of land surface (feet above sea level) | Depth (feet) | Depth to top of sample interval (feet) | Depth to bottom of sample interval (feet) | Water level (feet below land surface) | Water level date | Site type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Zone 1: Northern Mountain Front** | | | | | | | | | | | |
| DB445 | 16N.06E.31.444 | 353403106201601 | 353403 | 1062016 | 1/5/1965 | nd | 80 | 70 | 80 | 30. | 1965 | Well |
| DB455 | 16N.06E.18.300 | 353638106210701 | 353638 | 1062107 | 2/12/1965 | nd | nd | nd | nd | nd | nd | Well |
| | **Zone 2: Northwestern** | | | | | | | | | | | |
| DB427 | 15N.02E.22.414 | 353042106424401 | 353042 | 1064244 | 2/27/1965 | nd | 323 | 271 | 297 | 140. | 6/13/1952 | Well |
| DB428 | 15N.02E.22.300 | 353043106431801 | 353043 | 1064318 | 5/19/1952 | nd | nd | nd | nd | nd | nd | Well |
| DB429 | 15N.02E.22.423 | 353045106424101 | 353045 | 1064241 | 1/20/1960 | nd | nd | nd | nd | nd | nd | Well |
| DB436 | 15N.02E.12.432 | 353226106404501 | 353226 | 1064045 | 4/4/1974 | nd | 503 | nd | nd | 376.27 | 12/18/1951 | Well |
| DB447 | 16N.03E.29.3442 | 353454106384701 | 353454 | 1063847 | 6/8/1973 | nd | na | na | na | na | na | Spring |
| | **Zone 3: West Central** | | | | | | | | | | | |
| DB019 | 02N.01E.09.220 | 342512106500701 | 342512 | 1065007 | 8/23/1949 | nd | nd | nd | nd | nd | nd | Well |
| DB022 | 03N.01E.34.32 | 342623106493901 | 342623 | 1064939 | 8/24/1949 | nd | nd | nd | nd | nd | nd | Well |
| DB031 | 03N.01E.23.331 | 342753106485501 | 342753 | 1064855 | 4/11/1995 | 4,746 | 210 | 200 | 210 | 9.74 | 4/11/1995 | Well |
| DB058 | 05N.01E.13.332 | 343730106460301 | 343730 | 1064603 | 3/2/1965 | nd | nd | nd | nd | nd | nd | Well |
| DB066 | 06N.01E.33.433 | 344147106502901 | 344147 | 1065029 | 6/6/1980 | nd | 556 | nd | nd | 417.5 | 5/24/1956 | Well |
| DB073 | 06N.02E.18.232 | 344500106460301 | 344500 | 1064603 | 4/9/1995 | 4,830 | 355 | 345 | 355 | 7.22 | 4/9/1995 | Well |
| DB074 | 06N.02E.10.341 | 344522106432001 | 344522 | 1064320 | 4/6/1995 | 4,829 | 160 | 150 | 160 | 8.88 | 4/6/1995 | Well |
| DB077 | 06N.01E.05.421 | 344721106442201 | 344721 | 1064422 | 12/18/1951 | nd | nd | nd | nd | nd | nd | Well |
| DB082 | 07N.02E.28.234 | 344819106440001 | 344819 | 1064400 | 11/28/1956 | nd | nd | nd | nd | nd | nd | Well |
| DB084 | 07N.02E.28.234 | 344822106435001 | 344822 | 1064350 | 10/16/1957 | nd | 365 | nd | nd | 10. | 11/28/1956 | Well |
| DB091 | 07N.02E.21.332 | 344852106442901 | 344854 | 1064426 | 8/6/1952 | nd | 607 | nd | nd | 32.53 | 3/26/1956 | Well |
| DB108 | 07N.02E.07.11414 | 345111106464101 | 345111 | 1064641 | 3/12/1975 | nd | nd | nd | nd | nd | nd | Well |
| DB109 | 07N.02E.07.11414A | 345113106464101 | 345113 | 1064641 | 7/16/1975 | nd | nd | nd | nd | nd | nd | Well |
| DB119 | 08N.02E.29.213 | 345359107453001 | 345359 | 1064530 | 4/29/1957 | nd | nd | nd | nd | nd | nd | Well |
| DB134 | 08N.01E.01.342 | 345654106463501 | 345654 | 1064635 | 5/28/1957 | nd | nd | nd | nd | nd | nd | Well |
| DB187 | 10N.02E.36.413 | 350254106405501 | 350254 | 1064055 | 5/18/1965 | nd | 60 | nd | nd | 12. | 11/1/1956 | Well |
| DB189 | 10N.03E.32.314 | 350256106390801 | 350256 | 1063909 | 2/27/1974 | nd | 765 | 189 | 765 | 30.24 | 5/20/1982 | Well |
| DB191 | 10N.02E.33.240 | 350308106433401 | 350308 | 1064334 | 8/25/1973 | nd | nd | nd | nd | nd | nd | Well |
| DB215 | 10N.02E.25.213 | 350411106405501 | 350412 | 1064053 | 5/21/1957 | nd | 360 | nd | nd | nd | nd | Well |
| DB223 | 10N.01E.30.222 | 350421106520905 | 350421 | 1065209 | 8/4/1960 | nd | nd | nd | nd | nd | nd | Well |
| DB232 | 10N.01E.22.322 | 350449106493101 | 350449 | 1064931 | 1/17/1983 | 5,790 | 1,179 | 980 | 1,179 | 881. | 1/25/1982 | Well |
| DB234 | 10N.02E.28.212 | 350453106445401 | 350453 | 1064454 | 6/28/1972 | nd | nd | nd | nd | nd | nd | Well |
| DB253 | LAND GRANT | 350612106440901 | 350612 | 1064409 | 12/1/1978 | nd | nd | nd | nd | nd | nd | Well |
| DB323 | 11N.02E.22.441 | 350946106424601 | 350946 | 1064246 | 4/25/1957 | nd | 240 | nd | nd | 228.6 | 4/25/1957 | Well |
| DB453 | 16N.02E.27.2134 | 353533106425301 | 353533 | 1064253 | 4/4/1974 | nd | 220 | nd | nd | 101.98 | 1/24/1984 | Well |
| | **Zone 4: Western Boundary** | | | | | | | | | | | |
| DB007 | 01N.02W.01.330 | 341845106575801 | 342000 | 1070040 | 8/23/1949 | nd | nd | nd | nd | 9.93 | 11/30/1949 | Well |
| DB010 | 01N.01E.05.100 | 342048106515801 | 342048 | 1065158 | 2/15/1950 | nd | nd | nd | nd | nd | nd | Well |
| DB026 | 03N.01W.25.444 | 342707106532201 | 342707 | 1065322 | nd | nd | 70 | nd | nd | 34.97 | 11/21/1949 | Well |
| DB032 | 03N.01W.21.332 | 342802106572401 | 342802 | 1065724 | 10/22/1982 | 5,125 | 405 | nd | nd | 352. | 5/28/1980 | Well |
| DB036 | 03N.03W.12.313 | 342947107064901 | 342947 | 1070649 | 3/18/1981 | nd | nd | nd | nd | nd | nd | Well |
| DB038 | 04N.03W.35.211 | 343152107073001 | 343152 | 1070730 | 1/5/1950 | nd | na | na | na | na | na | Spring |
| DB041 | 04N.03W.25.334 | 343209107065401 | 343209 | 1070654 | 1/5/1950 | nd | na | na | na | na | na | Spring |
| DB068 | 06N.02W.31.400 | 344201107050801 | 344201 | 1070508 | 9/13/1950 | nd | nd | nd | nd | nd | nd | Well |
| DB069 | 06N.01W.29.130 | 344310106581801 | 344310 | 1065818 | 6/6/1980 | nd | 567 | 434 | 564 | 380. | 6/6/1980 | Well |
| DB071 | 06N.02W.13.234 | 344449106594901 | 344449 | 1065949 | 5/29/1957 | nd | 133 | nd | nd | 74.49 | 4/26/1956 | Well |
| DB116 | LAND GRANT | 345312107051801 | 345312 | 1070518 | 9/3/1941 | nd | na | na | na | na | na | Spring |
| DB117 | LAND GRANT | 345312107052501 | 345312 | 1070525 | 4/21/1975 | nd | na | na | na | na | na | Spring |
| DB433 | 15N.01E.13.422 | 353146106464401 | 353146 | 1064646 | 6/3/1959 | nd | 12 | nd | nd | 4. | 6/3/1959 | Well |
| DB450 | 16N.02E.29.321 | 353525106450201 | 353525 | 1064502 | 3/20/1997 | nd | na | na | na | na | na | Spring |
| DB451 | 16N.02E.29.142 | 353528106451101 | 353528 | 1064511 | 8/30/1962 | nd | na | na | na | na | na | Spring |
| | **Zone 5: Rio Puerco** | | | | | | | | | | | |
| DB024 | 03N.01E.34.430A | 342629106493901 | 342629 | 1064939 | 8/24/1949 | nd | nd | nd | nd | 20. | 6/1/1948 | Well |
| DB051 | 04N.01W.12.341 | 343459106535401 | 343459 | 1065354 | 6/4/1980 | nd | 77 | nd | nd | 58.43 | 1/23/1985 | Well |
| DB055 | 04N.01W.01.4111 | 343606106534201 | 343606 | 1065342 | 1/9/1950 | nd | nd | nd | nd | nd | nd | Well |
| DB057 | 05N.01E.28.114 | 343720106505501 | 343720 | 1065055 | 4/24/1956 | nd | nd | nd | nd | 393.1 | 5/18/1956 | Well |
| DB063 | 05N.01W.14.231 | 343955106545001 | 343955 | 1065450 | 5/27/1980 | nd | 100 | nd | nd | 90.73 | 4/30/1956 | Well |
| DB086 | LAND GRANT | 344830107040401 | 344830 | 1070404 | 5/16/1975 | nd | nd | nd | nd | nd | nd | Well |
| DB089 | 07N.01W.23.334 | 344843106550601 | 344843 | 1065506 | 6/6/1980 | nd | 576 | nd | nd | 508.8 | 4/26/1956 | Well |
| DB103 | LAND GRANT | 345028107014301 | 345028 | 1070143 | 6/5/1975 | nd | nd | nd | nd | nd | nd | Well |
| DB114 | 07N.01W.31.124 | 345230106591501 | 344748 | 1065905 | 4/26/1956 | nd | 97 | nd | nd | 74.11 | 2/10/1956 | Well |
| DB122 | 08N.02W.24.131 | 345420107003801 | 345420 | 1070038 | 5/28/1957 | nd | nd | nd | nd | nd | nd | Well |
| DB124 | 08N.02W.24.111 | 345440107004001 | 345440 | 1070040 | 4/29/1957 | nd | nd | nd | nd | nd | nd | Well |
| DB132 | 08N.02W.12.111 | 345632107003701 | 345632 | 1070037 | 4/29/1957 | nd | nd | nd | nd | 138.05 | 4/29/1957 | Well |
| DB157 | 09N.02W.10.300 | 350109107022501 | 350109 | 1070225 | 3/1/1965 | nd | nd | nd | nd | nd | nd | Well |
| DB175 | 09N.01W.04.432 | 350158106563801 | 350158 | 1065638 | 6/5/1975 | nd | nd | nd | nd | 81.21 | 1956 | Well |
| DB201 | 10N.02W.25.444 | 350336106593401 | 350336 | 1065934 | 9/26/1974 | nd | nd | nd | nd | nd | nd | Well |
| DB206 | 10N.02W.25.432 | 350343106594801 | 350343 | 1065948 | 6/6/1967 | nd | 193 | nd | nd | nd | nd | Well |
| DB209 | 10N.02W.24.4 | 350346106594601 | 350346 | 1065946 | 9/3/1953 | nd | nd | nd | nd | nd | nd | Well |

**Table E1.** Location and well-construction information for ground-water sites selected from the U.S. Geological Survey National Water Information System, by hydrochemical zone-- Continued

| Sample reference number | Well number | Station number | Latitude (dms) | Longitude (dms) | Sample date | Altitude of land surface (feet above sea level) | Depth (feet) | Depth to top of sample interval (feet) | Depth to bottom of sample interval (feet) | Water level (feet below land surface) | Water level date | Site type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DB219 | 10N.01E.30.222A | 350421106520901 | 350421 | 1065209 | 2/12/1955 | nd | nd | nd | nd | nd | nd | Well |
| DB220 | 10N.01E.30.222B | 350421106520902 | 350421 | 1065209 | 2/1/1956 | nd | nd | nd | nd | nd | nd | Well |
| DB221 | 10N.01E.30.222C | 350421106520903 | 350421 | 1065209 | 10/11/1956 | nd | nd | nd | nd | nd | nd | Well |
| DB222 | 10N.01E.30.222D | 350421106520904 | 350421 | 1065209 | 11/12/1958 | nd | nd | nd | nd | nd | nd | Well |
| DB235 | 10N.01W.21.132 | 350501106571201 | 350501 | 1065712 | 6/6/1967 | nd | 205 | nd | nd | nd | nd | Well |
| DB385 | 12N.01W.17.1 | 351621106515301 | 351621 | 1065153 | 4/28/1961 | nd | nd | nd | nd | nd | nd | Well |
| DB387 | 12N.01W.14.111 | 351627106550401 | 351627 | 1065504 | 6/20/1980 | nd | 120 | nd | nd | 107.17 | 6/20/1980 | Well |
| DB407 | 13N.01W.16.230 | 352127106564201 | 352127 | 1065642 | 6/19/1980 | nd | 50 | nd | nd | 15.2 | 6/19/1980 | Well |
| | **Zone 6: Southwestern Mountain Front** | | | | | | | | | | | |
| DB027 | 03N.03W.25.412 | 342717107060201 | 342717 | 1070602 | 12/22/1980 | nd | na | na | na | na | na | Spring |
| | **Zone 7: Abo Arroyo** | | | | | | | | | | | |
| DB011 | 02N.02E.30.334 | 342147106472601 | 342147 | 1064726 | 1/25/1950 | nd | nd | nd | nd | nd | nd | Well |
| DB014 | 02N.01E.23.323 | 342255106484401 | 342255 | 1064844 | 1/25/1950 | nd | nd | nd | nd | nd | nd | Well |
| DB017 | 02N.02E.17. | 342428106444501 | 342428 | 1064445 | 12/1/1949 | nd | nd | nd | nd | nd | nd | Well |
| DB023 | 03N.03E.32.310 | 342624106384201 | 342624 | 1063842 | 6/12/1980 | nd | nd | nd | nd | 379.35 | 6/12/1980 | Well |
| DB033 | 03N.03E.20. | 342826106392001 | 342826 | 1063920 | 12/1/1949 | nd | nd | nd | nd | nd | nd | Well |
| DB035 | 03N.03E.16.410 | 342900106380201 | 342900 | 1063802 | 12/1/1949 | nd | nd | nd | nd | nd | nd | Well |
| | **Zone 8: Eastern Mountain Front** | | | | | | | | | | | |
| DB013 | LAND GRANT | 342231106372401 | 342231 | 1063724 | 5/4/1976 | nd | nd | nd | nd | nd | nd | Well |
| DB037 | 03N.04E.03.110 | 343105106305301 | 343105 | 1063053 | 6/12/1980 | nd | nd | nd | nd | 322.05 | 6/12/1980 | Well |
| DB040 | 04N.02E.32.100 | 343158106452901 | 343158 | 1064529 | 6/12/1980 | nd | nd | nd | nd | 22.75 | 6/12/1980 | Well |
| DB045 | 04N.03E.26.144 | 343244106355201 | 343244 | 1063552 | 3/29/1950 | nd | nd | nd | nd | nd | nd | Well |
| DB048 | 04N.03E.18.220 | 343443106393201 | 343443 | 1063932 | 6/12/1980 | nd | 370 | 340 | 360 | 296.9 | 6/12/1980 | Well |
| DB052 | 04N.02E.15.443 | 343515106401901 | 343515 | 1064019 | 3/27/1950 | nd | nd | nd | nd | nd | nd | Well |
| DB064 | 05N.03E.08.222 | 344048106382501 | 344048 | 1063825 | 6/18/1980 | nd | nd | nd | nd | 238.8 | 5/15/1956 | Well |
| DB070 | 06N.04E.30.144 | 344358106324201 | 344358 | 1063242 | 5/28/1980 | nd | na | na | na | na | na | Spring |
| DB087 | 07N.03E.25.220 | 344832106341901 | 344832 | 1063419 | 6/18/1980 | nd | 655 | 542 | 655 | 480.4 | 6/18/1980 | Well |
| DB208 | 10N.04E.29.413 | 350346106322301 | 350346 | 1063227 | 5/5/1955 | nd | 1,004 | 504 | 1,004 | 466. | 7/29/1952 | Well |
| DB244 | 10N.04E.22.344 | 350529106303801 | 350529 | 1063038 | 10/4/1973 | nd | nd | nd | nd | nd | nd | Well |
| DB247 | 10N.04E.16.241 | 350537106310601 | 350537 | 1063106 | 11/14/1973 | 5,575 | nd | nd | nd | nd | nd | Well |
| DB274 | 10N.04E.03.223 | 350740106300201 | 350740 | 1063002 | 5/7/1956 | nd | 291 | nd | nd | nd | nd | Well |
| DB276 | 10N.04E.04.221 | 350747106310701 | 350747 | 1063107 | 4/6/1965 | nd | 1,242 | 786 | 1,242 | 718. | 4/13/1965 | Well |
| DB282 | 11N.04E.33.331 | 350800106314501 | 350800 | 1063145 | 2/14/1974 | nd | nd | nd | nd | nd | nd | Well |
| DB328 | 11N.04E.22.312 | 350957106304301 | 350957 | 1063043 | 3/16/1995 | nd | 655 | 645 | 655 | 475. | 8/11/1989 | Well |
| DB329 | 11N.04E.21.411 | 351001106312201 | 351001 | 1063124 | 3/15/1995 | nd | 930 | 877 | 882 | 830. | 7/21/1986 | Well |
| DB330 | 11N.04E.22.244 | 351005106295701 | 351004 | 1062957 | 3/24/1995 | nd | 515 | 495 | 505 | nd | nd | Well |
| DB338 | 11N.04E.17.434 | 351029106322001 | 351029 | 1063220 | 3/15/1995 | nd | 670 | 640 | 670 | 535. | 2/13/1987 | Well |
| DB339 | 11N.04E.16.341 | 351033106314201 | 351033 | 1063142 | 5/1/1957 | nd | 736 | nd | nd | 683.5 | 5/21/1985 | Well |
| DB345 | 11N.04E.15.244 | 351055106295401 | 351055 | 1062954 | 3/22/1995 | nd | 632 | 495 | 505 | nd | nd | Well |
| DB371 | 12N.04E.32.242 | 351336106315901 | 351336 | 1063159 | 5/7/1956 | nd | 628 | nd | nd | 569.98 | 1/25/1957 | Well |
| DB384 | 12N.04E.17.424 | 351556106315901 | 351556 | 1063159 | 5/7/1956 | nd | 305 | nd | nd | 294. | 3/25/1957 | Well |
| DB392 | 13N.04E.36.334 | 351818106282701 | 351818 | 1062827 | 8/9/1962 | nd | nd | nd | nd | nd | nd | Well |
| DB397 | 18N.04E.36.113 | 351900106283801 | 351900 | 1062838 | 2/21/1975 | nd | nd | nd | nd | nd | nd | Well |
| DB408 | 13N.05E.15.2414 | 352128106233501 | 352128 | 1062335 | 11/2/1962 | nd | na | na | na | na | na | Spring |
| | **Zone 9: Tijeras Fault Zone** | | | | | | | | | | | |
| DB138 | 09N.04E.35.200A | 345803106290601 | 345803 | 1062906 | 6/27/1944 | nd | nd | nd | nd | nd | nd | Well |
| DB143 | 09N.04E.24.113 | 345955106281501 | 345955 | 1062815 | 7/25/1945 | nd | na | na | na | na | na | Spring |
| DB144 | 09N.04E.20.221 | 345956106321601 | 345953 | 1063209 | 7/9/1957 | nd | 1,036 | nd | nd | 458.5 | 6/12/1959 | Well |
| DB146 | 09N.04E.24.2114 | 345957106281201 | 345957 | 1062812 | 7/25/1945 | nd | na | na | na | na | na | Spring |
| DB147 | 09N.04E.24.112 | 345958106281301 | 345958 | 1062813 | 7/25/1945 | nd | na | na | na | na | na | Spring |
| | **Zone 10: Tijeras Arroyo** | | | | | | | | | | | |
| DB198 | 10N.04E.34.214 | 350317106300901 | 350317 | 1063009 | 9/27/1957 | nd | 1,200 | nd | nd | 616.17 | 9/30/1957 | Well |
| DB202 | 10N.04E.26.431 | 350337106291203 | 350337 | 1062912 | 5/20/1992 | nd | 8 | nd | nd | 2.36 | 5/26/1992 | Well |
| DB203 | 10N.04E.26.332 | 350337106294003 | 350337 | 1062940 | 5/20/1992 | nd | 12 | nd | nd | 9.26 | 5/26/1992 | Well |
| DB205 | 10N.04E.26.341 | 350338106292801 | 350338 | 1062928 | 5/20/1992 | nd | 12 | nd | nd | 5.25 | 5/26/1992 | Well |
| DB213 | 10N.04E.34.214 | 350410106302301 | 350410 | 1063023 | 9/19/1973 | nd | nd | nd | nd | nd | nd | Well |
| | **Zone 11: Northeastern** | | | | | | | | | | | |
| DB410 | 13N.04E.01.412A | 352257106275301 | 352257 | 1062753 | 9/25/1974 | nd | nd | nd | nd | nd | nd | Well |
| DB411 | 13N.04E.01.421 | 352303106274601 | 352303 | 1062746 | 9/25/1974 | nd | nd | nd | nd | nd | nd | Well |
| DB412 | 13N.04E.01.412 | 352304106275501 | 352304 | 1062755 | 11/17/1952 | nd | nd | nd | nd | 44. | 10/15/1956 | Well |
| DB414 | 13N.04E.01.243 | 352307106274701 | 352307 | 1062747 | 5/11/1953 | nd | nd | nd | nd | 46. | 10/15/1956 | Well |
| DB415 | 13N.04E.01.233 | 352309106280301 | 352309 | 1062803 | 7/26/1952 | nd | nd | nd | nd | 21.27 | 11/22/1957 | Well |
| DB419 | 14N.08E.19.430 | 352510106140701 | 352510 | 1061407 | 11/1/1968 | nd | nd | nd | nd | nd | nd | Well |
| DB421 | 14N.05E.19.221 | 352607106264301 | 352607 | 1062643 | 2/4/1965 | nd | 98 | nd | nd | nd | nd | Well |
| DB431 | 15N.05E.13.330 | 353129106221201 | 353129 | 1062212 | 1/21/1965 | nd | 82 | 47 | 77 | 6. | 1962 | Well |
| DB442 | 15N.06E.06.411 | 353329106204001 | 353329 | 1062040 | 3/7/1995 | 5,225 | 138 | 131 | 138 | 24.28 | 3/7/1995 | Well |
| | **Zone 12: Central** | | | | | | | | | | | |
| DB062 | 05N.02E.00 | 343920106442801 | 343920 | 1064428 | 9/25/1972 | nd | nd | nd | nd | nd | nd | Well |
| DB072 | 06N.02E.03.344 | 344500106410501 | 344500 | 1064105 | 9/18/1951 | nd | 103 | nd | nd | 8.76 | 4/12/1956 | Well |
| DB075 | 06N.03E.07.240 | 344548106393301 | 344548 | 1063933 | 6/13/1980 | nd | 295 | nd | nd | 190. | 6/13/1980 | Well |

**Table E1.** Location and well-construction information for ground-water sites selected from the U.S. Geological Survey National Water Information System, by hydrochemical zone-- Continued

| Sample reference number | Well number | Station number | Latitude (dms) | Longitude (dms) | Sample date | Altitude of land surface (feet above sea level) | Depth (feet) | Depth to top of sample interval (feet) | Depth to bottom of sample interval (feet) | Water level (feet below land surface) | Water level date | Site type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DB079 | 07N.02E.26.333 | 344743106423001 | 344743 | 1064230 | 7/22/1963 | nd | nd | nd | nd | nd | nd | Well |
| DB081 | 07N.03E.30.313A | 344819106402601 | 344819 | 1064026 | 2/17/1982 | nd | 170 | nd | nd | nd | nd | Well |
| DB083 | 07N.03E.30.313 | 344820106402601 | 344820 | 1064026 | 2/17/1982 | nd | 107 | nd | nd | nd | nd | Well |
| DB088 | 07N.02E.26.112 | 344832106422301 | 344832 | 1064223 | 3/9/1956 | nd | nd | nd | nd | nd | nd | Well |
| DB093 | 07N.02E.23.414 | 344900106415801 | 344900 | 1064158 | 4/9/1995 | 4,852 | 187 | 177 | 187 | 5.78 | 4/9/1995 | Well |
| DB094 | 07N.02E.22.231 | 344916106430401 | 344916 | 1064304 | 4/12/1995 | 4,853 | 178 | 173 | 178 | 3.53 | 4/12/1995 | Well |
| DB095 | 07N.02E.23.212 | 344932106415101 | 344932 | 1064151 | 8/3/1977 | nd | nd | nd | nd | nd | nd | Well |
| DB096 | 07N.02E.23.212A | 344932106415102 | 344932 | 1064151 | 8/3/1977 | nd | nd | nd | nd | nd | nd | Well |
| DB101 | 07N.02E.28.333 | 345006106423001 | 345006 | 1064230 | 11/15/1976 | nd | nd | nd | nd | nd | nd | Well |
| DB123 | 08N.02E.24.244 | 345425106403301 | 345425 | 1064033 | 4/30/1965 | nd | 100 | nd | nd | nd | nd | Well |
| DB133 | 08N.02E.02.321 | 345653106421801 | 345653 | 1064218 | 8/6/1985 | nd | 65 | nd | nd | nd | nd | Well |
| DB135 | 08N.02E.01.3223 | 345711106411001 | 345711 | 1064110 | 8/5/1993 | nd | 17 | 6 | 16 | 4.08 | 8/5/1993 | Well |
| DB136 | 08N.02E.02.121 | 345718106421501 | 345718 | 1064215 | 8/9/1985 | nd | 119 | nd | nd | nd | nd | Well |
| DB137 | 09N.02E.35.400 | 345736106414701 | 345736 | 1064147 | 8/3/1963 | nd | nd | nd | nd | nd | nd | Well |
| DB139 | 09N.02E.36.222 | 345810106403401 | 345810 | 1064034 | 4/23/1995 | 4,907 | 220 | 210 | 220 | 8.99 | 4/23/1995 | Well |
| DB140 | LAND GRANT | 345851106431601 | 345851 | 1064316 | 8/16/1985 | nd | 176 | nd | nd | nd | nd | Well |
| DB141 | 09N.02E.24.3311 | 345919106412801 | 345919 | 1064128 | 8/13/1993 | nd | 19 | 9 | 19 | 6.25 | 8/13/1993 | Well |
| DB142 | 09N.02E.23.233 | 345939106415901 | 345939 | 1064159 | 11/2/1987 | nd | 140 | nd | nd | nd | nd | Well |
| DB145 | 09N.03E.20.122 | 345956106390801 | 345956 | 1063908 | 8/5/1985 | nd | 305 | nd | nd | nd | nd | Well |
| DB148 | 09N.02E.13443 | 350003106404001 | 350003 | 1064040 | 8/8/1985 | nd | 58 | nd | nd | nd | nd | Well |
| DB149 | 09N.03E.18.434A | 350005106394302 | 350005 | 1063943 | 4/23/1965 | nd | 170 | 129 | nd | nd | nd | Well |
| DB150 | 09N.02E.13.431 | 350005106405401 | 350005 | 1064054 | 8/8/1985 | nd | 50 | nd | nd | nd | nd | Well |
| DB151 | 09N.02E.14.1344 | 350029106422101 | 350029 | 1064221 | 8/17/1993 | nd | 13 | 7 | 12 | 7.29 | 8/17/1993 | Well |
| DB153 | 09N.03E.18.242 | 350037106392701 | 350037 | 1063927 | 8/5/1985 | nd | 103 | nd | nd | nd | nd | Well |
| DB155 | 09N.02E.11.442 | 350104106413401 | 350104 | 1064134 | 4/20/1965 | nd | 251 | nd | nd | 5.6 | 8/1/1961 | Well |
| DB156 | 09N.03E.08.300 | 350107106390901 | 350107 | 1063909 | 8/16/1946 | nd | nd | nd | nd | nd | nd | Well |
| DB159 | 09N.02E.11.241 | 350130106414201 | 350130 | 1064142 | 6/23/1961 | nd | 86 | 25 | 80 | 8.04 | 8/1/1956 | Well |
| DB161 | 09N.03E.09.113 | 350133106381801 | 350133 | 1063818 | 5/22/1956 | nd | nd | nd | nd | nd | nd | Well |
| DB162 | 09N.03E.08.144A | 350135106390601 | 350135 | 1063906 | 11/9/1993 | nd | 149 | 139 | 144 | nd | nd | Well |
| DB168 | 09N.03E.07.241A | 350138106393201 | 350138 | 1063932 | 11/8/1993 | nd | 148 | 138 | 143 | nd | nd | Well |
| DB169 | 09N.03E.07.241B | 350138106393202 | 350138 | 1063932 | 11/8/1993 | nd | 101 | 91 | 96 | nd | nd | Well |
| DB170 | 09N.03E.07.241C | 350138106393203 | 350138 | 1063932 | 11/8/1993 | nd | 49 | 39 | 44 | nd | nd | Well |
| DB176 | LAND GRANT | 350204106411201 | 350204 | 1064112 | 9/15/1985 | nd | 18 | nd | nd | nd | nd | Well |
| DB179 | 09N.03E.05.234 | 350216106383901 | 350216 | 1063839 | 5/2/1957 | nd | 92 | nd | nd | 60. | 10/16/1956 | Well |
| DB180 | LAND GRANT | 350223106420801 | 350223 | 1064208 | 9/19/1985 | nd | 70 | nd | nd | nd | nd | Well |
| DB181 | LAND GRANT | 350223106420802 | 350223 | 1064208 | 9/19/1985 | nd | 24 | nd | nd | nd | nd | Well |
| DB183 | 09N.02E.02.200 | 350226106414701 | 350226 | 1064147 | 8/23/1954 | nd | nd | nd | nd | nd | nd | Well |
| DB185 | 10N.03E.32.444 | 350238106382401 | 350238 | 1063824 | 6/25/1980 | nd | nd | nd | nd | nd | nd | Well |
| DB186 | 10N.02E.35.3443 | 350241106420701 | 350241 | 1064207 | 9/28/1993 | nd | 28 | 18 | 28 | 9.57 | 9/28/1993 | Well |
| DB188 | 10N.03E.32.413 | 350255106384401 | 350255 | 1063844 | 6/25/1980 | nd | nd | nd | nd | nd | nd | Well |
| DB190 | 10N.03E.32.412 | 350304106383401 | 350301 | 1063837 | 6/25/1980 | nd | 503 | 360 | 503 | 59.1 | 6/30/1982 | Well |
| DB192 | 10N.03E.36.132 | 350313106345701 | 350313 | 1063457 | 5/19/1956 | nd | 997 | nd | nd | 400. | 5/19/1956 | Well |
| DB193 | 10N.03E.35.241 | 350313106352201 | 350313 | 1063522 | 10/25/1960 | nd | nd | nd | nd | nd | nd | Well |
| DB194 | 10N.03E.33.231 | 350313106374701 | 350313 | 1063747 | 6/25/1980 | nd | nd | nd | nd | nd | nd | Well |
| DB195 | 10N.03E.32.141 | 350315106390401 | 350315 | 1063904 | 5/21/1957 | nd | nd | nd | nd | nd | nd | Well |
| DB197 | 10N.03E.31.1314 | 350316106402001 | 350316 | 1064020 | 8/16/1993 | nd | 20 | 10 | 20 | 10.46 | 8/16/1993 | Well |
| DB199 | 10N.03E.35.111 | 350327106360901 | 350328 | 1063613 | 7/11/1957 | nd | 1,032 | 491 | 1,000 | 358. | 10/1/1952 | Well |
| DB207 | 10N.03E.29.3342 | 350344106391201 | 350336 | 1063912 | 8/11/1993 | nd | 29 | 14 | 29 | 12.1 | 8/11/1993 | Well |
| DB225 | 10N.03E.20.344 | 350426106385601 | 350426 | 1063856 | 5/22/1957 | nd | 418 | nd | nd | nd | nd | Well |
| DB226 | 10N.03E.21.433 | 350427106374601 | 350427 | 1063746 | 4/26/1957 | nd | 323 | nd | nd | nd | nd | Well |
| DB228 | 10N.02E.24.33221 | 350436106411701 | 350436 | 1064117 | 8/10/1993 | nd | 28 | 18 | 28 | 9.96 | 8/10/1993 | Well |
| DB230 | 10N.03E.19.2333 | 350447106395201 | 350447 | 1063952 | 8/4/1993 | nd | 18 | 8 | 18 | 7.69 | 8/4/1993 | Well |
| DB233 | 10N.02E.24.233 | 350452106405701 | 350452 | 1064057 | 5/21/1957 | nd | 336 | 176 | 336 | nd | nd | Well |
| DB236 | 10N.03E.20.124 | 350505106385701 | 350505 | 1063857 | 5/1/1957 | nd | 250 | nd | nd | nd | nd | Well |
| DB237 | 10N.03E.20.124A | 350505106385702 | 350505 | 1063857 | 5/1/1957 | nd | 60 | nd | nd | nd | nd | Well |
| DB239 | 10N.03E.19.111 | 350510106402601 | 350510 | 1064026 | 4/26/1957 | nd | 100 | nd | nd | 5.67 | 12/7/1956 | Well |
| DB242 | 10N.03E.17.343 | 350518106390601 | 350518 | 1063906 | 5/1/1957 | nd | 520 | nd | nd | 25. | 10/10/1956 | Well |
| DB246 | 10N.02E.14.4244 | 350534106413101 | 350534 | 1064131 | 8/17/1993 | nd | 16 | 11 | 16 | 11.24 | 8/17/1993 | Well |
| DB250 | 10N.02E.14.211 | 350605106415701 | 350605 | 1064157 | 4/26/1957 | nd | 162 | nd | nd | 140.33 | 12/6/1956 | Well |
| DB252 | 10N.03E.08.443 | 350612106383501 | 350612 | 1063835 | 5/21/1957 | nd | 351 | nd | nd | nd | nd | Well |
| DB256 | 10N.03E.11.244 | 350636106351301 | 350636 | 1063513 | 5/22/1957 | nd | 376 | 327 | 376 | nd | nd | Well |
| DB258 | 10N.03E.08.243 | 350637106383601 | 350637 | 1063836 | 5/21/1957 | nd | 370 | 200 | 327 | nd | nd | Well |
| DB259 | LAND GRANT | 350639106380501 | 350639 | 1063805 | 8/29/1984 | nd | nd | nd | nd | nd | nd | Well |
| DB260 | 10N.02E.12.4124 | 350639106410001 | 350639 | 1064100 | 8/4/1993 | nd | 27 | 16 | 26 | 14.7 | 8/4/1993 | Well |
| DB261 | 10N.03E.11.200 | 350646106352501 | 350646 | 1063525 | 5/15/1952 | nd | nd | nd | nd | nd | nd | Well |
| DB262 | LAND GRANT | 350647106411001 | 350647 | 1064110 | 8/17/1984 | nd | nd | nd | nd | nd | nd | Well |
| DB265 | LAND GRANT | 350702106393701 | 350702 | 1063937 | 8/27/1984 | nd | nd | nd | nd | nd | nd | Well |
| DB267 | 10N.03E.05.444 | 350704106382601 | 350704 | 1063826 | 5/22/1957 | nd | 296 | 163 | 273 | nd | nd | Well |
| DB269 | LAND GRANT | 350706106401301 | 350706 | 1064013 | 8/22/1984 | nd | nd | nd | nd | nd | nd | Well |
| DB270 | LAND GRANT | 350718106403601 | 350718 | 1064036 | 8/21/1984 | nd | nd | nd | nd | nd | nd | Well |
| DB273 | LAND GRANT | 350734106400401 | 350734 | 1064004 | 8/10/1984 | nd | nd | nd | nd | nd | nd | Well |

**Table E1.** Location and well-construction information for ground-water sites selected from the U.S. Geological Survey National Water Information System, by hydrochemical zone-- Continued

| Sample reference number | Well number | Station number | Latitude (dms) | Longitude (dms) | Sample date | Altitude of land surface (feet above sea level) | Depth (feet) | Depth to top of sample interval (feet) | Depth to bottom of sample interval (feet) | Water level (feet below land surface) | Water level date | Site type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DB275 | LAND GRANT | 350743106410101 | 350743 | 1064101 | 8/14/1984 | nd | nd | nd | nd | nd | nd | Well |
| DB279 | 10N.02E.02.212 | 350748106415001 | 350748 | 1064150 | 4/26/1957 | nd | 250 | nd | nd | nd | nd | Well |
| DB283 | LAND GRANT | 350807106403301 | 350807 | 1064033 | 8/22/1984 | nd | nd | nd | nd | nd | nd | Well |
| DB286 | LAND GRANT | 350815106372201 | 350815 | 1063722 | 8/9/1984 | nd | nd | nd | nd | nd | nd | Well |
| DB288 | 11N.03E.32.234A | 350821106383701 | 350821 | 1063837 | 8/13/1985 | nd | 132 | 123 | 128 | nd | nd | Well |
| DB291 | 11N.03E.35.244 | 350822106351301 | 350822 | 1063513 | 11/5/1960 | nd | nd | nd | nd | nd | nd | Well |
| DB292 | LAND GRANT | 350825106401701 | 350825 | 1064017 | 8/13/1984 | nd | nd | nd | nd | nd | nd | Well |
| DB294 | LAND GRANT | 350827106391301 | 350827 | 1063913 | 9/13/1985 | nd | 150 | 140 | 145 | nd | nd | Well |
| DB295 | LAND GRANT | 350827106391302 | 350827 | 1063913 | 9/13/1985 | nd | 99 | 90 | 95 | nd | nd | Well |
| DB296 | LAND GRANT | 350827106391303 | 350827 | 1063913 | 9/13/1985 | nd | 50 | 40 | 45 | nd | nd | Well |
| DB298 | 11N.03E.34.141 | 350828106365701 | 350828 | 1063657 | 5/1/1957 | nd | 150 | nd | nd | 78.95 | 12/11/1956 | Well |
| DB299 | LAND GRANT | 350828106382001 | 350828 | 1063820 | 8/20/1984 | nd | nd | nd | nd | nd | nd | Well |
| DB308 | 11N.02E.25.341A | 350854106403701 | 350854 | 1064037 | 8/14/1985 | nd | 152 | 140 | 145 | nd | nd | Well |
| DB309 | 11N.02E.25.341B | 350854106403702 | 350854 | 1064037 | 8/14/1985 | nd | 93 | 83 | 88 | nd | nd | Well |
| DB310 | 11N.02E.25.341C | 350854106403703 | 350854 | 1064037 | 8/14/1985 | nd | 48 | 40 | 45 | nd | nd | Well |
| DB312 | LAND GRANT | 350859106390601 | 350859 | 1063906 | 8/17/1984 | nd | nd | nd | nd | nd | nd | Well |
| DB317 | LAND GRANT | 350907106394501 | 350907 | 1063945 | 8/14/1984 | nd | nd | nd | nd | nd | nd | Well |
| DB318 | LAND GRANT | 350908106382001 | 350908 | 1063820 | 8/20/1984 | nd | nd | nd | nd | nd | nd | Well |
| DB320 | LAND GRANT | 350928106380501 | 350928 | 1063805 | 8/27/1984 | nd | nd | nd | nd | nd | nd | Well |
| DB325 | 11N.03E.20.400B | 350948106383502 | 350948 | 1063835 | 5/21/1950 | nd | nd | nd | nd | nd | nd | Well |
| DB327 | 11N.03E.22.3143 | 350951106370701 | 350951 | 1063707 | | nd | nd | nd | nd | nd | nd | Well |
| DB332 | 11N.03E.21.132 | 351012106380701 | 351012 | 1063807 | 11/8/1956 | nd | 60 | nd | nd | 10. | 11/1/1956 | Well |
| DB333 | 11N.03E.21.132A | 351012106380702 | 351012 | 1063807 | 4/23/1965 | nd | 201 | 171 | 201 | nd | nd | Well |
| DB340 | 11N.03E.13.332 | 351034106345601 | 351034 | 1063456 | 3/13/1995 | nd | | | | 261.2 | 2/24/1993 | Well |
| DB350 | 11N.03E.17.141 | 351059106385901 | 351059 | 1063859 | 1/5/1994 | nd | 150 | 135 | 145 | 19.56 | 2/14/1992 | Well |
| DB351 | 11N.03E.17.141A | 351059106385902 | 351059 | 1063859 | 1/4/1994 | nd | 25 | 10 | 20 | 6.76 | 12/3/1992 | Well |
| DB352 | 11N.03E.17.141B | 351059106385903 | 351059 | 1063859 | 1/5/1994 | nd | 600 | 545 | 555 | 37.71 | 12/3/1992 | Well |
| DB353 | 11N.03E.13.231 | 351106106343601 | 351106 | 1063436 | 3/14/1995 | nd | 364 | 352 | 362 | 275. | 10/9/1980 | Well |
| DB354 | 11N.04E.18.124 | 351108106333601 | 351108 | 1063336 | 3/15/1995 | nd | 575 | nd | nd | nd | nd | Well |
| DB355 | 11N.03E.15.1234 | 351109106365501 | 351109 | 1063655 | 8/1/1993 | nd | 27 | 17 | 27 | 17.36 | 8/1/1993 | Well |
| DB356 | 11N.03E.15.121 | 351117106365801 | 351117 | 1063658 | 4/23/1965 | nd | 168 | 160 | 168 | nd | nd | Well |
| DB357 | 11N.O3E.16.111 | 351120106381601 | 351120 | 1063816 | 5/4/1995 | 4,993 | 300 | 260 | 280 | 29.26 | 5/4/1995 | Well |
| DB358 | 11N.03E.10.3442 | 351125106364601 | 351125 | 1063646 | 8/1/1993 | nd | 31 | 21 | 31 | 15.17 | 8/1/1993 | Well |
| DB362 | 11N.03E.02.33142 | 351221106360601 | 351221 | 1063606 | 8/18/1993 | nd | 16 | 10 | 15 | 11.15 | 8/18/1993 | Well |
| DB366 | 12N.03E.35.243 | 351304106352201 | 351333 | 1063522 | 5/8/1956 | nd | 15 | nd | nd | nd | nd | Well |
| DB367 | 12N.03E.34.4413 | 351311106362801 | 351311 | 1063628 | 8/12/1993 | nd | 17 | 7 | 17 | 5.9 | 8/12/1993 | Well |
| DB370 | 12N.03E.31.134 | 351334106401701 | 351334 | 1064017 | 4/27/1965 | nd | 338 | nd | nd | 270. | 1/22/1964 | Well |
| DB372 | 12N.03E.35.132 | 351338106360501 | 351338 | 1063605 | 3/6/1995 | 5,011 | 250 | 240 | 250 | 40. | 5/7/1993 | Well |
| DB373 | 12N.03E.34.1141 | 351347106370301 | 351347 | 1063706 | 8/12/1993 | nd | 29 | 18 | 28 | 17.94 | 8/12/1993 | Well |
| DB375 | 12N.03E.27.4122 | 351421106363201 | 351421 | 1063632 | 9/27/1993 | nd | 40 | 25 | 40 | 20.63 | 9/23/1993 | Well |
| DB376 | 12N.02E.25.421 | 351422106404201 | 351422 | 1064042 | 12/12/1974 | 5,370 | nd | nd | nd | nd | nd | Well |
| DB378 | 12N.04E.30.124 | 351440106334301 | 351440 | 1063343 | 5/7/1956 | nd | nd | nd | nd | 154.53 | 3/29/1956 | Well |
| DB379 | 12N.03E.30.121 | 351446106400601 | 351446 | 1064006 | 12/12/1974 | 5,356 | nd | nd | nd | nd | nd | Well |
| DB381 | 12N.03E.27.222 | 351447106361601 | 351447 | 1063616 | 5/1/1957 | nd | nd | nd | nd | nd | nd | Well |
| DB382 | 12N.03E.26.112 | 351448106360201 | 351448 | 1063602 | 5/1/1957 | nd | 25 | nd | nd | 7. | 5/1/1957 | Well |
| DB383 | 12N.03E.24.423 | 351504106341801 | 351504 | 1063418 | 2/26/1965 | nd | 96 | 61 | 96 | 35. | 1961 | Well |
| DB389 | 12N.04E.06.200 | 351806106332001 | 351806 | 1063320 | 1/21/1965 | nd | nd | nd | nd | nd | nd | Well |
| DB390 | 12N.04E.06.213 | 351807106332801 | 351807 | 1063328 | 5/1/1957 | nd | 480 | nd | nd | 15.41 | 10/29/1956 | Well |
| DB391 | 12N.04E.05.214 | 351809106321901 | 351809 | 1063219 | 9/25/1974 | nd | nd | nd | nd | nd | nd | Well |
| DB398 | 13N.03E.36.123 | 351900106344101 | 351900 | 1063441 | 2/21/1975 | nd | nd | nd | nd | nd | nd | Well |
| DB400 | 13N.04E.29.421 | 351932106320201 | 351932 | 1063202 | 7/26/1952 | nd | nd | nd | nd | 6. | 7/26/1952 | Well |
| DB413 | 13N.04E.01.234 | 352306106275801 | 352307 | 1062756 | 9/25/1974 | nd | 550 | nd | nd | 24. | 1/15/1956 | Well |
| DB468 | 07N.02E.13.441 | 354917106404101 | 344917 | 1064041 | 6/24/1968 | nd | nd | nd | nd | nd | nd | Well |
| | **Zone 13: Discharge** | | | | | | | | | | | |
| DB009 | 01N.01E.04.123 | 342041106504601 | 342041 | 1065046 | 4/11/1995 | 4,725 | 89 | 84 | 88 | 21.45 | 4/11/1995 | Well |
| DB021 | 03N.02E.31.431 | 342607106461901 | 342607 | 1064619 | 6/11/1980 | nd | nd | nd | nd | 100. | 6/11/1980 | Well |
| DB025 | 03N.02E.33.222 | 342650106430301 | 342650 | 1064303 | 5/30/1980 | nd | 320 | nd | nd | 177.95 | 5/30/1980 | Well |
| DB029 | 03N.02E.27.123 | 342740106432301 | 342740 | 1064323 | 5/30/1980 | nd | 380 | nd | nd | 120.6 | 5/30/1980 | Well |

**Table E2.** Summary of field parameters and major-element chemistry for selected ground-water sites in the U.S. Geological Survey National Water Information System that were included in the final data set, by hydrochemical zone

[nd, not determined; <, less than; Temp., field water temperature; ºC, degrees Celsius; $O_2$, dissolved oxygen; mg/L, milligrams per liter; Sp. Cond., specific conductance in µS/cm, microsiemens per centimeter at 25 ºC; $Ca^{2+}$, calcium; $Mg^{2+}$, magnesium, $Na^{+}$, sodium; $K^{+}$, potassium; $Cl^{-}$, chloride; $SO_4^{2-}$, sulfate; $HCO_3^{-}$, total titration alkalinity as bicarbonate]

| Sample reference number | Sp. Cond. (µS/cm) | pH | Temp (ºC) | $O_2$ (mg/L) | $Ca^{2+}$ (mg/L) | $Mg^{2+}$ (mg/L) | $Na^{+}$ (mg/L) | $K^{+}$ (mg/L) | Na + K (mg/L as Na) | $HCO_3^{-}$ (mg/L) | $SO_4^{2-}$ (mg/L) | $Cl^{-}$ (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Zone 1: Northern Mountain Front** | | | | | | | | | | | | |
| DB445 | 365 | 7.7 | nd | nd | 42. | 8.8 | nd | nd | 23 | 190 | 29 | 5 |
| DB455 | 248 | 7.4 | nd | nd | 27. | 4.7 | nd | nd | 17 | 120 | 18 | 6 |
| **Zone 2: Northwestern** | | | | | | | | | | | | |
| DB427 | 519 | 7.6 | nd | nd | 48. | 9. | nd | nd | 46 | 160 | 66 | 36 |
| DB428 | 848 | 7.9 | nd | nd | 71. | 15. | nd | nd | 86 | 160 | 190 | 60 |
| DB429 | 458 | 7.9 | nd | nd | 45. | 5.2 | nd | nd | 45 | 160 | 47 | 34 |
| DB436 | 490 | 7.9 | 17.0 | nd | 49. | 1.5 | 56 | 5.5 | nd | 228 | 57 | 4 |
| DB447 | 367 | 7.5 | nd | nd | 31. | 4. | 46 | 3.3 | nd | 211 | 20 | 3 |
| **Zone 3: West Central** | | | | | | | | | | | | |
| DB019 | 820 | nd | nd | nd | 14. | 3.1 | nd | nd | 160 | 110 | 240 | 28 |
| DB022 | 850 | nd | nd | nd | 26. | 9.6 | nd | nd | 140 | 120 | 220 | 39 |
| DB031 | 874 | 8.1 | 20.2 | <0.10 | 28. | 11. | 140 | 7.3 | nd | 163 | 200 | 58 |
| DB058 | 737 | 8.0 | nd | nd | 39. | 13. | nd | nd | 100 | 180 | 180 | 26 |
| DB066 | 875 | 8.0 | 20.7 | nd | 57. | 17. | 130 | 5.8 | nd | 240 | 240 | 32 |
| DB073 | 648 | 8.6 | 18.1 | 2.20 | 7.1 | 1.7 | 130 | 3.2 | nd | 168 | 130 | 16 |
| DB074 | 479 | 8.4 | 17.5 | 0.30 | 11. | 3.7 | 86 | 5.1 | nd | 174 | 69 | 16 |
| DB077 | 660 | nd | nd | nd | 17. | 8.4 | nd | nd | 110 | 160 | 160 | 18 |
| DB082 | 488 | 8.0 | 18.5 | nd | 10. | 4.3 | nd | nd | 94 | 180 | 68 | 18 |
| DB084 | 470 | 8.1 | 18.0 | nd | 10. | 3.1 | nd | nd | 96 | 190 | 73 | 9 |
| DB091 | 506 | nd | nd | nd | 12. | 3.1 | nd | nd | 100 | 190 | 76 | 18 |
| DB108 | 511 | 7.7 | 18.5 | nd | 17. | 6.4 | 84 | 5.0 | nd | 180 | 90 | 12 |
| DB109 | 688 | 8.6 | 29.0 | 5.60 | 13. | 1. | 130 | 6.0 | nd | 146 | 160 | 13 |
| DB119 | 470 | 7.9 | 19.0 | nd | 23. | 6.6 | nd | nd | 65 | 180 | 46 | 20 |
| DB134 | 475 | 8.1 | 20.0 | nd | 27. | 6.9 | nd | nd | 66 | 140 | 96 | 12 |
| DB187 | 545 | 8.2 | nd | nd | 39. | 11. | nd | nd | 65 | 190 | 100 | 14 |
| DB189 | 514 | 8.0 | 20.5 | nd | 23. | 5.4 | 77 | 8.3 | nd | 169 | 79 | 22 |
| DB191 | 524 | 8.9 | 30.0 | nd | 6.1 | 0.4 | 110 | 2.0 | nd | 165 | 84 | 13 |
| DB215 | 556 | 7.7 | 19.0 | nd | 33. | 6.2 | nd | nd | 81 | 180 | 110 | 17 |
| DB223 | 502 | 7.9 | 23.5 | nd | 28. | 5.1 | nd | nd | 76 | 170 | 92 | 14 |
| DB232 | 1,250 | 7.8 | 32.0 | nd | 22. | 5.2 | 240 | 7.4 | nd | 252 | 220 | 100 |
| DB234 | 657 | 8.6 | 30.0 | nd | nd | nd | nd | nd | nd | nd | nd | nd |
| DB253 | 440 | 8.5 | 30.0 | nd | 2.5 | 0.2 | 100 | 1.4 | nd | 171 | 62 | 7 |
| DB323 | 2,300 | 7.4 | 20.0 | nd | 220. | 58. | nd | nd | 270 | 220 | 1,100 | 31 |
| DB453 | 704 | 8.1 | 15.0 | nd | 64. | 9.2 | 69 | 9.6 | nd | 185 | 190 | 5 |
| **Zone 4: Western Boundary** | | | | | | | | | | | | |
| DB007 | 4,830 | nd | nd | nd | 150. | 68. | nd | nd | 860 | 300 | 840 | 1,000 |
| DB010 | 3,910 | nd | nd | nd | 140. | 75. | nd | nd | 640 | 260 | 900 | 640 |
| DB026 | 3,520 | nd | nd | nd | 110. | 50. | nd | nd | 620 | 280 | 710 | 610 |
| DB032 | 1,810 | 7.6 | 22.0 | nd | 93. | 41. | 220 | 9.3 | nd | 246 | 290 | 300 |
| DB036 | 1,850 | 8.1 | 18.5 | nd | 200. | 57. | 200 | 3.7 | nd | 122 | 1,000 | 13 |
| DB038 | 5,110 | nd | 6.5 | nd | 128. | 69. | nd | nd | 885 | 350 | 463 | 1,240 |
| DB041 | 5,200 | nd | 16.0 | nd | 138. | 67. | nd | nd | 887 | 354 | 471 | 1,250 |
| DB068 | 6,520 | 7.7 | nd | nd | 280. | 120. | nd | nd | 1,100 | 280 | 1,100 | 1,500 |
| DB069 | 5,400 | 8.0 | 18.8 | nd | 220. | 71. | 1,100 | 15.0 | nd | 240 | 1,400 | 1,200 |
| DB071 | 5,800 | 8.3 | 18.0 | nd | 9.1 | 9.8 | nd | nd | 1,400 | 870 | 1,200 | 820 |
| DB116 | nd | nd | 22.0 | nd | 523. | 165. | 6,716 | 194.0 | nd | 1,362 | 6,625 | 6,250 |
| DB117 | 41,400 | 7.3 | nd | nd | 560. | 350. | 11,000 | 320.0 | nd | 1,530 | 8,900 | 11,000 |

**Table E2.** Summary of field parameters and major-element chemistry for selected ground-water sites in the U.S. Geological Survey National Water Information System that were included in the final data set, by hydrochemical zone-- Continued

| Sample reference number | Sp. Cond. (µS/cm) | pH | Temp (ºC) | $O_2$ (mg/L) | $Ca^{2+}$ (mg/L) | $Mg^{2+}$ (mg/L) | $Na^{+}$ (mg/L) | $K^{+}$ (mg/L) | Na + K (mg/L as Na) | $HCO_3^{-}$ (mg/L) | $SO_4^{2-}$ (mg/L) | $Cl^{-}$ (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DB433 | 23,000 | 8.0 | nd | nd | 580. | 150. | nd | nd | 5,800 | 400 | 7,600 | 4,600 |
| DB450 | 5,770 | 6.6 | 58.5 | nd | 70.7 | 12.2 | 1,129 | 72.5 | nd | 1,009 | 282 | 1,159 |
| DB451 | 5,680 | 8.0 | 35.0 | nd | 100. | 8.6 | nd | nd | 1,100 | 1,280 | 286 | 1,140 |
| DB452 | 5,694 | 8.0 | 23.0 | nd | 110. | 21. | 1,300 | 73.0 | nd | 1,440 | 270 | 1,200 |
| | **Zone 5: Rio Puerco** | | | | | | | | | | | |
| DB024 | 3,460 | nd | nd | nd | 260. | 110. | nd | nd | 380 | 180 | 1,100 | 480 |
| DB051 | 5,100 | 7.3 | 15.2 | nd | 360. | 160. | 720 | 11.0 | nd | 240 | 2,400 | 330 |
| DB055 | 3,270 | nd | nd | nd | 280. | 100. | nd | nd | 340 | 200 | 1,100 | 410 |
| DB057 | 2,960 | 7.2 | 22.0 | nd | 320. | 120. | nd | nd | 220 | 170 | 1,200 | 250 |
| DB063 | 3,600 | 7.0 | 18.0 | nd | 380. | 120. | 430 | 12.0 | nd | 366 | 1,800 | 220 |
| DB086 | 4,660 | 7.7 | 19.0 | nd | 410. | 110. | 520 | 34.0 | nd | 117 | 1,900 | 480 |
| DB089 | 1,380 | 8.0 | 16.2 | nd | 110. | 35. | 160 | 8.8 | nd | 96 | 640 | 21 |
| DB103 | 9,420 | 8.3 | nd | nd | 92. | 30. | 2,200 | 33.0 | nd | 464 | 2,600 | 1,500 |
| DB114 | 8,540 | 7.7 | 18.0 | nd | 110. | 55. | nd | nd | 1,900 | 910 | 2,400 | 1,000 |
| DB122 | 5,290 | 7.3 | 18.0 | nd | 330. | 140. | nd | nd | 830 | 270 | 2,200 | 500 |
| DB124 | 4,910 | 7.4 | 16.5 | nd | 140. | 43. | nd | nd | 1,000 | 680 | 1,900 | 200 |
| DB132 | 4,910 | 7.4 | 16.5 | nd | 140. | 43. | nd | nd | 1,000 | 680 | 1,900 | 200 |
| DB157 | 5,870 | 8.4 | nd | nd | 24. | 13. | nd | nd | 1,480 | 610 | 2,600 | 78 |
| DB175 | 4,360 | 8.1 | nd | nd | 45. | 13. | 1,000 | 7.1 | nd | 897 | 1,300 | 200 |
| DB201 | 2,180 | 8.0 | nd | nd | 92. | 1.2 | 380 | 6.0 | nd | 89 | 870 | 53 |
| DB206 | 919 | 8.3 | 20.5 | nd | 58. | 26. | nd | nd | 110 | 180 | 280 | 21 |
| DB209 | 932 | nd | nd | nd | 56. | 29. | nd | nd | 110 | 150 | 300 | 23 |
| DB219 | 1,420 | 7.8 | nd | nd | 110. | 27. | 180 | 7.2 | nd | 100 | 630 | 20 |
| DB220 | 1,530 | 7.5 | 25.5 | 3.40 | 130. | 28. | nd | nd | 180 | 100 | 680 | 22 |
| DB221 | 1,530 | 7.5 | 25.5 | nd | 130. | 39. | nd | nd | 170 | 100 | 700 | 24 |
| DB222 | 1,550 | 7.5 | 25.5 | nd | 130. | 25. | nd | nd | 200 | 97 | 720 | 24 |
| DB235 | 951 | 8.4 | 21.5 | nd | 47. | 6. | nd | nd | 160 | 160 | 300 | 20 |
| DB385 | 10,000 | 8.6 | nd | nd | 56. | 14. | nd | nd | 2,600 | 510 | 3,400 | 1,300 |
| DB387 | 1,180 | 8.3 | 20.0 | nd | 19. | 5.7 | 240 | 2.5 | nd | 410 | 210 | 5 |
| DB407 | 1,650 | 7.5 | 16.0 | nd | 84. | 21. | 280 | 4.6 | nd | 350 | 510 | 39 |
| | **Zone 6: Southwestern Mountain Front** | | | | | | | | | | | |
| DB027 | 478 | 7.9 | 7.5 | nd | 68. | 15. | 19 | 2.5 | nd | 268 | 35 | 7 |
| | **Zone 7: Abo Arroyo** | | | | | | | | | | | |
| DB011 | 1,130 | nd | 20.3 | nd | 77. | 32. | nd | nd | 120 | 120 | 390 | 42 |
| DB014 | 1,070 | nd | nd | nd | 88. | 35. | nd | nd | 84 | 99 | 310 | 94 |
| DB017 | 1,040 | nd | nd | nd | 100. | 38. | nd | nd | 74 | 130 | 380 | 48 |
| DB023 | 1,080 | 7.8 | 20.7 | nd | 110. | 40. | 65 | 3.1 | nd | 150 | 420 | 14 |
| DB033 | 1,100 | nd | nd | nd | 130. | 45. | nd | nd | 52 | 160 | 440 | 28 |
| DB035 | 834 | nd | 19.0 | nd | 94. | 33. | nd | nd | 42 | 170 | 280 | 19 |
| | **Zone 8: Eastern Mountain Front** | | | | | | | | | | | |
| DB013 | 466 | 7.9 | nd | nd | 30. | 16. | 45 | 2.7 | nd | 158 | 59 | 34 |
| DB037 | 440 | 8.1 | 22.4 | nd | 47. | 13. | 34 | 2.6 | nd | 180 | 55 | 26 |
| DB040 | 281 | 8.3 | 22.0 | nd | 29. | 9. | 23 | 4.6 | nd | 146 | 30 | 13 |
| DB045 | 263 | nd | 22.0 | nd | 20. | 6. | nd | nd | 28 | 98 | 40 | 7 |
| DB048 | 265 | 8.5 | 24.9 | nd | 12. | 2.7 | 43 | 1.6 | nd | 97 | 56 | 5 |
| DB052 | 357 | nd | 20.5 | nd | 40. | 9.7 | nd | nd | 21 | 140 | 40 | 17 |
| DB064 | 250 | 8.0 | 21.9 | nd | 34. | 4.7 | 17 | 1.9 | nd | 130 | 22 | 7 |
| DB070 | 340 | 7.8 | 15.5 | nd | 52. | 4.9 | 19 | 0.6 | nd | 160 | 34 | 9 |
| DB087 | 305 | 7.9 | 23.0 | nd | 33. | 3.5 | 31 | 1.8 | nd | 150 | 30 | 5 |
| DB208 | 555 | 7.6 | 21.5 | nd | 74. | 14. | nd | nd | 26 | 230 | 82 | 12 |
| DB244 | 339 | 8.0 | 24.5 | nd | 37. | 3.3 | 28 | 2.4 | nd | 151 | 33 | 7 |
| DB247 | 283 | 8.2 | 25.0 | nd | 19. | 0.9 | 41 | 1.9 | nd | 139 | 21 | 5 |
| DB274 | 466 | 7.7 | 24.5 | nd | 65. | 10. | nd | nd | 22 | 200 | 54 | 14 |
| DB276 | 285 | 7.9 | 24.0 | nd | 37. | 1.8 | nd | nd | 23 | 150 | 18 | 5 |
| DB282 | 275 | 7.9 | 25.5 | nd | 30. | 1.4 | 26 | 2.0 | nd | 139 | 15 | 7 |

**Table E2.** Summary of field parameters and major-element chemistry for selected ground-water sites in the U.S. Geological Survey National Water Information System that were included in the final data set, by hydrochemical zone-- Continued

| Sample reference number | Sp. Cond. (µS/cm) | pH | Temp (ºC) | $O_2$ (mg/L) | $Ca^{2+}$ (mg/L) | $Mg^{2+}$ (mg/L) | $Na^{+}$ (mg/L) | $K^{+}$ (mg/L) | Na + K (mg/L as Na) | $HCO_3^{-}$ (mg/L) | $SO_4^{2-}$ (mg/L) | $Cl^{-}$ (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DB328 | 376 | 7.7 | 18.0 | nd | 50. | 3.8 | 17 | 1.3 | nd | 183 | 15 | 5 |
| DB329 | 317 | 7.6 | 13.6 | nd | 43. | 3.4 | 19 | 1.3 | nd | 163 | 17 | 5 |
| DB330 | 454 | 7.5 | 17.0 | nd | 71. | 8.2 | 14 | 1.7 | nd | 232 | 26 | 7 |
| DB338 | 604 | 7.4 | 15.4 | nd | 59. | 5.2 | 54 | 2.4 | nd | 168 | 32 | 84 |
| DB339 | 331 | 7.5 | 20.5 | nd | 43. | 7.4 | nd | nd | 17 | 170 | 21 | 6 |
| DB345 | 416 | 7.3 | 18.0 | nd | 53. | 7.1 | 20 | 1.5 | nd | 176 | 33 | 10 |
| DB371 | 735 | 7.7 | 18.5 | nd | 73. | 15. | nd | nd | 56 | 180 | 63 | 100 |
| DB384 | 329 | 7.9 | 20.0 | nd | 40. | 5.9 | nd | nd | 24 | 140 | 39 | 12 |
| DB392 | 439 | 7.5 | nd | nd | 79. | 4.9 | nd | nd | 11 | 260 | 21 | 4 |
| DB397 | 440 | 7.3 | 17.5 | nd | 71. | 7.3 | 12 | 1.4 | nd | 238 | 26 | 4 |
| DB408 | 590 | 7.4 | 23.5 | nd | 74. | 9.6 | nd | nd | 47 | 329 | 38 | 9 |
| **Zone 9: Tijeras Fault Zone** | | | | | | | | | | | | |
| DB138 | 1,480 | 7.5 | 16.5 | nd | 180. | 36. | nd | nd | 98 | 700 | 59 | 120 |
| DB143 | 2,540 | nd | 17.0 | nd | 224. | 51. | nd | nd | 288 | 956 | 100 | 355 |
| DB144 | 704 | 7.6 | 23.0 | nd | 66. | 19. | nd | nd | 58 | 280 | 59 | 48 |
| DB146 | 3,400 | nd | 16.0 | nd | 279. | 65. | nd | nd | 402 | 1,230 | 125 | 492 |
| DB147 | nd | nd | 18.5 | nd | 188. | 44. | nd | nd | 190 | 748 | 78 | 255 |
| **Zone 10: Tijeras Arroyo** | | | | | | | | | | | | |
| DB198 | 636 | 7.3 | 14.3 | nd | 79. | 22. | nd | nd | 26 | 240 | 100 | 16 |
| DB202 | 1,080 | 7.2 | 15.7 | nd | 130. | 30. | 55 | 4.1 | nd | 298 | 150 | 130 |
| DB203 | 980 | 7.5 | 16.0 | nd | 110. | 27. | 52 | 5.0 | nd | 260 | 130 | 120 |
| DB205 | 980 | 7.4 | 16.2 | nd | 120. | 28. | 53 | 4.2 | nd | 269 | 140 | 120 |
| DB213 | 630 | 7.6 | 15.5 | nd | 80. | 19. | 27 | 3.7 | nd | 254 | 100 | 17 |
| **Zone 11: Northeastern** | | | | | | | | | | | | |
| DB410 | 1,050 | nd | 19.5 | nd | 150. | 22. | 50 | 3.0 | nd | 193 | 350 | 24 |
| DB411 | 1,880 | 6.4 | 21.5 | nd | 210. | 51. | 180 | 11.0 | nd | 514 | 580 | 53 |
| DB412 | 1,120 | nd | nd | nd | 120. | 29. | nd | nd | 92 | 350 | 280 | 32 |
| DB414 | 1,520 | nd | nd | nd | 170. | 38. | nd | nd | 140 | 490 | 380 | 55 |
| DB415 | 1,940 | 7.7 | nd | nd | 280. | 55. | nd | nd | 120 | 190 | 890 | 71 |
| DB419 | 1,360 | 7.9 | nd | nd | 160. | 45. | nd | nd | 100 | 400 | 400 | 42 |
| DB421 | 1,020 | 7.5 | nd | nd | 120. | 22. | nd | nd | 88 | 390 | 220 | 19 |
| DB431 | 1,190 | 7.3 | nd | nd | 150. | 25. | nd | nd | 92 | 200 | 450 | 22 |
| DB442 | 724 | 7.3 | 17.1 | 2.20 | 69. | 18. | 58 | 6.1 | nd | 213 | 190 | 9 |
| **Zone 12: Central** | | | | | | | | | | | | |
| DB062 | 470 | 7.6 | nd | nd | 44. | 13. | 31 | 6.0 | nd | 158 | 71 | 36 |
| DB072 | 879 | 7.6 | nd | nd | 100. | 18. | nd | nd | 67 | 280 | 180 | 39 |
| DB075 | 315 | 8.2 | 20.7 | nd | 37. | 9.3 | 23 | 3.6 | nd | 150 | 37 | 9 |
| DB079 | 861 | 7.5 | 14.0 | nd | 110. | 15. | nd | nd | 64 | 300 | 180 | 33 |
| DB081 | 427 | 8.0 | nd | nd | 41. | 11. | 25 | 3.4 | nd | 134 | 73 | 22 |
| DB083 | 532 | 8.1 | nd | nd | 51. | 14. | 34 | 3.8 | nd | 106 | 130 | 39 |
| DB088 | 609 | 7.6 | 15.0 | nd | 71. | 13. | nd | nd | 33 | 220 | 110 | 4 |
| DB093 | 317 | 8.0 | 15.8 | 0.10 | 31. | 9.7 | 17 | 6.7 | nd | 144 | 32 | 7 |
| DB094 | 309 | 8.1 | 14.8 | 0.10 | 31. | 7.5 | 16 | 8.1 | nd | 118 | 42 | 10 |
| DB095 | 295 | 8.2 | nd | nd | 29. | 9. | 20 | 5.5 | nd | 130 | 38 | 11 |
| DB096 | 295 | 7.6 | nd | nd | 200. | 30. | 98 | 8.5 | nd | 310 | 330 | 200 |
| DB101 | 583 | 7.8 | nd | nd | 67. | 18. | 22 | 5.3 | nd | 112 | 150 | 45 |
| DB123 | 588 | 7.8 | nd | nd | 70. | 12. | nd | nd | 41 | 220 | 92 | 23 |
| DB133 | 670 | 7.7 | 16.2 | nd | 88. | 10. | 44 | 5.3 | nd | 293 | 92 | 11 |
| DB135 | 400 | 8.0 | 16.0 | 0.10 | 41. | 5.5 | 32 | 3.5 | nd | 148 | 65 | <0.1 |
| DB136 | 520 | 7.7 | 17.5 | nd | 75. | 10. | 23 | 7.2 | nd | 162 | 99 | 24 |
| DB137 | 936 | 7.8 | 15.5 | nd | 110. | 11. | nd | nd | 88 | 320 | 200 | 38 |
| DB139 | 373 | 8.0 | 16.2 | 0.10 | 33. | 6.5 | 28 | 5.9 | nd | 141 | 36 | 22 |
| DB140 | 450 | 8.0 | 18.0 | nd | 50. | 11. | 20 | 7.4 | nd | 105 | 110 | 11 |
| DB141 | 800 | 7.3 | 18.1 | 0.10 | 120. | 17. | 47 | 10.0 | nd | 376 | 130 | 28 |
| DB142 | 482 | nd | nd | nd | 52. | 9.5 | 26 | 7.0 | nd | 124 | 90 | 22 |

**Table E2.** Summary of field parameters and major-element chemistry for selected ground-water sites in the U.S. Geological Survey National Water Information System that were included in the final data set, by hydrochemical zone-- Continued

| Sample reference number | Sp. Cond. (µS/cm) | pH | Temp (ºC) | $O_2$ (mg/L) | $Ca^{2+}$ (mg/L) | $Mg^{2+}$ (mg/L) | $Na^{+}$ (mg/L) | $K^{+}$ (mg/L) | Na + K (mg/L as Na) | $HCO_3^{-}$ (mg/L) | $SO_4^{2-}$ (mg/L) | $Cl^{-}$ (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DB145 | 350 | 7.7 | 23.8 | nd | 34. | 6.5 | 28 | 8.0 | nd | 133 | 30 | 20 |
| DB148 | 500 | 8.0 | 15.5 | nd | 30. | 6.1 | 66 | 6.6 | nd | 162 | 80 | 20 |
| DB149 | 341 | 7.8 | nd | nd | 42. | 6.1 | nd | nd | 19 | 137 | 29 | 19 |
| DB150 | 420 | 7.7 | 15.0 | nd | 42. | 6.5 | 42 | 4.5 | nd | 166 | 56 | 16 |
| DB151 | 982 | 7.3 | 23.4 | 0.91 | 110. | 13. | 76 | 8.8 | nd | 356 | 180 | 30 |
| DB153 | 580 | 7.6 | 20.5 | nd | 82. | 13. | 24 | 7.8 | nd | 190 | 78 | 47 |
| DB155 | 803 | 7.8 | nd | nd | 100. | 15. | nd | nd | 54 | 240 | 180 | 30 |
| DB156 | 327 | nd | nd | nd | 40. | 5.8 | nd | nd | 22 | 160 | 29 | 10 |
| DB159 | 549 | 8.1 | 16.5 | nd | 10. | 5.8 | nd | nd | 100 | 180 | 74 | 27 |
| DB161 | 389 | 7.7 | 25.0 | nd | 32. | 8.6 | nd | nd | 34 | 130 | 33 | 32 |
| DB162 | 350 | 7.2 | 19.5 | nd | 36. | 7. | 17 | 6.9 | nd | 139 | 31 | 21 |
| DB168 | 400 | 7.9 | 18.5 | nd | 35. | 2.9 | 21 | 12.0 | nd | 77 | 70 | 17 |
| DB169 | 370 | 8.2 | 18.5 | nd | 30. | 6.4 | 28 | 8.8 | nd | 141 | 34 | 27 |
| DB170 | 640 | 8.2 | 18.0 | nd | 51. | 13. | 60 | 11.0 | nd | 224 | 110 | 19 |
| DB176 | 925 | 7.3 | 16.8 | nd | 130. | 14. | 75 | 6.9 | nd | 341 | 220 | 37 |
| DB179 | 296 | 7.8 | 20.5 | nd | 32. | 9.3 | nd | nd | 14 | 130 | 31 | 6 |
| DB180 | 825 | 7.6 | 16.8 | nd | 85. | 13. | 88 | 6.3 | nd | 339 | 160 | 29 |
| DB181 | 760 | 7.5 | 16.9 | nd | 97. | 14. | 70 | 7.5 | nd | 294 | 160 | 29 |
| DB183 | 763 | nd | nd | nd | 70. | 12. | nd | nd | 88 | 300 | 140 | 25 |
| DB185 | 595 | 7.1 | 23.5 | nd | 84. | 14. | 30 | 6.2 | nd | 232 | 110 | 38 |
| DB186 | 479 | 7.7 | 18.1 | 2.65 | 51. | 7.9 | 35 | 5.4 | nd | 190 | 79 | 9 |
| DB188 | 465 | 7.4 | 26.0 | nd | 34. | 7.3 | 48 | 8.1 | nd | 115 | 65 | 36 |
| DB190 | 400 | 7.6 | 26.0 | nd | 28. | 6.7 | 40 | 8.8 | nd | 115 | 47 | 33 |
| DB192 | 318 | 7.8 | 20.0 | nd | 32. | 6.6 | nd | nd | 25 | 130 | 36 | 9 |
| DB193 | 263 | 8.0 | 16.5 | nd | 38. | 1. | nd | nd | 17 | 120 | 26 | 6 |
| DB194 | 400 | 7.5 | 25.0 | nd | 34. | 7.2 | 33 | 6.9 | nd | 134 | 34 | 35 |
| DB195 | 389 | 8.0 | 25.5 | nd | 17. | 7.1 | nd | nd | 54 | 150 | 33 | 19 |
| DB197 | 711 | 7.3 | 16.5 | 0.05 | 89. | 12. | 40 | 5.4 | nd | 324 | 100 | 14 |
| DB199 | 292 | 7.9 | nd | nd | 33. | 6.6 | nd | nd | 19 | 130 | 30 | 9 |
| DB207 | 420 | 7.6 | 17.2 | 0.05 | 48. | 6.9 | 25 | 3.4 | nd | 166 | 67 | 10 |
| DB225 | 405 | 7.9 | nd | nd | 30. | 9. | nd | nd | 41 | 140 | 48 | 22 |
| DB226 | 467 | 8.0 | nd | nd | 53. | 14. | nd | nd | 21 | 110 | 94 | 30 |
| DB228 | 750 | 7.2 | 18.6 | 0.20 | 85. | 11. | 61 | 7.4 | nd | 274 | 150 | 24 |
| DB230 | 490 | 7.5 | 17.7 | 0.10 | 61. | 8.8 | 29 | 4.1 | nd | 210 | 69 | 14 |
| DB233 | 454 | 7.7 | 16.5 | nd | 33. | 6.2 | nd | nd | 56 | 160 | 78 | 15 |
| DB236 | 566 | 7.6 | nd | nd | 46. | 16. | nd | nd | 51 | 170 | 99 | 32 |
| DB237 | 916 | 7.6 | nd | nd | 89. | 26. | nd | nd | 75 | 250 | 210 | 46 |
| DB239 | 556 | 7.7 | 14.0 | nd | 63. | 13. | nd | nd | 38 | 190 | 110 | 16 |
| DB242 | 889 | 7.5 | 18.0 | nd | 110. | 29. | nd | nd | 40 | 230 | 210 | 52 |
| DB246 | 574 | 7.5 | 18.9 | 0.20 | 68. | 10. | 30 | 4.5 | nd | 226 | 99 | 12 |
| DB250 | 583 | 8.0 | 16.0 | nd | 58. | 14. | nd | nd | 45 | 170 | 120 | 20 |
| DB252 | 585 | 7.7 | 20.0 | nd | 63. | 13. | nd | nd | 41 | 180 | 110 | 24 |
| DB256 | 326 | 7.8 | 17.0 | nd | 40. | 4.8 | nd | nd | 20 | 140 | 29 | 10 |
| DB258 | 380 | 7.8 | 20.0 | nd | 38. | 8.1 | nd | nd | 29 | 140 | 42 | 19 |
| DB259 | 870 | 7.2 | 17.5 | 4.70 | 97. | 15. | 79 | 7.3 | nd | 341 | 190 | 19 |
| DB260 | 500 | 7.8 | 16.0 | 0.10 | 60. | 8. | 35 | 4.9 | nd | 201 | 83 | <0.1 |
| DB261 | 313 | 8.0 | nd | nd | 40. | 5.2 | nd | nd | 20 | 140 | 34 | 8 |
| DB262 | 350 | 7.9 | 15.0 | 0.20 | 44. | 5.9 | 25 | 3.7 | nd | 134 | 65 | 9 |
| DB265 | 790 | 7.3 | 16.0 | 0.20 | 99. | 17. | 43 | 9.5 | nd | 268 | 200 | 15 |
| DB267 | 315 | 7.8 | 15.5 | nd | 34. | 7.6 | nd | nd | 21 | 130 | 37 | 10 |
| DB269 | 900 | 7.4 | 16.0 | 0.10 | 120. | 18. | 68 | 8.9 | nd | 354 | 210 | 22 |
| DB270 | 530 | 7.8 | 17.5 | 0.30 | 71. | 12. | 30 | 7.6 | nd | 220 | 110 | 11 |
| DB273 | 790 | 7.6 | 17.0 | 0.20 | 80. | 13. | 80 | 8.1 | nd | 354 | 130 | 13 |
| DB275 | 420 | 7.8 | 15.0 | 0.10 | 50. | 6.8 | 28 | 4.2 | nd | 146 | 73 | 8 |
| DB279 | 614 | 7.7 | nd | nd | 61. | 19. | nd | nd | 38 | 170 | 130 | 26 |
| DB283 | 630 | 7.4 | 14.0 | 0.20 | 71. | 13. | 44 | 5.7 | nd | 220 | 110 | 20 |
| DB286 | 590 | 7.9 | 17.5 | 0.20 | 63. | 11. | 23 | 4.3 | nd | 93 | 110 | 55 |

**Table E2.** Summary of field parameters and major-element chemistry for selected ground-water sites in the U.S. Geological Survey National Water Information System that were included in the final data set, by hydrochemical zone-- Continued

| Sample reference number | Sp. Cond. (µS/cm) | pH | Temp (ºC) | $O_2$ (mg/L) | $Ca^{2+}$ (mg/L) | $Mg^{2+}$ (mg/L) | $Na^{+}$ (mg/L) | $K^{+}$ (mg/L) | Na + K (mg/L as Na) | $HCO_3^{-}$ (mg/L) | $SO_4^{2-}$ (mg/L) | $Cl^{-}$ (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DB288 | 270 | 7.9 | 17.5 | nd | 30. | 6.7 | 17 | 6.2 | nd | 121 | 30 | 10 |
| DB291 | 275 | 8.1 | 17.0 | nd | 34. | 4.1 | nd | nd | 21 | 130 | 28 | 10 |
| DB292 | 487 | 7.8 | 16.0 | 0.20 | 51. | 7.2 | 41 | 3.5 | nd | 171 | 68 | 26 |
| DB294 | 700 | 7.2 | 16.5 | nd | 98. | 29. | 30 | 15.0 | nd | 355 | 120 | 15 |
| DB295 | 800 | 7.4 | 15.5 | nd | 88. | 24. | 65 | 14.0 | nd | 371 | 150 | 13 |
| DB296 | 910 | 7.3 | 15.5 | nd | 130. | 22. | 55 | 7.3 | nd | 422 | 190 | 13 |
| DB298 | 291 | 7.7 | 16.5 | nd | 34. | 9. | nd | nd | 13 | 130 | 31 | 10 |
| DB299 | 610 | 7.7 | 17.0 | 0.20 | 81. | 16. | 27 | 5.5 | nd | 207 | 86 | 62 |
| DB308 | 419 | 7.9 | 17.0 | nd | 51. | 10. | 31 | 6.5 | nd | 157 | 89 | 14 |
| DB309 | 315 | 8.1 | 16.0 | nd | 30. | 6.2 | 31 | 6.5 | nd | 126 | 53 | 10 |
| DB310 | 430 | 7.9 | 15.0 | nd | 47. | 8.7 | 31 | 6.9 | nd | 172 | 72 | 11 |
| DB312 | 570 | 7.6 | 16.0 | 0.40 | 73. | 19. | 25 | 8.2 | nd | 220 | 110 | 25 |
| DB317 | 700 | 7.4 | 15.0 | 0.10 | 100. | 13. | 42 | 5.4 | nd | 341 | 110 | 7 |
| DB318 | 760 | 7.4 | 17.0 | 0.20 | 110. | 27. | 31 | 7.1 | nd | 341 | 150 | 25 |
| DB320 | 380 | 7.8 | 18.0 | 0. 0 | 43. | 9.6 | 17 | 4.2 | nd | 110 | 70 | 22 |
| DB325 | 343 | nd | nd | nd | 40. | 10. | nd | nd | 12 | 140 | 41 | 4 |
| DB327 | 958 | 8.4 | nd | nd | 100. | 11. | nd | nd | 110 | 330 | 220 | 22 |
| DB332 | 939 | 7.6 | nd | nd | 120. | 27. | nd | nd | 49 | 380 | 170 | 26 |
| DB333 | 365 | 7.6 | nd | nd | 40. | 8.5 | nd | nd | 22 | 132 | 47 | 18 |
| DB340 | 600 | 7.5 | 16.6 | nd | 83. | 13. | 23 | 3.6 | nd | 220 | 92 | 17 |
| DB350 | 430 | 8.0 | 12.5 | nd | 55. | 9.1 | 18 | 4.7 | nd | 155 | 73 | 12 |
| DB351 | 386 | 8.0 | 8.5 | nd | 46. | 7.3 | 22 | 2.9 | nd | 151 | 58 | 8 |
| DB352 | 323 | 8.0 | 15.3 | nd | 37. | 6.9 | 16 | 6.4 | nd | 146 | 33 | 7 |
| DB353 | 527 | 8.1 | 15.3 | nd | 73. | 13. | 21 | 3.6 | nd | 198 | 83 | 17 |
| DB354 | 344 | 7.7 | 17.5 | nd | 27. | 6.7 | 32 | 6.1 | nd | 151 | 31 | 10 |
| DB355 | 800 | 7.2 | 19.7 | 1.80 | 130. | 12. | 36 | 6.1 | nd | 339 | 160 | 22 |
| DB356 | 281 | 8.0 | nd | nd | 35. | 4.5 | nd | nd | 17 | 120 | 30 | 8 |
| DB357 | 280 | 8.1 | 14.3 | 0.10 | 31. | 5.8 | 14 | 4.5 | nd | 126 | 26 | 7 |
| DB358 | 700 | 7.3 | 18.3 | 0.20 | 95. | 12. | 35 | 5.1 | nd | 244 | 160 | 21 |
| DB362 | 765 | 7.1 | 17.5 | 0.20 | 110. | 14. | 33 | 5.1 | nd | 362 | 66 | 44 |
| DB366 | 521 | 7.8 | 10.5 | nd | 63. | 10. | nd | nd | 38 | 190 | 94 | 18 |
| DB367 | 420 | 7.8 | 16.0 | 0.05 | 48. | 6.8 | 28 | 3.3 | nd | 170 | 59 | 11 |
| DB370 | 501 | 7.8 | nd | nd | 57. | 10. | nd | nd | 29 | 130 | 58 | 51 |
| DB372 | 317 | 8.0 | 15.0 | <0.05 | 32. | 11. | 14 | 5.7 | nd | 148 | 30 | 8 |
| DB373 | 900 | 7.2 | 16.0 | 3.80 | 130. | 27. | 34 | 1.5 | nd | 513 | 85 | 8 |
| DB375 | 751 | 7.2 | 17.1 | 4.10 | 100. | 12. | 28 | 4.1 | nd | 324 | 95 | 9 |
| DB376 | 352 | 7.4 | 13.0 | nd | 28. | 5. | 36 | 7.6 | nd | 156 | 35 | 7 |
| DB378 | 631 | 7.8 | 17.0 | nd | 70. | 19. | nd | nd | 36 | 210 | 84 | 44 |
| DB379 | 348 | 7.5 | 16.0 | nd | 31. | 5.9 | 30 | 6.4 | nd | 142 | 37 | 7 |
| DB381 | 906 | 7.5 | 15.0 | nd | 120. | 22. | nd | nd | 58 | 380 | 150 | 17 |
| DB382 | 380 | 7.6 | nd | nd | 44. | 12. | nd | nd | 17 | 140 | 60 | 14 |
| DB383 | 878 | 7.5 | nd | nd | 110. | 17. | nd | nd | 60 | 360 | 140 | 22 |
| DB389 | 666 | 7.5 | nd | nd | 60. | 11. | nd | nd | 69 | 250 | 85 | 37 |
| DB390 | 501 | 7.8 | 18.0 | nd | 37. | 11. | nd | nd | 56 | 170 | 53 | 46 |
| DB391 | 642 | nd | 27.0 | nd | 41. | 6.8 | 79 | 7.9 | nd | 200 | 40 | 72 |
| DB398 | 860 | 7.7 | nd | nd | 98. | 15. | 55 | 5.8 | nd | 223 | 170 | 47 |
| DB400 | 524 | 7.6 | nd | nd | 30. | 6.1 | nd | nd | 81 | 230 | 46 | 28 |
| DB413 | 749 | 6.6 | 25.5 | nd | 65. | 15. | 77 | 11.0 | nd | 394 | 29 | 35 |
| DB468 | 327 | 7.9 | nd | nd | 34. | 8.5 | 21 | 5.0 | nd | 130 | 41 | 11 |
| **Zone 13: Discharge** | | | | | | | | | | | | |
| DB009 | 1,771 | 7.7 | 17.2 | 0.10 | 130. | 36. | 190 | 8.9 | nd | 202 | 340 | 280 |
| DB021 | 1,150 | 8.3 | 22.5 | nd | 84. | 27. | 120 | 27.0 | nd | 120 | 240 | 190 |
| DB025 | 3,400 | 7.6 | 17.5 | nd | 98. | 31. | 770 | 8.6 | nd | 180 | 330 | 1,100 |
| DB029 | 975 | 7.9 | 17.0 | nd | 48. | 17. | 140 | 22.0 | nd | 140 | 170 | 150 |

**Table E3.** Summary of minor- and trace-element chemistry for selected ground-water sites in the U.S. Geological Survey National Water Information System that were included in the final data set, by hydrochemical zone

[nd, not determined; <, less than; mg/L, milligrams per liter; µg/L, micrograms per liter; F, fluoride; Br, bromide; $SiO_2$, silica; $NO_3$, nitrate; N, nitrogen; Al, aluminum; As, arsenic; Ba, barium; B, boron; Fe, iron; Li, lithium; Mn, manganese; Mo, molybdenum]

| Sample reference number | F (mg/L) | Br (mg/L) | $SiO_2$ (mg/L) | $NO_3$ (mg/L as N) | Al (mg/L) | As (µg/L) | Ba (mg/L) | B (mg/L) | Fe (mg/L) | Li (mg/L) | Mn (mg/L) | Mo (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Zone 1: Northern Mountain Front** | | | | | | | | | | | | |
| DB445 | 0.4 | nd | 39. | 0.32 | nd | nd | nd | nd | 0.020 | nd | nd | nd |
| DB455 | 0.5 | nd | 56. | 0.50 | nd | nd | nd | nd | 0.060 | nd | nd | nd |
| **Zone 2: Northwestern** | | | | | | | | | | | | |
| DB427 | 0.6 | nd | 31. | 1.80 | nd | nd | nd | nd | 0.040 | nd | nd | nd |
| DB428 | 0.6 | nd | 23. | 2.30 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB429 | 0.6 | nd | 30. | 1.30 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB436 | 0.4 | <0.1 | 36. | nd | nd | 4 | nd | 0.110 | 1.700 | nd | <0.010 | nd |
| DB447 | 0.4 | 0.030 | 33. | nd | nd | 15 | nd | 0.050 | 0.020 | nd | <0.010 | nd |
| **Zone 3: West Central** | | | | | | | | | | | | |
| DB019 | 1.1 | nd | 34. | 0.72 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB022 | nd | nd | nd | 0.27 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB031 | 1.0 | 0.180 | 35. | nd | 0.004 | 5 | 0.018 | nd | <0.003 | nd | <0.001 | 10 |
| DB058 | 1.0 | nd | 29. | 1.20 | nd | nd | nd | nd | 0.030 | nd | nd | nd |
| DB066 | 0.9 | nd | 24. | nd | nd | nd | nd | 0.250 | 0.330 | nd | 0.020 | nd |
| DB073 | 1.3 | 0.130 | 45. | nd | 0.015 | 22 | 0.018 | nd | 0.012 | nd | <0.001 | 12 |
| DB074 | 1.0 | 0.090 | 45. | nd | 0.003 | 19 | 0.026 | nd | <0.003 | nd | <0.001 | 4 |
| DB077 | 0.9 | nd | 39. | 1.40 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB082 | 0.8 | nd | 51. | 0.02 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB084 | 1.8 | nd | 50. | 0.02 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB091 | 1.0 | nd | 48. | 0.11 | nd | nd | nd | nd | 0.040 | nd | nd | nd |
| DB108 | 1.1 | nd | 39. | 0.30 | nd | 7 | nd | 0.150 | 0.020 | nd | <0.010 | nd |
| DB109 | 1.2 | nd | 68. | 0.83 | nd | 24 | nd | 0.450 | 0.070 | nd | <0.010 | nd |
| DB119 | 1.2 | nd | 52. | 0.09 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB134 | 1.2 | nd | 44. | 0.16 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB187 | 0.5 | nd | 47. | 0.02 | nd | nd | nd | nd | 0.380 | nd | nd | nd |
| DB189 | 0.8 | nd | 75. | nd | nd | 29 | <0.100 | 0.200 | 0.030 | nd | <0.010 | nd |
| DB191 | 1.1 | nd | 40. | nd | nd | 45 | <0.100 | 0.260 | 0.030 | nd | 0.020 | nd |
| DB215 | 0.6 | nd | 60. | 0.05 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB223 | 0.8 | nd | 60. | 0.16 | nd | nd | nd | nd | 0.020 | nd | nd | nd |
| DB232 | 0.8 | nd | 49. | nd | nd | 31 | 0.019 | nd | 0.500 | nd | 0.088 | nd |
| DB234 | 2.2 | nd | nd | nd | nd | 70 | 0.000 | 0.360 | 0.020 | nd | 0.010 | nd |
| DB253 | 1.0 | nd | 30. | nd | nd | 28 | 0.020 | nd | 0.030 | nd | 0.005 | nd |
| DB323 | 0.6 | nd | 15. | 1.60 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB453 | 0.5 | <0.1 | 30. | nd | nd | 12 | nd | 0.240 | 3.700 | nd | 0.020 | nd |
| **Zone 4: Western Boundary** | | | | | | | | | | | | |
| DB007 | 1.0 | nd | 18. | 0.34 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB010 | 0.6 | nd | 26. | 0.45 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB026 | nd | nd | nd | 0.86 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB032 | 0.8 | nd | 23. | nd | nd | <1 | 0.040 | nd | 0.016 | nd | 0.064 | nd |
| DB036 | 1.0 | nd | 17. | nd | nd | 3 | 0.000 | 0.510 | 0.590 | nd | 0.060 | nd |
| DB038 | 1.0 | nd | 22. | 2.00 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB041 | 0.8 | nd | 24. | 0.97 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB068 | nd | nd | 25. | 0.86 | nd | nd | nd | nd | nd | nd | nd | nd |

**Table E3.** Summary of minor- and trace-element chemistry for selected ground-water sites in the U.S. Geological Survey National Water Information System that were included in the final data set, by hydrochemical zone-- Continued

| Sample reference number | F (mg/L) | Br (mg/L) | $SiO_2$ (mg/L) | $NO_3$ (mg/L as N) | Al (mg/L) | As (µg/L) | Ba (mg/L) | B (mg/L) | Fe (mg/L) | Li (mg/L) | Mn (mg/L) | Mo (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DB069 | 0.6 | nd | 17. | nd | nd | nd | nd | 0.900 | 0.220 | nd | 0.060 | nd |
| DB071 | 5.0 | nd | 22. | 0.18 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB116 | 4.3 | nd | 20. | nd | nd | nd | nd | nd | 0.091 | nd | nd | nd |
| DB117 | 3.8 | 27.000 | 19. | nd | nd | nd | nd | 14.000 | 0.020 | nd | 0.220 | nd |
| DB433 | 5.7 | nd | 29. | 0.29 | nd | nd | nd | 8.100 | nd | nd | nd | nd |
| DB450 | 6.86 | nd | 37.6 | nd | nd | nd | nd | nd | <0.015 | 0.006 | 0.070 | nd |
| DB451 | 7.3 | nd | 48. | 0.07 | nd | nd | nd | 6.100 | nd | nd | nd | nd |
| DB452 | 4.0 | 5.000 | 68. | nd | nd | 69 | nd | 8.200 | 0.050 | nd | 1.300 | nd |
| **Zone 5: Rio Puerco** | | | | | | | | | | | | |
| DB024 | nd | nd | nd | 0.61 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB051 | 0.6 | nd | 16. | nd | nd | nd | nd | 0.730 | 0.100 | nd | 0.010 | nd |
| DB055 | 0.1 | nd | 24. | 2.70 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB057 | 0.2 | nd | 24. | 0.29 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB063 | 0.5 | nd | 17. | nd | nd | nd | nd | 0.400 | 0.110 | nd | 0.010 | nd |
| DB086 | 1.3 | 0.900 | 13. | nd | nd | nd | nd | 1.500 | 1.200 | nd | 0.040 | nd |
| DB089 | 1.0 | nd | 26. | nd | nd | nd | nd | 0.200 | 0.050 | nd | 0.007 | nd |
| DB103 | 1.3 | 4.800 | 15. | nd | nd | nd | nd | 3.700 | 0.090 | nd | 0.040 | nd |
| DB114 | 0.4 | nd | 27. | 0.52 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB122 | 0.8 | nd | 13. | 0.75 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB124 | 2.0 | nd | 16. | 0.27 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB132 | 2.0 | nd | 16. | 0.27 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB157 | 2.9 | nd | 7.7 | 0.07 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB175 | 3.4 | 0.800 | 13. | nd | nd | nd | nd | 1.800 | 0.020 | nd | 0.070 | nd |
| DB201 | 0.6 | nd | nd | nd | nd | nd | nd | 0.180 | <0.010 | nd | nd | nd |
| DB206 | 0.9 | nd | 23. | 2.30 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB209 | 1.2 | nd | 21. | 1.40 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB219 | 0.6 | nd | 15. | 0.88 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB220 | 0.5 | nd | 19. | 0.97 | nd | nd | nd | nd | 0.000 | nd | nd | nd |
| DB221 | 0.6 | nd | 18. | 0.79 | nd | nd | nd | nd | 0.020 | nd | nd | nd |
| DB222 | 0.6 | nd | 19. | 0.81 | nd | nd | nd | nd | 0.010 | nd | nd | nd |
| DB235 | 0.3 | nd | 19. | 0.02 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB385 | 1.3 | nd | 9.1 | 0.14 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB387 | 1.9 | nd | 27. | nd | nd | nd | nd | 0.230 | 0.050 | nd | 0.004 | nd |
| DB407 | 1.3 | nd | 22. | nd | nd | nd | nd | 0.230 | <0.010 | nd | 0.002 | nd |
| **Zone 6: Southwestern Mountain Front** | | | | | | | | | | | | |
| DB027 | 1.3 | nd | 26. | nd | nd | 0 | 0.030 | 0.010 | <0.010 | nd | 0.009 | nd |
| **Zone 7: Abo Arroyo** | | | | | | | | | | | | |
| DB011 | 2.0 | nd | 24. | 1.10 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB014 | 1.0 | nd | 27. | 0.99 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB017 | nd | nd | nd | 1.80 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB023 | 0.9 | nd | 27. | nd | nd | nd | nd | 0.130 | 0.010 | nd | <0.001 | nd |
| DB033 | nd | nd | nd | 1.40 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB035 | nd | nd | nd | 1.40 | nd | nd | nd | nd | nd | nd | nd | nd |
| **Zone 8: Eastern Mountain Front** | | | | | | | | | | | | |
| DB013 | 2.3 | nd | 17. | nd | nd | nd | nd | 0.130 | 0.070 | 0.040 | nd | nd |
| DB037 | 0.8 | nd | 23. | nd | nd | nd | nd | 0.060 | <0.010 | nd | 0.004 | nd |
| DB040 | 0.4 | nd | 56. | nd | nd | 8 | 0.090 | 0.010 | 0.030 | nd | <0.001 | nd |
| DB045 | 0.6 | nd | 17. | 0.36 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB048 | 0.7 | nd | 29. | nd | nd | nd | nd | 0.060 | <0.010 | nd | <0.001 | nd |

**Table E3.** Summary of minor- and trace-element chemistry for selected ground-water sites in the U.S. Geological Survey National Water Information System that were included in the final data set, by hydrochemical zone-- Continued

| Sample reference number | F (mg/L) | Br (mg/L) | $SiO_2$ (mg/L) | $NO_3$ (mg/L as N) | Al (mg/L) | As (µg/L) | Ba (mg/L) | B (mg/L) | Fe (mg/L) | Li (mg/L) | Mn (mg/L) | Mo (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DB052 | 0.4 | nd | 49. | 0.54 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB064 | 0.6 | nd | 40. | nd | nd | nd | nd | 0.020 | 0.050 | nd | 0.002 | nd |
| DB070 | 0.4 | nd | 11. | nd | nd | nd | nd | 0.040 | 0.010 | nd | 0.020 | nd |
| DB087 | 0.3 | nd | 26. | nd | nd | nd | nd | 0.050 | <0.010 | nd | 0.003 | nd |
| DB208 | 0.3 | nd | 27. | 0.90 | nd | nd | nd | nd | 0.010 | nd | nd | nd |
| DB244 | 0.7 | nd | 24. | nd | nd | 2 | <0.100 | 0.030 | 0.040 | nd | <0.010 | nd |
| DB247 | 1.0 | nd | 34. | nd | nd | <1 | <0.100 | 0.006 | 0.040 | nd | <0.010 | nd |
| DB274 | 1.4 | nd | 23. | 1.10 | nd | nd | nd | nd | 0.020 | nd | nd | nd |
| DB276 | 0.8 | nd | 26. | 0.11 | nd | nd | nd | nd | 0.030 | nd | nd | nd |
| DB282 | 0.9 | nd | 32. | nd | nd | 4 | <0.100 | 0.030 | 0.030 | nd | 0.050 | nd |
| DB328 | 0.6 | nd | 26. | nd | nd | <1 | nd | 0.020 | 0.008 | nd | 0.001 | nd |
| DB329 | 0.5 | nd | 26. | nd | nd | <1 | nd | 0.020 | 0.007 | nd | 0.003 | nd |
| DB330 | 1.8 | nd | 23. | nd | nd | <1 | nd | 0.020 | 0.012 | nd | 0.001 | nd |
| DB338 | 0.8 | nd | 32. | nd | nd | 2 | nd | 0.220 | 0.006 | nd | <0.001 | nd |
| DB339 | 0.6 | nd | 26. | 0.16 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB345 | 1.5 | nd | 26. | nd | nd | <1 | nd | 0.020 | 0.013 | nd | <0.001 | nd |
| DB371 | 0.2 | nd | 48. | 0.09 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB384 | 0.6 | nd | 47. | 0.16 | nd | nd | nd | nd | 0.060 | nd | nd | nd |
| DB392 | 0.3 | nd | 19. | 0.20 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB397 | 0.3 | 0.000 | 24. | nd | nd | nd | nd | 0.030 | 0.040 | nd | <0.010 | nd |
| DB408 | 1.4 | nd | 16. | 0.20 | nd | nd | nd | nd | nd | nd | nd | nd |
| **Zone 9: Tijeras Fault Zone** | | | | | | | | | | | | |
| DB138 | nd | nd | nd | 3.20 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB143 | 0.8 | nd | 16. | 1.10 | nd | nd | nd | nd | 0.000 | nd | nd | nd |
| DB144 | 1.3 | nd | 28. | 2.20 | nd | nd | nd | nd | 0.020 | nd | nd | nd |
| DB146 | 1.2 | nd | 15. | 0.77 | nd | nd | nd | nd | 0.060 | nd | nd | nd |
| DB147 | 0.8 | nd | 18. | 1.80 | nd | nd | nd | nd | 0.000 | nd | nd | nd |
| **Zone 10: Tijeras Arroyo** | | | | | | | | | | | | |
| DB198 | 0.6 | nd | 20. | 3.80 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB202 | 0.7 | nd | 19. | nd | nd | <1 | nd | 0.100 | 0.004 | nd | nd | nd |
| DB203 | 0.6 | nd | 19. | 0.62 | nd | <1 | nd | 0.070 | 0.006 | nd | nd | nd |
| DB205 | 0.6 | nd | 17. | nd | nd | <1 | nd | 0.060 | 0.011 | nd | nd | nd |
| DB213 | 0.7 | nd | 20. | nd | nd | <1 | <0.100 | 0.050 | <0.010 | nd | <0.010 | nd |
| **Zone 11: Northeastern** | | | | | | | | | | | | |
| DB410 | 0.4 | nd | 39. | nd | nd | 3 | <0.100 | 0.360 | 0.030 | nd | <0.010 | nd |
| DB411 | 0.4 | nd | 78. | nd | nd | 4 | <0.100 | 0.270 | 3.000 | nd | 0.070 | nd |
| DB412 | 0.4 | nd | 72. | 0.32 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB414 | 0.5 | nd | 74. | 0.56 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB415 | 0.4 | nd | 42. | 4.50 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB419 | 1.0 | nd | 25. | 0.02 | nd | nd | nd | nd | 0.000 | nd | nd | nd |
| DB421 | 0.6 | nd | 35. | 0.02 | nd | nd | nd | nd | 0.170 | nd | nd | nd |
| DB431 | 0.5 | nd | 34. | 0.02 | nd | nd | nd | nd | 0.160 | nd | nd | nd |
| DB442 | 0.4 | 0.110 | 63. | nd | 0.003 | 4 | 0.048 | nd | <0.003 | nd | <0.001 | 5 |
| **Zone 12: Central** | | | | | | | | | | | | |
| DB062 | 0.6 | nd | 0.1 | nd | nd | nd | nd | nd | 0.060 | nd | 0.008 | nd |
| DB072 | nd | nd | nd | 0.47 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB075 | 0.7 | nd | 41. | nd | nd | nd | nd | 0.060 | 0.030 | nd | 0.006 | nd |
| DB079 | 0.5 | nd | 31. | 0.05 | nd | nd | nd | nd | 0.200 | nd | nd | nd |
| DB081 | 0.4 | nd | 36. | nd | nd | nd | nd | nd | <0.010 | nd | 0.002 | nd |

**Table E3.** Summary of minor- and trace-element chemistry for selected ground-water sites in the U.S. Geological Survey National Water Information System that were included in the final data set, by hydrochemical zone-- Continued

| Sample reference number | F (mg/L) | Br (mg/L) | $SiO_2$ (mg/L) | $NO_3$ (mg/L as N) | Al (mg/L) | As (µg/L) | Ba (mg/L) | B (mg/L) | Fe (mg/L) | Li (mg/L) | Mn (mg/L) | Mo (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DB083 | 0.3 | nd | 34. | nd | nd | nd | nd | nd | 0.012 | nd | 0.064 | nd |
| DB088 | 0.4 | nd | 35. | 0.14 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB093 | 0.5 | 0.050 | 46. | nd | 0.003 | 6 | 0.083 | nd | 0.037 | nd | <0.001 | 4 |
| DB094 | 0.3 | 0.050 | 48. | nd | 0.004 | 6 | 0.074 | nd | <0.003 | nd | 0.008 | 3 |
| DB095 | 0.4 | nd | 45. | nd | nd | nd | nd | 0.050 | 0.090 | nd | nd | nd |
| DB096 | 0.2 | nd | 33. | nd | nd | nd | nd | 0.160 | <0.010 | nd | nd | nd |
| DB101 | 0.3 | nd | 32. | nd | nd | nd | nd | nd | 0.030 | nd | <0.010 | nd |
| DB123 | 0.3 | nd | 37. | 0.05 | nd | nd | nd | nd | 0.180 | nd | nd | nd |
| DB133 | 0.4 | 0.055 | 34. | nd | <0.010 | 5 | 0.075 | 0.090 | 0.340 | nd | 1.000 | <10 |
| DB135 | 0.4 | nd | 25. | nd | 0.004 | 2 | 0.117 | nd | 0.260 | nd | 0.600 | 5 |
| DB136 | 0.3 | nd | 51. | nd | <0.010 | 3 | 0.120 | 0.060 | 0.072 | nd | 0.850 | <10 |
| DB137 | 0.4 | nd | 37. | 0.02 | nd | nd | nd | nd | 0.840 | nd | nd | nd |
| DB139 | 0.5 | 0.080 | 57. | nd | 0.003 | 10 | 0.027 | nd | 0.003 | nd | 0.002 | 3 |
| DB140 | 0.4 | 0.083 | 60. | nd | <0.010 | 7 | 0.079 | 0.060 | 0.005 | nd | 0.007 | <10 |
| DB141 | 0.7 | 0.110 | 31. | 1.65 | 0.004 | 3 | 0.110 | nd | 0.009 | nd | 2.400 | 6 |
| DB142 | 0.3 | nd | 50. | nd | nd | nd | nd | nd | 0.046 | nd | 0.800 | nd |
| DB145 | 0.6 | 0.069 | 74. | 0.19 | <0.010 | 15 | 0.140 | 0.060 | 0.021 | nd | 0.003 | <10 |
| DB148 | 0.7 | nd | 55. | nd | <0.010 | 18 | 0.085 | 0.190 | 0.005 | nd | 0.180 | <10 |
| DB149 | 0.5 | nd | 58. | 0.07 | nd | nd | nd | nd | 0.040 | nd | nd | nd |
| DB150 | 0.5 | 0.028 | 36. | nd | <0.010 | 18 | 0.092 | 0.110 | 0.005 | nd | 0.520 | <10 |
| DB151 | 0.8 | 0.140 | 37. | nd | 0.004 | 10 | 0.113 | nd | 0.100 | nd | 0.230 | 11 |
| DB153 | 0.4 | 0.170 | 63. | nd | <0.010 | 3 | 0.200 | 0.080 | 0.042 | nd | 0.004 | <10 |
| DB155 | 0.4 | nd | 42. | 0.05 | nd | nd | nd | nd | 0.040 | nd | nd | nd |
| DB156 | 0.6 | nd | nd | 0.07 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB159 | nd | nd | 2.9 | 0.25 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB161 | 0.5 | nd | 69. | 0.11 | nd | nd | nd | 0.070 | 0.050 | nd | nd | nd |
| DB162 | 0.5 | nd | 66. | nd | nd | 6 | 0.085 | nd | nd | nd | nd | nd |
| DB168 | 0.1 | nd | 17. | nd | nd | 8 | 0.053 | nd | nd | nd | nd | nd |
| DB169 | 0.5 | nd | 82. | nd | nd | 15 | 0.069 | nd | nd | nd | nd | nd |
| DB170 | 0.7 | nd | 66. | nd | nd | 9 | 0.052 | nd | nd | nd | nd | nd |
| DB176 | 0.6 | 0.095 | 27. | 1.09 | 0.010 | 2 | 0.075 | 0.190 | 0.210 | nd | 0.840 | 20 |
| DB179 | 0.6 | nd | 57. | 0.02 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB180 | 0.6 | nd | 38. | nd | 0.010 | 7 | 0.072 | 0.200 | 0.210 | nd | 0.870 | 10 |
| DB181 | 0.7 | 0.093 | 32. | nd | 0.010 | 5 | 0.097 | 0.150 | <0.003 | nd | 0.680 | <10 |
| DB183 | 0.8 | nd | 38. | 0.11 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB185 | 0.3 | nd | 50. | 0.01 | nd | 3 | 0.200 | 0.120 | 0.050 | nd | nd | nd |
| DB186 | 0.6 | 0.120 | 36. | nd | 0.014 | 4 | 0.062 | nd | 0.110 | nd | 0.570 | 5 |
| DB188 | 0.7 | nd | 71. | 0.39 | nd | 21 | 0.100 | 0.170 | <0.010 | nd | nd | nd |
| DB190 | 0.0 | nd | 78. | 0.41 | nd | 21 | 0.100 | 0.110 | <0.010 | nd | nd | nd |
| DB192 | 0.4 | nd | 38. | 0.07 | nd | nd | nd | 0.060 | 0.040 | nd | nd | nd |
| DB193 | 0.4 | nd | 32. | 0.02 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB194 | 0.5 | nd | 71. | 0.26 | nd | 13 | 0.100 | 0.120 | <0.010 | nd | nd | nd |
| DB195 | 0.8 | nd | 73. | 0.29 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB197 | 0.7 | 0.080 | 34. | nd | 0.002 | 9 | 0.066 | nd | 2.160 | nd | 1.010 | 6 |
| DB199 | 0.4 | nd | 38. | 0.05 | nd | nd | nd | nd | 0.000 | nd | nd | nd |
| DB207 | 0.4 | 0.040 | 26. | nd | 0.003 | 6 | 0.062 | nd | 0.210 | nd | 0.230 | 7 |
| DB225 | 0.4 | nd | 81. | 0.18 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB226 | 0.4 | nd | 45. | 0.29 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB228 | 0.8 | 0.170 | 31. | 0.08 | 0.003 | 10 | 0.111 | nd | 0.032 | nd | 0.410 | 10 |
| DB230 | 0.4 | 0.040 | 25. | nd | 0.003 | 4 | 0.127 | nd | 0.120 | nd | 0.810 | 4 |
| DB233 | 0.6 | nd | 62. | 0.02 | nd | nd | nd | nd | nd | nd | nd | nd |

**Table E3.** Summary of minor- and trace-element chemistry for selected ground-water sites in the U.S. Geological Survey National Water Information System that were included in the final data set, by hydrochemical zone-- Continued

| Sample reference number | F (mg/L) | Br (mg/L) | $SiO_2$ (mg/L) | $NO_3$ (mg/L as N) | Al (mg/L) | As (μg/L) | Ba (mg/L) | B (mg/L) | Fe (mg/L) | Li (mg/L) | Mn (mg/L) | Mo (μg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DB236 | 0.6 | nd | 75. | 0.02 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB237 | 0.6 | nd | 73. | 0.05 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB239 | 0.4 | nd | 33. | 0.07 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB242 | 0.4 | nd | 61. | 0.02 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB246 | 0.4 | 0.050 | 24. | nd | 0.002 | 5 | 0.143 | nd | 0.009 | nd | 1.200 | 4 |
| DB250 | 0.4 | nd | 51. | 0.29 | nd | nd | nd | 0.030 | nd | nd | nd | nd |
| DB252 | 0.4 | nd | 64. | 0.09 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB256 | 0.2 | nd | 40. | 0.16 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB258 | 0.4 | nd | 58. | 0.05 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB259 | 0.1 | nd | 49. | nd | nd | 3 | 0.030 | nd | 0.008 | nd | 0.001 | nd |
| DB260 | 0.4 | 0.050 | 23. | 2.78 | 0.003 | 4 | 0.125 | nd | 0.011 | nd | 0.710 | 5 |
| DB261 | 0.3 | nd | 41. | 0.07 | nd | nd | nd | nd | 0.010 | nd | nd | nd |
| DB262 | 0.4 | nd | nd | nd | nd | 2 | 0.081 | nd | 0.170 | nd | 0.910 | nd |
| DB265 | 0.5 | nd | 47. | nd | nd | 5 | 0.046 | nd | 0.480 | nd | 2.300 | nd |
| DB267 | 0.2 | nd | 50. | 0.02 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB269 | 0.4 | nd | 40. | nd | nd | 3 | 0.099 | nd | 0.960 | nd | 2.800 | nd |
| DB270 | 0.3 | nd | 57. | nd | nd | 4 | 0.190 | nd | 0.047 | nd | 1.400 | nd |
| DB273 | 0.5 | nd | 34. | nd | nd | 4 | 0.086 | nd | 0.341 | nd | 1.600 | nd |
| DB275 | 0.4 | nd | 34. | nd | nd | 3 | 0.130 | nd | 0.110 | nd | 0.690 | nd |
| DB279 | 0.6 | nd | 75. | 0.59 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB283 | 0.5 | nd | 37. | nd | nd | 3 | 0.091 | nd | 0.230 | nd | 0.880 | nd |
| DB286 | 0.3 | nd | 35. | nd | nd | 3 | 0.120 | nd | 0.000 | nd | 0.003 | nd |
| DB288 | 0.4 | 0.054 | 55. | nd | 0.010 | 7 | 0.084 | 0.050 | 0.003 | nd | 0.013 | <10 |
| DB291 | 0.4 | nd | 33. | 0.00 | nd | nd | nd | nd | 0.230 | nd | nd | nd |
| DB292 | 0.6 | nd | 27. | nd | nd | 3 | 0.071 | nd | 0.300 | nd | 1.100 | nd |
| DB294 | 0.2 | 0.067 | 63. | nd | 0.010 | 3 | 0.120 | 0.150 | 0.004 | nd | 0.057 | <10 |
| DB295 | 0.2 | 0.066 | 64. | nd | <0.010 | 4 | 0.062 | 0.150 | <0.003 | nd | 0.049 | 20 |
| DB296 | 0.6 | 0.065 | 42. | nd | <0.010 | 5 | 0.051 | 0.110 | 0.770 | nd | 3.200 | 10 |
| DB298 | 0.4 | nd | 35. | 0.05 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB299 | 0.2 | nd | 47. | nd | nd | 2 | 0.300 | nd | 0.017 | nd | 0.090 | nd |
| DB308 | 0.3 | 0.078 | 57. | nd | <0.010 | 5 | 0.047 | 0.050 | <0.003 | nd | 0.037 | <10 |
| DB309 | 0.5 | 0.051 | 61. | nd | <0.010 | 7 | 0.039 | 0.060 | 0.003 | nd | 0.009 | 10 |
| DB310 | 0.4 | 0.034 | 46. | nd | <0.010 | 4 | 0.062 | 0.080 | 0.025 | nd | 0.470 | 10 |
| DB312 | 0.3 | nd | 51. | nd | nd | 2 | 0.100 | nd | 0.036 | nd | 0.074 | nd |
| DB317 | 0.6 | nd | 35. | nd | nd | 4 | 0.190 | nd | 0.740 | nd | 2.400 | nd |
| DB318 | 0.1 | nd | 37. | nd | nd | <1 | 0.110 | nd | 0.120 | nd | 0.073 | nd |
| DB320 | 0.3 | nd | 29. | nd | nd | 2 | 0.180 | nd | 0.081 | nd | 0.036 | nd |
| DB325 | 0.4 | nd | 38. | 0.00 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB327 | 0.2 | nd | 28. | 0.02 | nd | nd | nd | nd | 0.000 | nd | nd | nd |
| DB332 | 0.6 | nd | 31. | 0.02 | nd | nd | nd | nd | 0.040 | nd | nd | nd |
| DB333 | 0.3 | nd | 30. | 0.02 | nd | nd | nd | nd | 0.680 | nd | nd | nd |
| DB340 | 0.3 | nd | 27. | nd | nd | 1 | 0.150 | 0.040 | 0.004 | nd | 0.200 | nd |
| DB350 | 0.2 | nd | 38. | nd | nd | 2 | 0.081 | nd | nd | nd | nd | nd |
| DB351 | 0.3 | nd | 17. | nd | nd | 3 | 0.098 | nd | nd | nd | nd | nd |
| DB352 | 0.3 | nd | 65. | nd | nd | 4 | 0.051 | nd | nd | nd | nd | nd |
| DB353 | 0.2 | nd | 29. | nd | nd | 4 | nd | 0.050 | 0.023 | nd | 0.094 | nd |
| DB354 | 0.7 | nd | 64. | nd | nd | 18 | nd | 0.090 | 0.340 | nd | 0.012 | nd |
| DB355 | 0.7 | 0.080 | 22. | nd | 0.003 | 1 | 0.140 | nd | 0.005 | nd | 0.130 | 9 |
| DB356 | 0.4 | nd | 26. | 0.02 | nd | nd | nd | nd | 0.190 | nd | nd | nd |
| DB357 | 0.3 | 0.040 | 49. | nd | 0.005 | 4 | 0.063 | nd | <0.003 | nd | 0.002 | 3 |
| DB358 | 0.5 | 0.090 | 32. | nd | 0.005 | 2 | 0.177 | nd | 1.400 | nd | 1.100 | 6 |

**Table E3.** Summary of minor- and trace-element chemistry for selected ground-water sites in the U.S. Geological Survey National Water Information System that were included in the final data set, by hydrochemical zone-- Continued

| Sample reference number | F (mg/L) | Br (mg/L) | $SiO_2$ (mg/L) | $NO_3$ (mg/L as N) | Al (mg/L) | As (µg/L) | Ba (mg/L) | B (mg/L) | Fe (mg/L) | Li (mg/L) | Mn (mg/L) | Mo (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DB362 | 0.5 | 0.120 | 33. | nd | 0.002 | 3 | 0.187 | nd | 0.045 | nd | 2.300 | 8 |
| DB366 | 0.4 | nd | 24. | 0.07 | nd | nd | nd | nd | 0.010 | nd | nd | nd |
| DB367 | nd | <0.010 | 22. | nd | 0.002 | 3 | 0.128 | nd | 0.470 | nd | 0.280 | 4 |
| DB370 | 0.5 | nd | 52. | 0.79 | nd | nd | nd | nd | 0.050 | nd | nd | nd |
| DB372 | 0.5 | 0.030 | 57. | nd | 0.003 | 6 | 0.052 | nd | <0.003 | nd | 0.009 | 4 |
| DB373 | nd | 0.220 | 59. | nd | 0.004 | 6 | 0.072 | nd | 0.004 | nd | 0.004 | 11 |
| DB375 | 0.5 | 0.070 | 30. | nd | 0.002 | 3 | 0.162 | nd | 0.004 | nd | <0.001 | 5 |
| DB376 | 0.3 | nd | 70. | nd | nd | 7 | <0.100 | 0.080 | 0.080 | nd | <0.010 | nd |
| DB378 | 0.4 | nd | 35. | 1.90 | nd | nd | nd | 0.120 | 0.010 | nd | nd | nd |
| DB379 | 0.4 | nd | 60. | nd | nd | 9 | <0.100 | 0.080 | 0.070 | nd | <0.010 | nd |
| DB381 | 0.4 | nd | 34. | 3.40 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB382 | 0.4 | nd | 26. | 0.02 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB383 | 0.4 | nd | 37. | 1.60 | nd | nd | nd | nd | 0.080 | nd | nd | nd |
| DB389 | 0.6 | nd | 50. | 0.05 | nd | nd | nd | nd | 0.050 | nd | nd | nd |
| DB390 | 0.8 | nd | nd | 0.11 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB391 | 1.0 | 0.310 | 73. | nd | nd | nd | nd | 0.560 | nd | nd | nd | nd |
| DB398 | 0.4 | 0.300 | 29. | nd | nd | nd | nd | 0.110 | <0.010 | nd | 0.070 | nd |
| DB400 | 1.4 | nd | 91. | 0.11 | nd | nd | nd | nd | nd | nd | nd | nd |
| DB413 | 0.3 | nd | 100. | nd | nd | 9 | <0.100 | 0.380 | 0.200 | nd | <0.010 | nd |
| DB468 | 0.3 | nd | 34. | 0.00 | nd | nd | nd | 0.020 | 0.050 | nd | nd | nd |
| **Zone 13: Discharge** | | | | | | | | | | | | |
| DB009 | 1.1 | 0.400 | 39. | nd | 0.004 | 18 | 0.034 | nd | 0.550 | nd | 0.260 | 12 |
| DB021 | 1.4 | nd | 56. | nd | nd | nd | nd | 0.960 | 0.080 | nd | 0.004 | nd |
| DB025 | 2.9 | nd | 30. | nd | nd | 4 | 0.030 | 0.860 | 0.040 | nd | 0.010 | nd |
| DB029 | 1.7 | nd | 44. | nd | nd | 17 | 0.030 | 0.220 | 0.010 | nd | 0.020 | nd |

# Appendix F. Supplementary water-quality data from the City of Albuquerque database

**Table F1.** Location and well-construction information for City of Albuquerque production wells, by hydrochemical zone

[All water-quality data represent median values for samples collected by the City of Albuquerque from 1988 to 1997 (Bexfield and others, 1999). nd, not determined; <, less than; dms, degrees-minutes-seconds]

| Sample reference number | Station name | Latitude (dms) | Longitude (dms) | Altitude of land surface (feet above sea level) | Depth (feet) | Depth to top of sample interval (feet) | Depth to bottom of sample interval (feet) | Water level (feet below land surface) | Water level date |
|---|---|---|---|---|---|---|---|---|---|
| | **Zone 3: West Central** | | | | | | | | |
| WWATI01 | Atrisco 1 | 350418 | 1064124 | 4,945 | 1,295 | 280 | 1,283 | 47. | 3/19/1996 |
| WWCOL01 | College 1 | 350646 | 1064433 | 5,336 | 1,662 | 660 | 1,650 | 434.8 | 2/19/1998 |
| WWCOL03 | College 3 | 350723 | 1064233 | 5,180 | 1,490 | 432 | 1,440 | nd | nd |
| WWLEV02 | Leavitt 2 | 350248 | 1064340 | 5,073 | 1,133 | 281 | 1,121 | 162.6 | 1/7/1998 |
| WWLEV03 | Leavitt 3 | 350228 | 1064358 | 5,080 | 1,520 | 514 | 1,500 | 244. | 1/23/1996 |
| WWVC02 | Volcano Cliffs 2 | 350912 | 1064341 | 5,328 | 900 | 528 | 876 | 460. | 3/21/1996 |
| WWVC03 | Volcano Cliffs 3 | 351000 | 1064345 | 5,345 | 1,315 | 659 | 1,302 | 468. | 3/21/1996 |
| WWWM01 | West Mesa 1 | 350428 | 1064418 | 5,175 | 1,176 | 504 | 1,176 | 299. | 3/30/1996 |
| WWWM02 | West Mesa 2 | 350508 | 1064356 | 5,165 | 1,402 | 394 | 1,402 | 279. | 4/8/1993 |
| WWWM04 | West Mesa 4 | 350449 | 1064320 | 5,105 | 1,287 | 387 | 1,275 | 226. | 3/30/1996 |
| WWZAM01 | Zamora 1 | 350919 | 1064251 | 5,168 | 970 | 450 | 950 | 233.4 | 1/28/1998 |
| | **Zone 8: Eastern Mountain Front** | | | | | | | | |
| WWLOM05 | Lomas 5 | 350421 | 1063124 | 5,494 | 1,670 | 830 | 1,658 | 644.22 | 12/30/1997 |
| WWLOM06 | Lomas 6 | 350408 | 1063110 | 5,529 | 1,704 | 880 | 1,692 | 676.77 | 12/30/1997 |
| WWLOV03 | Love 3 | 350512 | 1063218 | 5,405 | 1,260 | 600 | 1,260 | 553. | 4/29/1996 |
| WWLOV04 | Love 4 | 350512 | 1063257 | 5,370 | 1,284 | 600 | 1,284 | 540. | 4/12/1996 |
| WWLOV05 | Love 5 | 350450 | 1063240 | 5,390 | 1,248 | 660 | 1,248 | 552.03 | 4/14/1997 |
| WWLOV06 | Love 6 | 350553 | 1063138 | 5,505 | 1,521 | 753 | 1,509 | 651.33 | 1/8/1997 |
| WWLOV07 | Love 7 | 350608 | 1063213 | 5,440 | 1,485 | 645 | 1,473 | 581. | 4/5/1994 |
| WWLOV08 | Love 8 | 350539 | 1063330 | 5,316 | 1,455 | 640 | 1,440 | 463.3 | 1/12/1998 |
| WWPON02 | Ponderosa 2 | 350802 | 1063152 | 5,600 | 1,581 | 801 | 1,569 | 735.64 | 2/9/1998 |
| WWPON03 | Ponderosa 3 | 350821 | 1063210 | 5,527 | 1,602 | 870 | 1,590 | 667. | 2/27/1996 |
| WWPON04 | Ponderosa 4 | 350836 | 1063148 | 5,629 | 1,549 | 936 | 1,738 | 766.5 | 12/29/1997 |
| WWPON05 | Ponderosa 5 | 350916 | 1063151 | 5,630 | 1,626 | 939 | 1,613 | 746.33 | 1/9/1997 |
| WWPON06 | Ponderosa 6 | 350852 | 1063220 | 5,558 | 1,675 | 852 | 1,662 | 672.42 | 12/29/1997 |
| WWRIG01 | Ridgecrest 1 | 350405 | 1063219 | 5,442 | 1,260 | 636 | 1,260 | 277. | 4/10/1996 |
| WWRIG02 | Ridgecrest 2 | 350424 | 1063235 | 5,416 | 1,512 | 730 | 1,500 | 566.42 | 1/12/1998 |
| WWTOM01 | Thomas 1 | 350753 | 1063256 | 5,445 | 1,092 | 624 | 1,092 | 595. | 4/9/1996 |
| WWTOM02 | Thomas 2 | 350749 | 1063235 | 5,490 | 1,224 | 696 | 1,224 | 629. | 4/9/1996 |
| WWTOM03 | Thomas 3 | 350816 | 1063313 | 5,415 | 1,200 | 672 | 1,200 | 551. | 7/18/1994 |
| WWTOM04 | Thomas 4 | 350813 | 1063241 | 5,485 | 1,020 | 672 | 1,020 | 622. | 12/18/1995 |
| WWTOM08 | Thomas 8 | 350712 | 1063231 | 5,462 | 1,655 | 835 | 1,635 | 605.77 | 2/23/1998 |
| WWWLK02 | Walker 2 | 351024 | 1063212 | 5,596 | 1,786 | 852 | 1,773 | 694. | 4/11/1996 |
| | **Zone 12: Central** | | | | | | | | |
| WWATI02 | Atrisco 2 | 350445 | 1064115 | 4,945 | 544 | 108 | 250 | 15. | 11/30/1996 |
| WWATI04 | Atrisco 4 | 350509 | 1064142 | 4,950 | 500 | 98 | 475 | 12.32 | 2/9/1998 |
| WWBUR01 | Burton 1 | 350359 | 1063624 | 5,315 | 1,312 | 676 | 1,292 | 447.03 | 12/29/1997 |
| WWBUR03 | Burton 3 | 350439 | 1063559 | 5,215 | 994 | 358 | 994 | 360. | 3/19/1996 |
| WWBUR04 | Burton 4 | 350343 | 1063634 | 5,275 | 1,276 | 636 | 1,276 | 440. | 3/27/1996 |
| WWCHW01 | Charles 1 | 350628 | 1063348 | 5,315 | 1,056 | 456 | 1,032 | 477. | 4/23/1996 |
| WWCHW02 | Charles 2 | 350605 | 1063415 | 5,262 | 1,020 | 432 | 996 | 411.18 | 1/26/1998 |
| WWCHW03 | Charles 3 | 350640 | 1063427 | 5,275 | 1,020 | 420 | 996 | 405. | 5/27/1990 |
| WWCHW05 | Charles 5 | 350615 | 1063460 | 5,222 | 1,400 | 625 | 1,385 | 357.62 | 1/12/1998 |
| WWCOR02 | Coronado 2 | 351007 | 1063439 | 5,242 | 1,390 | 590 | 1,390 | 330.05 | 12/18/1998 |
| WWDUR02 | Duranes 2 | 350711 | 1064047 | 4,970 | 804 | 180 | 804 | 22.11 | 12/29/1997 |

**Table F1.** Location and well-construction information for City of Albuquerque production wells, by hydrochemical zone-- Continued

| Sample reference number | Station name | Latitude (dms) | Longitude (dms) | Altitude of land surface (feet above sea level) | Depth (feet) | Depth to top of sample interval (feet) | Depth to bottom of sample interval (feet) | Water level (feet below land surface) | Water level date |
|---|---|---|---|---|---|---|---|---|---|
| WWDUR03 | Duranes 3 | 350630 | 1064043 | 4,962 | 950 | 132 | 950 | 23.72 | 12/29/1997 |
| WWDUR04 | Duranes 4 | 350628 | 1064115 | 4,960 | 950 | 144 | 950 | 13.75 | 2/9/1998 |
| WWDUR05 | Duranes 5 | 350606 | 1064116 | 4,960 | 950 | 152 | 950 | 10.85 | 2/9/1998 |
| WWDUR06 | Duranes 6 | 350653 | 1064030 | 4,962 | 500 | 260 | 500 | 32.6 | 12/29/1997 |
| WWGON02 | Gonzales 2 | 350635 | 1064150 | 5,100 | 1,115 | 400 | 1,100 | 152.28 | 12/30/1997 |
| WWGRG01 | Griegos 1 | 350823 | 1063950 | 4,972 | 802 | 232 | 802 | 30.56 | 1/27/1998 |
| WWGRG02 | Griegos 2 | 350749 | 1064007 | 4,965 | 820 | 164 | 820 | 29. | 6/8/1994 |
| WWGRG04 | Griegos 4 | 350824 | 1063902 | 4,975 | 804 | 218 | 804 | 48. | 3/13/1996 |
| WWLYN02 | Leyendecker 2 | 350729 | 1063407 | 5,298 | 996 | 468 | 996 | 436.15 | 12/16/1997 |
| WWLYN03 | Leyendecker 3 | 350815 | 1063438 | 5,265 | 996 | 456 | 996 | 393.4 | 12/16/1997 |
| WWLYN04 | Leyendecker 4 | 350814 | 1063407 | 5,325 | 996 | 480 | 996 | 455. | 12/5/1996 |
| WWMIL01 | Miles 1 | 350307 | 1063748 | 5,154 | 1,165 | 404 | 1,153 | 260.7 | 12/15/1997 |
| WWRIG05 | Ridgecrest 5 | 350420 | 1063345 | 5,355 | 1,470 | 636 | 1,260 | 418.98 | 2/10/1998 |
| WWSJ01 | San Jose 1 | 350316 | 1063848 | 4,950 | 600 | nd | nd | 41.13 | 12/15/1997 |
| WWSJ03 | San Jose 3 | 350343 | 1063901 | 4,952 | 1,032 | 192 | 1,032 | 41.3 | 12/15/1997 |
| WWTOM05 | Thomas 5 | 350744 | 1063335 | 5,356 | 1,450 | 722 | 1,450 | 489.79 | 2/23/1998 |
| WWTOM07 | Thomas 7 | 350712 | 1063339 | 5,347 | 1,475 | 659 | 1,460 | 481.96 | 2/23/1998 |
| WWVAN01 | Vol Andia 1 | 350805 | 1063548 | 5,144 | 972 | 300 | 972 | 262.99 | 1/12/1998 |
| WWVAN03 | Vol Andia 3 | 350741 | 1063616 | 5,110 | 900 | 264 | 900 | 230.01 | 1/8/1997 |
| WWVAN04 | Vol Andia 4 | 350803 | 1063512 | 5,200 | 876 | 372 | 876 | 327.37 | 12/29/1997 |
| WWVAN06 | Vol Andia 6 | 350826 | 1063525 | 5,178 | 984 | 324 | 984 | 294.95 | 12/29/1997 |
| WWWEB02 | Webster 2 | 351012 | 1063335 | 5,387 | 1,346 | 608 | 1,334 | 490. | 12/14/1995 |
| WWYAL02 | Yale 2 | 350358 | 1063729 | 5,128 | 1,191 | 351 | 1,179 | 249.95 | 1/26/1998 |
| WWYAL03 | Yale 3 | 350435 | 1063800 | 5,080 | 1,004 | 320 | 992 | 204. | 4/24/1989 |

**Table F2.** Summary of field parameters and major- and minor-element chemistry for City of Albuquerque production wells included in the final data set, by hydrochemical zone

[All water-quality data represent median values for samples collected by the City of Albuquerque from 1988 to 1997 (Bexfield and others, 1999). nd, not determined; <, less than; Sp. Cond., specific conductance in µS/cm, microsiemens per centimeter at 25 ºC; Temp., field water temperature; ºC, degrees Celsius; mg/L, milligrams per liter; $Ca^{2+}$, calcium; $Mg^{2+}$, magnesium, $Na^{+}$, sodium; $K^{+}$, potassium; $HCO_3^-$, total titration alkalinity as bicarbonate; $SO_4^{2-}$, sulfate; $Cl^-$, chloride; $F^-$, fluoride; $Br^-$, bromide; $SiO_2$, silica; $NO_3^-$, nitrate; N, nitrogen]

| Sample reference number | Station name | Primary hydro-chemical zone | Sp. Cond. (µS/cm) | pH | Temp. (ºC) | $Ca^{2+}$ (mg/L) | $Mg^{2+}$ (mg/L) | $Na^{+}$ (mg/L) | $K^{+}$ (mg/L) | $HCO_3^-$ (mg/L) | $SO_4^{2-}$ (mg/L) | $Cl^-$ (mg/L) | $F^-$ (mg/L) | $Br^-$ (mg/L) | $SiO_2$ (mg/L) | $NO_3^-$ as N (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Zone 3: West Central** | | | | | | | | | | | | | | | |
| WWATI01 | Atrisco 1 | 3 | 570 | 8.8 | 31.5 | 7.98 | 1.3 | 107.4 | 1.5 | 143 | 110.0 | 19.8 | 0.92 | <0.5 | 46.9 | 1.53 |
| WWCOL01 | College 1 | 3 | 484 | 8.7 | 28.0 | 3.6 | 0.4 | 104.2 | 1.1 | 200 | 55.3 | 5.5 | 1.50 | <0.5 | 28.7 | 2.91 |
| WWCOL03 | College 3 | 3 | 474 | 8.2 | 24.6 | 11.9 | 2.2 | 88.9 | 4.7 | 157 | 79.2 | 11.4 | 1.22 | <0.5 | 49.9 | 1.19 |
| WWLEV02 | Leavitt 2 | 3 | 503 | 8.7 | 23.9 | 4.4 | 0.5 | 105.5 | 1.2 | 183 | 68.1 | 18.8 | 1.46 | <0.5 | 29.8 | 1.31 |
| WWLEV03 | Leavitt 3 | 3 | 695 | 9.0 | 33.4 | 2.45 | 0.1 | 140.4 | <1.0 | 160 | 133.0 | 31.6 | 1.02 | <0.5 | 38.6 | 1.78 |
| WWVC02 | Volcano Cliffs 2 | 3 | 361 | 8.0 | 24.0 | 20.98 | 4.7 | 48.8 | 6.6 | 144 | 45.8 | 7.8 | 0.99 | <0.5 | 70.3 | 1.68 |
| WWVC03 | Volcano Cliffs 3 | 3 | 387 | 8.1 | 24.4 | 16.08 | 3.5 | 61.5 | 5.8 | 152 | 47.7 | 7.4 | 1.00 | <0.5 | 65.2 | 1.91 |
| WWWM01 | West Mesa 1 | 3 | 501 | 9.0 | 29.5 | 1.92 | 0.1 | 108.1 | <1.0 | 194 | 67.9 | 6.3 | 1.10 | <0.5 | 36.2 | 1.71 |
| WWWM02 | West Mesa 2 | 3 | 444 | 8.6 | 25.0 | 5.12 | 0.8 | 91.9 | 1.5 | 184 | 49.4 | 7.3 | 1.33 | nd | 32.4 | nd |
| WWWM04 | West Mesa 4 | 3 | 486 | 8.9 | 29.8 | 3.26 | 0.3 | 112.1 | <1.0 | 174 | 87.0 | 14.8 | 1.08 | <0.5 | 35.8 | 1.71 |
| WWZAM01 | Zamora 1 | 3 | 416 | 7.9 | 24.2 | 20.33 | 3.7 | 59.9 | 7.2 | 157 | 57.4 | 9.2 | 0.78 | <0.5 | 70.8 | 0.86 |
| | **Zone 8: Eastern Mountain Front** | | | | | | | | | | | | | | | |
| WWLOM05 | Lomas 5 | 8 | 333 | 7.9 | 26.7 | 28.81 | 3.9 | 39.6 | 2.5 | 152 | 31.7 | 6.5 | 1.31 | <0.5 | 26.6 | 0.54 |
| WWLOM06 | Lomas 6 | 8 | 421 | 7.7 | 25.0 | 45.93 | 6.8 | 39.1 | 2.8 | 175 | 56.2 | 9.6 | 0.87 | <0.5 | 25.8 | 0.94 |
| WWLOV03 | Love 3 | 8 | 309 | 7.8 | 23.2 | 36.7 | 1.8 | 26.9 | 2.4 | 130 | 19.0 | 17.3 | 0.67 | <0.5 | 30.2 | 0.31 |
| WWLOV04 | Love 4 | 8 | 364 | 7.7 | 22.7 | 46.45 | 2.6 | 27.6 | 2.7 | 137 | 21.2 | 35.0 | 0.48 | <0.5 | 29.8 | 0.31 |
| WWLOV05 | Love 5 | 8 | 325 | 7.8 | 22.6 | 38.84 | 3.0 | 26.5 | 2.7 | 133 | 19.6 | 22.1 | 0.56 | <0.5 | 28.1 | 0.33 |
| WWLOV06 | Love 6 | 8 | 260 | 7.9 | 25.3 | 24.45 | 1.0 | 33.1 | 1.6 | 133 | 16.8 | 4.8 | 0.87 | <0.5 | 29.1 | 0.43 |
| WWLOV07 | Love 7 | 8 | 326 | 7.7 | 24.0 | 40.3 | 1.6 | 26.4 | 2.2 | 129 | 19.1 | 25.0 | 0.60 | <0.5 | 30.6 | 0.25 |
| WWLOV08 | Love 8 | 8 | 440 | 7.7 | 21.7 | 49.77 | 4.6 | 33.7 | 3.0 | 139 | 25.7 | 49.0 | 0.37 | <0.5 | 33.9 | 0.17 |
| WWPON02 | Ponderosa 2 | 8 | 328 | 7.8 | 25.4 | 42.56 | 1.7 | 27.0 | 1.9 | 133 | 19.6 | 23.5 | 0.79 | <0.5 | 30.4 | 0.19 |
| WWPON03 | Ponderosa 3 | 8 | 630 | 7.6 | 28.1 | 58.08 | 5.9 | 54.6 | 4.9 | 162 | 35.1 | 90.2 | 0.63 | <0.5 | 39.7 | <0.05 |
| WWPON04 | Ponderosa 4 | 8 | 352 | 7.8 | 26.3 | 42.0 | 1.6 | 35.0 | 1.9 | 136 | 19.0 | 33.3 | 0.98 | <0.5 | 30.1 | 0.16 |
| WWPON05 | Ponderosa 5 | 8 | 445 | 7.7 | 25.8 | 52.06 | 2.1 | 35.7 | 2.2 | 133 | 23.3 | 55.8 | 0.78 | <0.5 | 31.1 | 0.18 |
| WWPON06 | Ponderosa 6 | 8 | 634 | 7.6 | 27.8 | 48.82 | 7.1 | 65.1 | 5.4 | 168 | 36.7 | 87.8 | 0.97 | <0.5 | 42.9 | <0.05 |
| WWRIG01 | Ridgecrest 1 | 8 | 400 | 7.5 | 22.7 | 52.4 | 7.6 | 29.0 | 2.5 | 178 | 51.8 | 11.4 | 0.69 | <0.5 | 27.0 | 0.88 |
| WWRIG02 | Ridgecrest 2 | 8 | 328 | 7.8 | 23.8 | 33.61 | 3.3 | 27.7 | 2.7 | 122 | 19.8 | 27.0 | 0.69 | <0.5 | 28.0 | 0.28 |
| WWTOM01 | Thomas 1 | 8 | 472 | 7.6 | 22.2 | 55.4 | 3.7 | 37.9 | 2.1 | 162 | 30.3 | 46.2 | 0.46 | <0.5 | 30.7 | 0.55 |
| WWTOM02 | Thomas 2 | 8 | 443 | 7.6 | 24.5 | 52.01 | 3.3 | 40.7 | 2.1 | 160 | 26.7 | 53.6 | 0.48 | <0.5 | 30.9 | 0.21 |
| WWTOM03 | Thomas 3 | 8 | 473 | 7.6 | 21.4 | 54.3 | 4.6 | 43.7 | 2.0 | 171 | 36.0 | 41.9 | 0.63 | <0.5 | 36.4 | 0.11 |
| WWTOM04 | Thomas 4 | 8 | 500 | 7.6 | 24.0 | 60.09 | 4.2 | 52.0 | 2.3 | 170 | 30.0 | 64.0 | 0.52 | <0.5 | 34.6 | 0.19 |
| WWTOM08 | Thomas 8 | 8 | 579 | 7.6 | 26.0 | 69.62 | 4.3 | 39.5 | 3.4 | 145 | 28.4 | 86.2 | 0.47 | <0.5 | 32.0 | <0.05 |
| WWWLK02 | Walker 2 | 8 | 631 | 7.7 | 28.8 | 39.11 | 5.8 | 79.2 | 5.1 | 171 | 35.9 | 83.7 | 1.23 | <0.5 | 41.6 | <0.05 |
| | **Zone 12: Central** | | | | | | | | | | | | | | | |
| WWATI02 | Atrisco 2 | 12 | 584 | 7.5 | 18.3 | 44.44 | 9.3 | 66.0 | 8.7 | 201 | 111.0 | 16.6 | 0.72 | <0.5 | 65.9 | <0.05 |
| WWATI04 | Atrisco 4 | 12 | 465 | 7.8 | 21.5 | 27.67 | 5.8 | 61.6 | 6.6 | 165 | 77.1 | 12.2 | 1.01 | <0.5 | 65.8 | 0.37 |
| WWBUR01 | Burton 1 | 12 | 411 | 7.8 | 24.5 | 30.99 | 7.0 | 39.8 | 6.0 | 134 | 34.4 | 36.1 | 0.63 | <0.5 | 64.5 | 0.18 |
| WWBUR03 | Burton 3 | 12 | 391 | 7.7 | 20.6 | 42.68 | 7.8 | 26.0 | 4.1 | 130 | 41.9 | 30.5 | 0.51 | <0.5 | 49.7 | 0.42 |
| WWBUR04 | Burton 4 | 12 | 440 | 7.9 | 26.2 | 28.37 | 6.6 | 48.2 | 6.8 | 137 | 35.8 | 41.6 | 0.71 | <0.5 | 70.2 | 0.24 |
| WWCHW01 | Charles 1 | 12 | 346 | 7.8 | 19.6 | 38.1 | 3.0 | 31.4 | 2.0 | 145 | 31.3 | 18.0 | 0.51 | <0.5 | 26.8 | 0.25 |
| WWCHW02 | Charles 2 | 12 | 314 | 7.8 | 19.0 | 39.9 | 3.5 | 21.8 | 1.9 | 135 | 34.4 | 11.5 | 0.53 | <0.5 | 29.0 | 0.36 |
| WWCHW03 | Charles 3 | 12 | 305 | 7.8 | 18.4 | 39.39 | 3.6 | 19.7 | 1.8 | 131 | 30.7 | 9.5 | 0.54 | <0.5 | 33.1 | 0.49 |
| WWCHW05 | Charles 5 | 12 | 337 | 7.8 | 19.4 | 40.55 | 4.3 | 24.2 | 2.5 | 128 | 28.9 | 19.9 | 0.54 | <0.5 | 40.4 | 0.10 |
| WWCOR02 | Coronado 2 | 12 | 451 | 7.8 | 20.8 | 31.55 | 7.8 | 49.2 | 5.3 | 169 | 48.2 | 24.6 | 0.79 | <0.5 | 52.3 | 0.13 |
| WWDUR02 | Duranes 2 | 12 | 418 | 7.9 | 19.1 | 27.59 | 5.6 | 49.0 | 6.6 | 152 | 67.5 | 10.5 | 0.65 | <0.5 | 63.7 | <0.05 |
| WWDUR03 | Duranes 3 | 12 | 505 | 7.7 | 19.0 | 39.54 | 8.0 | 54.2 | 7.4 | 181 | 88.2 | 12.7 | 0.56 | <0.5 | 62.4 | <0.05 |
| WWDUR04 | Duranes 4 | 12 | 441 | 8.0 | 19.6 | 20.4 | 4.0 | 67.4 | 6.5 | 155 | 70.8 | 12.4 | 1.03 | <0.5 | 63.6 | <0.05 |
| WWDUR05 | Duranes 5 | 12 | 436 | 7.9 | 20.4 | 23.69 | 4.5 | 60.7 | 6.2 | 158 | 67.7 | 12.2 | 0.98 | <0.5 | 63.0 | 0.13 |
| WWDUR06 | Duranes 6 | 12 | 511 | 7.4 | 19.0 | 52.57 | 12.3 | 42.3 | 9.7 | 204 | 93.4 | 14.4 | 0.41 | <0.5 | 69.5 | <0.05 |
| WWGON02 | Gonzales 2 | 12 | 432 | 7.9 | 25.3 | 22.21 | 4.2 | 62.1 | 6.9 | 158 | 63.5 | 10.0 | 0.98 | <0.5 | 68.8 | 0.32 |
| WWGRG01 | Griegos 1 | 12 | 405 | 7.6 | 17.9 | 41.17 | 11.5 | 23.6 | 8.2 | 156 | 60.7 | 12.1 | 0.41 | <0.5 | 64.4 | <0.05 |
| WWGRG02 | Griegos 2 | 12 | 482 | 7.6 | 18.5 | 47.01 | 11.8 | 34.3 | 8.6 | 196 | 79.2 | 12.4 | 0.40 | <0.5 | 68.5 | <0.05 |
| WWGRG04 | Griegos 4 | 12 | 344 | 7.7 | 18.6 | 29.37 | 8.1 | 36.0 | 7.5 | 157 | 45.3 | 9.4 | 0.68 | <0.5 | 64.7 | <0.05 |
| WWLYN02 | Leyendecker 2 | 12 | 324 | 7.7 | 18.9 | 42.21 | 3.5 | 22.8 | 2.4 | 139 | 32.7 | 10.2 | 0.56 | <0.5 | 32.0 | 0.37 |
| WWLYN03 | Leyendecker 3 | 12 | 301 | 7.8 | 18.0 | 40.05 | 4.2 | 17.3 | 2.1 | 133 | 29.9 | 8.0 | 0.50 | <0.5 | 31.6 | 0.45 |
| WWLYN04 | Leyendecker 4 | 12 | 338 | 7.7 | 19.2 | 42.91 | 4.3 | 23.7 | 2.0 | 149 | 33.9 | 11.1 | 0.58 | <0.5 | 32.9 | 0.43 |
| WWMIL01 | Miles 1 | 12 | 424 | 7.9 | 25.5 | 34.95 | 7.5 | 41.0 | 7.4 | 132 | 39.0 | 38.6 | 0.69 | <0.5 | 71.0 | 0.29 |
| WWRIG05 | Ridgecrest 5 | 12 | 378 | 7.7 | 22.3 | 41.42 | 5.7 | 24.4 | 2.9 | 133 | 26.6 | 32.6 | 0.45 | <0.5 | 37.1 | 0.13 |
| WWSJ01 | San Jose 1 | 12 | 570 | 7.3 | 19.0 | 56.53 | 13.4 | 36.2 | 9.2 | 205 | 108.5 | 16.3 | 0.33 | <0.5 | 69.4 | <0.05 |
| WWSJ03 | San Jose 3 | 12 | 433 | 8.1 | 24.3 | 17.56 | 4.1 | 65.4 | 6.1 | 141 | 69.3 | 14.7 | 0.95 | <0.5 | 66.7 | 0.33 |
| WWTOM05 | Thomas 5 | 12 | 384 | 7.6 | 21.3 | 40.31 | 3.7 | 36.9 | 2.4 | 161 | 36.1 | 18.1 | 0.67 | <0.5 | 36.2 | <0.05 |
| WWTOM07 | Thomas 7 | 12 | 399 | 7.6 | 21.3 | 42.75 | 3.9 | 35.8 | 2.7 | 155 | 34.5 | 26.9 | 0.65 | <0.5 | 35.0 | 0.12 |
| WWVAN01 | Vol Andia 1 | 12 | 375 | 7.9 | 17.2 | 54.7 | 6.6 | 21.2 | 2.3 | 134 | 51.7 | 13.5 | 0.45 | <0.5 | 31.6 | 0.88 |
| WWVAN03 | Vol Andia 3 | 12 | 375 | 7.9 | 18.0 | 51.24 | 6.6 | 21.1 | 2.9 | 123 | 56.7 | 17.8 | 0.49 | <0.5 | 37.3 | 0.42 |
| WWVAN04 | Vol Andia 4 | 12 | 313 | 7.9 | 17.0 | 43.01 | 4.8 | 16.9 | 1.9 | 132 | 35.6 | 9.5 | 0.45 | <0.5 | 30.9 | 0.91 |
| WWVAN06 | Vol Andia 6 | 12 | 315 | 7.8 | 16.7 | 40.86 | 5.1 | 17.7 | 2.2 | 133 | 36.7 | 8.8 | 0.44 | <0.5 | 30.9 | 0.62 |
| WWWEB02 | Webster 2 | 12 | 412 | 7.8 | 21.2 | 29.96 | 7.4 | 44.1 | 6.3 | 160 | 38.6 | 25.2 | 0.75 | <0.5 | 61.8 | <0.05 |
| WWYAL02 | Yale 2 | 12 | 420 | 7.7 | 23.1 | 37.1 | 8.0 | 33.1 | 6.9 | 131 | 40.1 | 34.8 | 0.60 | <0.5 | 66.5 | 0.46 |
| WWYAL03 | Yale 3 | 12 | 471 | 7.6 | 24.7 | 44.28 | 9.2 | 38.6 | 7.8 | 150 | 67.1 | 29.5 | 0.54 | <0.5 | 73.2 | 0.56 |

**Table F3.** Summary of trace-element chemistry for City of Albuquerque production wells included in the final data set, by hydrochemical zone

[All water-quality data represent median values for samples collected by the City of Albuquerque from 1988 to 1997 (Bexfield and others, 1999). nd, not determined; <, less than; mg/L, milligrams per liter; µg/L, micrograms per liter; Al, aluminum; As, arsenic; Ba, barium; B, boron; Cr, chromium; Cu, copper; Fe, iron; Pb, lead; Li, lithium; Mn, manganese; Sr, strontium; V, vanadium; Zn, zinc]

| Sample reference number | Station name | Al (mg/L) | As (µg/L) | Ba (mg/L) | B (mg/L) | Cr (µg/L) | Cu (µg/L) | Fe (mg/L) | Pb (µg/L) | Li (mg/L) | Mn (mg/L) | Sr (mg/L) | V (µg/L) | Zn (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Zone 3: West Central** | | | | | | | | | | | | | |
| WWATI01 | Atrisco 1 | <0.040 | 21.7 | 0.010 | 0.352 | 23.0 | <5.0 | <0.010 | <2.0 | 0.150 | <0.002 | 0.097 | 45.5 | <5.0 |
| WWCOL01 | College 1 | <0.040 | 48.9 | 0.034 | 0.317 | 9.0 | <5.0 | 0.011 | <2.0 | 0.040 | <0.002 | 0.064 | 98.6 | <5.0 |
| WWCOL03 | College 3 | <0.040 | 24.7 | 0.037 | 0.251 | 7.0 | <5.0 | <0.010 | 2.0 | 0.060 | <0.002 | 0.203 | 43.4 | <5.0 |
| WWLEV02 | Leavitt 2 | <0.040 | 34.0 | 0.017 | 0.269 | 5.0 | <5.0 | <0.010 | <2.0 | 0.040 | <0.002 | 0.059 | 70.9 | <5.0 |
| WWLEV03 | Leavitt 3 | <0.040 | 34.6 | 0.008 | 0.322 | 23.0 | <5.0 | <0.010 | <2.0 | 0.080 | <0.002 | 0.052 | 74.2 | <5.0 |
| WWVC02 | Volcano Cliffs 2 | <0.040 | 11.4 | 0.058 | 0.157 | 5.0 | <5.0 | <0.010 | <2.0 | 0.050 | <0.002 | 0.351 | 21.1 | <5.0 |
| WWVC03 | Volcano Cliffs 3 | <0.040 | 15.0 | 0.054 | 0.181 | 6.0 | <5.0 | <0.010 | <2.0 | 0.050 | <0.002 | 0.266 | 27.8 | <5.0 |
| WWWM01 | West Mesa 1 | <0.040 | 27.2 | 0.023 | 0.282 | 11.0 | <5.0 | <0.010 | <2.0 | 0.040 | <0.002 | 0.059 | 48.9 | <5.0 |
| WWWM02 | West Mesa 2 | <0.040 | 39.5 | 0.022 | 0.229 | nd | <5.0 | <0.010 | <2.0 | 0.040 | <0.002 | 0.079 | 60.0 | <5.0 |
| WWWM04 | West Mesa 4 | <0.040 | 35.9 | 0.021 | 0.262 | 17.0 | <5.0 | <0.010 | <2.0 | 0.040 | <0.002 | 0.063 | 62.0 | <5.0 |
| WWZAM01 | Zamora 1 | <0.040 | 14.4 | 0.054 | 0.173 | 5.0 | <5.0 | <0.010 | <2.0 | nd | <0.002 | 0.317 | 27.3 | <5.0 |
| | **Zone 8: Eastern Mountain Front** | | | | | | | | | | | | | |
| WWLOM05 | Lomas 5 | <0.040 | 4.0 | 0.084 | <0.050 | <1.0 | <5.0 | <0.010 | <2.0 | 0.020 | <0.002 | 0.203 | <10.0 | <5.0 |
| WWLOM06 | Lomas 6 | <0.040 | <2.0 | 0.095 | <0.050 | <1.0 | <5.0 | 0.016 | <2.0 | 0.020 | 0.005 | 0.259 | <10.0 | 6.0 |
| WWLOV03 | Love 3 | <0.040 | <2.0 | 0.171 | <0.050 | 1.0 | <5.0 | 0.012 | <2.0 | 0.020 | <0.002 | 0.363 | <10.0 | 8.0 |
| WWLOV04 | Love 4 | <0.040 | <2.0 | 0.200 | 0.051 | 1.0 | <5.0 | <0.010 | <2.0 | 0.020 | <0.002 | 0.466 | <10.0 | <5.0 |
| WWLOV05 | Love 5 | <0.040 | <2.0 | 0.155 | <0.050 | 2.0 | <5.0 | 0.013 | <2.0 | 0.020 | <0.002 | 0.368 | <10.0 | <5.0 |
| WWLOV06 | Love 6 | <0.040 | <2.0 | 0.096 | <0.050 | 1.0 | <5.0 | 0.011 | <2.0 | 0.020 | <0.002 | 0.202 | <10.0 | <5.0 |
| WWLOV07 | Love 7 | <0.040 | 4.0 | 0.184 | <0.050 | 1.0 | <5.0 | 0.013 | <2.0 | 0.020 | 0.006 | 0.400 | <10.0 | <5.0 |
| WWLOV08 | Love 8 | <0.040 | <2.0 | 0.182 | 0.093 | 2.0 | <5.0 | 0.016 | <2.0 | 0.020 | 0.002 | 0.397 | <10.0 | 13.0 |
| WWPON02 | Ponderosa 2 | <0.040 | 6.0 | 0.154 | <0.050 | <1.0 | <5.0 | <0.010 | <2.0 | 0.030 | 0.003 | 0.287 | <10.0 | 6.0 |
| WWPON03 | Ponderosa 3 | <0.040 | 23.2 | 0.194 | 0.226 | <1.0 | <5.0 | 0.019 | <2.0 | 0.070 | 0.029 | 0.539 | <10.0 | 7.0 |
| WWPON04 | Ponderosa 4 | <0.040 | 14.0 | 0.121 | <0.050 | <1.0 | <5.0 | <0.010 | <2.0 | 0.030 | 0.007 | 0.268 | <10.0 | 7.0 |
| WWPON05 | Ponderosa 5 | <0.040 | 25.4 | 0.121 | 0.051 | <1.0 | <5.0 | <0.010 | <2.0 | 0.030 | 0.003 | 0.350 | <10.0 | <5.0 |
| WWPON06 | Ponderosa 6 | <0.040 | 33.9 | 0.128 | 0.232 | <1.0 | <5.0 | 0.037 | <2.0 | 0.100 | 0.056 | 0.415 | <10.0 | 6.0 |
| WWRIG01 | Ridgecrest 1 | <0.040 | <2.0 | 0.082 | <0.050 | <1.0 | <5.0 | 0.011 | <2.0 | 0.020 | <0.002 | 0.279 | <10.0 | 7.0 |
| WWRIG02 | Ridgecrest 2 | <0.040 | <2.0 | 0.150 | <0.050 | 2.0 | <5.0 | <0.010 | <2.0 | 0.020 | <0.002 | 0.359 | <10.0 | 6.0 |
| WWTOM01 | Thomas 1 | <0.040 | <2.0 | 0.165 | 0.074 | 1.0 | <5.0 | 0.010 | <2.0 | 0.020 | <0.002 | 0.320 | <10.0 | <5.0 |
| WWTOM02 | Thomas 2 | <0.040 | <2.0 | 0.158 | 0.103 | <1.0 | <5.0 | 0.020 | <2.0 | 0.020 | 0.002 | 0.282 | <10.0 | <5.0 |
| WWTOM03 | Thomas 3 | <0.040 | 6.2 | 0.127 | 0.114 | 2.0 | <5.0 | 0.033 | <2.0 | 0.020 | 0.003 | 0.327 | <10.0 | <5.0 |
| WWTOM04 | Thomas 4 | <0.040 | <2.0 | 0.156 | 0.120 | <1.0 | <5.0 | 0.027 | <2.0 | 0.020 | 0.003 | 0.328 | <10.0 | 8.0 |
| WWTOM08 | Thomas 8 | <0.040 | 12.9 | 0.198 | 0.184 | <1.0 | <5.0 | 0.059 | <2.0 | 0.000 | 0.044 | 0.508 | <10.0 | 9.0 |
| WWWLK02 | Walker 2 | <0.040 | 35.5 | 0.084 | 0.224 | <1.0 | <5.0 | 0.018 | <2.0 | 0.120 | 0.021 | 0.266 | <10.0 | <5.0 |
| | **Zone 12: Central** | | | | | | | | | | | | | |
| WWATI02 | Atrisco 2 | <0.040 | 6.5 | 0.052 | 0.139 | <1.0 | <5.0 | 0.011 | <2.0 | 0.070 | 0.017 | 0.697 | 12.2 | 6.0 |
| WWATI04 | Atrisco 4 | <0.040 | 9.7 | 0.050 | 0.147 | 3.0 | <5.0 | <0.010 | <2.0 | 0.070 | <0.002 | 0.406 | 19.9 | <5.0 |
| WWBUR01 | Burton 1 | <0.040 | 15.0 | 0.118 | 0.134 | 2.0 | <5.0 | <0.010 | <2.0 | 0.080 | <0.002 | 0.332 | 10.5 | <5.0 |
| WWBUR03 | Burton 3 | <0.040 | 5.0 | 0.115 | 0.092 | <1.0 | <5.0 | <0.010 | <2.0 | 0.030 | <0.002 | 0.359 | <10.0 | <5.0 |
| WWBUR04 | Burton 4 | <0.040 | 20.8 | 0.102 | 0.155 | 1.0 | <5.0 | <0.010 | <2.0 | 0.100 | <0.002 | 0.297 | 14.0 | 7.0 |
| WWCHW01 | Charles 1 | <0.040 | <2.0 | 0.136 | 0.094 | 2.0 | <5.0 | <0.010 | <2.0 | 0.020 | <0.002 | 0.185 | <10.0 | <5.0 |
| WWCHW02 | Charles 2 | <0.040 | <2.0 | 0.088 | 0.052 | <1.0 | <5.0 | 0.013 | <2.0 | 0.010 | <0.002 | 0.207 | <10.0 | 5.0 |
| WWCHW03 | Charles 3 | <0.040 | 2.0 | 0.082 | 0.054 | <1.0 | <5.0 | <0.010 | <2.0 | 0.020 | <0.002 | 0.192 | <10.0 | 7.0 |
| WWCHW05 | Charles 5 | <0.040 | 4.0 | 0.099 | 0.067 | <1.0 | <5.0 | <0.010 | <2.0 | 0.030 | <0.002 | 0.293 | <10.0 | 9.0 |
| WWCOR02 | Coronado 2 | <0.040 | 15.6 | 0.075 | 0.168 | 1.0 | <5.0 | 0.011 | <2.0 | 0.000 | <0.002 | 0.344 | 11.0 | <5.0 |
| WWDUR02 | Duranes 2 | <0.040 | 7.6 | 0.054 | 0.099 | 1.0 | <5.0 | <0.010 | <2.0 | 0.070 | 0.003 | 0.379 | 13.6 | <5.0 |
| WWDUR03 | Duranes 3 | <0.040 | 6.2 | 0.051 | 0.126 | 1.0 | <5.0 | 0.015 | <2.0 | 0.080 | 0.114 | 0.504 | 12.0 | 6.0 |
| WWDUR04 | Duranes 4 | <0.040 | 12.9 | 0.045 | 0.124 | 1.0 | <5.0 | <0.010 | <2.0 | 0.070 | <0.002 | 0.319 | 21.1 | <5.0 |
| WWDUR05 | Duranes 5 | <0.040 | 10.0 | 0.043 | 0.141 | 2.0 | <5.0 | <0.010 | <2.0 | 0.060 | 0.004 | 0.353 | 16.7 | <5.0 |
| WWDUR06 | Duranes 6 | <0.040 | 4.3 | 0.058 | 0.110 | <1.0 | <5.0 | 0.021 | <2.0 | 0.100 | 0.003 | 0.869 | <10.0 | <5.0 |
| WWGON02 | Gonzales 2 | <0.040 | 12.8 | 0.048 | 0.160 | 4.0 | <5.0 | <0.010 | <2.0 | 0.000 | <0.002 | 0.329 | 24.5 | 5.0 |
| WWGRG01 | Griegos 1 | <0.040 | 6.1 | 0.062 | 0.068 | <1.0 | <5.0 | 0.014 | <2.0 | 0.070 | <0.002 | 0.638 | <10.0 | 5.0 |
| WWGRG02 | Griegos 2 | <0.040 | 5.0 | 0.062 | 0.073 | <1.0 | 9.0 | 0.014 | 3.0 | 0.080 | 0.016 | 0.710 | <10.0 | 8.0 |
| WWGRG04 | Griegos 4 | <0.040 | 13.0 | 0.054 | 0.074 | <1.0 | <5.0 | 0.014 | <2.0 | 0.090 | <0.002 | 0.422 | 15.7 | 6.0 |
| WWLYN02 | Leyendecker 2 | <0.040 | 3.0 | 0.076 | 0.057 | <1.0 | <5.0 | <0.010 | <2.0 | 0.030 | <0.002 | 0.201 | <10.0 | <5.0 |
| WWLYN03 | Leyendecker 3 | <0.040 | 6.0 | 0.083 | <0.050 | <1.0 | <5.0 | <0.010 | <2.0 | 0.030 | <0.002 | 0.241 | <10.0 | <5.0 |
| WWLYN04 | Leyendecker 4 | <0.040 | 5.0 | 0.075 | 0.064 | <1.0 | <5.0 | <0.010 | <2.0 | 0.040 | <0.002 | 0.230 | <10.0 | <5.0 |

**Table F3.** Summary of trace-element chemistry for City of Albuquerque production wells included in the final data set, by hydrochemical zone-- Continued

| Sample reference number | Station name | Al (mg/L) | As (µg/L) | Ba (mg/L) | B (mg/L) | Cr (µg/L) | Cu (µg/L) | Fe (mg/L) | Pb (µg/L) | Li (mg/L) | Mn (mg/L) | Sr (mg/L) | V (µg/L) | Zn (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WWMIL01 | Miles 1 | <0.040 | 16.1 | 0.089 | 0.130 | 1.0 | <5.0 | 0.011 | <2.0 | 0.060 | <0.002 | 0.399 | 15.0 | 7.0 |
| WWRIG05 | Ridgecrest 5 | <0.040 | 5.0 | 0.160 | 0.088 | 2.0 | <5.0 | 0.018 | <2.0 | 0.030 | 0.004 | 0.348 | <10.0 | <5.0 |
| WWSJ01 | San Jose 1 | <0.040 | 6.4 | 0.043 | 0.133 | <1.0 | <5.0 | <0.010 | <2.0 | 0.080 | <0.002 | 0.675 | <10.0 | <5.0 |
| WWSJ03 | San Jose 3 | <0.040 | 32.7 | 0.062 | 0.230 | 3.0 | <5.0 | <0.010 | <2.0 | 0.110 | <0.002 | 0.259 | 28.7 | <5.0 |
| WWTOM05 | Thomas 5 | <0.040 | 8.6 | 0.086 | 0.113 | 2.0 | <5.0 | 0.011 | <2.0 | 0.040 | 0.003 | 0.277 | <10.0 | 9.0 |
| WWTOM07 | Thomas 7 | <0.040 | 6.1 | 0.108 | 0.123 | 2.0 | <5.0 | 0.010 | <2.0 | 0.030 | 0.004 | 0.303 | <10.0 | 8.0 |
| WWVAN01 | Vol Andia 1 | <0.040 | 7.0 | 0.123 | 0.051 | <1.0 | <5.0 | <0.010 | <2.0 | 0.030 | 0.002 | 0.423 | <10.0 | 5.0 |
| WWVAN03 | Vol Andia 3 | <0.040 | 6.8 | 0.100 | 0.058 | <1.0 | <5.0 | <0.010 | <2.0 | 0.030 | <0.002 | 0.403 | <10.0 | <5.0 |
| WWVAN04 | Vol Andia 4 | <0.040 | 8.0 | 0.092 | <0.050 | <1.0 | <5.0 | <0.010 | <2.0 | 0.030 | <0.002 | 0.278 | <10.0 | <5.0 |
| WWVAN06 | Vol Andia 6 | <0.040 | 7.9 | 0.126 | 0.052 | <1.0 | <5.0 | 0.010 | <2.0 | 0.030 | 0.003 | 0.303 | <10.0 | 6.0 |
| WWWEB02 | Webster 2 | <0.040 | 27.0 | 0.079 | 0.144 | 1.0 | <5.0 | <0.010 | <2.0 | 0.140 | <0.002 | 0.312 | 16.9 | 6.0 |
| WWYAL02 | Yale 2 | <0.040 | 10.8 | 0.102 | 0.115 | 3.0 | <5.0 | <0.010 | <2.0 | 0.060 | <0.002 | 0.382 | <10.0 | <5.0 |
| WWYAL03 | Yale 3 | <0.040 | 13.0 | 0.089 | 0.170 | 4.0 | <5.0 | 0.015 | <2.0 | 0.090 | <0.002 | 0.470 | <10.0 | 13.0 |