OCCURRENCE AND SOURCES OF ARSENIC IN GROUND WATER OF THE MIDDLE RIO GRANDE BASIN, CENTRAL NEW MEXICO

By

Laura M. Bexfield

Thesis

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ABSTRACT

An understanding of the occurrence and sources of arsenic in ground water of the Middle Rio Grande Basin (MRGB), central New Mexico, is essential to the establishment of drinking-water supplies that will consistently meet the new standard of 10 micrograms per liter established by the U.S. Environmental Protection Agency for arsenic in drinking water. New chemical data from 288 ground-water sites, supplemented by historical data from the U.S. Geological Survey and the City of Albuquerque, show that arsenic concentrations in ground water exceed 10 micrograms per liter across broad areas of the basin. The data indicate that arsenic concentrations in the MRGB are determined primarily by the source and geochemical origin of ground water rather than by chemical processes within the basin. One primary source of arsenic to the basin is related to volcanic activity in the Jemez Mountains to the north, where dilute recharge water likely flows through rocks that have been altered by contact with geothermal fluids. The other primary source is mineralized water of deep origin that mixes with shallower ground water in several locations around the MRGB, particularly along major structural features. Values of pH that exceed 8.5, where present, appear to cause desorption of arsenic from metal oxides. Analysis of normative salt assemblages calculated using the computer program SNORM (Bodine and Jones, 1986) indicates that MRGB ground waters associated with carbonate-rock dissolution and weathering of calcic lithologies tend to have smaller arsenic concentrations than ground waters associated with hydrothermal systems or with the weathering of sodium-dominated siliceous rocks.

ACKNOWLEGMENTS

The successful completion of this investigation required the contributions of a large number of people. Particular thanks go to the chief of the MRGB study, Niel Plummer, who generously provided me access to data from the study for use in this thesis, along with the resources, guidance, and support necessary to analyze the data. I am also thankful to Fred Phillips and Rob Bowman of New Mexico Tech for their guidance and support. A debt of gratitude is owed to Scott Anderholm of the U.S. Geological Survey (USGS) for his exceedingly generous advice and encouragement. Others who contributed substantially to this study include Bill Lindberg with the City of Albuquerque Water Utility Division, who provided access to chemical data for City of Albuquerque water-supply wells; Blair Jones and Alan Welch of the USGS, who provided very helpful advice and commentary; and Sean Connell and Nelia Dunbar of the New Mexico Bureau of Geology and Mineral Resources (NMBGMR), who provided answers to numerous questions. I also appreciate the cooperation and efforts of the many landowners, government agencies, and companies who provided access to their wells, in addition to those people who helped obtain sampling permission from well owners/operators. Particular thanks also go to 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 Eurybiades Busenberg, Jerry Casile, Mike Doughten, Ward Sanford, Andrew Stack, Julian Wayland, and Peggy Widman.

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INTRODUCTION

An understanding of the occurrence, behavior, and sources of As in ground water of the Middle Rio Grande Basin (MRGB) of central New Mexico (fig. 1) is essential to the establishment of drinking-water supplies that will consistently meet the new standard of 10 μg/L established by the U.S. Environmental Protection Agency (U.S. EPA) for As in drinking water (Federal Register, January 22, 2001). The more than 700,000 residents of the MRBG between Cochiti Lake and San Acacia currently (2001) rely almost exclusively on ground water from the Santa Fe Group aquifer system for drinking-water supplies. Arsenic has been detected in ground water of the basin in concentrations exceeding 600 μg/L. Concentrations greater than 10 μg/L are common across large areas, including population centers. Of the 92 wells currently used by the City of Albuquerque to supply drinking water to more than 450,000 basin residents, just over half meet the new U.S. EPA standard for As (City of Albuquerque, 2000). Capital expenses for compliance with the new standard for the City of Albuquerque alone have been estimated at 150 million dollars (Soussan, 2001). Greater knowledge of the distribution and source of elevated As concentrations in ground water of the basin will enhance the ability of water suppliers to locate water sources meeting the U.S. EPA standard and to choose appropriate treatment options in areas where the As content of the available water supply exceeds the standard.

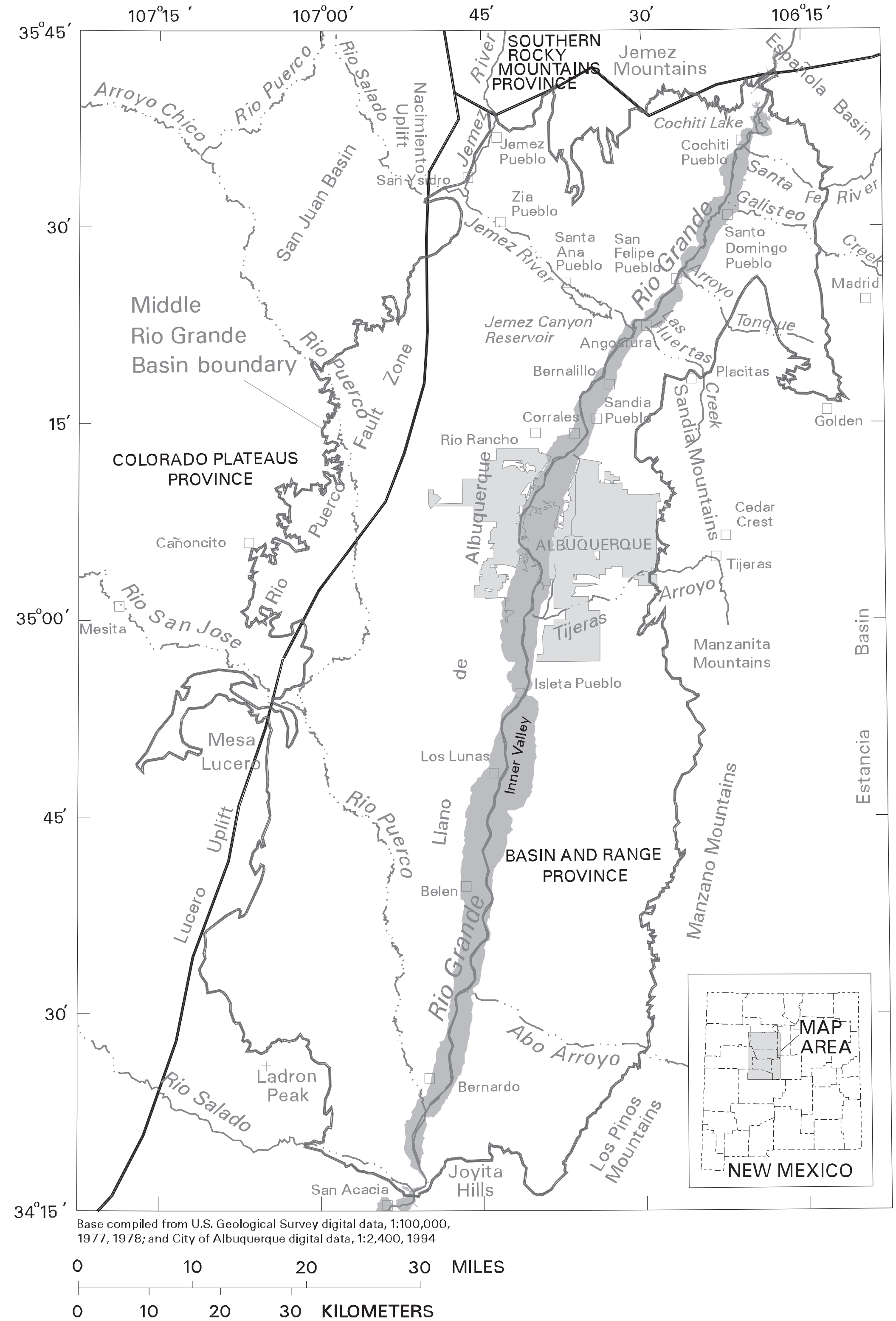


Figure 1.--Selected features of the Middle Rio Grande Basin and vicinity.

The ability to investigate the occurrence and behavior of As in ground water of the MRGB has been enhanced by collection of water samples from 288 wells and springs and 15 surface-water sites between 1996 and 1998 as a part of the U.S. Geological Survey (USGS) MRGB study of ground-water chemistry to better characterize the ground-water flow system of the basin (Plummer and others, 1997a and b, 1998, 1999, and 2001a and b), hereafter referred to as the "MRGB study." Samples were collected for a wide variety of constituents, including major- and minor-element chemistry, isotopic composition, and dissolved-gas content. In addition to greatly increasing the number of ground-water sites for which As and other chemical data are available, the MRGB study has enhanced understanding of the ground-water flow system in the basin. Improved knowledge of recharge sources and flow paths and of chemical processes occurring in ground water of the basin permit better characterization of As sources and behavior.

Purpose and Scope

The purpose of this investigation is to establish the spatial distribution of As in ground water of the MRGB and to determine the primary processes controlling its occurrence. In particular, I mapped As concentrations across the basin and with depth in the aquifer. Then I characterized the occurrence of As in relation to important aspects of the ground-water system, including source waters, flow paths, and hydrogeologic units. I also characterized the occurrence of As in relation to other measured chemical parameters, including major- and minor-element chemistry and isotopic composition of ground water. These relationships were then used to determine the primary hydrologic features and physical and chemical processes controlling the distribution of As in ground water of the basin.

Previous Investigations

The geohydrologic framework of the MRGB has been the subject of numerous previous investigations. Thorn and others (1993) summarized the geohydrology of the MRGB (otherwise known as the Albuquerque Basin) and cited most publications that have contributed to the current knowledge. Kelley (1977) and Lozinsky (1988) provided detailed studies of the geology of the basin, 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. Investigations of ground-water resources within 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 geohydrologic framework of the MRGB have been conducted, many of which are part of a multi-disciplinary 5-year effort by the USGS and other agencies to improve understanding of the area's water resources. Included in the USGS program are investigations of fault locations and lithologic variations using high-resolution aeromagnetic data and estimation of mountain-front recharge using environmental tracers. Although publications of final results do not currently (2001) exist for all of these studies, abstracts detailing their objectives and progress can be found in Cole (2001). An additional publication that was not a part of this 5-year effort is the predevelopment water-level map of the MRGB by Bexfield and Anderholm (2000).

Several 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. Logan (1990) conducted a similar type of study for the Albuquerque area using geochemical data then available, from primarily 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 drinking-water supply wells and Bexfield and Anderholm (in press) discuss the implications of those data for the ground-water system of the Albuquerque area. As mentioned previously, the MRGB study has added substantially to the quantity of available chemical data. Preliminary results of the investigation, including implications for recharge sources and flow paths, are given in Plummer and others (1997a and b, 1998, 1999, and 2001a and b) and Sanford and others (1997, 1998, and 2001a and b).

The presence of As in water and sediments of the MRGB has long been recognized as a problem and has been the subject of previous investigations. CH2M Hill (1990 and 1991) conducted a study of As under contract to the City of Albuquerque. The investigators compiled ground-water quality data for the basin from the City of Albuquerque, the State of New Mexico, and the USGS. The availability of As data was limited primarily to the vicinity of Albuquerque, and largely to total (as opposed to dissolved) As concentrations from City of Albuquerque water-supply wells. Based on the spatial distribution of As and correlations between As and other water-quality parameters, the investigators concluded that As probably was from deep sources in most of the basin; they also recognized the volcanic center in the Jemez Mountains north of the basin as a source of As-rich water (CH2M Hill, 1990 and 1991). During a subsequent study through the University of Houston, As speciation was performed on ground water from 87 City of

Albuquerque wells; the study showed that most wells contained only As (V), although some wells contained significant As (III) (Bill Lindberg, City of Albuquerque, written commun., 2000).

Chapin and Dunbar (1994) used existing water-quality data to characterize the regional occurrence of As in selected geothermal areas, in ground water of the MRGB and the Socorro area, and in surface water of the Rio Grande throughout New Mexico. They discussed the potential roles of volcanic and potassium metasomatised rocks in increasing the As content of surface and ground water. In particular, they emphasized that volcanic rocks can be intensely altered by local hydrothermal systems, leading to dramatic increases in As content. They also discussed ground-water inflow as a likely source of As to regional surface water, and sorption of As onto sediments (particularly Fe, Mn, and Al oxides) as a likely method of removal of As from surface water.

Stanton and others (2001a and b) examined sediment and rock samples from cores at three different locations in the MRGB for content and potential mobility of As. They concluded that most As in the core was associated with acid-extractable amorphous and crystalline oxides, primarily Fe oxides, but that most As available to ground water was present as the “anion-exchangeable” fraction sorbed on Fe oxides and clays.

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 is located in the Rio Grande rift, covers about 3,060 mi^2 (7930 km^2) and contains basin-fill deposits up to about 14,000 ft (4,300 m) thick (Thorn and others, 1993). The boundaries of the basin have been defined by the extent of Cenozoic deposits. The basin is partly surrounded 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 and has a flood plain up to about 4.5 mi (7.2 km) wide. Land-surface altitude above sea level ranges from about 4,700 ft (1,400 m) at the southern end of the basin to more than 6,300 ft (1,900 m) at the northern end.

Most land in the MRGB is classified as rangeland, while forest and urban and agricultural land also are significant (Thorn and others, 1993). 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 located primarily in the Rio Grande flood plain, where depth to water generally is less than about 25 ft (7.6 m) (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 prevent ground-water levels from rising closer than several feet below land surface.

Climate

The climate of the MRGB generally is categorized as semiarid, although the climate in parts of the surrounding mountains ranges to humid continental (Thorn and others, 1993). As a result of altitude differences, precipitation in the region varies widely with location. Between 1961 and 1990, mean annual precipitation varied from about 8.5 in. (22 cm) for weather stations at lower elevations within the basin (table 1 and fig. 2) to more than 19.0 in. (48.3 cm) for at weather stations in surrounding areas of higher elevation. Mean annual snowfall ranged from 4.0 in. (10 cm) at Bernardo to 61.4 in. (156 cm) at Sandia Park.

Table 1.--Climatic data from selected stations in the Middle Rio Grande Basin and vicinity, 1961-90
[From National Oceanic and Atmospheric Administration digital data]

Station name	Station elevation, in feet above sea level	Mean January temperature, in degrees Fahrenheit	Mean July temperature, in degrees Fahrenheit	Mean annual temperature, in degrees Fahrenheit	Mean annual precipitation, in inches	Mean annual snowfall, in inches
Albuquerque WSFO AP	5,309	34.3	78.6	56.3	8.88	11.4
Sandia Park	7,019	30.3	69.5	49.9	19.11	61.4
Bernardo[1]	4,735	36.1	77.4	56.8	8.45	4.0
Mountainair	6,520	32.0	70.8	51.3	13.65	27.9

[1]Station began operation in 1962; data used in calculations were for 1962-90.

At lower elevations, most precipitation falls 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-

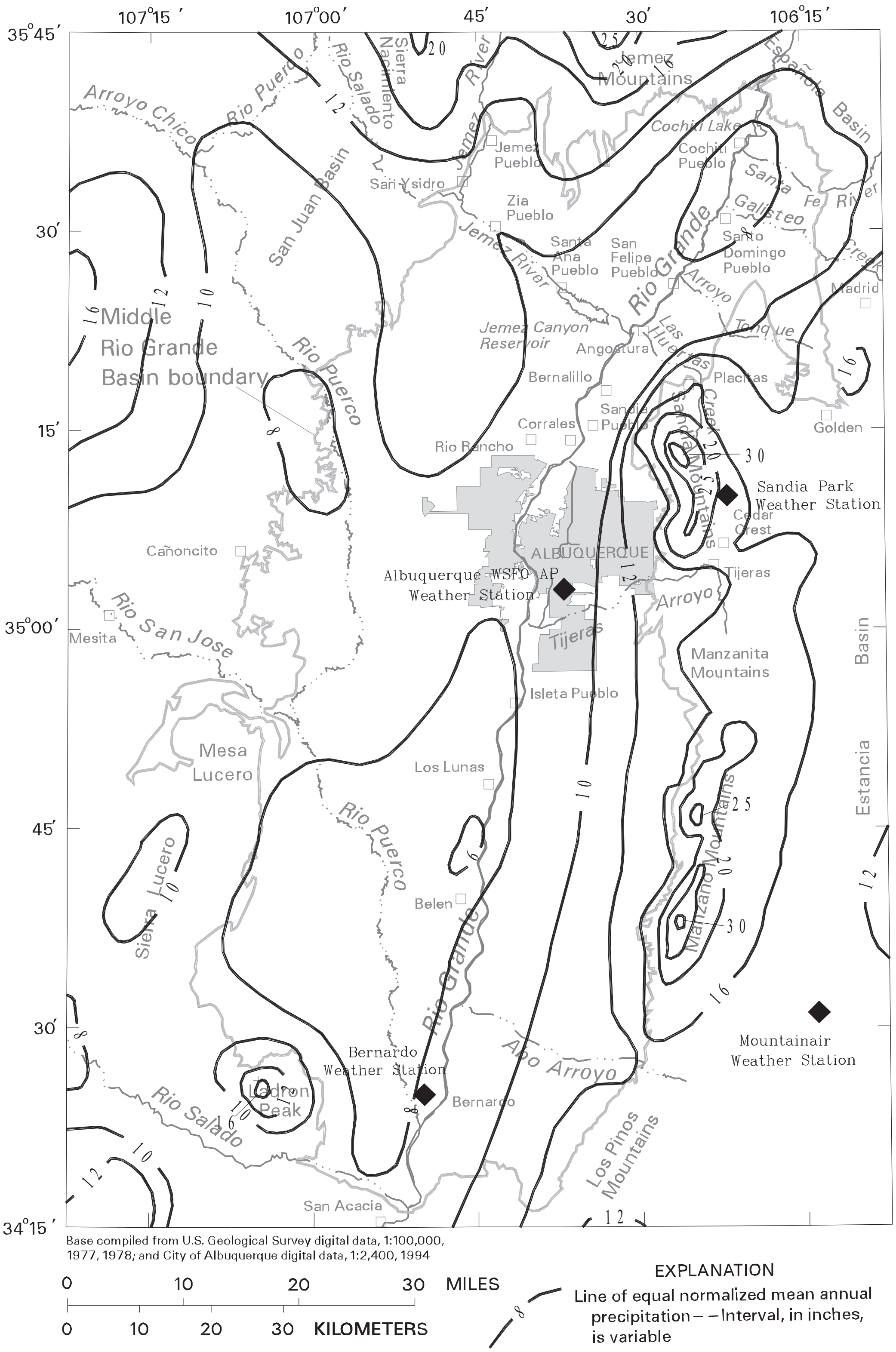


Figure 2.--Normalized mean annual precipitation in the Middle Rio Grande Basin and vicinity, central New Mexico, 1931-60 (from U.S. Department of Commerce, no date).

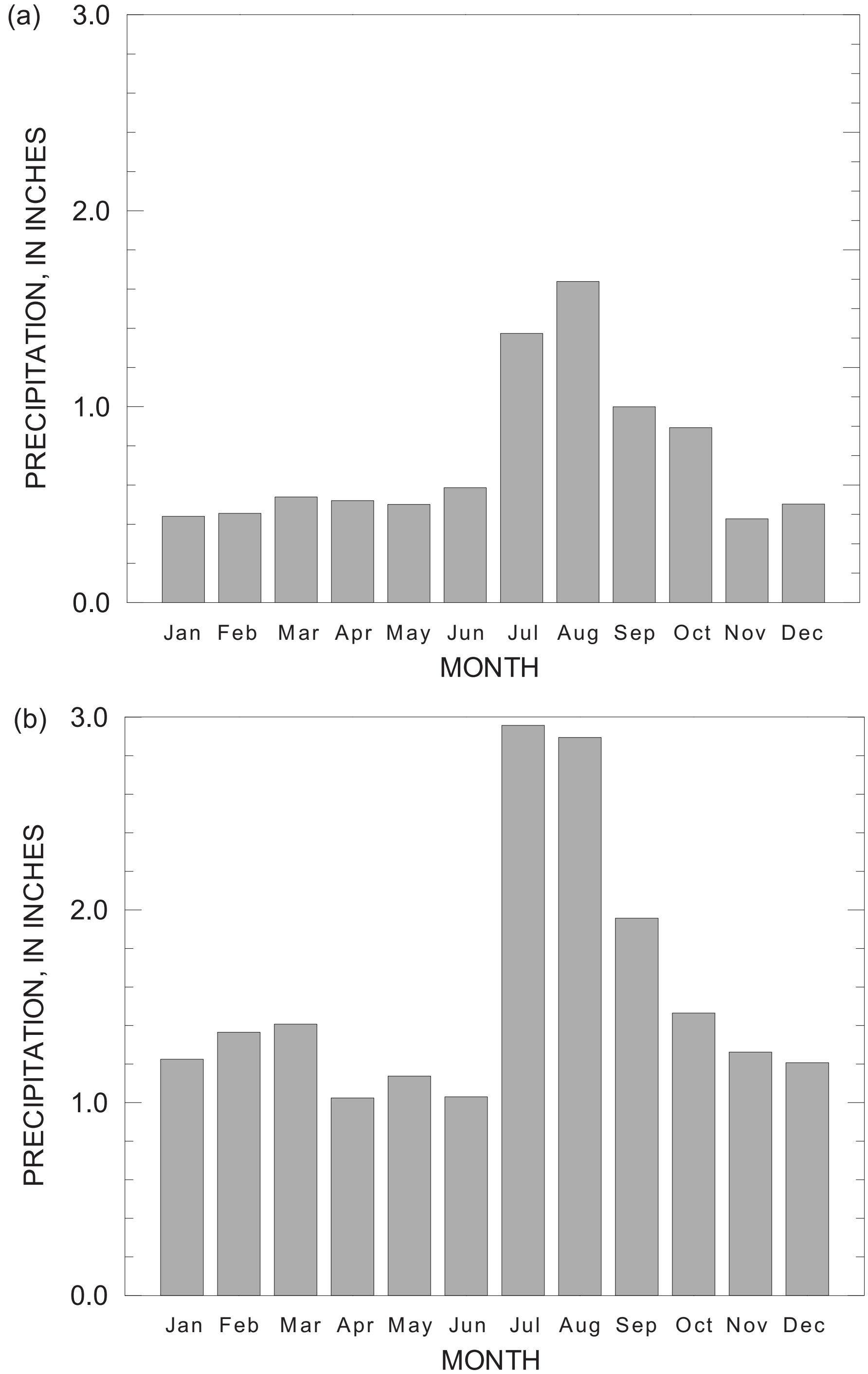


Figure 3.--Average monthly precipitation at the (a) Albuquerque Airport and (b) Sandia Park stations, 1961-90.

intensity storms of longer duration. Winter storms make a greater contribution to annual precipitation at higher elevations, 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 Albuquerque, total annual precipitation between 1961 and 1990 ranged from 4.99 to 13.11 in. (12.7 to 33.3 cm); at Sandia Park, the range was 10.41 to 28.59 in. (26.44 to 72.62 cm). Annual potential evaporation in the region is substantially greater than annual precipitation, ranging from less than 50 in. (130 cm) in the eastern part of the basin to more than 60 in. (150 cm) in the southern and central parts of the basin (Thorn and others, 1993). Mean annual temperatures for weather stations in the region range between 49.9 and 56.8 degrees Fahrenheit (°F), or 9.9 to 13.8 degrees Celsius (°C) (table 1). For 1961-90, mean monthly temperatures at Albuquerque ranged from 34.3 °F (1.3 °C) in January to 78.6 °F (25.9 °C) in July.

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. Where it enters the MRGB, the Rio Grande has a drainage area of about 14,900 mi^2 (38,600 km^2).

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).

Periodic flooding resulted in the emplacement of a system of levees and jetty jack works during the 1920's-50's to confine the river to a single channel. Also during this time period, the existing system of irrigation canals in the valley was improved and levees and interior and riverside drains were constructed.

Substantial irrigation diversions both upstream and downstream of Albuquerque affect the discharge of the Rio Grande. Since 1973, discharge has been regulated by Cochiti Dam at the north end of the basin. 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 1974-98[1], the mean annual discharge of the Rio Grande at Albuquerque was about 1,450 ft^3/s (41.1 m^3/s) (Ortiz and others, 1999).

The Rio Grande alternately gains and loses as it flows through the MRGB. At the north end of the basin, ground-water inflow apparently adds to discharge in the river between Cochiti Dam (mean annual discharge 1,444 ft^3/s (40.89 m^3/s) for water years 1971-98) and San Felipe (mean annual discharge 1,583 ft^3/s (44.83 m^3/s) for water years 1974-98), a river reach with no surface-water inflow except perhaps from arroyos during large storm events (Ortiz and others, 1999). In the vicinity of Albuquerque, water is known to seep into the aquifer 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 ft/d (0.018 to 0.037 m/d). Spiegel (1955) indicates that in Socorro County, at the south end of the basin, the inner

[1] The water year is the 12-month period from October 1 through September 30. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months.

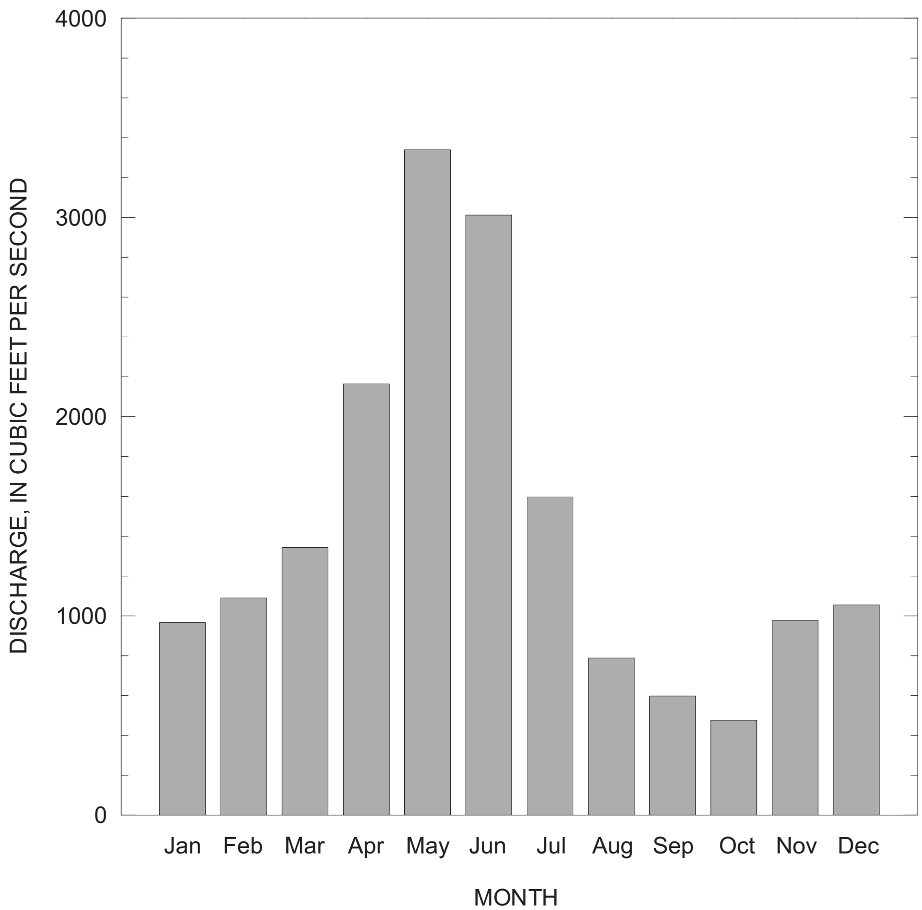


Figure 4.--Mean monthly discharge for the Rio Grande at Albuquerque, water years 1974-98.

valley of the Rio Grande gains ground water from the adjacent mesas, but the river channel might actually lose water naturally due to evapotranspiration, in addition to loss through irrigation diversions.

Tributaries

Although the Rio Grande is the only perennial stream in the MRGB, several tributaries can contribute substantial flow to the Rio Grande, and can potentially contribute substantial quantities of recharge to the underlying aquifer. Of the tributaries for which detailed streamflow records are available, the Jemez River and the Rio Puerco are among the largest. 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 Jemez River originates in the Jemez Mountains at the north end of the basin (fig. 1), which exceed 11,000 ft (3,400 m) in elevation and have been the center of major volcanic activity. In its upper reaches, the river is fed by both ground-water discharge, including discharge from some geothermal springs, and snowmelt, which typically contributes most of the discharge from March through June. At the Jemez River near Jemez [Pueblo], the mean annual discharge for 1954-98 was 79.6 ft^3/s (2.25 m^3/s); on average, about 70 percent of the total annual discharge was recorded from March through June (Ortiz and others, 1999). Upstream of Jemez Pueblo, 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 Jemez streamflow gage and Santa Ana Pueblo (fig. 1). During March the river generally gained throughout this reach, while during August (when evapotranspiration is large) 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 primarily for desilting and flood control); the mean average discharge below the dam was 62.6 ft^3/s (1.77 m^3/s) for 1943-98. Where the Jemez River meets the Rio Grande north of Bernalillo, its drainage area is about 1,050 mi^2 (2720 km^2) (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, outside 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 former streamflow gage (Rio Puerco at Rio Puerco) located about 6 mi (10 km) 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 ft^3/s (1.6 m^3/s). 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, where its drainage area is about 7,350 mi^2 (19,000 km^2) and its mean annual discharge (at the Rio Puerco near Bernardo) was 42.5 ft^3/s (1.20 m^3/s) for water years 1940-98. Records of discharge for 1940-47 for the Rio Puerco at Rio Puerco and near Bernardo indicated that this reach of the river lost an average of at least 5,800 acre-ft/yr (7,200,000 m^3/yr) (Spiegel, 1955).

Tijeras Arroyo enters the MRGB just south of the Sandia Mountains (fig. 1). The arroyo drains mainly Paleozoic and Precambrian rocks at elevations up to about 9,800 ft (3,000 m) and has a drainage area of about 99.3 mi^2 (257 km^2) where it enters the basin (Anderholm, 2000). Although flow in Tijeras Arroyo is perennial in some sections east of the basin due to spring and ground-water discharge, water in the arroyo typically infiltrates a short distance inside the basin boundary due to the increasing 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 ft (460 m) apart were operated near the mountain front for the periods April 1943-June 1949 and May 1989-September 1991. The data show that the mean annual discharge in Tijeras Arroyo has decreased substantially from greater than 13 ft^3/s (0.37 m^3/s) during 1944-48 (U.S. Geological Survey, 1960) to less than 0.15 ft^3/s (0.0042 m^3/s) during 1990-91 (data from the U.S. Geological Survey National Water Information System database), possibly as the result of recent development in the watershed (Anderholm, 2000).

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 mi^2, or 642 km^2). The arroyo drains mostly Paleozoic sedimentary rocks, along with some crystalline Precambrian rocks (Anderholm, 2000). Data collected from a streamflow gage near the mountain front for October1996-September 1997 show a small amount of perennial flow, which infiltrates a short distance inside the basin boundary. Anderholm (2000) assumes a discharge of about 0.35 ft^3/s (0.0099 m^3/s) in calculating the yearly base flow at the gage site. Summer storms result in large flows that can account for over half the annual discharge at the gage (Anderholm, 2000) and that periodically reach the Rio Grande.

Several additional ephemeral channels have the potential to contribute substantial amounts of recharge to the aquifer 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 the Santa Fe River, Galisteo Creek, Las Huertas Creek, Arroyo Tonque, and the Rio Salado (fig. 1).

Geologic Setting

Tectonic Framework

For this study, the MRGB (or Albuquerque Basin) is defined as by Thorn and others (1993) to include the Santo Domingo Basin and the Hagan Embayment (fig. 5). As defined, the basin is about 100 mi (160 km) long and 35 mi (56 km) 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 geophysical

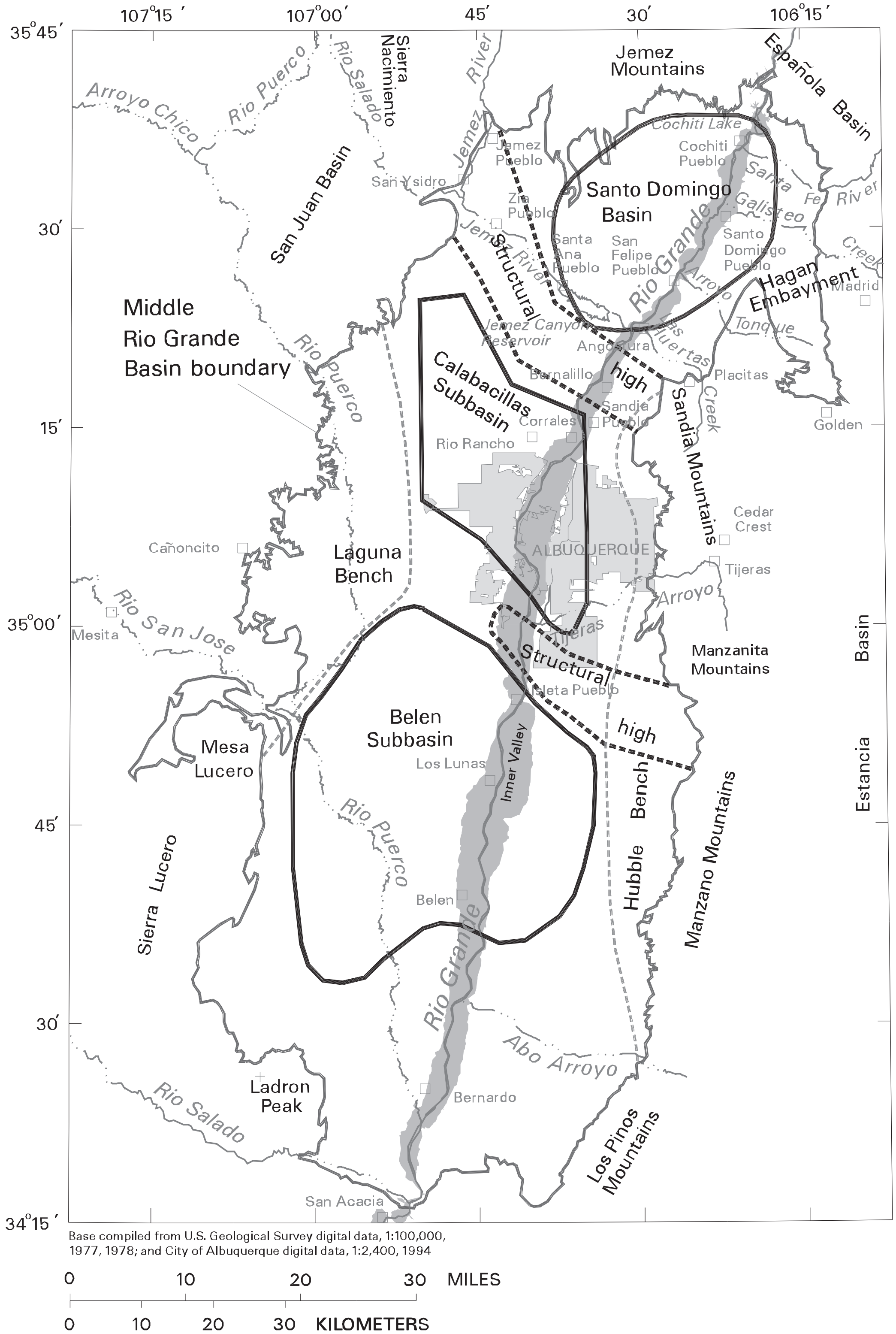


Figure 5.--Simplified structure of the Middle Rio Grande Basin.

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). 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 basin fill, but its thickness here can be less than 3,000 ft (910 m), compared with more than 10,000 ft (3,050 ft) within the Santo Domingo Basin and the two subbasins (Grauch and others, 1999 and 2001). The deep, inner portions of the subbasins generally are also bordered on the sides by relatively shallow benches that step up to the margin areas (Hawley and Haase, 1992). These include the Hubble 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 mainly 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. The northeast section of the basin (east of the Jemez Mountains) is connected to the Española Basin by a narrow area referred to by Kelley (1977) as the White Rock channel.

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 unconformably overlain 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. To the south, 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 with a general north-south strike (fig. 6). Most of these faults offset only relatively homogeneous Santa Fe Group deposits, although a few 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 thoroughly characterized, the predevelopment water-level map of Bexfield and

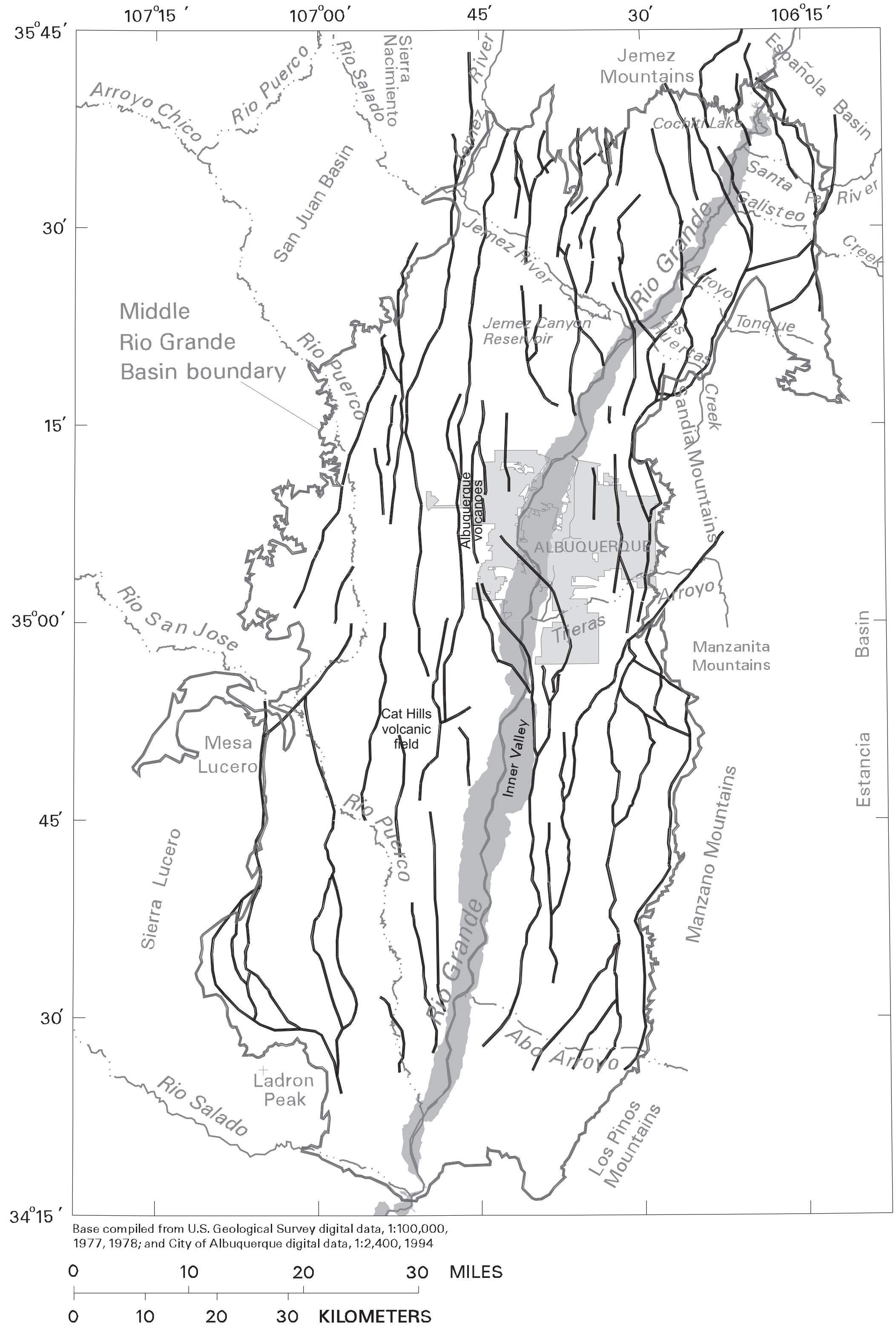


Figure 6.--Major faults and volcanic fields of the Middle Rio Grande Basin. (Faults from Mark Hudson and Scott Minor, U.S. Geological Survey, written commun., 1999.)

Anderholm (2000) indicates that faults near the basin margins that juxtapose different geologic units can have an effect on predevelopment hydraulic heads. Another property of faults that has not been well characterized in the MRGB is their potential to facilitate upward flow of deep water into relatively shallow parts of the aquifer.

Santa Fe Group Aquifer System

The primary aquifer 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 (i.e., 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 deposits. For this investigation, 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 largely from Hawley and Haase (1992), except where otherwise specified.

Hydrostratigraphic Units

Santa Fe Group deposits, which range in thickness from about 3,000 to over 14,000 ft (about 910 to over 4,200 m), have been broadly divided 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. The group also contains volcanic rocks and sediments that could be of significance for As concentrations in ground water. The lower Santa Fe Group, which was deposited about 30 to 15 million years ago and ranges in thickness from less than 1,000 to about 3,500 ft (less than 300 to about 1,100 m), represents deposition in a relatively 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 deposits are primarily associated with playa lakes and compose poor aquifer materials.

The middle Santa Fe Group, which was deposited about 15 to 5 million years ago and ranges from about 250 to 9,000 ft thick, represents the time of the most active tectonism and highest sedimentation rates in the basin. Deposition of piedmont-slope sediments continued and fluvial sediments were deposited 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 flowed into playa lakes 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 (1998a) 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 ft thick, consists largely of intertonguing piedoment-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, 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. Santa Fe Group deposition ended approximately 1 million years ago, when the Rio Grande and Rio Puerco began to cut their present valleys.

Post-Santa Fe Group sediments were deposited during a series of river incision and partial backfilling episodes. The river valley has been aggrading over about the past 10,000 to 15,000 years due to input of sediment from large tributaries. Younger basin and valley fills include fan, pediment, inset-terrace, eolian, and floodplain deposits and volcanics. Younger valley fill is up to about 130 ft 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 conceptual diagram of the extent of major lithostratigraphic units during the Pliocene is shown in figure 7. The Sierra Ladrones Formation is subdivided into: piedmont facies along the east and southwest margins of the basin, which contain only rare volcanics; ancestral Rio Grande facies through the center of the basin, which contain volcanic material derived from north of the basin; and ancestral Rio Puerco/Rio San Jose facies in the southwest, which contain basaltic volcanic sediments derived from west of the basin (fig. 7) (Connell and others, 1999; Sean Connell, NMBGMR, written commun., 2001). Fluvial deposits of the ancestral Rio Jemez, which contain abundant silicic-intermediate-basaltic volcanic sediments derived from the Jemez Mountains, comprise

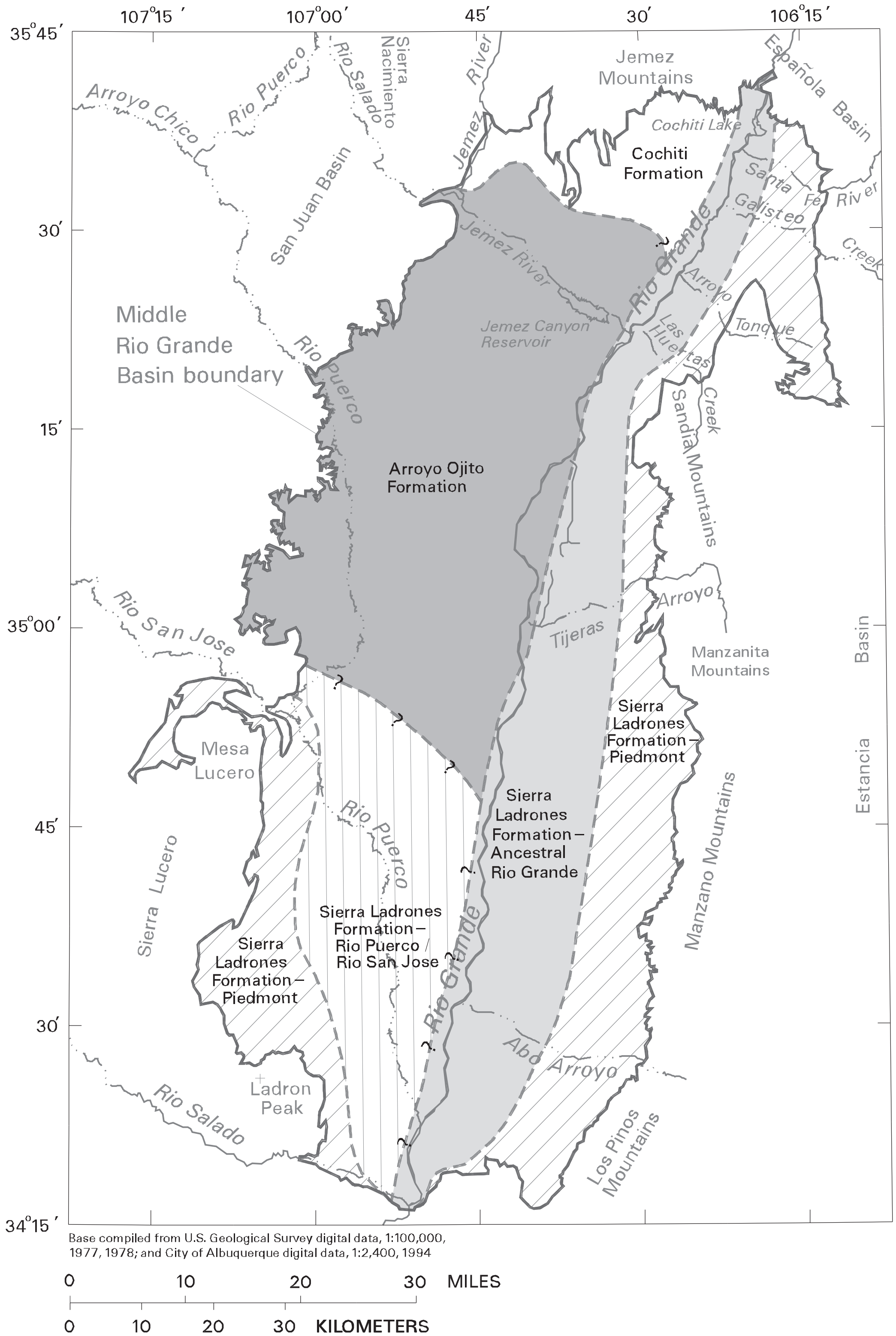


Figure 7.--Inferred lateral extent of major lithostratigraphic units during the Pliocene. (Modified from Connell and others, 1999.)

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, which include basaltic volcanic material from sources west of the basin.

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 ft/d (1.5 m/d) for most of the lower and middle Santa Fe Group to more than 40 ft/d (12 m/d) 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 drinking-water supply 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 northeast part of Albuquerque, sediments at depths of about 200 to 3,200 ft were described as volcanic-rich, with glassy pumice being present from about 200 to 400 ft. Hawley and Haase concluded that the glassy pumice was probably derived from the Jemez volcanic field, while 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. Mudrocks that were 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) and Stone and others (1998) 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. Lozinsky (1988) also noted that calcite generally was the primary cement.

Ground-Water Flow System

The ground-water flow system of the MRGB between Cochiti and San Acacia is quite complex and in some areas has not been particularly well characterized due to a lack of data. Multiple sources of recharge to the ground-water system exist across the basin. Land use, particularly the existence of irrigation and septic systems, has added to the potential sources of recharge. Characterization of the flow system also has been complicated by drawdown due to sustained ground-water pumping, especially in the vicinity of Albuquerque, which has altered directions of ground-water flow and probably changed the rates of recharge occurring from various sources. The existence of faults that juxtapose relatively permeable deposits with impermeable units also appears to affect directions and rates of ground-water flow. Such faults also have been proposed as possible conduits for the upward flow of relatively deep ground water (Bexfield and Anderholm, in press).

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. 8). Near the basin margins, ground-water flow has historically been oriented primarily toward the central part of the basin. On various predevelopment water-level maps of the region (Bjorklund and Maxwell, 1961; Titus, 1961; Titus, 1963; Bexfield and Anderholm, 2000), a ground-water trough is apparent west of the Rio Grande, from just south of the Jemez River down to the area of Los Lunas (fig. 8). 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), but ground-water modeling results of Sanford and others (2001a) indicate the trough may have developed as a result of the low quantity of recharge and its spatial distribution.

In the vicinity of Albuquerque, a steady increase in ground-water pumping since about the mid-1940's has resulted in substantial water-level declines of up to 160 ft (49 m) or more, as indicated by water-level data for 1992 (fig. 9). These declines have resulted in ground-water movement being directed into the major pumping centers on the east and west sides of the Rio Grande. Smaller-scale changes in ground-water flow

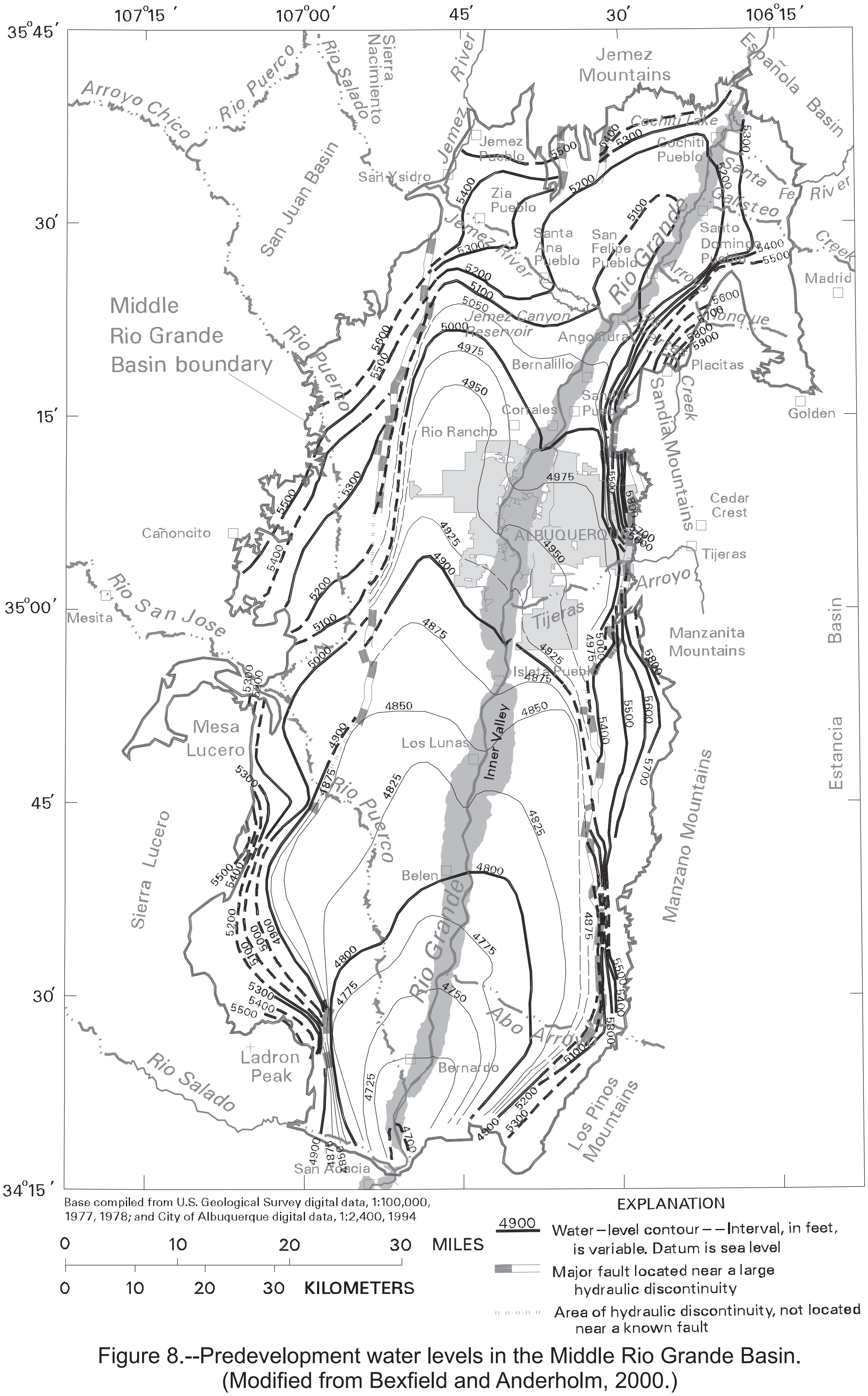


Figure 8.--Predevelopment water levels in the Middle Rio Grande Basin. (Modified from Bexfield and Anderholm, 2000.)

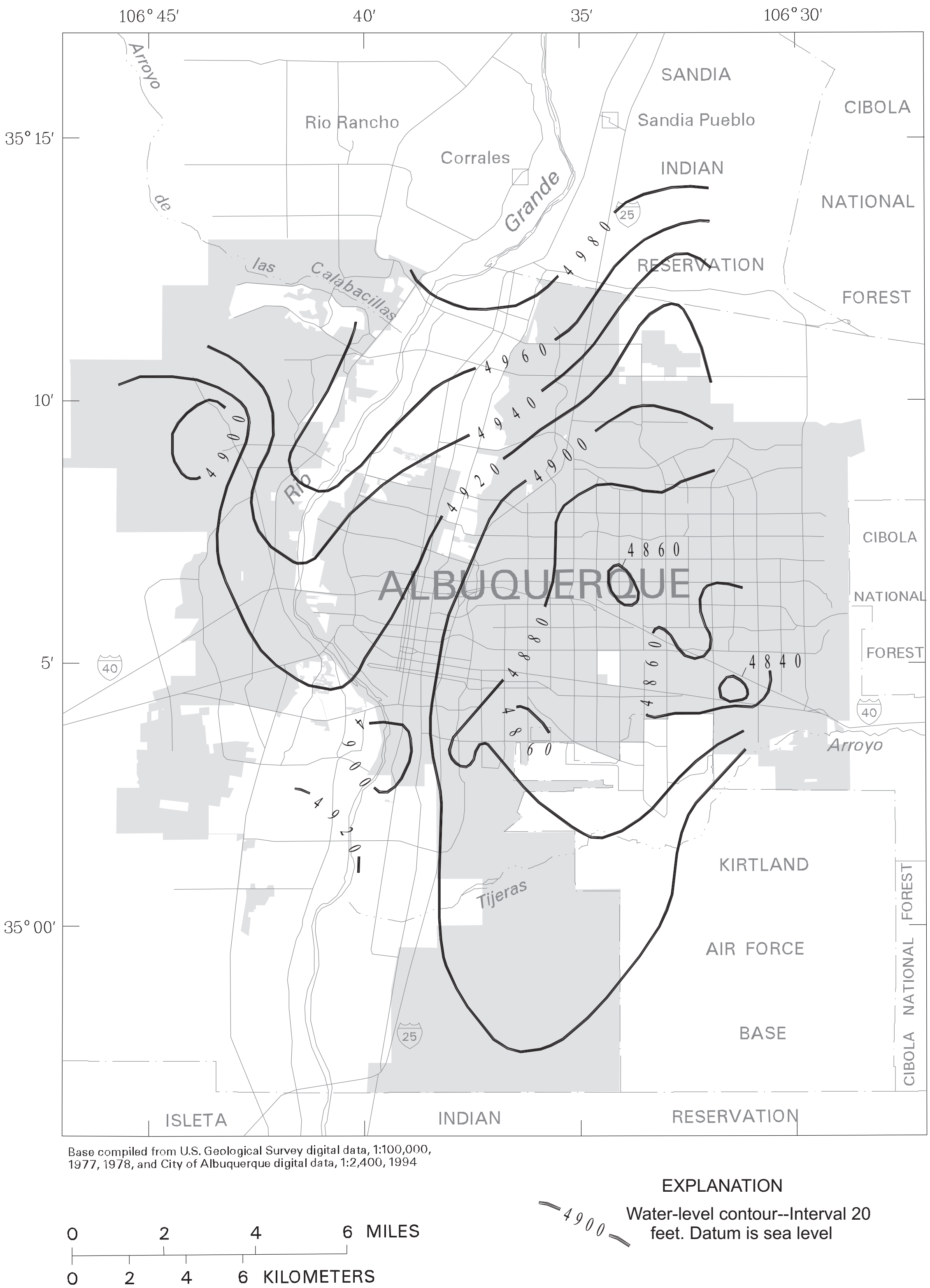


Figure 9.--Water levels that represent 1992 conditions in the Santa Fe Group aquifer system in the Albuquerque area (modified from Thorn and others, 1993).

directions likely have also occurred as a result of ground-water pumping in the vicinity of other communities, such as Bernalillo, Los Lunas, and Belen.

Bexfield and Anderholm (in press) investigated water levels in deep nested piezometers in the Albuquerque area and found that the direction and magnitude of vertical gradients differed substantially around the city. Vertical gradients in piezometer nests in the Rio Grande flood plain and west of the river were directed primarily downward. In piezometer nests on the mesa east of the Rio Grande, vertical gradients were directed primarily upward, except in the two shallowest completions of a nest located near the mountain front. 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 ground-water 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). Estimates of the quantity of mountain-front recharge along the east side of the basin range from about 11,150 to 71,630 acre-ft/yr (13,750,000 to 88,360,000 m^3/yr) (Anderholm, 2000). No studies have been performed specifically to estimate quantities of mountain-front recharge along the Jemez Mountains in the northern part of the basin or the Ladron Mountains in the southwest. 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, ground water inflows from the Tertiary deposits of the upgradient Española

Basin and possibly from the Jemez volcanic deposits. Along the western margin, ground water probably inflows from Mesozoic rocks of the San Juan Basin toward the north and from Precambrian and Palezoic rocks toward the south. Deep ground water may also inflow 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, but the quantity of inflow in these areas is not clear.

As discussed above, water is known to seep to the ground-water system from the Rio Grande and its tributary streams and arroyos, as well as from the irrigation system in the Rio Grande flood plain. Kernodle and others (1995) estimated through use of their ground-water model that about 79,000 acre-ft (9,700,000 m^3) of water was contributed to the aquifer system from the Rio Grande and associated canals during the year ending in March 1994. The model also assumed 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). Other sources that probably contribute to recharge, particularly in the Rio Grande flood plain—where depths to water typically are less than about 25 ft (7.6 m)—include excess irrigation water and septic systems.

Ground water discharges from the MRGB to the Socorro Basin near San Acacia (fig. 1). Ground water also discharges 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 discharged primarily through evapotranspiration. However, ground-water pumpage, which was estimated by Kernodle and others (1995) to be about 152,700 acre-ft (188,400,000 m^3) in 1990 for all uses, has substantially reduced the amount of ground-water discharge through evapotranspiration.

METHODS

To obtain the most accurate representation of water chemistry in the MRGB that could reasonably be achieved, data collected specifically for the MRGB study were supplemented with data obtained from previous studies. 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 National Water Information System (NWIS) database and a database maintained by the City of Albuquerque on water chemistry from its drinking-water supply 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. Aspects of sample collection and analysis are discussed below for each data source.

MRGB Study

Collection of ground-water samples

For the MRGB study, more than 300 sets of ground-water samples were collected at 288 ground-water sites (wells and springs) across the basin. Samples from these sites were analyzed for a wide variety of constituents, including: major- and minor-element chemistry, oxygen-18 and deuterium content of water, carbon-13 and carbon-14 content of dissolved inorganic carbon, sulfur-34 content of dissolved sulfate, tritium, and contents of selected dissolved gases (including dissolved oxygen, nitrogen, argon, methane, helium, tritiogenic helium-3, chlorofluorocarbons, sulfur hexafluoride, neon, and carbon dioxide) (Plummer and others, in prep.). However, this investigation focuses mainly on data for field parameters and major- and minor-element chemistry (Appendix I).

Ground-water sampling sites for the MRGB study 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 (i.e. short screened intervals) and groups of wells that allowed samples to be obtained from a variety of depths within the aquifer at a given location. However, in most areas of the basin except the vicinity of Albuquerque, so few wells were available for sampling that well construction was not an important consideration.

Ground-water sampling sites consisted of 280 wells and 8 springs. 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 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 stock), and 3 were classified as other (wells with submersible pumps, where water is used primarily for stock). Well depths ranged from about 23 to 2,020 ft, with a median of about 500 ft. Screen lengths ranged from 0 to 1,270 ft, with a median of 20 ft. 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. Aside from the windmills and from 48 production wells equipped with turbine pumps, most wells were sampled using either a dedicated or transportable submersible pump. 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, while monitoring wells typically provided the most discrete sampling intervals.

For wells sampled as part of the MRGB study, at least 3 casing volumes of water were purged and field parameters (specific conductance, water temperature, pH, and dissolved-oxygen concentration) were allowed to stabilize before sample collection. At each ground-water site, field parameters were recorded and samples were passed through a 0.45-micron filter for laboratory analysis of dissolved concentrations of selected major and minor elements. Major- and minor-element samples were collected in polyethylene bottles, and minor-element samples were preserved with Ultrex nitric acid in the field. At 9 ground-water sites, samples for minor elements were collected using a range of filter sizes. Differences among analytical results for samples filtered using 0.45-micron capsule filters, tangential filtration at 0.1 microns, and tangential filtration at 30,000 Daltons were negligible; As concentrations using the three methods differed by no more than 1 μg/L, and were typically identical within the analytical precision of +/- 5 percent.

Collection of surface-water samples

In addition to ground-water samples, multiple surface-water samples also were collected for the MRGB study. Samples were collected as frequently as monthly at up to 14 surface-water sites, including sites on the Rio Grande and associated drains and irrigation canals, the Jemez River, the Rio Puerco, and Tijeras Arroyo (fig. 1), between

Table 2.--Summary of construction information for MRGB study wells by well type [Length of sample interval is in feet; all other data are in feet below land surface; --, no data]

Parameter	Number	Minimum	Median	Maximum
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	0	20	40
Depth to water	32	8	252	530
Monitoring wells				
Depth of well	116	23	394	1805
Depth to top of sample interval	115	10	349	1634
Depth to bottom of sample interval	115	20	415	1795
Length of sample interval	115	5	10	270
Depth to water	115	6	98	887
Production wells				
Depth of well	81	81	1000	2020
Depth to top of sample interval	79	19	425	1355
Depth to bottom of sample interval	79	81	950	2000
Length of sample interval	79	18	400	1270
Depth to water	81	4	269	1101
Stock wells				
Depth of well	3	120	192	460
Depth to top of sample interval	0	--	--	--
Depth to bottom of sample interval	0	--	--	--
Length of sample interval	0	--	--	--
Depth to water	2	107	139	171
Windmills				
Depth of well	44	42	291	1109
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

January 1997 and April 1999. Samples were dipped from streams rather than integrated across their widths and depths. Surface-water samples were filtered and preserved in the same manner as ground-water samples were, and were analyzed for the same field parameters and major and minor constituents. Some surface-water samples were also analyzed for selected isotopes and dissolved gases, but these data were not used in this investigation. Chemical data for selected sites are summarized in table 3.

Sample Analysis

Analysis of major and minor elements for the MRGB study was performed in the USGS Water Chemistry Laboratory in Reston, Virginia. Analysis of major cations and silica was performed using a multi-element direct-current plasma spectrometer, and that of major anions was performed using ion chromatography. The analysis of minor elements was performed using EPA Method 200.8 (U.S. EPA, 1994) with an inductively coupled plasma-mass spectrometer. The As detection limit was 0.1 μg/L. Further details of analytical techniques and quality-control measures are given in Busenberg and others (2000).

Data Selection

Site locations, sample reference numbers (three numbers preceded by “NM”), and well-construction information are listed in Appendix I for the MRGB study ground-water samples that were included in the main body of data discussed in this report; site locations also are shown in figure 10. Data from some of the ground-water sites sampled for the MRGB study have not been included in this main body of data. Data for a few sites were removed from the data set because the sites fell outside of the boundaries of

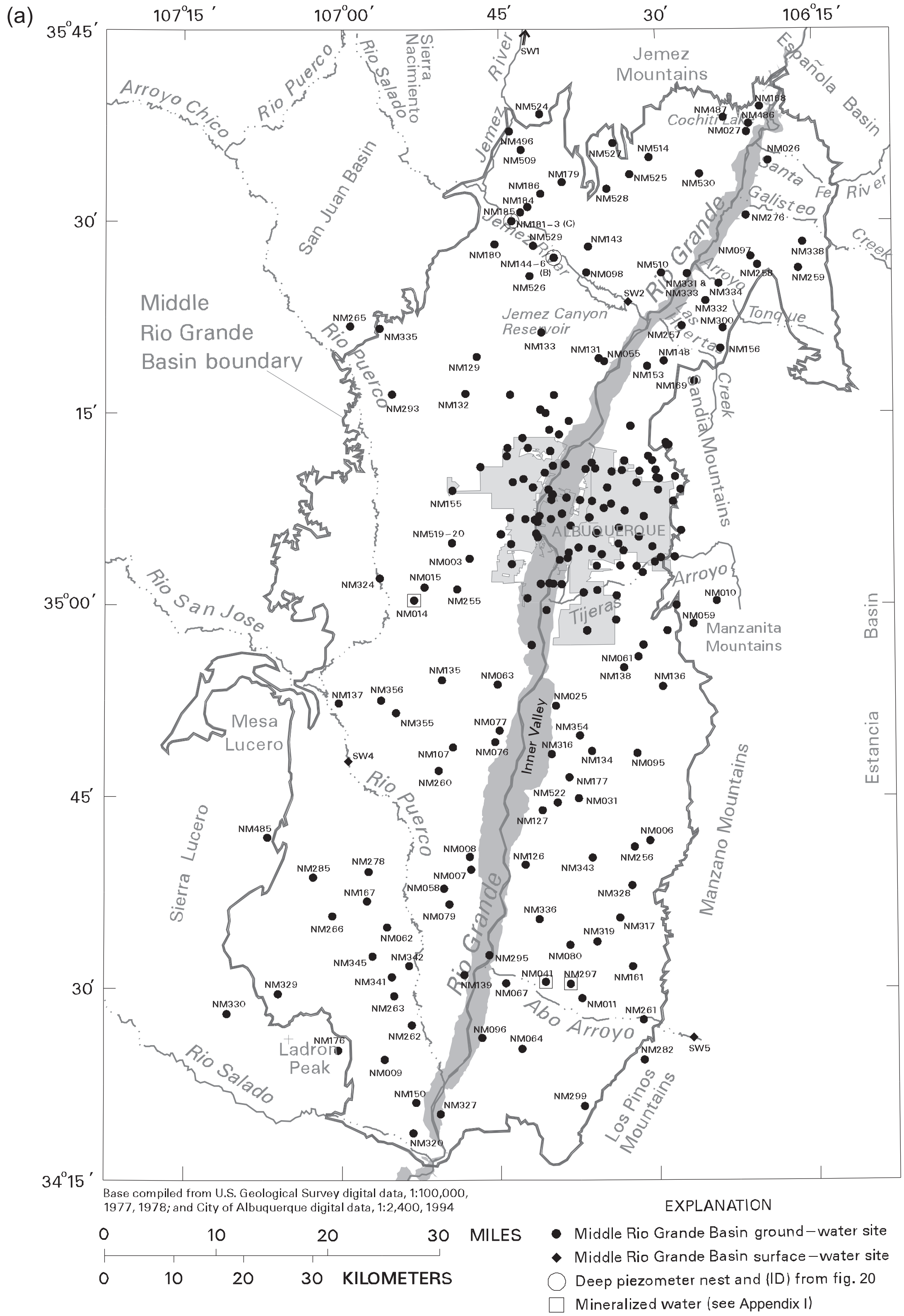
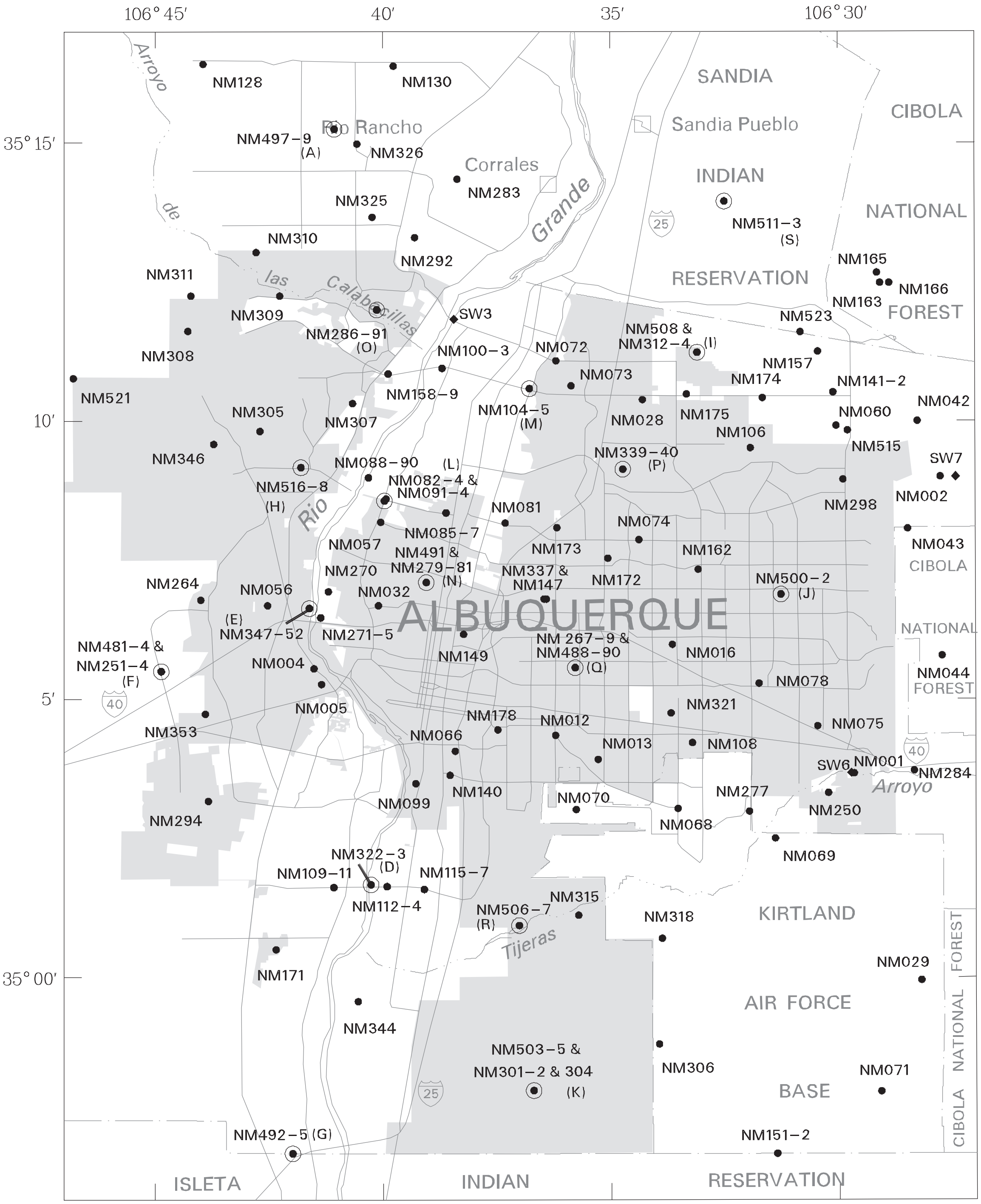


Figure 10.--Locations of ground-water and surface-water samples collected for the Middle Rio Grande Basin study (a) outside and (b) inside the Albuquerque area.

(b)



Base compiled from U.S. Geological Survey digital data, 1:100,000, 1977, 1978, and City of Albuquerque digital data, 1:2,400, 1994 the MRGB and were known to have produced water from an aquifer system other than that of the Santa Fe Group. Data for other sites were removed because the sites were sampled more than once; in these cases, the more recent sample data were retained. Data for a few other selected sites were removed from the main data set describing the typical regional occurrence of As in the MRGB 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, wells that were believed to have been affected by contamination from landfills or other sources, wells that were believed to have been strongly affected by local evapotranspiration, wells that were believed to produce water associated primarily with geothermal systems, and wells that were believed to have been affected only locally and at relatively shallow depths by surface-water bodies. Some of these data are nevertheless discussed in terms of unusual waters that could represent certain sources of As to the basin; these data are listed in a separate section of Appendix I.

No data were removed from the MRGB data set based on analytical ion balances for major elements. Only three samples that had not been removed from the data set for other reasons did not balance to within ten percent (balances were calculated as the difference between the total meq/L of cations and the total meq/L of anions divided by the average of these two numbers, then multiplied by 100 to obtain a value in percent); these were NM071, NM075, and NM523. Laboratory analyses were repeated for these samples and the cause of the problem with ion balance was determined to likely be faulty alkalinity values, which could not be repeated.

USGS NWIS 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) 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 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 trace-element analyses were then removed from the data set. All but one of these samples had associated major-element analyses. Samples with major-element analyses that did not give an ion balance of ten percent or better also were discarded. Finally, duplicate ground-water samples for the same site were eliminated. In general, the most recent sample was retained, unless an older sample was analyzed for more parameters. For the same ground-water site, a sample collected specifically for MRGB study was always retained over any samples available from the NWIS database. Site locations and sample reference numbers (three numbers preceded by "DB"), in addition to well-construction and water-level information (where available), are listed in Appendix I for all NWIS ground-water samples that were retained in the final data set. Ground-water sites where these samples were collected are shown in figure 11. Surface-water samples having dissolved As data also were retrieved from the NWIS database for selected sites (table 3 and figs. 10 and 11) to analyze the presence of As in potential sources of recharge to the ground-water system.

Chemical analysis of most NWIS samples was performed at a USGS laboratory; methods of analysis vary because the dates of sample collection encompass many years.

(a)

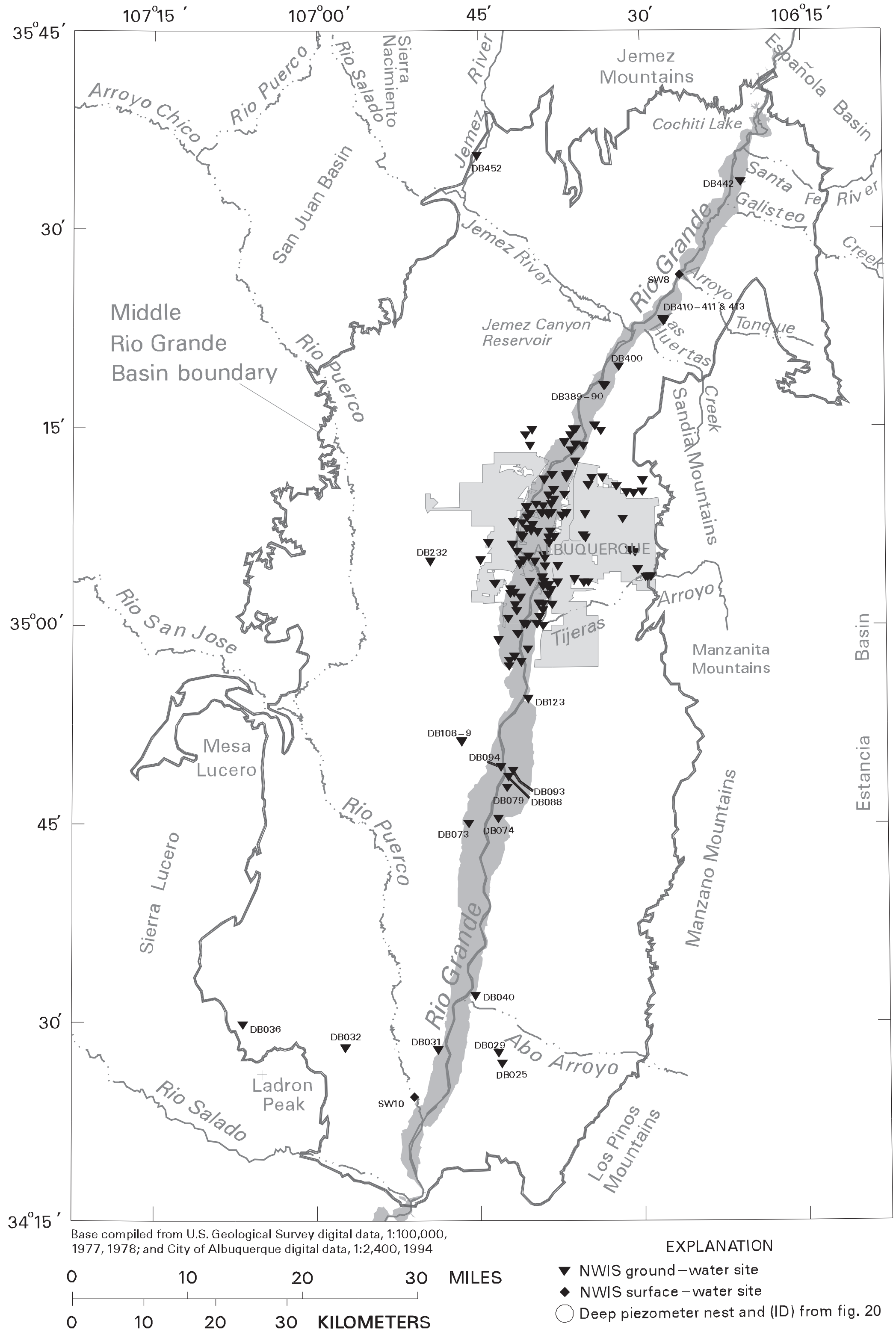
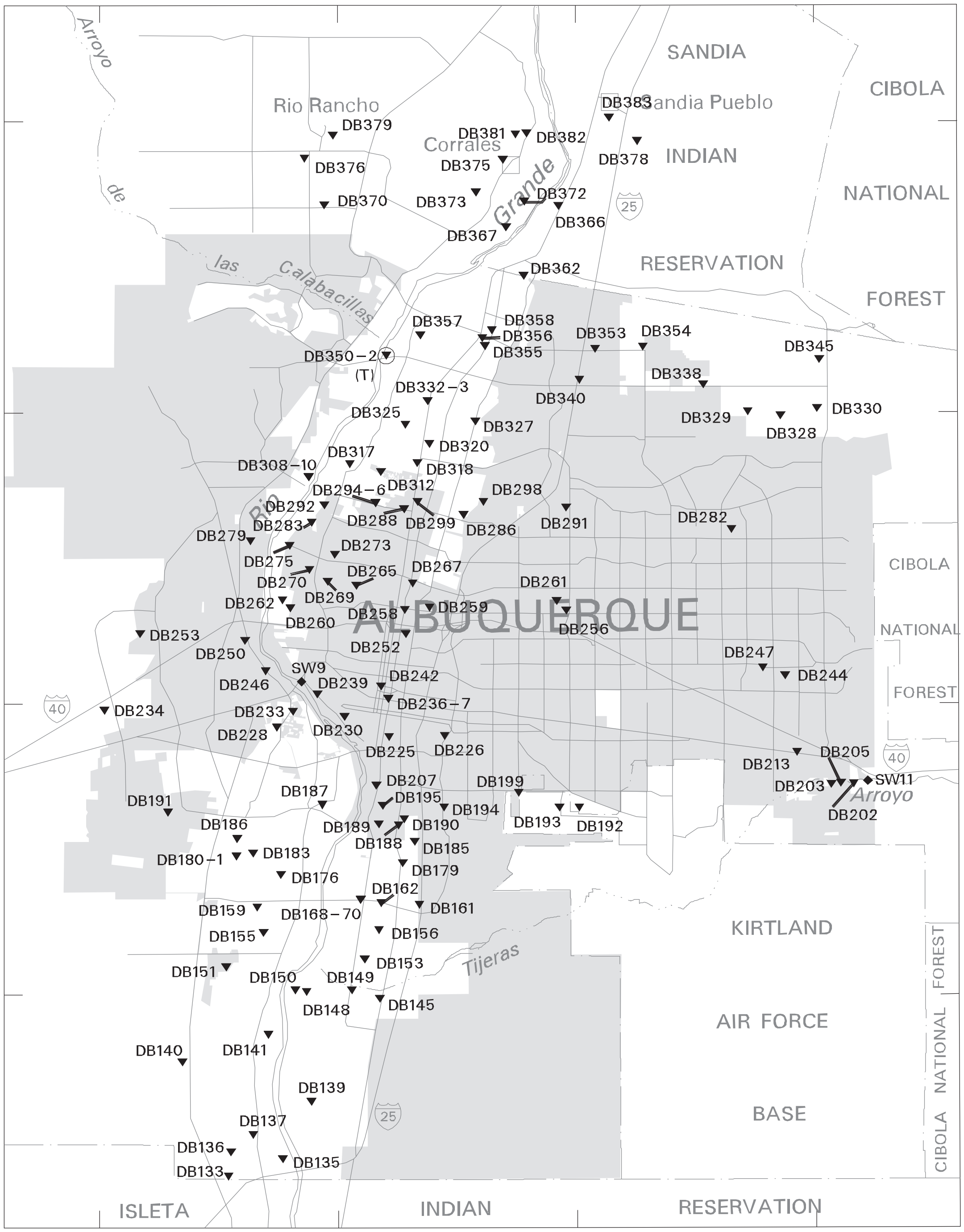


Figure 11.--Locations of ground-water and surface-water samples from the U.S. Geological Survey NWIS database included in the final data set, (a) outside and (b) inside the Albuquerque area.

(b)



Base compiled from U.S. Geological Survey digital data, 1:100,000, 1977, 1978, and City of Albuquerque digital data, 1:2,400, 1994

0 2 4 6 MILES

0 2 4 6 KILOMETERS

All minor-element samples are believed to have been passed through 0.45-micron filters and acidified in the field.

City of Albuquerque Database

Since 1988, the City of Albuquerque has periodically collected and analyzed water-quality samples from its drinking-water supply wells (fig. 12) 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), which also describes methods of sampling and analysis. In particular, major- and minor-element samples were not filtered and minor-element samples were acidified on the day of collection. Arsenic was analyzed by graphite furnace atomic absorption spectroscopy. Iron, Mn, and Zn were analyzed by atomic absorption spectroscopy; other trace elements generally were analyzed using an inductively coupled plasma-optical emission spectrophotometer (ICP-OES). Major cations also generally were analyzed by ICP-OES. Other than bicarbonate, which was determined by titration, analysis of major anions was performed by ion chromatography.

The median constituent concentrations presented by Bexfield and others (1999) for each of 93 drinking-water supply wells were included in the data set used for this investigation. Also included were median values from one additional municipal well (College 3) that had been sampled several times, but had been removed from service as a drinking-water supply well (and, therefore, had not been included in the Bexfield and others report). 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. The median chemical values should be reasonably representative of “typical” water chemistry for the

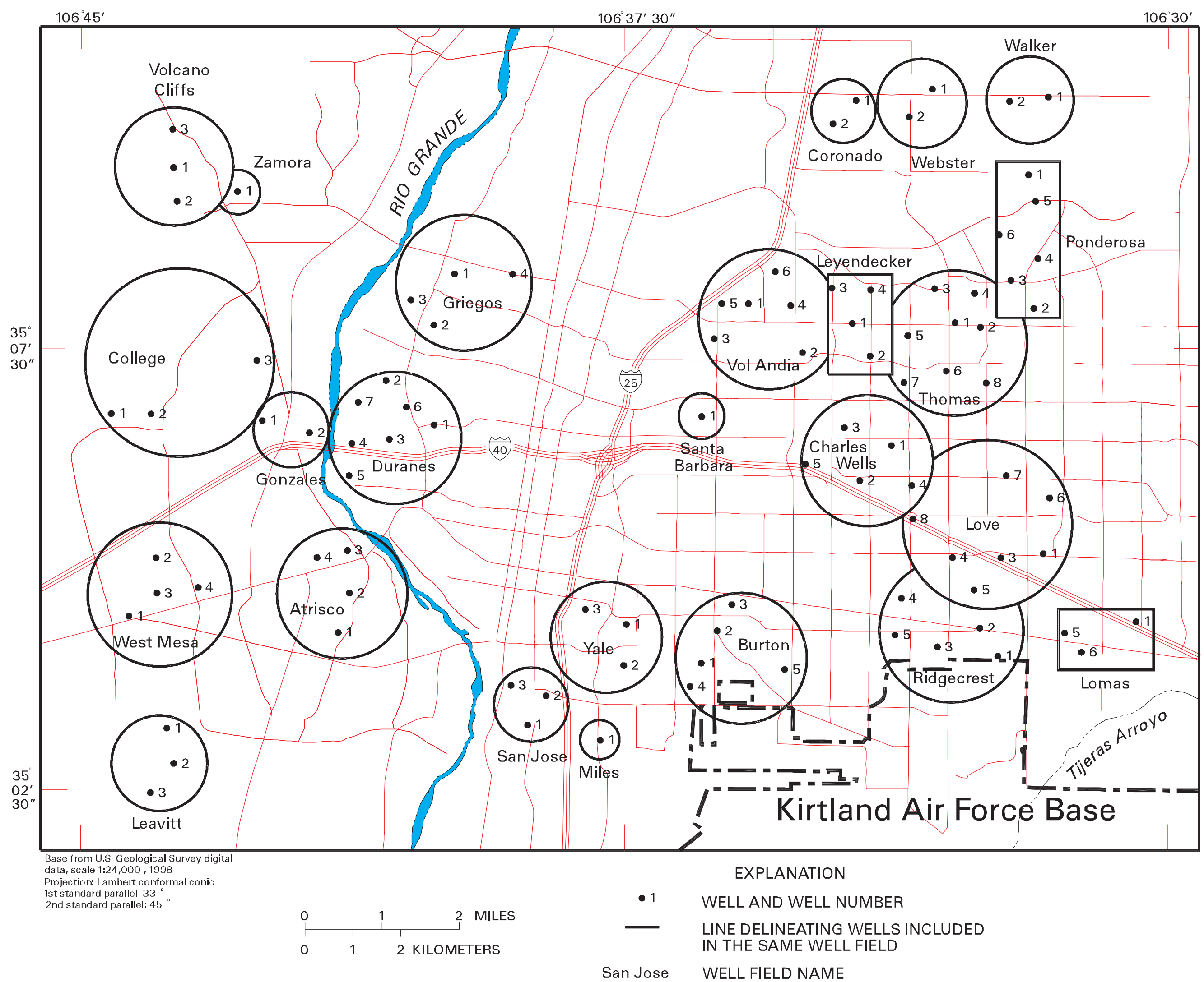


Figure 12.--Locations of City of Albuquerque drinking-water supply wells.
Wells for which City of Albuquerque data were included in the final data set are listed in Appendix I.

city wells, especially given that Bexfield and Anderholm (in press) found that temporal variability for most chemical parameters was typically quite small (values generally varied by less than 20 percent, including As values). For drinking-water supply wells that had also been sampled specifically for the MRGB study, the City of Albuquerque data were eliminated. However, City of Albuquerque data were retained in favor of historical NWIS data when data existed from both of these sources for the same well. Site locations and sample reference numbers (two or three letters designating the well field, followed by two digits designating the well number), in addition to well-construction and water-level information, are listed in Appendix I for all City of Albuquerque median ground-water compositions that were retained in the final data set.

Data from the unfiltered City of Albuquerque samples are believed to be comparable to those of the filtered samples from the MRGB study and the NWIS database. This conclusion is based on the results of the filtration test described above for selected MRGB ground-water sites, in which differences observed among results for the various levels of filtration were generally within analytical error, as well as on comparison of filtered samples for the MRGB study with median values of unfiltered samples from the city database for the same site.

HYDROCHEMICAL FRAMEWORK OF THE MIDDLE RIO GRANDE BASIN

Investigation of the occurrence and behavior of As in ground water of the MRGB requires a fundamental understanding of the complex hydrologic system of the basin and consideration of the large regional variation in water chemistry. The large number of samples and wide range of chemical and isotopic substances analyzed as a part of the MRGB study were used to delineate 13 separate water-quality zones having unique chemical characteristics that appear to change little as water moves through the basin (fig. 13) (Plummer and others, 2001a). These zones represent 12 sources of ground-water recharge to the basin and one area of ground-water discharge. Plummer and others (2001a) summarize median values of selected chemical parameters, stable isotopes, and radiocarbon ages for the water-quality zones. The different chemical characteristics of ground water in these zones complicate investigation of relationships between As and other chemical parameters. The differences in chemical characteristics are demonstrated by the median parameter values given in table 4 (which differ in some cases from values in Plummer and others (2001a) because selected samples were removed from the data set used in this study, as described in the Methods section) and the representative major-element compositions shown in figure 14, where the water types used below are defined.

Three distinct water-quality zones receive ground-water recharge from areas north of the MRGB (fig. 13). Ground water of the Northern Mountain Front zone is characterized by small specific conductance and pH relative to other water-quality zones

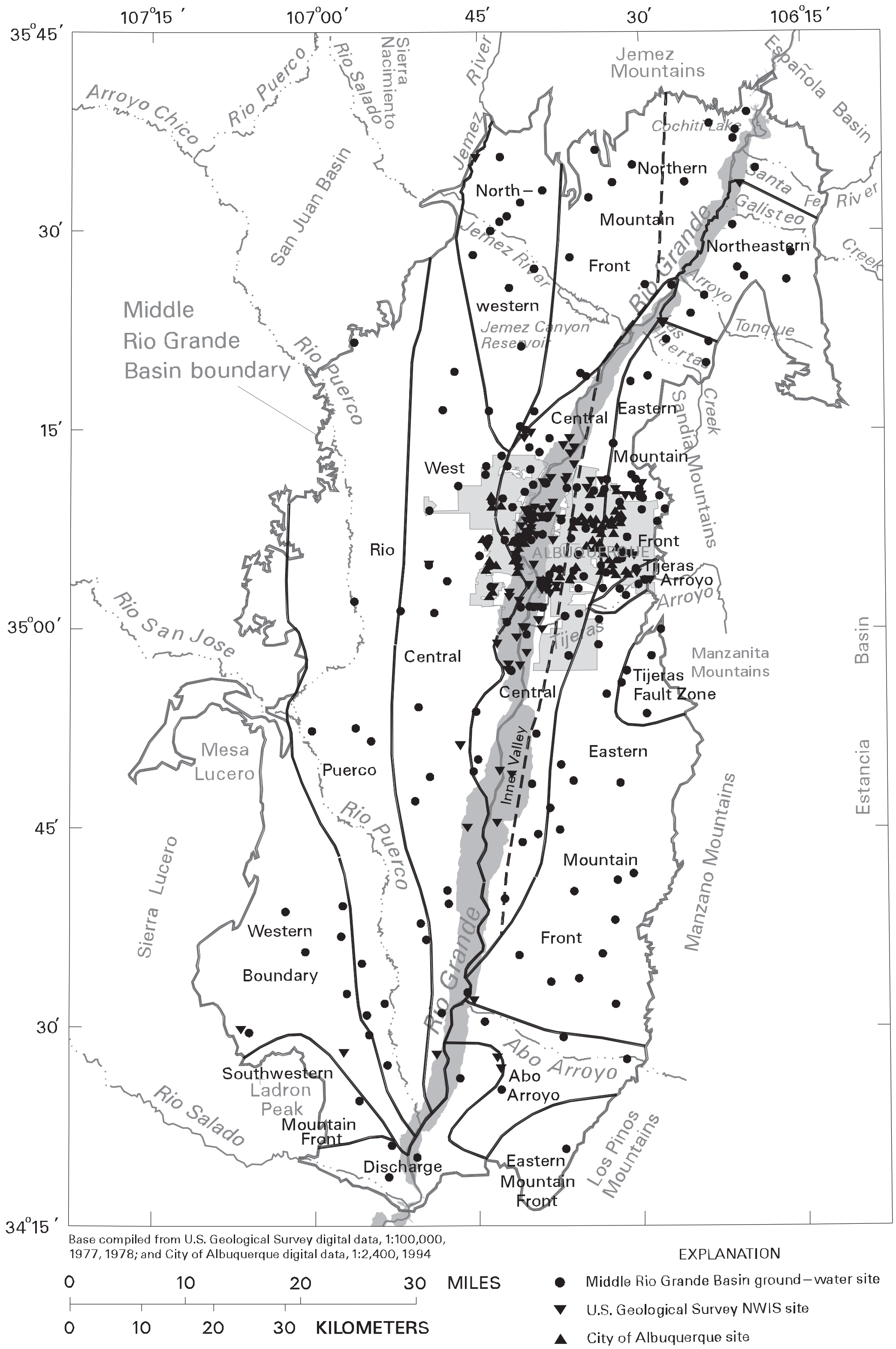


Figure 13.--Water-quality zones defined for the Middle Rio Grande Basin. The dashed line represents the possible extent of the West-Central zone at depth beneath other zones (modified from Plummer and others, 2001a).

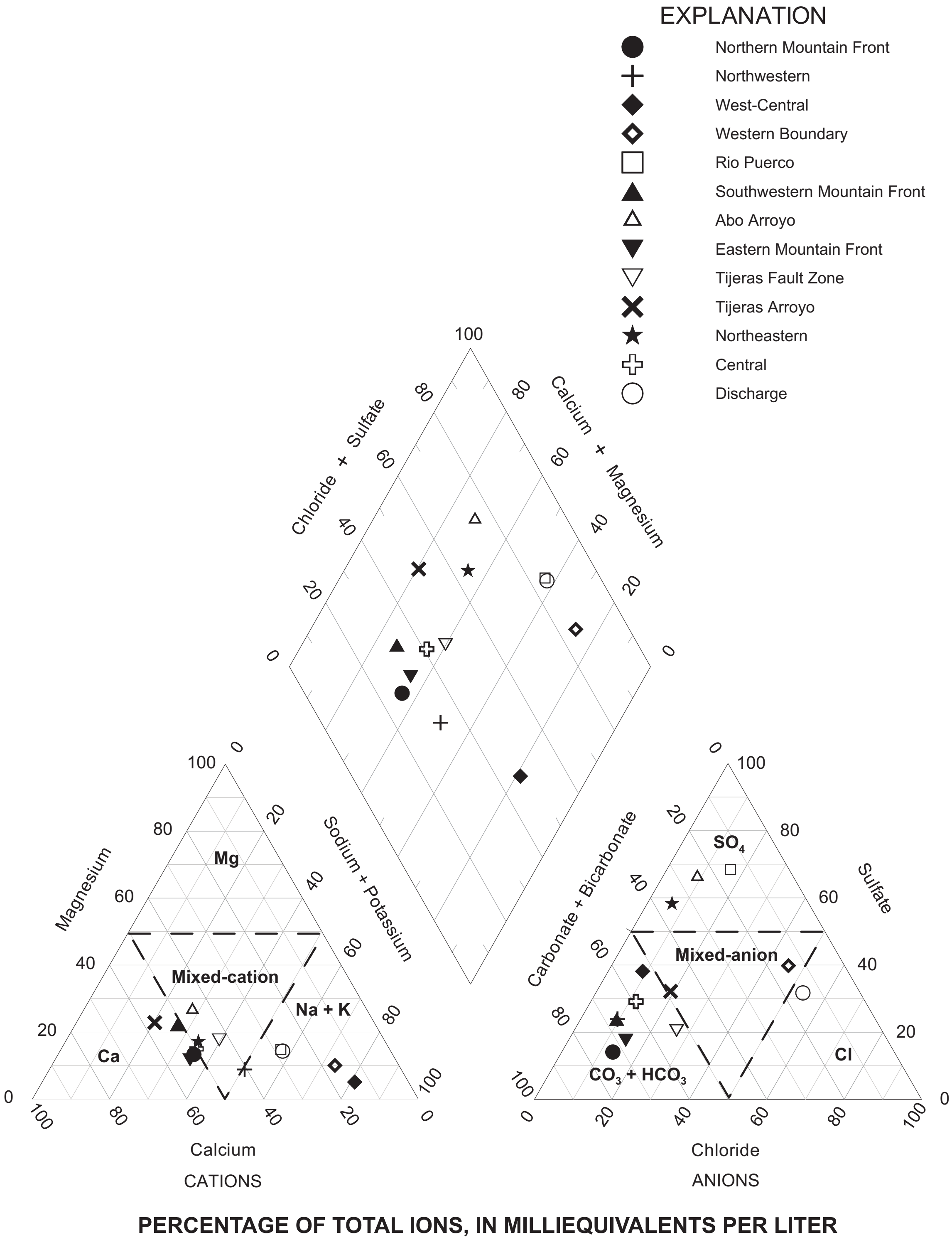


Figure 14.--Representative major-element compositions for ground water from the various water-quality zones.

(table 4). Ground water in this zone tends to have particularly small concentrations of Cl, Na, SO_4, and several minor elements, but particularly large SiO_2 concentrations. The dominant water type is Ca / CO_3 + HCO_3. The major-element compositions of most samples from the Northern Mountain Front zone imply that the primary source of recharge is mountain-front recharge along the eastern part of the Jemez Mountains, which consist largely of Tertiary volcanic rocks. However, some samples show evidence of mixing with a high-Cl water. Some important processes in the zone may include silicate weathering, ion exchange, and calcite dissolution. The median radiocarbon age of ground water in the zone is 8.8 thousand years before present (ka BP) (Plummer and others, 2001a). According to geologic maps available for the area (Smith and others, 1970; Smith and Kuhle, 1998; Connell and others, 1999), most wells sampled in this zone are completed in the Cochiti Formation, the Arroyo Ojito Formation, or axial river deposits of the Rio Grande (fig. 7). Ground water of the zone appears to flow from the Jemez mountain front to the south and east, probably discharging to the Rio Grande and/or mixing with greater quantities of water from other water-quality zones to the south.

Compared to most other zones, ground water of the Northwestern zone generally has relatively small specific conductance, relatively large pH, relatively small concentrations of Ca, Mg, Cl, and SO_4, and relatively large concentrations of NO_3 and some minor elements (table 4). Silica concentrations are substantially smaller than those of the adjacent Northern Mountain Front zone. The dominant water types are Na + K / and mixed-cation / CO_3 + HCO_3. The compositions of most ground-water samples from the Northwestern zone (including stable-isotope compositions) imply that the primary source of water is recharge at relatively low elevations along the western base of the

Jemez Mountains, although a few samples show evidence of local mixing with infiltration from the Jemez River. The median radiocarbon age of ground water in the Northwestern zone is 8.8 ka BP. Wells appear to be completed in either the Zia Sand Formation of Miocene time or the Cochiti or Arroyo Ojito Formations (fig. 7) (Smith and others, 1970; Craigg, 1992; Connell and others, 1999). Ground water of the zone probably flows primarily southward and mixes at its southern end with greater quantities of water from other, downgradient zones.

Ground water of the West-Central zone typically has moderate specific conductance relative to other zones (table 4). Ca, Mg, and Sr concentrations are particularly small, while pH values, Na concentrations, and some minor-element concentrations are particularly large. The dominant water type is Na + K / CO_3 + HCO_3, although Na + K / mixed-anion and Na + K / SO_4 water types also are relatively common. The median radiocarbon age of ground water in the West-Central zone is 19.9 ka BP. Ground water of the zone appears to extend most of the length of the MRGB and flows at depth under the Northwestern zone and probably parts of the Northern Mountain Front and Central zones. The major-element compositions of most samples from the West-Central zone show that the water probably recharged in the area of the Jemez Mountains. The old ages of West-Central-zone ground water, along with light stable isotopes, imply that ground water in the zone recharges farther north than recharge to the overlying Northwestern zone and generally travels longer, deeper flow paths into the basin. However, the exact area of recharge is uncertain. Most wells appear to be completed in the Zia Sand Formation, Arroyo Ojito Formation, or Cochiti Formation, whereas those at the southern end may be completed in sediments of the Sierra Ladrones

Formation (fig. 7) (Smith and others, 1970; Craigg, 1992; Connell and others, 1998b; Connell and others, 1999). Ground water of the zone probably flows primarily south, discharging to the Rio Grande at its southern end and possibly mixing with water of the Central zone along its eastern boundary.

Three distinct water-quality zones exist along the western margin of the MRGB (fig. 13). Ground water of the Western Boundary zone typically has the largest specific conductance of any zone (table 4). Concentrations of Na, K, and Cl are particularly large. The typical water types are Na + K / Cl and Na + K / mixed-anion. Ground water of the Western Boundary zone probably is a mixture of Na-Cl brine leaking into the basin from Paleozoic rocks (typically limestone, sandstone, and shale) along the western margin and infiltrating precipitation/arroyo flow within the basin. The median radiocarbon age of ground water in the Western Boundary zone is 20.4 ka BP. Most wells of the zone appear to be completed in sediments of the Sierra Ladrones Formation that were derived either from the western piedmont or the ancestral Rio Puerco and Rio San Jose (Connell and others, 1999). Ground water of the zone probably flows primarily to the southeast, discharges to the Rio Grande at its southern end, and mixes with water of the Rio Puerco zone along its eastern boundary (fig. 13).

Ground water of the Rio Puerco zone typically has the second-largest specific conductance and the largest SO_4 concentration of any zone. The dominant water types are mixed-cation / and Na + K / SO_4. The median radiocarbon age of ground water in the Rio Puerco zone is 8.1 ka BP. Ground water of this zone likely is a mixture of water from the Western Boundary zone with surface water that infiltrates through the Rio Puerco and/or ground water that leaks into the basin from Mesozoic rocks (typically Cretaceous sandstone and shale with local Jurassic gypsum and clastic units) along the northwestern boundary. Most wells of the zone appear to be completed in sediments of the Sierra Ladrones Formation that were derived from the ancestral Rio Puerco and Rio San Jose (Connell and others, 1999). Ground water of the zone probably flows primarily southeast, discharges to the Rio Grande, and possibly mixes with some water of the West-Central zone along its eastern boundary.

The Southwestern Mountain Front zone is delineated on the basis of only two samples, so that analysis of the ground-water chemistry of the zone is difficult. The median values of the two samples in the zone indicate that specific conductance is moderately small (particularly compared to water of the Western Boundary and Rio Puerco zones), as are concentrations of Na and K (table 4). Water types of the two samples are mixed-cation / and Ca / CO_3 + HCO_3; the single available radiocarbon age for the zone is 7.4 ka BP. The compositions of the two samples indicate that the primary source of water probably is mountain-front recharge along the Ladron Mountains, which consist mainly of Precambrian granitic and metamorphic rocks. Ground water of the zone probably mixes with greater quantities of water from the downgradient Western Boundary zone to the southeast, although some water may discharge to the Rio Grande.

Five water-quality zones receive ground-water recharge primarily from sources located along the eastern boundary of the MRGB (fig. 13). Ground water of the Eastern Mountain Front zone typically has the second-smallest conductance of any zone (table 4). Compared to other zones, concentrations of Mg, Na, Cl, SO_4, and several minor elements are relatively small. The dominant water type is Ca / CO_3 + HCO_3. The major-constituent compositions of most samples from the zone are consistent with a mountain-front recharge source along the Sandia, Manzanita, and Manzano Mountains, which consist primarily of west-facing Precambrian metamorphic and plutonic rocks that are overlain by Paleozoic limestone and sandstone (Anderholm, 1988; Hawley and Haase, 1992). However, several samples downgradient of the mountain front show evidence of mixing with high-Cl water. Ground water of the Eastern Mountain Front zone has a median radiocarbon age of 5.2 ka BP. Most wells appear to be completed in piedmont deposits in the eastern part of the zone or in axial-river deposits of the Rio Grande farther from the mountain front (Connell, 1997; Connell and others, 1998a; Connell and others, 1998b; Connell and others, 1999). Ground water of the zone probably flows primarily west and south and discharges to the Rio Grande at its southern end, possibly mixing with water of the Central zone along its western boundary.

Ground water of the Abo Arroyo zone typically has a moderately large specific conductance; concentrations of Mg, SO_4, and NO_3 are relatively large (table 4). The typical water type is mixed-cation / SO_4. Ground-water compositions from much of the Abo Arroyo zone appear to be consistent with a major recharge source being infiltration through the arroyo, which drains mostly Paleozoic sedimentary rocks and some crystalline Precambrian rocks (Anderholm, 2000). However, a few samples indicate that substantial mixing occurs locally with water that recharged along the mountain front or through the Rio Grande. The median radiocarbon age of ground water in the Abo Arroyo zone is 9.4 ka BP. Most wells of the zone probably are completed in either piedmont deposits or axial channel deposits of the Rio Grande (Connell and others, 1999). The ground water probably flows primarily southwest and 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 Tijeras Fault Zone zone typically has a relatively large specific conductance (table 4). Compared to other zones, pH values and SiO_2 concentrations are relatively small, whereas alkalinity values and concentrations of Ca, Mg, Cl, and SO_4 are relatively large. Mixed-cation / CO_3 + HCO_3 is the most common water type. Ground water of the zone appears to contain at least a fraction of high-Cl water, such as from deep fracture systems, that likely mixes with shallow mountain-front recharge water. Rocks present in the area include Precambrian granitic rocks and greenstone and Pennsylvanian limestone. The median radiocarbon age of ground water in the Tijeras Fault Zone zone is 16.3 ka BP. Most wells of the zone probably are completed in either Paleozoic rocks (Grace Haggerty, Gram, Inc., written commun., 1996) or basin-fill deposits derived from the eastern piedmont (Connell and others, 1999). Ground water of the zone probably mixes with greater quantities of more dilute water from the Eastern Mountain Front zone downgradient to the southwest.

Ground water of the Tijeras Arroyo zone typically has a moderate specific conductance (table 4). Compared to other zones, pH values and concentrations of Na, K, SiO_2, and several minor constituents are relatively small, while alkalinity values and concentrations of NO_3 are relatively large. Concentrations of SO_4 also are large relative to the Eastern Mountain Front zone. Water types are Ca / CO_3 + HCO_3 and Ca / mixed-anion. Ground-water samples from the Tijeras Arroyo zone generally appear to be a mixture of dilute mountain-front recharge water and infiltration through Tijeras Arroyo, which drains primarily Paleozoic and Precambrian rocks east of the basin. With greater distance downgradient, dilute mountain-front water dominates the chemical composition of the ground water to a greater degree. The median radiocarbon age of ground water in the Tijeras Arroyo zone is 3.2 ka BP. Most wells of the zone likely are completed either in stream alluvium (Karlstrom and others, 1994) or sediments from the eastern piedmont (Connell and others, 1998a ; Connell and others, 1999). Water of the zone probably flows primarily west and south and mixes with a greater quantity of water from the Eastern Mountain Front and/or Central zone.

Ground water of the Northeastern zone typically has a relatively large specific conductance (table 4). Compared to other zones, alkalinity values and concentrations of Ca, Na, Sr, SO_4, and SiO_2 are relatively large. The dominant water types are Ca / SO_4 and mixed-cation / SO_4. Ground water in the zone appears to be derived from more than one primary source, including mountain-front recharge water, arroyo infiltration, and/or ground-water inflow from gypsum-containing rocks outside the basin. The median radiocarbon age of ground water in the Northeastern zone is 10 ka BP. Most wells of the zone probably are completed in either piedmont deposits, which include abundant volcanic rocks in the Hagan embayment, or axial channel deposits of the Rio Grande (Smith and Kuhle, 1998; Connell and others, 1999; Sean Connell, NMBGMR, written commun., 2001). Ground water of the zone probably flows primarily northwest and discharges to the Rio Grande.

Two water-quality zones are located mainly near the center of the MRGB (fig. 13). Ground water of the Central zone, which extends parallel to the Rio Grande along much of the length of the basin, typically has a relatively small specific conductance (table 4). Compared to other zones, concentrations of dissolved oxygen (DO), Na, and

SO_4 are relatively small, whereas concentrations of K and SiO_2 are relatively large. The dominant water types are Ca / CO_3 + HCO_3 and mixed-cation / CO_3 + HCO_3. The composition of ground water in the zone, including isotopic composition, generally appears consistent with a primary source from the Rio Grande. However, some ground-water samples have unusually large Cl concentrations and may be affected by evapotranspiration or mixing with high-Cl water. The median radiocarbon age of ground water in the Central zone is 4.3 ka BP. Most wells of the Central zone probably are completed in either the Quaternary alluvium or axial channel deposits of the Rio Grande or in sediments of the Arroyo Ojito Formation (Connell, 1997; Connell and others, 1998a and b; Connell and others, 1999). Ground water of the zone probably flows primarily south and discharges to the Rio Grande.

Ground water of the Discharge zone, located at the southern end of the MRGB, typically has a relatively large specific conductance (table 4). Compared to other zones, concentrations of Na, K, Cl, SiO_2, and several minor elements are relatively large and DO concentrations are relatively small. Water types are somewhat varied, but anions tend to be mixed or dominated by Cl. Ground water of the Discharge zone probably contains fractions of both ground water observed in adjacent water-quality zones and deep, high-Cl ground water that is moving upward as a result of the convergence of structural boundaries at the southern end of the MRGB. The median radiocarbon age of ground water in the zone is 17.9 ka BP. Most wells of the zone appear to be completed in fluvial deposits of the ancestral Rio Grande or ancestral Rio Puerco and Rio San Jose (Connell and others, 1999). Ground water of this zone probably discharges to the Rio Grande or to the Socorro Basin to the south.

GEOCHEMISTRY OF ARSENIC

Arsenic is a metalloid that exists in nature in a range of oxidation states from –3 to +5 and can form a substantial number of inorganic and organic compounds. Its crustal abundance has been estimated at about 2.0 to 3.0 parts per million (Cullen and Reimer, 1989; Robertson, 1989). When igneous rocks are formed, As generally is separated in the later stages of cooling magmas (Robertson, 1989) and typically is strongly enriched in volcanic gases compared to the magmas (Chapin and Dunbar, 1994). Arsenic tends to be relatively abundant and mobile in rocks formed by silicic volcanism and in associated volcaniclastic sediments and hydrothermal systems (Chapin and Dunbar, 1994). Welch and others (1988) state that As tends to be relatively high in volcanic glass, aluminosilicate minerals, and igneous rocks containing iron oxide because As readily substitutes for silicon, ferric iron, and aluminum in crystal lattices of silicate minerals.

Arsenic concentrations generally are larger in sedimentary rocks than in igneous and metamorphic rocks (Welch and others, 1988). In particular, As concentrations can be particularly large in shales and clays as a result of adsorption by clay minerals (typically in nonmarine environments) or incorporation in pyrite and organic matter (typically in marine environments); by contrast, As concentrations in sandstones and carbonate rocks generally are relatively low (Welch and others, 1988). According to Robertson (1989), the most common compounds of As are the sulfides in the reduced form and arsenates in the oxidized form. Arsenic-bearing minerals include realgar (AsS), orpiment (As_2S_3), arsenopyrite (FeAsS), claudetite (As_2O_3), arsenolite (As_4O_6), arsenic pentoxide (As_2O_5), and scorodite ($FeAsO_4$-$2H_2O$).

Arsenic in natural waters is most commonly present as either As (III) or As (V), and generally exists as an oxyanion. Arsenate ($H_nAsO_4^{3-n}$) is the most stable species in oxygenated waters, while arsenite ($H_nAsO_3^{3-n}$) dominates under reducing conditions, such as those typically found in deep ground-water flow systems. The particular species that dominate at equilibrium under particular conditions of pH and Eh are shown in figure 15. However, it has been demonstrated that the distribution of arsenate versus arsenite generally cannot be predicted through field Eh measurements or data for other redox couples (Welch and others, 1988).

Arsenite, which is a substantially more toxic form of As than arsenate, tends to be the more mobile form because it is not as easily adsorbed to the surfaces of minerals and compounds, such as oxides of iron and aluminum. Laboratory studies have shown that the sorption of As by amorphous iron oxides is dependent on both Eh and pH. The greater adsorption of arsenate relative to arsenite has been attributed to the differing charges of the species that dominate at particular pH values as a result of differing pK_a's (Cullen and Reimer, 1989; Smith and others, 1999). At pH values typical of most natural waters, arsenate is present as the negatively charged $H_2AsO_4^-$ or $HAsO_4^{2-}$ species, whereas arsenite is present as the neutral H_3AsO_3 species (fig. 15); therefore, electrostatic interaction with sediment surfaces is generally greater for arsenate species. Arsenite sorption tends to increase with pH, at least partly due to dissociation of H_3AsO_3 to $H_2AsO_3^-$. In contrast, arsenate is less strongly adsorbed at pH values larger than about 7.0 to 8.0 than at smaller pH values, probably due to competition from hydroxide ions for

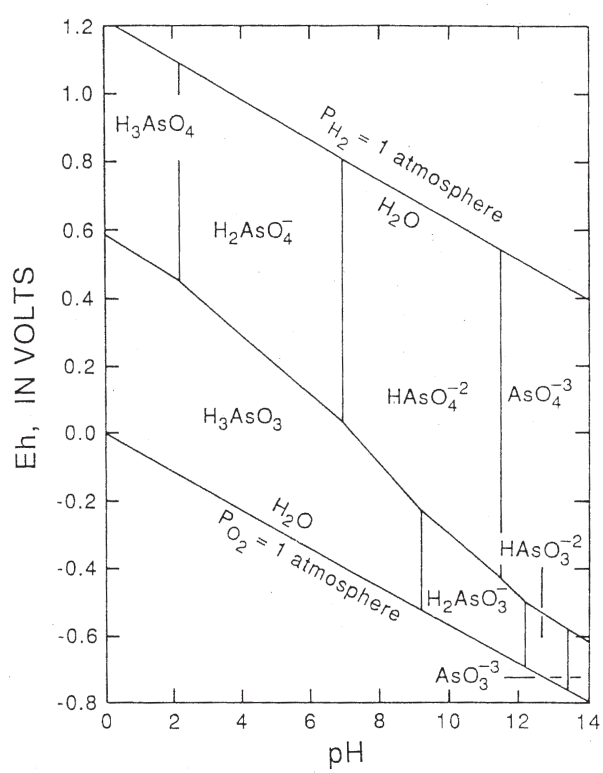


Figure 15.--Stability fields for dissolved forms of arsenic at 25°C as a function of Eh and pH (from Robertson, 1989).

sorption sites (Boyle and others, 1998; Smith and others, 1998; Welch and others, 1988; Welch and others, 2000). The generally greater sorption of arsenate relative to arsenite means that arsenic mobility is likely to be increased when aquifer conditions change from oxidizing to reducing. Also, increases in pH values can have different implications for the mobility of arsenic depending on whether arsenate or arsenite species dominate.

Welch and others (2000) compiled data on the occurrence of As in natural waters. They indicate that the concentration of As in rain in unpolluted areas generally is considerably less than 1 μg/L, and that As concentrations in most streams and rivers in the United States also are 1 μg/L or less. Arsenic concentrations in thermal waters were generally found to be larger than concentrations in non-thermal waters. Arsenic concentrations in ground water of the United States were found to vary somewhat for different physiographic provinces. The 75th percentile of As concentration equaled or exceeded 5 μg/L for the Intermontane Plateaus and Pacific Mountain System provinces. Figure 16 shows that arsenic concentrations retained in the data set for this investigation of ground water in the MRGB generally are somewhat larger than concentrations throughout the Intermontane Plateaus province, in which the MRGB is located. Welch and others (2000) state that As in ground water can be both dissolved and particulate-bound, and that even ground-water samples passed through 0.45-micron filters can contain some particulate-bound component.

Previous studies have found that a variety of processes affect As concentrations in ground water. These processes include evaporative concentration, the presence of thermal water, mineral precipitation/dissolution, adsorption/desorption, chemical transformations, ion exchange, and biological activity (Welch and others, 1988; Welch and others, 2000).

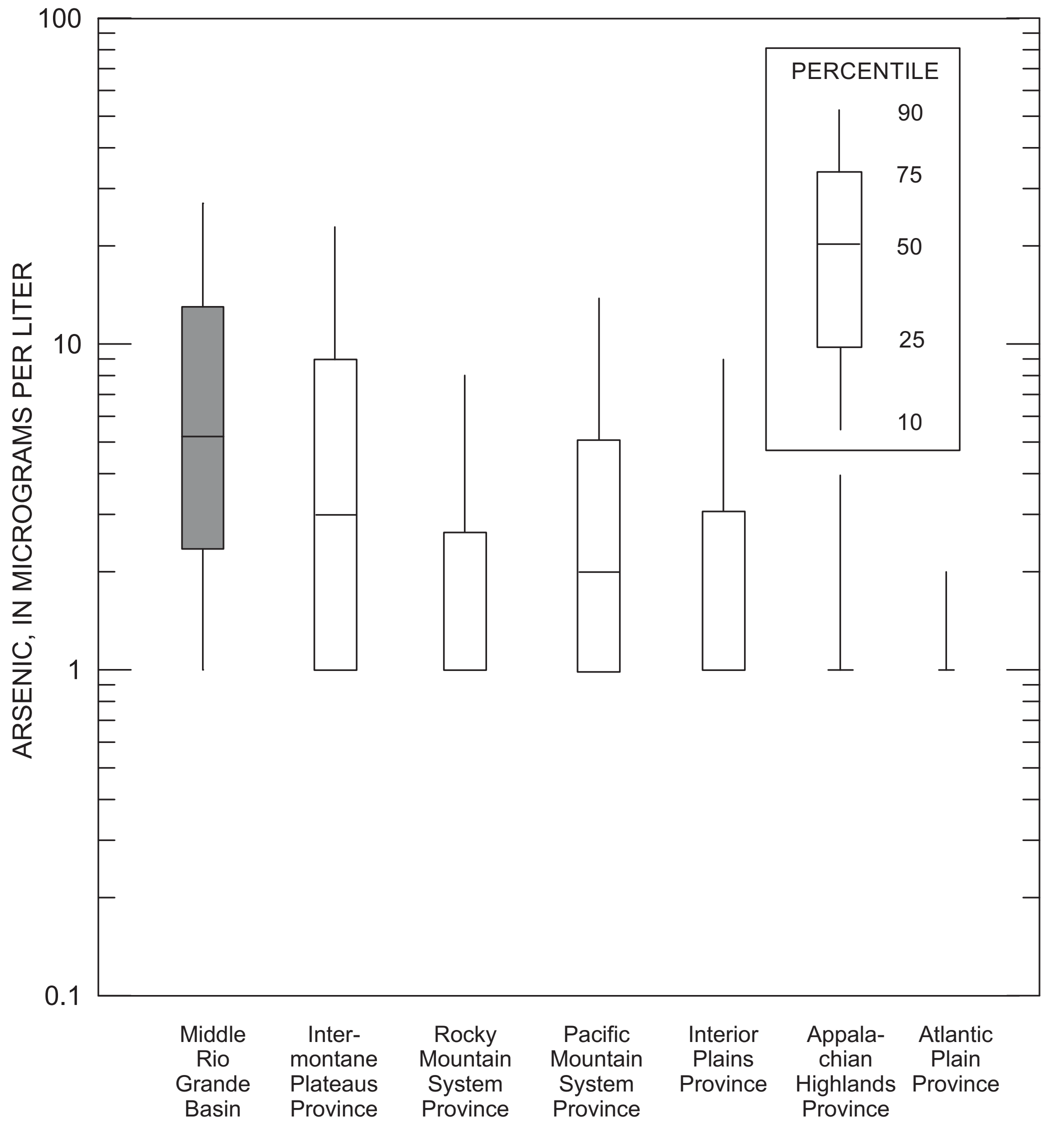


Figure 16.--Comparison of arsenic concentrations in ground water of the Middle Rio Grande Basin with those summarized by Welch and others (2000) for various physiographic provinces.

In some cases, elevated As concentrations have been associated with anthropogenic sources, such as agricultural and industrial uses.

Several previous studies have suggested that the dissolution of As-bearing sulfide or iron minerals can be the primary source of As in ground water. For example, sulfide minerals have been proposed as the likely source of As to ground water in parts of the northeastern United States (Welch and others, 2000). Oxidation of As-containing pyrite as a result of increasingly oxidizing conditions over time has been proposed as a source of As to ground water in Wisconsin (Burkel and Stoll, 1999). Reductive dissolution of Fe oxides has been proposed as an important source of As to ground water in Bangladesh and West Bengal (Chowdhury and others, 1999; Nickson and others, 2000), and has been shown to release As from contaminated soils (Masscheleyn and others, 1991). The occurrence of alkaline conditions and introduction of a competing anion have been proposed as mechanisms for the release of As sorbed onto metal oxides (Welch and others, 2000). Welch and others (1988) state that elevated As concentrations in ground water have not been shown to be associated with the substitution of As in aluminosilicate minerals.

ARSENIC CONCENTRATIONS IN WATERS OF THE MIDDLE RIO GRANDE BASIN

Surface Water

As discussed above, both the Rio Grande and several ephemeral streams have been shown to contribute recharge to the Santa Fe Group aquifer system. Data on the As concentrations in surface water of these streams can be used to characterize their potential to contribute As to the ground-water system. Chemical data, including arsenic concentrations, for surface water in several of these streams is available from the MRGB study and the USGS NWIS database. These data are summarized in table 3 and discussed below.

Although the major-element compositions of ground water in the MRGB indicate only very local recharge from the Jemez River, this river is of particular interest with respect to As concentrations because it is fed partially by ground-water discharge in its upper reaches, including discharge from geothermal springs known to have As concentrations exceeding 1 mg/L (Trainer, 1974; Shevenell and others, 1987). The Jemez River also flows into the Rio Grande, which is known to recharge the aquifer over large areas. For the 18 surface-water samples in the USGS NWIS database that have both dissolved-As data and discharge measurements at the Jemez River near Jemez (fig. 10a and table 3), As concentrations range from 7 to 54 μg/L; the discharge-weighted average As concentration is 18 μg/L. For the 23 such samples at the Jemez River below Jemez

Canyon Dam (fig. 10a and table 3), As concentrations range from 8 to 59 μg/L; the discharge-weighted average As concentration is 12 μg/L. Twelve samples also were collected at each of these Jemez River sites as part of the MRGB study. For the site near Jemez, the range in As concentrations in the MRGB samples is 6.7 to 77 μg/L; the median As concentration is 42 μg/L. For the site below Jemez Canyon Dam, the range in As concentrations is 21 to 28 μg/L; the median As concentration is 24 μg/L. As a whole, these data indicate that As concentrations in the Jemez River near and within the MRGB commonly exceed 10 μg/L.

Arsenic concentrations in the Rio Grande, which is believed to be the primary recharge source for the Central water-quality zone, typically are smaller at sites located above the inflow of the Jemez River than at sites located farther south. USGS NWIS data for 44 surface-water samples collected from the Rio Grande at San Felipe (above the Jemez River inflow) (fig. 11a and table 3) range from less than 1.0 to 4.0 μg/L; the discharge-weighted average concentration is 1.7 μg/L. Data for 13 samples collected from the Rio Grande at Albuquerque (fig. 11b and table 3) range from 2.0 to 4.0 μg/L; the discharge-weighted average concentration is 2.9 μg/L. Twenty-two surface-water samples collected at a site on the Rio Grande in northern Albuquerque for the MRGB study (fig. 10b and table 3) had As concentrations ranging from 1.9 to 5.3 μg/L; the median was 3.2 μg/L. Arsenic concentrations in the MRGB study samples generally increase during the winter and spring, when the Jemez River contributes a larger percentage of the flow of the Rio Grande (fig. 17). As a whole, these data indicate that As concentrations in the Rio Grande at and above Albuquerque do not commonly exceed 4 μg/L.

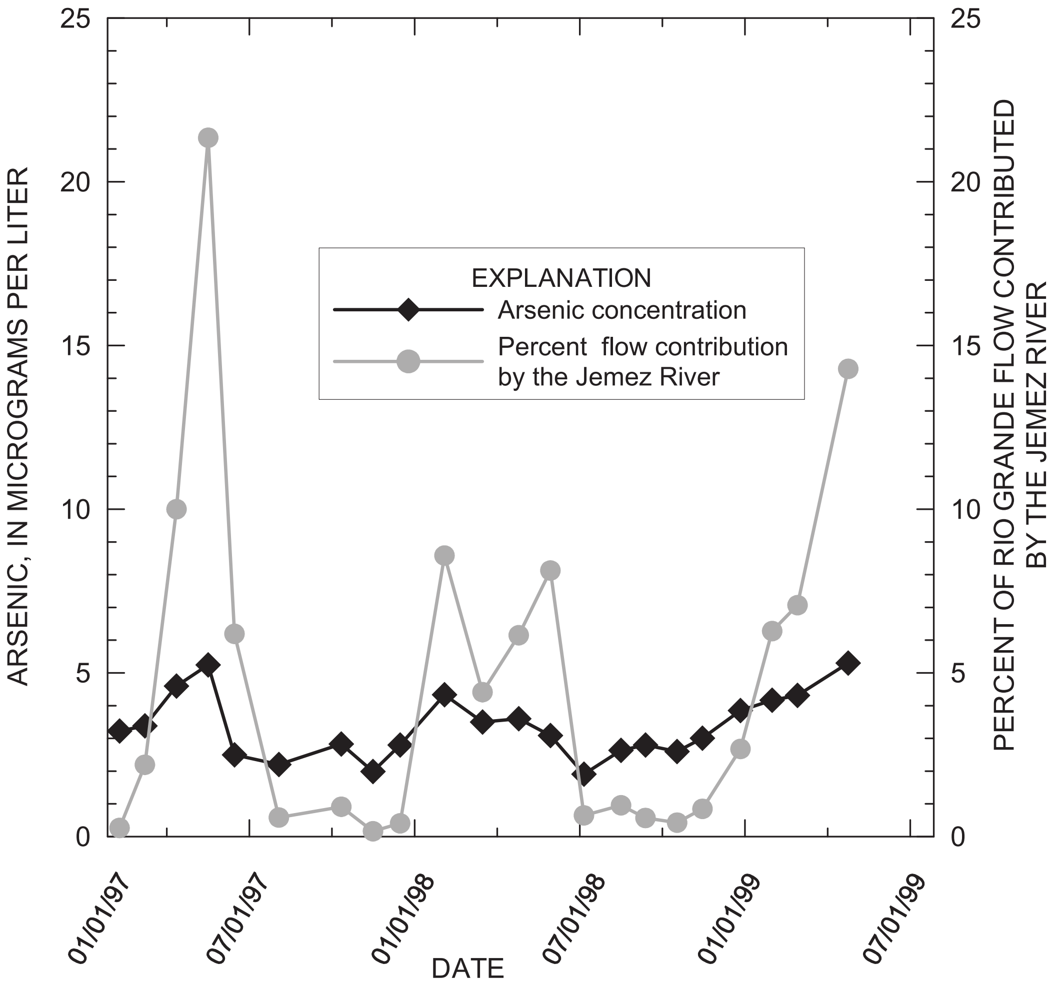


Figure 17.--Arsenic concentrations in the Rio Grande in northern Albuquerque and approximate percentage of Rio Grande flow contributed by the Jemez River.

Although the data sets are relatively small, some As data are also available for other streams that are known to contribute recharge to the aquifer of the MRGB. Twelve historical surface-water samples from the USGS NWIS database for the Rio Puerco at Bernardo (fig. 11a and table 3) indicate that As concentrations typically are quite low; all samples have concentrations of 2 μg/L or less. However, 9 samples collected farther north for the MRGB study (fig. 10a and table 3) show that As concentrations in the Rio Puerco can range from 1.1 to 12 μg/L and generally increase with increasing specific conductance; the median As concentration was 5.5 μg/L. Surface-water samples collected from Abo Arroyo for the MRGB study (fig. 10a and table 3) have As concentrations of only 1.5 and 2.1 μg/L; no chemical data were available for the arroyo from the USGS NWIS database. Twelve surface-water samples for Tijeras Arroyo from the USGS NWIS database (fig. 11b and table 3) all have As concentrations of 1.0 μg/L or less. Twenty-two samples collected from the same area for the MRGB study (fig. 10b and table 3) range in As concentration from 0.5 to 1.8 μg/L; the median concentration is 0.9 μg/L.

Similar to data collected from Abo and Tijeras Arroyos, data for Bear Canyon Arroyo, a small stream located along the Sandia Mountains near Albuquerque (fig. 10b and table 3), also indicate that As concentrations in ephemeral streamflow near the eastern mountain front typically are quite low. Twenty samples collected for the MRGB study at this site have As concentrations ranging from 0.1 to 0.5 μg/L; the median concentration is 0.2 μg/L.

Ground Water

Areal variations

Concentrations of As in ground water sampled in the MRGB range from less than 1 μg/L to more than 600 μg/L (Appendix I). The median As concentration for all ground-water samples compiled for this investigation within the MRGB is 5.3 μg/L. This median value probably is not representative of ground water throughout all locations and depths of the MRGB as a whole because the density of sample sites was larger in the Albuquerque area than across the rest of the basin, and most samples were obtained from wells completed in the upper few hundred feet of the aquifer. However, because most of the wells sampled were completed in parts of the aquifer used for drinking-water supplies, the median value of 5.3 μg/L probably is representative of the median As concentration in that part of the ground-water resource that is currently used. The 70th percentile of As concentrations for the basin is 10 μg/L; apparently, then, nearly one third of the wells supplying ground water for various uses in the basin do not meet the new U.S. EPA drinking-water standard of 10 μg/L (Federal Register, January 22, 2001).

Arsenic concentrations in the MRGB tend to be larger in the northwestern and central parts of the basin than along most basin margins (fig. 18). Concentrations near the eastern and western boundaries of the basin typically are less than about 3 μg/L, as are concentrations near the eastern half of the Jemez mountain front. Arsenic concentrations in the central part of the basin typically range between about 3 and 15 μg/L, although concentrations in several areas commonly exceed 20 μg/L. The most extensive areas of

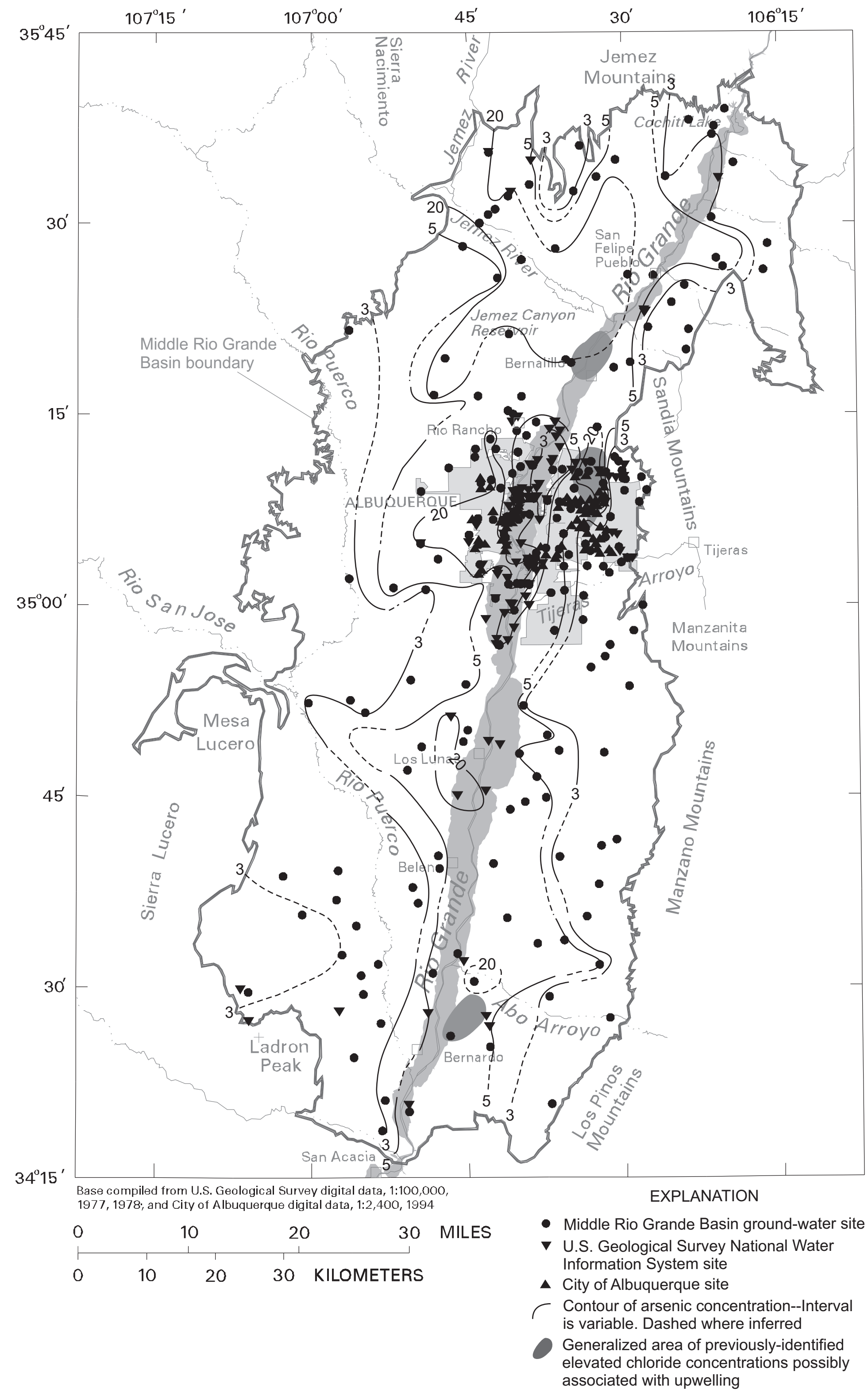


Figure 18.--Distribution of arsenic in ground water of the Middle Rio Grande Basin.

As concentrations larger than 20 μg/L occur in the northwestern and north-central parts of the basin; other, more localized areas of elevated As occur in the northeast part of Albuquerque and small parts of the southern half of the basin. No obvious or consistent trends in the areal patterns in As concentration (either increasing or decreasing) are seen with ground-water flow direction in the basin.

Arsenic concentrations appear to show a significant amount of variation with respect to water-quality zones (fig. 19). Arsenic concentrations are consistently small (90^{th} percentile of less than 10 μg/L) in the Western Boundary, Rio Puerco, Southwestern Mountain Front, Tijeras Fault Zone, and Tijeras Arroyo zones, which all have median As concentrations of 2.2 μg/L or less. The Northern Mountain Front, Abo Arroyo, Eastern Mountain Front, Northeastern, and Central zones include both high- and low-As areas. In these five zones, As concentrations typically range from about 1 μg/L to more than 20 μg/L, and the median As concentrations vary between 2.0 μg/L for the Eastern Mountain Front zone and 5.4 μg/L for the Central zone. Arsenic concentrations are consistently large (10^{th} percentile of greater than 3 μg/L) in the Northwestern, West-Central, and Discharge zones, which all have median As concentrations of 9.8 μg/L or more; the West-Central zone has the largest median As concentration (23 μg/L) of any zone. The occurrence of elevated As concentrations throughout the Northwestern and West-Central zones implies that As is already present in water recharging along the basin margins to these zones. Combined with knowledge of the hydrologic system of the MRGB and the general chemical character of ground water across the basin, these distinct patterns in As concentration by water-quality zone allow for several conclusions to be drawn about the sources and processes most likely to be affecting As concentrations.

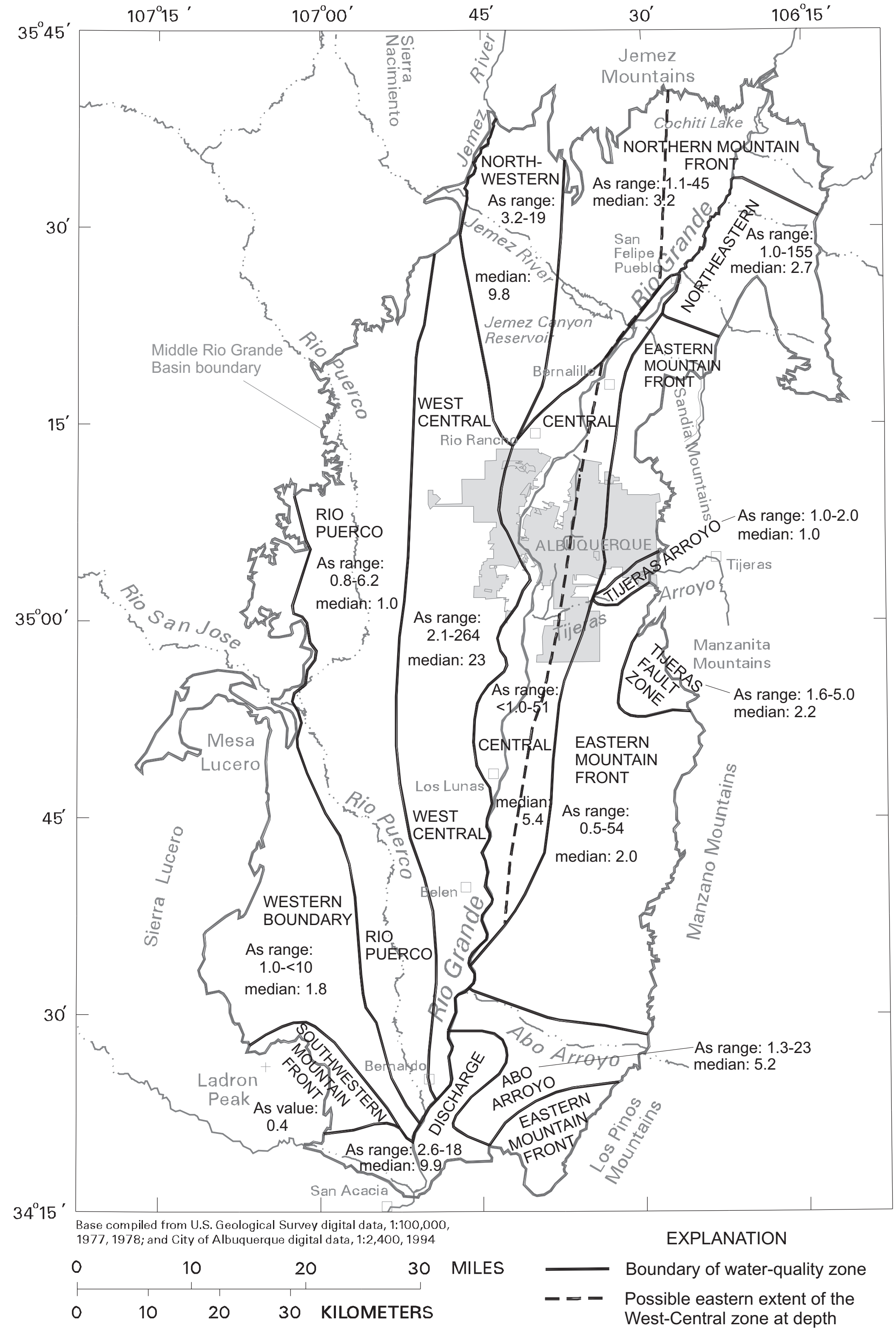
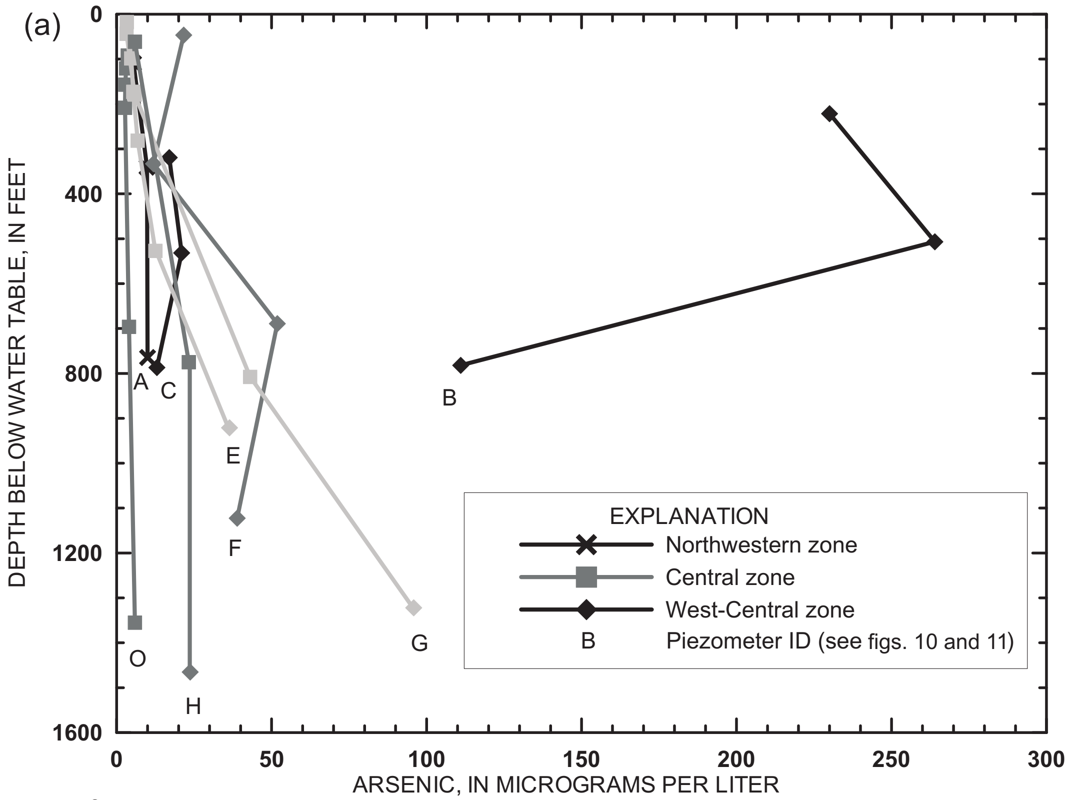


Figure 19.--Arsenic values, in micrograms per liter, for the various water-quality zones.

Variations with depth

In the MRGB, ground-water samples from deep piezometer nests (figs. 10 and 11), which have been installed primarily in the vicinity of Albuquerque, have provided important information about differences in water quality with depth in the aquifer. The amount of variability observed in As concentrations with depth ranges widely, from about 3 μg/L across 1,200 ft of aquifer to more than 100 μg/L across 550 ft of aquifer (figs. 20a and b).

Graphs of variability in As concentrations with depth below the water table (figs. 20a and b) were divided into two groups based on piezometer location; this division was made to enhance readability rather than to imply differences in the behavior of As concentrations with depth between the two areas. The graphs indicate that As concentrations consistently increase by a total of at least 5 micrograms per liter with depth below the water table in eleven piezometer nests (A, E, G, H, I, K, N, P, Q, R, and S). Of these eleven piezometer nests, one is completed entirely in water of the Northwestern zone, five are completed entirely in water of the Central zone, three show a transition from Central to West-Central zone water with increasing depth, and two show a transition between Central to Eastern Mountain Front zone water with depth. Arsenic concentrations show little change with depth in six piezometer nests (D, J, L, M, O, and T), completed mostly in water of the Central or Eastern Mountain Front zone. In the three piezometer nests (B, C, and F) completed entirely in water of the West-Central zone, the As concentration of the deepest piezometer is substantially smaller than the As concentration in at least one shallower piezometer. Only six piezometer nests produced ground water with an As concentration of 10 μg/L or less from all completions. These



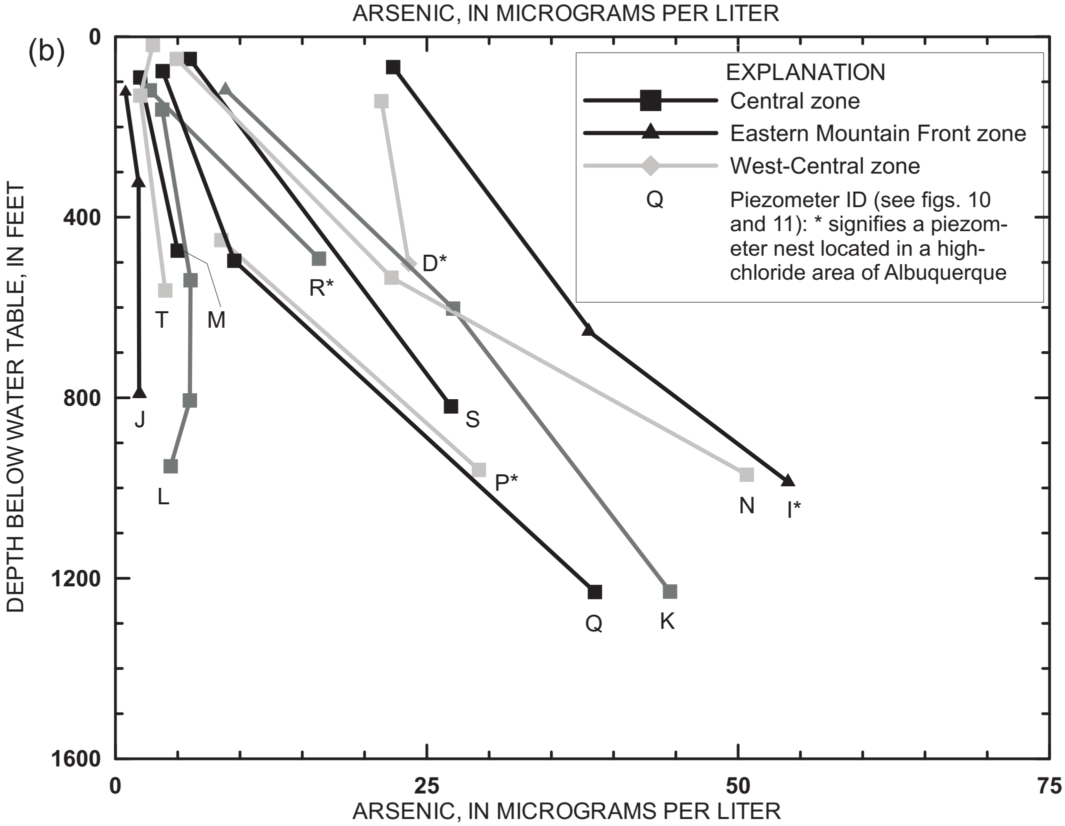


Figure 20.--Variation in arsenic concentrations in piezometer nests located (a) west of the Rio Grande and (b) east of the Rio Grande.

graphs indicate that in areas represented by these piezometer nests, ground water meeting the new U.S. EPA drinking-water standard of 10 μg/L for As cannot be obtained by increasing the depth of wells. However, these graphs also indicate that there are areas of the basin where As concentrations do not show consistent and substantial increases with depth, at least in the upper several hundred feet of the aquifer.

POSSIBLE FACTORS AFFECTING ARSENIC CONCENTRATIONS IN GROUND WATER

Because elevated As concentrations occur across broad areas of the MRGB, any conceptual model to explain the occurrence and behavior of As in the basin must consider sources and processes that can have effects across large areas. Therefore, although the possibility exists that land-use practices (such as industry, mining, and agriculture) have affected the As concentrations of ground water in very localized areas, land use is not an especially important consideration in this basin, which consists primarily of rangeland. Similarly, the absence of substantial quantities of organic matter in the aquifer in nearly all areas except the Rio Grande inner valley implies that biologically mediated reactions are unlikely to be a primary control on As concentrations in the basin. As discussed in the previous section on As geochemistry, other, larger-scale processes that have been investigated elsewhere as major controls on As concentrations in ground water include evaporation, mineral dissolution and precipitation, adsorption and desorption processes, and the presence of water associated with thermal sources. The evidence for and against the importance of such processes in affecting As concentrations in ground water of the MRGB is discussed below, and characteristics that are useful in determining the most important processes in selected water-quality zones are summarized in table 5.

Mineral dissolution

As discussed earlier, several previous studies of elevated As concentrations in ground water have suggested that the dissolution of As-bearing sulfide or iron minerals can be the primary source of As. In the MRGB, the dissolution of such minerals appears unlikely to be a major source of dissolved As to ground water.

The presence of dissolved oxygen and nitrate indicates oxidizing conditions throughout the aquifer at the depths sampled, except at relatively shallow depths in the Rio Grande inner valley (fig. 1). The predominance of oxidizing conditions across large areas of the aquifer is supported by data from the University of Houston As speciation study of City of Albuquerque drinking-water supply wells (Bill Lindberg, written commun., 2000), which showed that more than 90 percent of the As present in ground water from 76 of 87 wells was in the form of As (V). Therefore, although Fe oxides are known to be present in the Santa Fe Group aquifer (Stanton and others, 2001a and b), the reducing conditions that would favor dissolution generally are not present. Also, calculations of Pearson correlation coefficients (also known as r-values) for the Central zone—the primary zone having reducing conditions—indicated insignificant correlations for As with DO and NO_3, and insignificant or negative correlations for As with Fe and Mn (table 5); these results are not consistent with an increase in As resulting from the dissolution of Fe or Mn oxides.

Dissolution of sulfide minerals also is not a likely source of As because sulfide minerals are not common in sediments of the Santa Fe Group aquifer system (Hawley and Haase, 1992; Stanton and others, 2001a and b). Furthermore, sulfur isotope data (L.N. Plummer, unpublished data, 1999) indicate that most SO_4 present in ground water of the MRGB is derived from dissolution of evaporite deposits present along some basin margins rather than from oxidation of sulfide minerals. Also, Stanton and others (2001a and b) found that 10 percent or less of As present in a core obtained from the western part of Albuquerque was associated with the sulfide/organic fraction of the core. Pearson correlation coefficients calculated for water-quality zones with substantial concentrations of As do not show the strong positive correlations between As and SO_4 and negative correlations between As and pH that would be expected if As concentrations were increasing as a result of sulfide dissolution (table 5).

Adsorption processes

As discussed earlier, arsenate ions ($HAsO_4^{2-}$ in the pH range of about 6.8 to 11.6 and $H_2AsO_4^-$ in the pH range of about 2.2 to 6.8), which likely are the predominant form of As in ground water of the MRGB, sorb onto amorphous Fe oxides more strongly at lower pH values than at higher ones. A study by Robertson (1989) indicated that adsorption of arsenate ions on smectite or ferric oxyhydroxide was the major control on As in ground water of several alluvial basins in Arizona. Therefore, the variation in pH values across the MRGB, which range from 6.4 to 9.8, could contribute to variation in the concentration of As in ground water of the basin. A study by Stanton and others (2001a and b) to examine residence and mobility of Fe and As in sediment and rock samples from a core obtained from the western part of Albuquerque showed that the most likely source of soluble As is the “anion-exchangeable” fraction of As associated with clay and secondary Fe oxide surfaces, which could be mobilized by ground water having high pH and/or low Eh values.

The only water-quality zone with a statistically significant correlation between As and pH at the 0.05 level and a Pearson correlation coefficient greater than 0.3 is the West-Central zone (table 5), where the core studied by Stanton and others (2001a and b) was obtained. The correlation coefficient for the West-Central zone is 0.46, and a graph of As versus pH (fig. 21) for the zone shows that nearly all samples with As concentrations less than 20 µg/L have pH values of less than 8.5, while most samples with As concentrations exceeding 20 µg/L have pH values of 8.5 or greater. This behavior is consistent with desorption of arsenate. The observation that the largest As concentrations in the West-Central zone generally appear to be associated with pH values greater than about 8.5 may explain the lack of a strong overall relation between As and pH in other water-quality zones, where pH values generally do not exceed 8.5. It is nevertheless possible that desorption increases As concentrations in localized areas of elevated pH in other zones where "anion-exchangeable" As is available on sediments.

Despite the lack of a correlation between As and pH values in the Northwestern zone, As concentrations in ground water of this zone also may be affected by desorption. Compared to all other water-quality zones of the basin, the Northwestern and West-Central zones tend to have the smallest ratios of chloride concentration to concentrations of As, B, F, Mo, and V (table 6, fig. 22, and Appendix II). All of these trace elements exist as negative ions that could be sorbed in a similar manner on clay and/or Fe oxide surfaces. Robertson (1989) based his conclusion of a sorption control for As concentrations partly on correlations of As with pH, F, Mo, and V. Although the relations among these elements are not as clear in the MRGB (table 5), their elevated

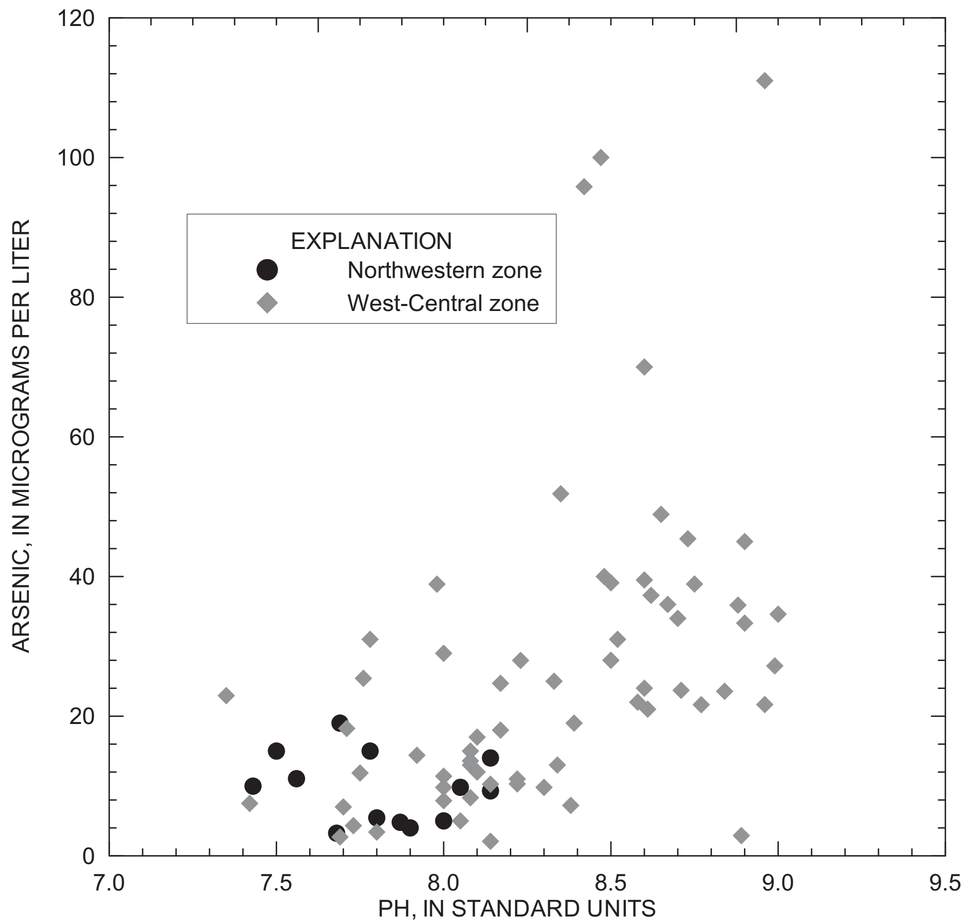


Figure 21.--Relation of arsenic to pH in ground water of the Northwestern and West-Central zones.

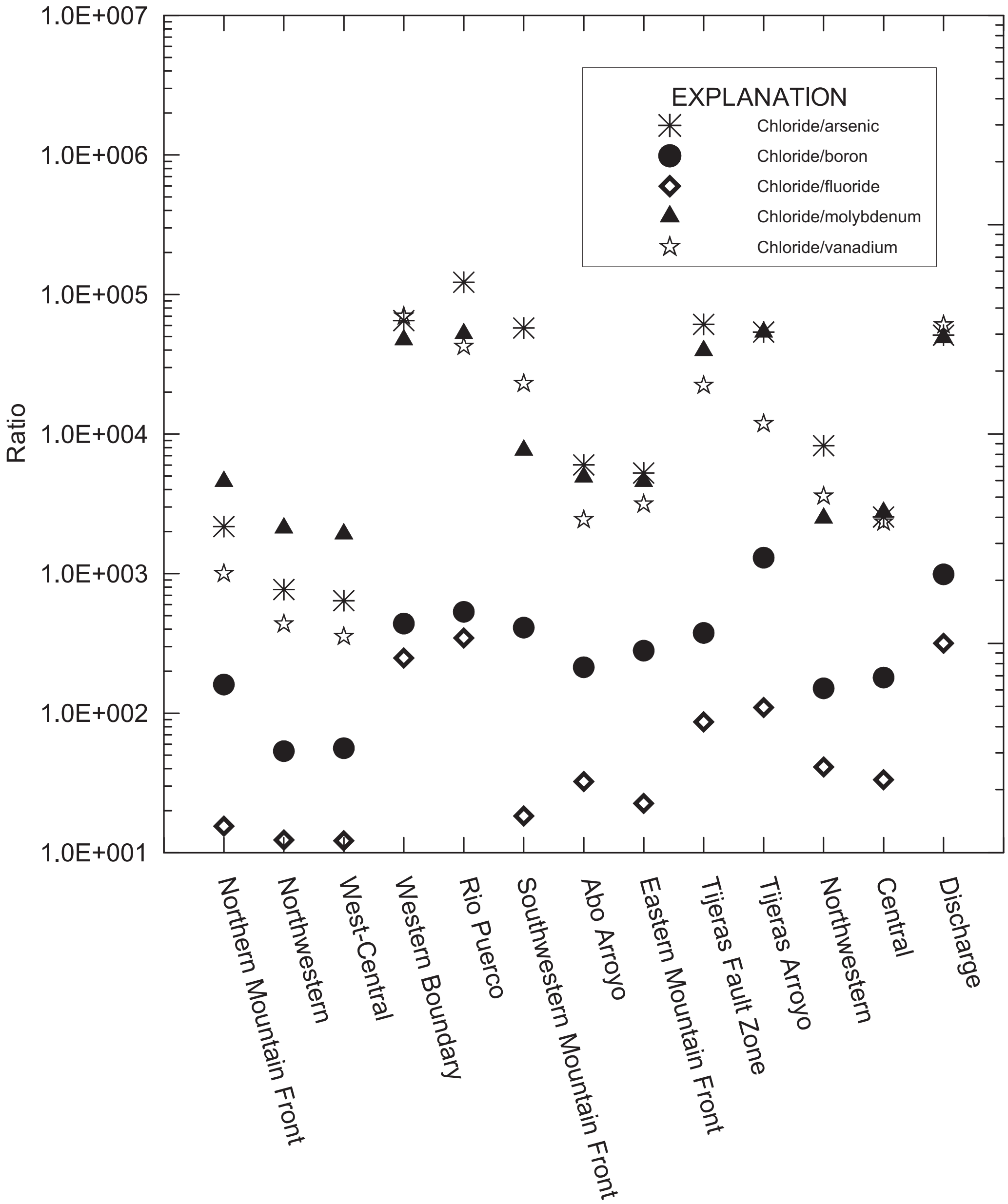


Figure 22.--Comparison of ratios of chloride to various minor elements in all water-quality zones.

concentrations relative to Cl in the Northwestern and West-Central zones as compared to other zones could suggest a common control by adsorption/desorption processes.

While adsorption/desorption of As associated with metal oxides appears likely to regulate dissolved-As concentrations in the West-Central zone (and may also affect concentrations in the Northwestern zone), this process does not provide a full explanation for the source of As to the ground water and sediments of the area. As is discussed below, water samples from the West-Central zone generally have As concentrations of greater than 10 μg/L even when they have similar pH values (generally 7.5 to 8.5), exist under similar redox conditions, and are obtained from sediments of similar origin and composition as low-As water samples from other hydrochemical zones.

Source area of water

Median values and ranges of As concentration vary substantially among water-quality zones (figs. 18 and 19), which implies that sources of water to the basin could be a primary factor affecting As concentrations. An association of As with source water would be consistent with observations of previous investigators indicating that thermal water and water from areas of intense evaporation commonly have high As concentrations (Welch and others, 2000). Therefore, the investigation of associations between As concentrations and the sources of water to the various water-quality zones of the MRGB is discussed below.

Water-quality zones with consistently small arsenic concentrations

Ground water of the Western Boundary, Rio Puerco, Southwestern Mountain Front, Tijeras Fault Zone, and Tijeras Arroyo zones of the MRGB has consistently small

As concentrations. Therefore, in these zones, the water source is low in As concentration and any geochemical reactions occurring within the basin are not releasing substantial quantities of As to ground water. The generally small As concentrations in surface water of the Rio Puerco and Tijeras Arroyo are consistent with the generally small As concentrations in zones that receive recharge from these sources.

Water-quality zones with variable arsenic concentrations

In five water-quality zones (Northern Mountain Front, Central, Eastern Mountain Front, Northeastern, and Abo Arroyo), elevated As concentrations are present in ground water in some areas but not others. In the Northern Mountain Front, Eastern Mountain Front, and Northeastern zones, As concentrations near basin margins are quite small (generally less than 2 μg/L), indicating that recharge water along these margins probably does not contain large As concentrations. Similarly, surface water in the Rio Grande, which is the primary source of recharge to the Central zone, and Abo Arroyo, which is a primary source of water to the Abo Arroyo zone, typically has As concentrations less than 4 μg/L. Therefore, elevated As concentrations in ground water of these five zones probably result from geochemical reactions and/or mixing with other waters downgradient from the primary recharge areas. However, in these zones, As concentrations do not appear to consistently increase or decrease along flow paths and, as previously discussed, there is little evidence of the control of As concentrations by mineral dissolution or desorption processes. Therefore, other potential As sources require investigation.

Previous investigators (Anderholm, 1988; Trainer and others, 2000; Bexfield and Anderholm, in press) have proposed that deep water with large Cl concentrations upwells in particular areas of the MRGB to mix with shallower ground water (fig. 18). In some parts of the Northern Mountain Front, Eastern Mountain Front, and Central zones in particular, large As concentrations in ground water have been shown to coincide closely with these areas of elevated Cl concentration (fig. 23) (Trainer and others, 2000; Bexfield and Anderholm, in press). Upwelling may occur as leakage along faults or as the result of the movement of ground water over structural highs between subbasins, as indicated by the clustering of high Cl and As concentrations along these features (fig. 23). Mixing with deep water with high Cl and As concentrations could explain the occurrence of elevated As concentrations in zones where the primary source water (surface water and/or mountain-front recharge) appears to have low As concentrations and little evidence exists for the influence of a particular geochemical reaction along a flow path. The observed decrease of both As and Cl with distance downgradient of these affected areas would be consistent with declining As concentrations as a result of dilution rather than adsorption.

Pearson correlation coefficients and chemical data from piezometer nests appear to lend support to the hypothesis that elevated As concentrations in the Northern Mountain Front, Eastern Mountain Front, and Central zones typically are associated with the upwelling of deep, mineralized water. Concentrations of As in the Northern Mountain Front zone are strongly associated with concentrations of SO_4, Na, B, Cl, Sr, and Li, and with specific conductance (values of all Pearson coefficients are positive and 0.67 or greater) (table 5). Significant correlations also exist with temperature (positive coefficient) and carbon-14 (negative coefficient). The inverse relation of As with carbon-14 in percent modern carbon indicates that As is positively correlated with ground-water age. These relations appear consistent with mixing with older, deeper, more mineralized

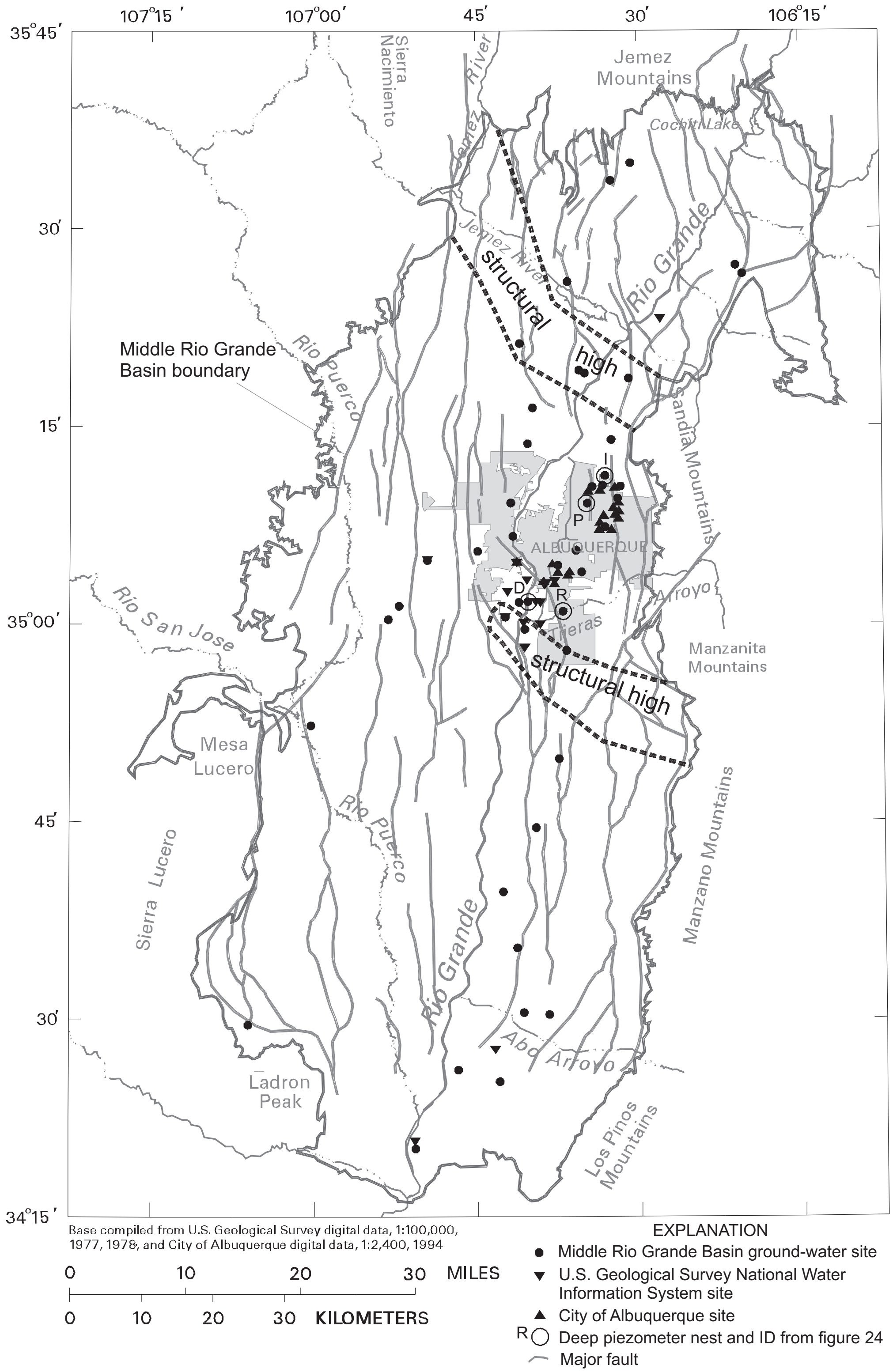


Figure 23.--Locations of ground-water samples having water-quality characteristics indicative of mixing with deep water (generally, chloride greater than 20 milligrams per liter and arsenic greater than 5 micrograms per liter) in relation to major structural features.

water. Anderholm (1988) and Trainer and others (2000) describe high-Cl water in the Bernalillo area (near the southern end of this zone) as conduit flow that may originate as geothermal fluid in the Valles Caldera of the Jemez Mountains. Arsenic, Cl, Na, B, and Li are all found at large concentrations (greater than 1500 milligrams per kilogram for Cl and Na and 2.7 milligrams per kilogram for As, B, and Li) in geothermal water of the caldera (Goff and others, 1988).

In the Eastern Mountain Front zone, high As concentrations in and near Albuquerque generally appear to occur in a narrow band coincident with an area of high Cl concentrations (fig. 23) (Logan, 1990; Bexfield and Anderholm, in press). Generally upward hydraulic-head gradients and increasing Cl and As concentrations with depth in deep piezometer nests in the area appear to support the hypothesis that mineralized water is moving upward from depth (figs. 20 and 24); Na and B also tend to increase with depth. In addition, from about 10 to 50 percent of the As in oxic ground water from several wells in this area is As (III) (Bill Lindberg, City of Albuquerque, written commun., 2000), suggesting a deep source. Water from a deeper, more reducing zone where As (III) predominates apparently mixes with more shallow, oxic water. Pearson correlation coefficients of 0.55 or larger occur between As and several constituents in the Eastern Mountain Front zone: carbon-14 and DO (negative coefficients), and Li, B, Na, Cl, Mo, K, V, and temperature (all positive coefficients) (table 5). These relations appear consistent with an As source associated with older, deeper, more mineralized water that also would likely have elevated concentrations of other trace elements. At the far southern end of the Eastern Mountain Front zone, one ground-water sample with a temperature of 53.8 °C and a sample slightly downgradient with a specific conductance

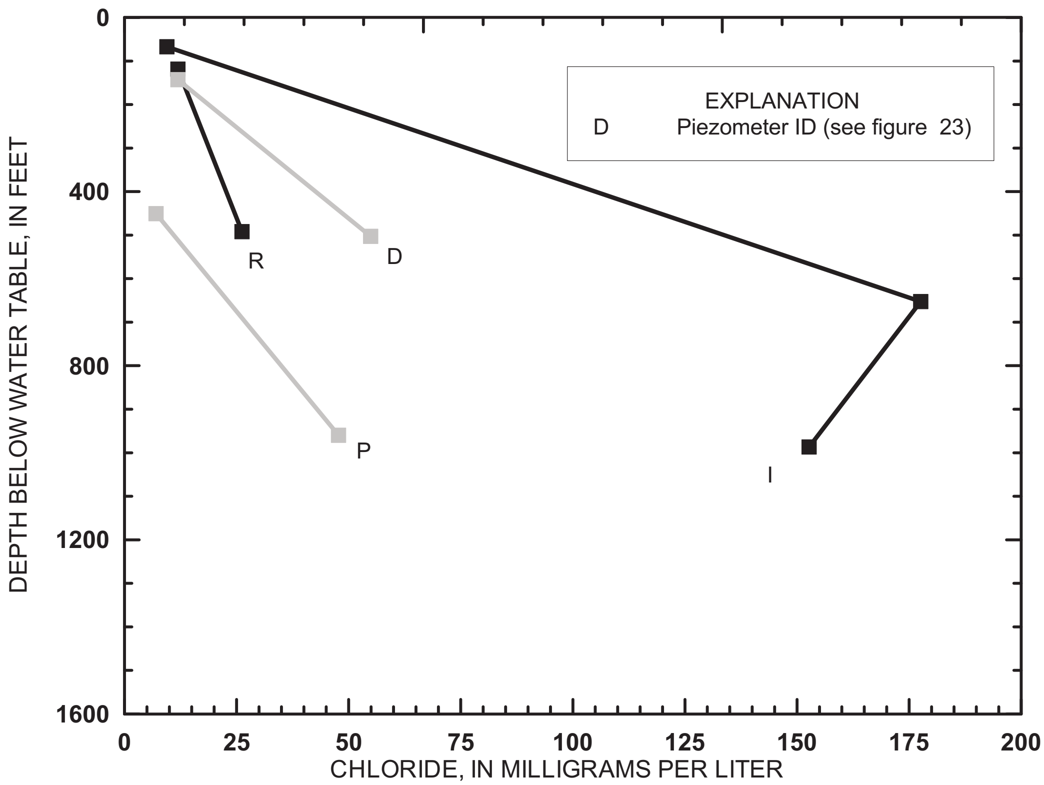


Figure 24.--Variation in chloride concentrations in piezometer nests located in high-chloride areas of Albuquerque.

of 8,200 µS/cm (with As concentrations of 52 and 33 µg/L, respectively, and classified as mineralized waters in Appendix I) indicate that deep, thermal water is upwelling in this area.

In the eastern part of the Central zone (approximately east of the dashed line of fig. 13), nearly all ground-water samples with As concentrations greater than 10 µg/L are coincident with areas of unusually large Cl concentrations (fig. 23). Therefore, it appears likely that elevated As concentrations in this area could also be associated with a high-Cl source. Arsenic concentrations within this area do not correlate strongly with Cl concentrations or specific conductance values, but one of the best correlation coefficients (-.72) is for As with carbon-14 content, indicating that elevated As concentrations are associated with older water (table 5). Other constituents that show correlation coefficients of 0.59 or better with As concentration in the area are Ca (negative coefficient) and F, B, Na, Li, and Mo (all positive coefficients), all of which would be consistent with a source of deep, old water with elevated concentrations of Na and minor constituents.

Elevated As concentrations in some other parts of the Central zone may also be associated with high-Cl upwelling (figs. 23 and 24), but investigation of this possibility is complicated by the likely existence of As-rich ground water (median concentration, 23 µg/L) of the West-Central zone at depth below the western part of the Central zone. Analysis of samples from piezometer nests in the western part of the Central zone show a shift toward a more typical West-Central zone composition (larger pH, smaller concentrations of Ca, Mg, and Sr, and larger concentrations of Na, V, F, and As) with depth. Therefore, in western parts of the Central zone where small Cl concentrations indicate little or no effect from deep, mineralized water, elevated As concentrations probably are the result of mixing between the Central-zone water originating at the Rio Grande and the deeper West-Central zone water, which apparently includes As desorbed from aquifer sediments. Arsenic in this area shows strong negative correlations with carbon-14 content and concentrations of Ca, Mg, and Sr and positive correlations with concentrations of V and F (table 5), which appears consistent with this conclusion.

In the Northeastern zone, the well that produces water with the largest As concentration (155 μg/L) is near an intersection of major faults and has a large Cl concentration (66.1 mg/L), indicating that upward movement of mineralized water along faults of the area could be the primary As source. A downgradient well having an As concentration of 7.5 μg/L and a Cl concentration of 22 mg/L may also include some component of deep, mineralized water.

In the Abo Arroyo zone, the two ground-water samples with As concentrations greater than 3 μg/L have relatively large pH values and SiO_2 and K concentrations relative to the other two samples, but their Cl concentrations are the smallest. It appears possible, though not certain, that silicate weathering may have increased pH enough to allow some As to desorb from aquifer materials.

Unfortunately, the exact origin of deep ground water with elevated Cl and As that is believed to affect waters in aforementioned zones is not clear. Fairly substantial differences in the chemistry of various "exotic" water samples believed to represent these deep, mineralized waters (fig. 10 and Appendix I) indicate that the origins of these deep waters likely differ across the basin, and indeed may differ over relatively short distances. The availability of only a few samples believed to represent such waters, and the existence of differences in chemistry among them, complicate efforts to look for unique relations among constituents that can indicate where "typical" zone waters have mixed with these mineralized waters.

Water-quality zones with consistently large arsenic concentrations

In contrast to zones with extensive areas of small As concentrations, nearly all ground-water samples from the Northwestern and West-Central zones have As concentrations of 5 μg/L or more. As discussed earlier, adsorption/desorption processes are a likely control on As concentrations along ground-water flow paths of the West-Central zone and could particularly increase concentrations in areas where pH exceeds 8.5. However, the process does not appear to provide a full explanation for elevated As concentrations in ground water at pH values as low as 7.4 (fig. 21), or for the ultimate source of As found in the sediments of the Northwestern and West-Central zones. The occurrence of elevated As concentrations in ground water near basin margins (fig. 18), along with the lack of a consistent increase in As concentrations downgradient, implies that the source water to the Northwestern and West-Central zones has relatively large As concentrations. The presence of silicic volcanic rocks and high-As geothermal waters in the Jemez Mountains (believed to be the primary recharge area to these zones) is consistent with this observation, as are elevated As concentrations in meteoric water outside the basin margins, such as in sample NM524 (Appendix I and fig.10), which has an As concentration of 23.2 μg/L and a pH of 6.9. However, the occurrence of elevated As in ground water near basin margins in zones in the northwest contrasts with the apparent lack of As in ground water near basin margins in most of the Northern Mountain Front zone, in the eastern Jemez Mountains. The general near-surface geology of the eastern and western parts of the Jemez Mountains is quite similar, consisting mainly of

Tertiary and Quaternary volcanic rocks. Therefore, some other feature must differ between these areas in order for As concentrations to be larger in recharge water from one area compared to the other.

One feature that could potentially account for the difference in As concentrations observed near recharge areas for the northern water-quality zones is the distribution of geothermal water from the Valles Caldera. Previous investigations (Trainer, 1975; Trainer, 1984; Goff and others, 1988; Trainer and others, 2000) have shown that mineralized water from the caldera probably flows primarily south and west, where it contributes to thermal springs, and probably does not leak from the caldera to the east. Mixing of mountain-front recharge water with small quantities of this geothermal water, typically with As concentrations larger than 1,000 μg/L, could increase As concentrations in the non-thermal recharge water.

A plot of As relative to Cl was used to examine the possibility that the mixing of geothermal water with mountain-front recharge water is sufficient to explain the As concentrations observed in most ground-water samples of the Northwestern and West-Central zones (fig. 25). Ground-water samples from these zones generally do not fall along the line representing conservative mixing between dilute mountain-front recharge water of modern age and water derived from Soda Dam Spring, a thermal spring located southwest of the Valles Caldera. Water from Soda Dam Spring has been shown to have an As-Cl ratio very similar to that found in geothermal water inside the caldera (Goff and others, 1988). Also, the graph shows no clear relation between the concentrations of As and Cl, which is consistent with a lack of correlation between these constituents for the two zones (table 5). Consequently, this graph supports the conclusion that As

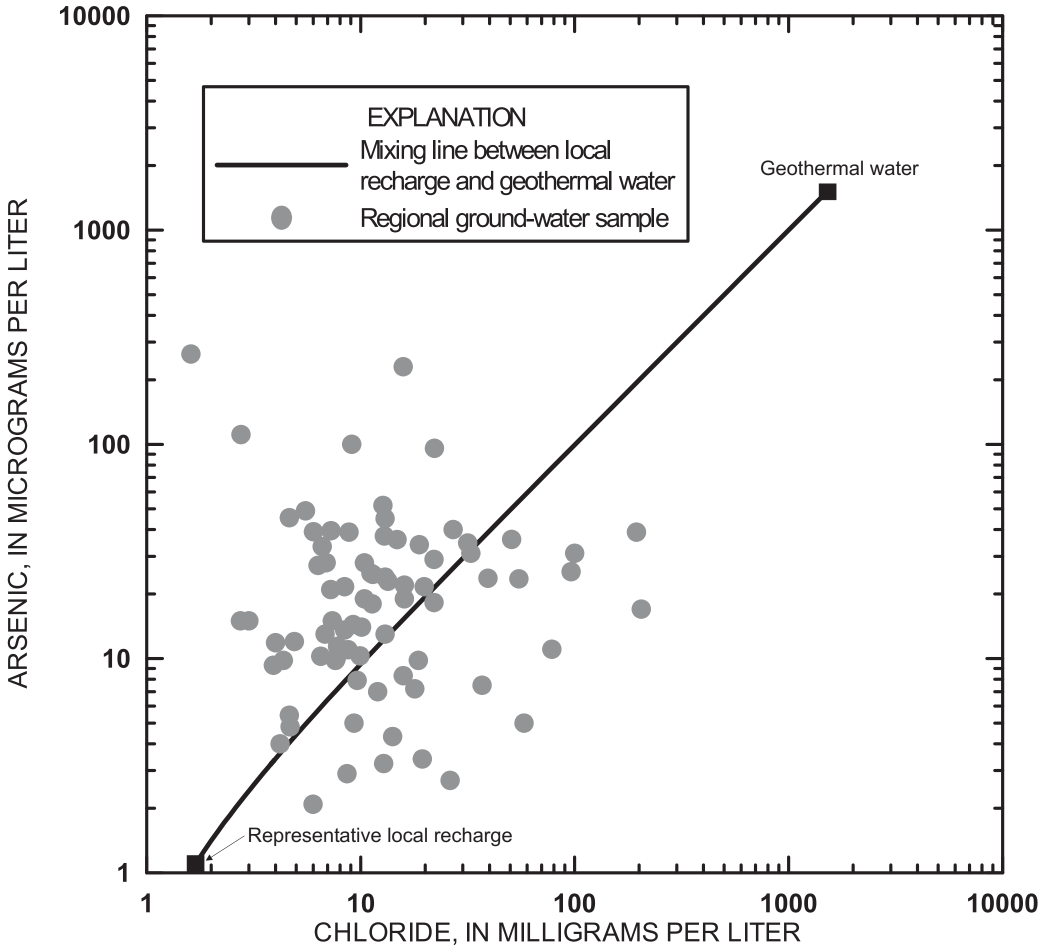


Figure 25.--Relation between arsenic and chloride in ground-water samples from the Northwestern and West-Central zones and in representative local recharge and geothermal water.

concentrations in the Northwest and West-Central zones are controlled primarily by a process (or processes) other than mixing with geothermal water from the caldera. Ratios of chloride concentration to the concentrations of multiple trace elements tend to be smaller in ground water of these zones than in geothermal fluids in and near the Valles Caldera (table 6 and Appendix II), indicating there likely is an additional and/or separate source of trace elements to ground water of these zones besides mixing with geothermal water.

Flow of mountain-front recharge water through rocks altered by contact with geothermal water is a possible source of As and other trace elements to ground water near the recharge areas of the Northwestern and West-Central zones that appears consistent with the observed chemistry. Local hydrothermal systems can often lead to intense alteration of rocks and sediments, particularly those of volcanic origin (Chapin and Dunbar, 1994). Contact with geothermal water typically enriches the rocks in certain trace elements, including As, Ba, Sb, Pb, and Zn. (Chapin and Dunbar, 1994; Dunbar and others, 1995; Ennis and others, 2000). Dunbar and others (1995) indicate that As associated with hydrothermally-altered rocks probably is largely sorbed to mineral phases, particularly mafic oxide surfaces, and could be mobilized by a secondary fluid phase moving through the altered rocks. These investigators do not specifically discuss possible effects of this alteration on concentrations of B, F, Mo, and V (the trace elements shown to be elevated relative to Cl in the Northwestern and West-Central zones as compared to other zones), but these elements are also known to exist as sorbing anions. Therefore, water moving through hydrothermally-altered rocks in the western Jemez Mountains might acquire As (and other trace elements) largely by desorption, and then transport the As into the Northwestern and West-Central zones of the MRGB, where adsorption/desorption processes involving Fe oxides in the basin-fill deposits control the concentration at any particular location along the flow path.

Hydrothermally-altered rocks have been observed at the land surface along the ring fracture, topographic rim, and flanks of the Valles Caldera, as well as at depths exceeding 5000 ft in core holes from the western part of the caldera (Charles and others, 1986; Hulen and Nielson, 1986; WoldeGabriel, 1990; Armstrong and others, 1995; Goff and Gallaher, 2001; Fraser Goff, Los Alamos National Laboratory, oral commun., 2001). These locations would be consistent with the likely recharge areas for the Northwestern and West-Central water-quality zones. Although hydrothermally-altered rocks appear to be most widespread in the western part of the caldera (i.e., in the source area to the Northwestern and West-Central water-quality zones), they also have been observed in the "Cochiti district," covering part of the source area to the Northern Mountain Front zone (WoldeGabriel, 1990). The existence of hydrothermally-altered rocks in this particular area might have contributed to the elevated As concentration of 28.9 μg/L in sample NM510 from the Northern Mountain Front zone, which does not have a particularly large Cl concentration indicative of mixing with mineralized water (Appendix I).

Similar to the Northwestern and West-Central zones, ground water of the Discharge zone also has As concentrations, in general, greater than or equal to 5 μg/L. The relatively large As concentrations of the zone are not surprising given that this area represents the drain for the ground-water system of the basin. Ground water in the zone typically is quite old with relatively large specific conductance values, indicating long flow paths and travel times. Interestingly, the smallest As concentrations occur in ground-water samples with the largest specific conductance values and Cl concentrations. These samples probably represent ground water with a substantial fraction of water sourced in the Western Boundary zone, which shows very low levels of As.

Geochemical origin of water

As discussed in the previous section, As concentrations in ground water of the MRGB appear to be closely associated with the source area of water. Further analysis was performed to investigate whether As in ground water from different source areas (i.e., water-quality zones), but similar geologic and hydrologic origins, occurred in similar concentrations. The computer program SNORM (Bodine and Jones, 1986) was used to calculate the salt norms of ground-water samples collected for the MRGB study and thereby classify the chemical origins of the waters. The MRGB study samples in particular were chosen for SNORM analysis because of the consistent availability of data for a selected subset of individual constituents used by the SNORM program.

Bodine and Jones (1986) describe the salt norm as "the quantitative ideal equilibrium assemblage that would crystallize if the water evaporated to dryness at 25° C and 1 bar pressure under atmospheric partial pressure of CO_2." The SNORM program uses 18 solute concentrations to directly compute the normative salt assemblage from a possible 63 salts (table 7). The reader is referred to Bodine and Jones (1986) for a detailed discussion of the operation of the SNORM program and the procedures used by the program to calculate the appropriate salt assemblages. The normative assemblages generated for natural waters fall into three broad categories, as described by Bodine and Jones (1986): meteoric norms (characterized by the lack of alkaline-earth-bearing chlorides), marine norms (dominated by sulfate and chloride salts and particularly

Table 7.--Normative salts available in SNORM (from Bodine and Jones, 1986)

	(Bi)carbonates		
Calcite	$CaCO_3$	Kalicinite	$KHCO_3$
Magnesite	$MgCO_3$	--	Li_2CO_3
Dolomite	$CaMg(CO_3)_2$	Teschemacherite	NH_4HCO_3
Trona	$Na_3H(CO_3)_2 \cdot 2H_2O$	Strontionite	$SrCO_3$
Pirssonite	$Na_2Ca(CO_3)_2 \cdot 2H_2O$	Witherite	$BaCO_3$
	Sulfates		
Anhydrite	$CaSO_4$	Bloedite	$Na_2Mg(SO_4)_2 \cdot 4H_2O$
Gypsum	$CaSO_4 \cdot 2H_2O$	Leonite	$K_2Mg(SO_4)_2 \cdot 4H_2O$
Kieserite	$MgSO_4 \cdot H_2O$	Picromerite	$K_2Mg(SO_2)_2 \cdot 6H_2O$
Epsomite	$MgSO_4 \cdot 7H_2O$	Aphthitalite	$K_3Na(SO_4)_2$
Arcanite	K_2SO_4	--	Li_2SO_4
Thenardite	Na_2SO_4	Mascagnite	$(NH_4)_2SO_4$
Mirabilite	$Na_2SO_4 \cdot 10H_2O$	Celestite	$SrSO_4$
Glauberite	$Na_2Ca(SO_4)_2$	Barite	$BaSO_4$
Syngenite	$K_2Ca(SO_4)_2 \cdot H_2O$	Burkeite	$Na_6CO_3(SO_4)_2$
Polyhalite	$K_2Ca_2Mg(SO_4)_4 \cdot \mathbf{2}H_2O$		
	Chlorides		
Antarcticite	$CaCl_2 \cdot 6H_2O$	Salammoniac	NH_4Cl
Bischofite	$MgCl_2 \cdot 6H_2O$	--	$SrCl_2 \cdot 2H_2O$
Tachyhydrite	$CaMg_2Cl_6 \cdot 12H_2O$	--	$SrCl_2 \cdot 6H_2O$
Sylvite	KCl	--	$BaCl_2 \cdot H_2O$
Carnallite	$KMgCl_3 \cdot 6H_2O$	--	$BaCl_2 \cdot 2H_2O$
Halite	$NaCl$	Kainite	$KMgClSO_4 \cdot 3H_2O$
--	$LiCl_2 \cdot H_2O$		
	Nitrates		
Nitrocalcite	$Ca(NO_3)_2 \cdot 4H_2O$	--	$LiNO_3 \cdot 3H_2O$
Nitromagnesite	$Mg(NO_3)_2 \cdot 4H_2O$	Ammonia niter	NH_4NO_3
Niter	KNO_3	--	$Sr(NO_3)_2$
Soda niter	$NaNO_3$	Nitrobarite	$Ba(NO_3)_2$
	Borates		
Inyoite	$Ca_2B_6O_{11} \cdot 13H_2O^+$	Borax	$Na_2B_4O_7 \cdot 10H_2O^+$
Indirite	$Mg_2B_6O_{11} \cdot 15H_2O^+$	Ulexite	$NaCaB_5O_9 \cdot 8H_2O^+$
	Fluorides		
Fluorite	CaF_2	Villiaumite	NaF
Sellaite	MgF_2	--	LiF
	Phosphates		
Hydroxyapatite	$Ca_5(PO_4)_3OH$	Fluorapatite	$Ca_5(PO_4)_3F$
--	$Mg_3(PO_4)_2$	Wagnerite	Mg_2PO_4F
--	Na_3PO_4		

characterized by magnesium-associated salts), and diagenetic norms (characterized by calcium-bearing chloride minerals that indicate solute diagenesis and highly altered fluid compositions). The major-solute categories represented by the normative salts typically are most indicative of the principal lithologies of the source area. As Bodine and Jones (1986) state, for the major anions, carbonate waters are associated with limestone dissolution or silicate hydrolysis, sulfate waters with oxidation of reduced sulfur and/or gypsum dissolution, and chloride waters with marine salts or hydrothermal systems; for the major cations, the alkalis are associated with siliceous crystalline rocks or pyroclastics, calcium with carbonate or plagioclase-rich rocks, and magnesium with mafic rocks and marine muds.

The salt assemblages generated by the SNORM program for the MRGB study samples in the basin can be used to investigate associations between As and particular source area lithologies. To facilitate comparison, the assemblages generated by the program were divided into seven broad salt groups based on the general lithologies associated with each salt and on patterns observed in the data. These seven groups consist of: anhydrite plus glauberite, burkeite plus trona, halite, calcite plus pirssonite, dolomite, thenardite plus aphthitalite, and a combination of other salts. For each sample, the percentage of total salts falling into each of these groups was calculated. The dominant salt group for each sample was then defined as the group having the largest percentage of salts (Appendix III); no sample had the largest percentage of salts categorized into the "other" salt group. The distribution of As concentrations among these various dominant salt groups is discussed below, as is the distribution of these dominant salt groups among the various water-quality zones (Appendix III).

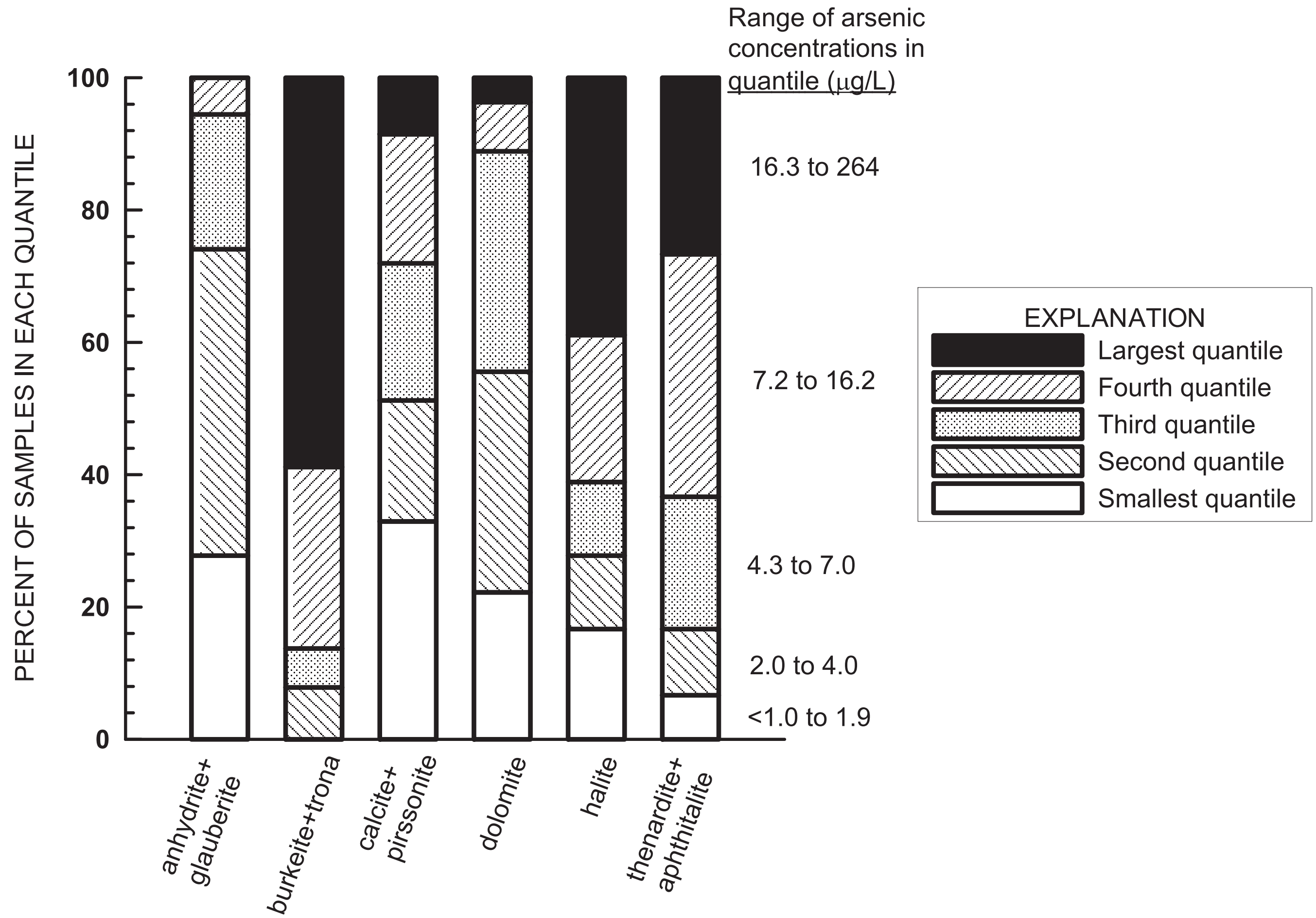


Figure 26.--Distribution of arsenic concentrations among ground-water samples in each dominant salt group.

To investigate the distribution of As concentrations among the various dominant salt groups, the concentrations reported for the MRGB study ground-water samples were divided into quantiles as shown in figure 26. For each dominant salt group, the percentage of samples having As concentrations within each quantile was determined. The results indicate that some salt assemblages tend to be associated with larger As concentrations than other assemblages.

Of the 262 MRGB samples that were analyzed and not considered “exotic,” 54 showed anhydrite plus glauberite as the dominant salt group. Seventy-four percent of these samples have As concentrations falling within the lower two quantiles (i.e., As concentrations of 4.0 μg/L or less); only 5.6 percent of the samples have As concentrations falling within the upper two quantiles (fig. 26). Therefore, in the MRGB, it appears that samples dominated by this combination of salts typically have relatively small As concentrations. The dominance of these salts tends to reflect dissolution of evaporitic $CaSO_4$ and sulfatic weathering in areas having calcic lithologies (Bodine and Jones, 1986). Most MRGB samples categorized in this salt group are from the Rio Puerco, Tijeras Arroyo, Northeastern, and Central water-quality zones. Also, 3 of the 4 samples from the Abo Arroyo zone and 2 of the 6 samples from the Tijeras Fault Zone zone are categorized in this group. Gypsum-bearing Mesozoic or Paleozoic rocks are known to be present in at least part of the source areas for the Rio Puerco, Tijeras Arroyo, Northeastern, and Abo Arroyo zones. Waters from different source areas that are derived from this same type of lithology, therefore, appear to contribute only small quantities of As to the basin. The lithology associated with Central-zone samples with large anhydrite plus glauberite is unclear.

Burkeite plus trona is the dominant salt group for 51 of the MRGB samples. Eighty-six percent of these samples have As concentrations falling within the upper two quantiles, and only 8 percent have concentrations falling within the lower two quantiles (fig. 26). Therefore, in the MRGB, it appears that samples dominated by this combination of salts typically have relatively large As concentrations. The dominance of these salts tends to reflect weathering of siliceous crystalline or clastic rocks (Bodine and Jones, 1986). Most MRGB samples categorized in this salt group are from the West-Central zone, although both the Eastern Mountain Front and Central zones include at least 4 samples categorized in this group. The volcanic source rocks for the West-Central zone may be the primary factor determining the unique salt assemblage of the West-Central zone samples compared to most other MRGB samples.

Calcite plus pirssonite is the dominant salt group for 82 of the MRGB samples. Fifty-one percent of these samples have As concentrations falling within the lower two quantiles, 21 percent have concentrations falling within the middle quantile, and 28 percent have concentrations falling within the upper two quantiles (fig. 26). This is a relatively even distribution compared to the anhydrite plus glauberite and burkeite plus trona samples, although samples in the calcite plus pirssonite salt group are somewhat more likely to have As concentrations below rather than above the median for the basin. This dominant salt assemblage is indicative of carbonate acid hydrolysis of rock-forming minerals and importance of calcium-plagioclase (Bodine and Jones, 1986). Most MRGB samples categorized with calcite as the dominant salt are from the Eastern Mountain Front and Central zones, although most samples from the Northern Mountain Front and Northwestern zones also fall into this category. Similar to the West-Central zone, Tertiary volcanics from the Jemez Mountains are the general type of rocks present in the source areas for the Northern Mountain Front and Northwestern zones. However, the difference in salt assemblages among these zones must reflect a difference in the exact compositions of the source rocks or in the chemical processes affecting the waters. The source area for the Eastern Mountain Front zone contains primarily Precambrian metamorphic rocks and Paleozoic limestones and sandstones. The waters of the Rio Grande that are the main source of recharge to the Central zone reflect a variety of lithologies in upstream source areas. Overall, a dominance of calcite plus pirssonite does not appear closely associated with a particular range of As concentrations in ground water of the basin.

Dolomite is the dominant salt for 27 MRGB samples. Fifty-six percent of these samples have As concentrations falling within the lower two quantiles, and only eleven percent have concentrations falling within the upper two quantiles. Therefore, in the MRGB, it appears that samples with dolomite as the dominant salt tend to have relatively small As concentrations. The dominance of dolomite tends to reflect carbonate-rock dissolution or hydrolysis of mixed calcium-magnesium silicates (Bodine and Jones, 1986). Most MRGB samples categorized in this group are from the Central and Eastern Mountain Front zones, although two samples from the Tijeras Fault Zone zone and the single sample from the Southwestern Mountain Front zone also fall into this group. Precambrian granitic and metamorphic rocks are among the primary lithologies of the source areas for the Eastern Mountain Front, Southwestern Mountain Front, and Tijeras Fault Zone zones. The source areas to the Eastern Mountain Front and Tijeras Fault Zone zones also contain Paleozoic limestones. Waters from different source areas that have similar lithologies resulting in dolomite as the dominant salt, therefore, appear to typically contribute only relatively small quantities of As to the basin.

Halite is the dominant salt for 18 MRGB samples. Sixty-one percent of these samples have As concentrations falling within the upper two quantiles, whereas 28 percent have concentrations within the lower two quantiles. Therefore, in the MRGB, it appears that samples with halite as the dominant salt are somewhat more likely to have relatively large As concentrations. The dominance of halite can reflect an ultimate source in marine rocks or hydrothermal systems or can be associated with recycling in continental basins (Bodine and Jones, 1986). MRGB samples categorized in the halite group come from a variety of water-quality zones: Northern Mountain Front, Western Boundary, Rio Puerco, Eastern Mountain Front, Tijeras Fault Zone, Central, and Discharge. The primary source rocks vary widely among these zones. Also, as discussed in previous sections, ground water in several of these zones are believed to be affected by mixing with a deep, mineralized water source having elevated Cl; each of the samples in this group that have As concentrations of greater than 5 μg/L is from one of these zones. The five samples in the halite group that have As concentrations of less than 5 μg/L are from zones associated with high-Cl brine from Paleozoic rocks located along the western boundary of the basin. Therefore, at least two types of high-Cl waters having different chemical characteristics appear to exist within the basin. Relative to the salt assemblages of the samples believed to be associated with the deep high-Cl source, the salt assemblages of the samples associated with the brine from Paleozoic rocks (such as NM485, Appendix III) tend to have smaller percentages of calcite, dolomite, and fluorite and larger percentages of celestite, magnesite, polyhalite, and sellaite. These differences in composition may reflect differences in source rocks or chemical processes affecting these waters.

Thenardite plus aphthitalite is the dominant salt assemblage for 30 MRGB samples. Sixty-three percent of these samples have As concentrations that fall within the upper two quantiles, whereas 17 percent have concentrations that fall within the lower two quantiles. Therefore, in the MRGB, it appears that samples with thenardite plus aphthitalite as the dominant salt assemblage tend to have relatively large As concentrations. The dominance of these salts is associated with sulfatic weathering of siliceous crystalline rocks (Bodine and Jones, 1986). Most of the MRGB samples categorized in this group are from the Central and West-Central water-quality zones; the one sample from the Abo Arroyo zone that has an As concentration greater than 20 µg/L also is categorized in this group. The lithology associated with these samples is unclear.

SNORM was also used to analyze several "exotic" waters from the Jemez Mountains and from within the MRGB. The primary salts for the two samples from geothermal springs in the Jemez Mountains were halite and calcite plus pirssonite, with some sylvite; the assemblages did not include anhydrite plus glauberite (Appendix III). The salt assemblages for these samples differed somewhat from those for the mineralized waters within the basin that are believed to be associated with deep, geothermal sources (Appendix III). The primary salt groups for the mineralized samples within the basin were halite and anhydrite plus glauberite. Quantities of all other salt groups were generally less than 5 percent, except for the "other" group. The primary "other" salts differed among the 3 samples, but included magnesite, syngenite, and/or sylvite. None of the trace "other" salts that were present in the assemblages of all three samples were unique to these samples as compared to typical samples for the basin. Several “typical” basin samples were discussed above as falling into the group with halite as the dominant salt and as probably resulting from mixing with a deep, mineralized source. In general, the assemblages of these “typical” basin samples appear to be consistent with a combination of both the assemblages of the “exotic” mineralized waters and of the more typical waters of the zones in which the samples are located.

Overall, analysis of ground-water samples from the MRGB using SNORM indicates that As concentrations can differ substantially between waters with different geologic and hydrologic origins, whereas waters from broadly similar origins tend to have similar As concentrations, even when recharged in geographically separate source areas. The use of SNORM, while it did not provide new insight into the evolution of waters in the MRGB, presented a convenient way to categorize different waters into groups having broadly similar chemical origins that are generally consistent with current knowledge of the geology and hydrology of the basin.

Other factors

The available data appear to indicate that the source area and chemical origin of waters recharging the MRGB are the primary factors determining the distribution of As in ground water of the basin. However, a few additional factors also were investigated for effects on As concentrations.

Evaporation

Evaporative concentration has been cited as a major process that can affect As concentrations in ground water, particularly in closed hydrologic basins of the western

United States (Welch and others, 2000). In the MRGB, there is little evidence that evaporation results in elevated As concentrations on a regional scale. Depth to water throughout most of the basin is greater than 50 ft, so that substantial evaporation of ground water is likely to occur only in recharge areas around the basin margins and in the inner valley of the Rio Grande. As discussed earlier, both Cl and As concentrations in ground water near the mountain fronts of the basin are generally quite small (less than 10 mg/L and 3 μg/L, respectively), except in the northwestern part of the basin where Cl concentrations still tend to be quite small although As concentrations are elevated. Therefore, evaporative concentration occurring during mountain-front recharge processes generally does not appear to be resulting in elevated As concentrations. Similarly, most ground-water samples that have been shown to be associated with infiltration through ephemeral streams or arroyos, such as the Rio Puerco, Tijeras Arroyo, Abo Arroyo, and arroyos in the Northeastern zone, have relatively small As concentrations, indicating little effect from evaporative concentration during recharge. Samples from water-quality zones associated with ground water leaking into the MRGB from the west also are low in As despite large Cl concentrations.

In the inner valley of the Rio Grande, evaporative concentration may increase both Cl and As concentrations in ground water locally. For example, elevated As concentrations (greater than 10 μg/L) occur in two shallow ground-water samples removed from the overall data set for this study because of large specific conductance values indicating local evaporative concentration (Appendix I, samples DB178 and DB403). However, 12 other ground-water samples removed from the data set for the same reason show As concentrations of less than 10 μg/L, and generally less than 5 μg/L (surface water in the Rio Grande, which provides recharge to the aquifer in this area, typically has an As concentration of about 3 μg/L; table 3). Therefore, evaporative concentration may locally elevate As concentrations in ground water of the inner valley, but it appears that in many cases As may then be effectively removed from solution through a process such as sorption. Further study of inner valley ground water and sediments would be necessary to confirm the occurrence of these processes.

As discussed earlier, elevated As concentrations in parts of the Northern Mountain Front, Eastern Mountain Front, Central, and Northwestern water-quality zones appear to be associated with areas of elevated Cl concentrations that likely are the result of mixing with deep, mineralized waters. In both the Northern and Eastern Mountain Front zones, Pearson correlation coefficients of greater than 0.50 between As and Cl indicate a relatively strong relation between these two constituents. If evaporative concentration were the primary factor resulting in increased Cl and As concentrations in the mineralized “end-member” waters, these waters probably would have originated in a setting such as a playa lake, where evaporation would occur while sediments were being deposited, allowing evaporated waters to become trapped in pore spaces (sediments deposited in playa lake settings are found in the lower Santa Fe Group). Such waters would be expected to have relatively heavy stable isotope signatures, as would the waters resulting from mixing between these mineralized waters and “typical” basin waters.

Unfortunately, the available data do not provide a clear indication of whether evaporative concentration played an important role in the evolution of the deep, mineralized waters of the basin. The three “exotic” samples within the basin that are believed to most closely approximate these types of waters have deuterium compositions of –60, –80, and –83 per mil. All of these values appear fairly typical or even somewhat light when compared to the median deuterium values for ground water in the water-quality zones in which the sampling sites are located. Whether these mineralized waters can be expected to have recharged at a similar elevation and temperature as surrounding "typical" waters is unclear; but, if so, these deuterium values do not appear to indicate substantial evaporative concentration of the "exotic" waters. Plots of deuterium versus chloride for ground-water samples from the water-quality zones believed to be affected by mixing with deep, mineralized waters also do not indicate that higher-Cl waters have the heavier deuterium compositions that might be expected if evaporative concentration had caused the increased Cl (fig. 27). However, if a higher-Cl water sample represents a mixture containing only a relatively small portion of deep, mineralized water, the deuterium composition of the resulting mixture might be only a few per mil different from the deuterium composition of a water sample that had not mixed with the deep water. (For example, if a water sample was a mixture of 90 percent "typical" zone water having a deuterium composition of –90 per mil and 10 percent mineralized water having a deuterium composition of –60 per mil, the resulting mixture would have a composition of –87 per mil.) Therefore, although the data do not support evaporative concentration as a major process in the evolution of the deep, mineralized waters of the basin, they do not provide clear evidence that the process has not occurred.

Ground-water age

Arsenic concentration and ground-water age were investigated for any apparent relation that could indicate whether the kinetics of chemical processes occurring either inside the MRGB or in ground-water source areas play a major role in controlling

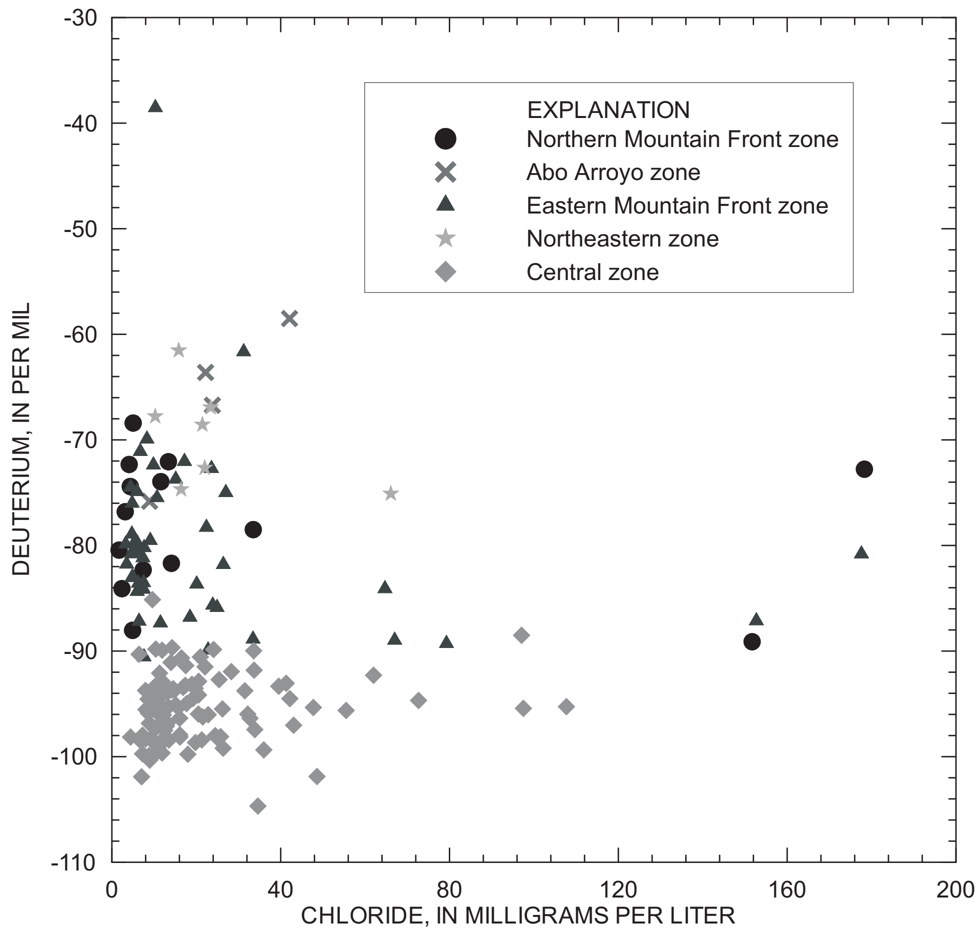


Figure 27.--Relationship between deuterium content and chloride concentration for zones with variable arsenic concentration.

As concentrations in the basin. Plummer and others (2001a) indicate that ground-water ages calculated from carbon-14 data collected during the MRGB study will require only small corrections for chemical processes occurring within the basin. Therefore, for this study, As concentrations were compared directly to carbon-14 concentrations to investigate the existence of relations between As concentration and ground-water age.

Statistical tests indicate that no significant correlation exists between As concentrations and carbon-14 values in the MRGB data set, providing little evidence for a relation between As and carbon-14 for the data set as a whole. The water-quality zone with the smallest median carbon-14 value (i.e., oldest age) is the Western Boundary zone, which has consistently small As concentrations. The next two smallest median carbon-14 values occur for the West-Central and Discharge zones, which have the largest two median As concentrations. The generally old ages and large As concentrations for ground water in these two zones could imply that long travel paths/contact times may contribute to the addition of more As to solution through desorption, mineral dissolution, or other chemical processes. Samples from locations near the Jemez mountain front indicate that the ground water of the West-Central zone is already quite old and elevated in As upon entering the MRGB. Therefore, contact time with the volcanic rocks of the Jemez Mountains source area could be a factor influencing As concentrations in this zone, whereas water of the Discharge zone has had long contact times with geologic materials within the MRGB. Other water-quality zones with relatively old water include the Tijeras Fault Zone and Northeastern zones, which have median As concentrations smaller than 3 μg/L, indicating that contact time is not always a determining factor in As concentration.

Pearson correlation coefficients discussed in an earlier section indicate that within an individual water-quality zone, larger As concentrations can be associated with older waters. For the Northern Mountain Front, Eastern Mountain Front, and Central zones, significant negative correlations with coefficients of 0.56 or greater exist between As and carbon-14. In all of these zones, mixing with deep, mineralized water has been proposed as a source of the elevated As concentrations of many samples. For the Central zone, mixing with the older waters of the West-Central zone also has been proposed to cause increased As concentrations. The exact processes that would cause elevated As in the deep, high-Cl waters of the basin have not been determined from this data set, but contact time is a potentially important factor in increasing As concentrations in these waters. Alternatively, the most important factors could include the higher temperatures encountered along deeper flow paths through the basin (correlation coefficients between As and temperature tend to be greater than 0.50 for the Northern Mountain Front, Eastern Mountain Front, and Central zones), or chemical processes related to the more reducing conditions present along these deeper flow paths, which could result in the dissolution of As-containing iron oxides (although this is not generally supported by correlation coefficients) or the limited sorption of As because of its presence as As (III).

Variability in basin-fill deposits

Concentrations of As in ground water of the MRGB also were examined for any relation to the various types of basin-fill deposits present within the basin. Figure 28 shows the distribution of ground-water samples of particular As and pH ranges compared to the lithostratigraphic units of Connell and others (1999). In a broad sense, As concentrations appear to have an association with individual units, as would be expected,

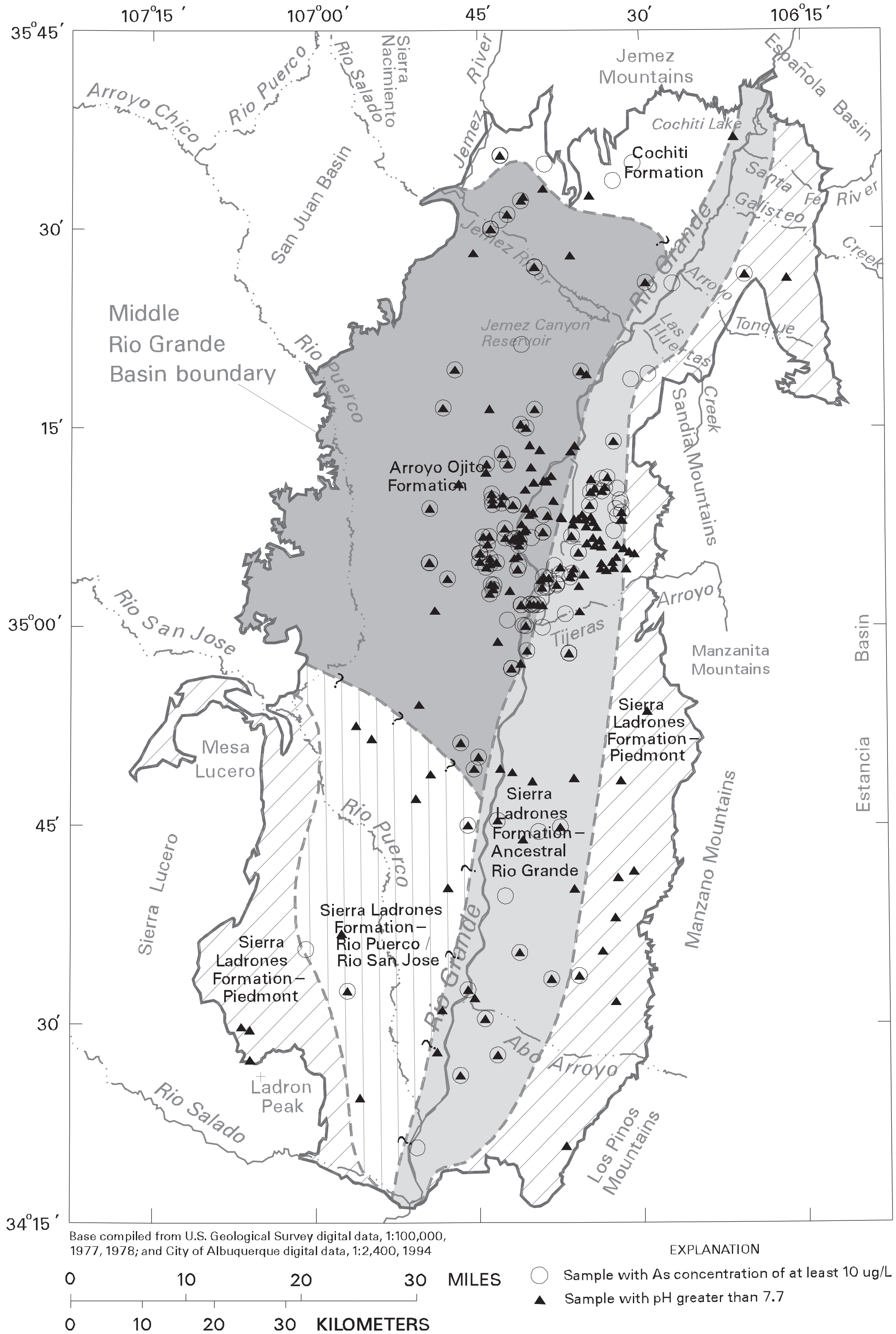


Figure 28.--Ground-water samples with arsenic concentrations of at least 10 micrograms per liter and pH values greater than 7.7, in relation to lithostratigraphic units of Connell and others (1999).

given that As concentrations were previously demonstrated to be related to the source areas and geochemical origins of ground water. In particular, ground water in piedmont deposits along the eastern and western margins of the basin has generally small As concentrations, except in areas of apparent upwelling. Most of these deposits are derived from calcic lithologies, as indicated by the predominant salts in ground-water samples originating from source areas along the basin margins. Similarly, most of the wells in the northwest part of the basin that have elevated As concentrations are completed in sediments derived from the silicic volcanic rocks of the Jemez Mountains.

Although there does appear to be a broad relation between As concentration and lithostratigraphic unit, ground-water samples from wells that are completed in similar basin-fill deposits and exist under similar redox conditions can have substantially different As concentrations. Figure 28 shows that the existence of volcanic material in basin-fill deposits does not always correspond to elevated As concentrations in ground water. For example, wells completed in the Arroyo Ojito Formation (containing volcanic sediments from the Jemez Mountains and from west of the basin) tend to have elevated As concentrations, whereas wells completed in sediments of the Sierra Ladrones Formation that were derived from the ancestral Rio Puerco/Rio San Jose (also containing volcanic sediments from west of the basin) tend to have small As concentrations.

Even wells that are completed in the same lithostratigraphic unit can have substantially different As concentrations, particularly when the source waters differ (i.e., when the wells are located in different water-quality zones). For example, several samples from piezometer nests of the Central zone have As concentrations of 3 to 7 μg/L at depths where pH values are about 7.7 to 9.0 and sediments are classified as being of the Arroyo Ojito Formation (fig. 28 and data in bold in Appendix I) (Connell and others, 1999; Jackson-Paul and others, 2001). Nearly all samples from the Northwestern and West-Central zones that exist under similar redox conditions in sediments of the same formation have As concentrations greater than 10 μg/L. If desorption from the volcanic-rich sediments of the Arroyo Ojito Formation was the primary source of As to ground water in the Northwestern and West-Central zones, ground-water samples from other zones that existed under similar redox conditions and were obtained from sediments of the same formation would be expected to have similarly large As concentrations. The observation that As concentrations can differ substantially among such wells supports the conclusion that processes affecting water in the recharge area (i.e., processes that result in a particular source-water composition) can be more important in determining the distribution of elevated As concentrations than processes occurring within the basin in association with a particular lithostratigraphic unit.

SUMMARY AND CONCLUSIONS

Availability of low-arsenic ground water for drinking-water supplies

This investigation indicates that the quantity of potable ground water (total dissolved solids less than about 500 mg/L) in the Middle Rio Grande Basin that will also meet the U.S. EPA drinking-water standard of 10 μg/L for As is limited. Figure 29 shows that most wells known to produce water meeting these criteria are located in the vicinity of Albuquerque between the Rio Grande inner valley and the eastern mountain front and south of Albuquerque near the eastern mountain front. Other clusters of wells that meet the criteria occur in the far northern part of the basin and at the northern end of the Sandia Mountains. However, even within these broad areas of generally small As concentrations, samples from some wells have As concentrations larger than 10 μg/L.

Although most of the wells sampled for this investigation were completed in the upper 1,750 ft of the Santa Fe Group aquifer, indications from deep piezometer nests are that As commonly increases with depth. Also, unpublished data from two oil wells near the center of the basin at depths of 2,600 to 6,600 ft below land surface indicate As concentrations exceeding 50 to 100 μg/L (Scott Anderholm, USGS, written commun., 2001). Therefore, it is doubtful that wells completed at greater depths would yield water with smaller As concentrations for municipal drinking-water supply.

Overall, future efforts to obtain sources of potable ground water in the MRGB that will meet the new U.S. EPA drinking-water standard for As should focus on areas

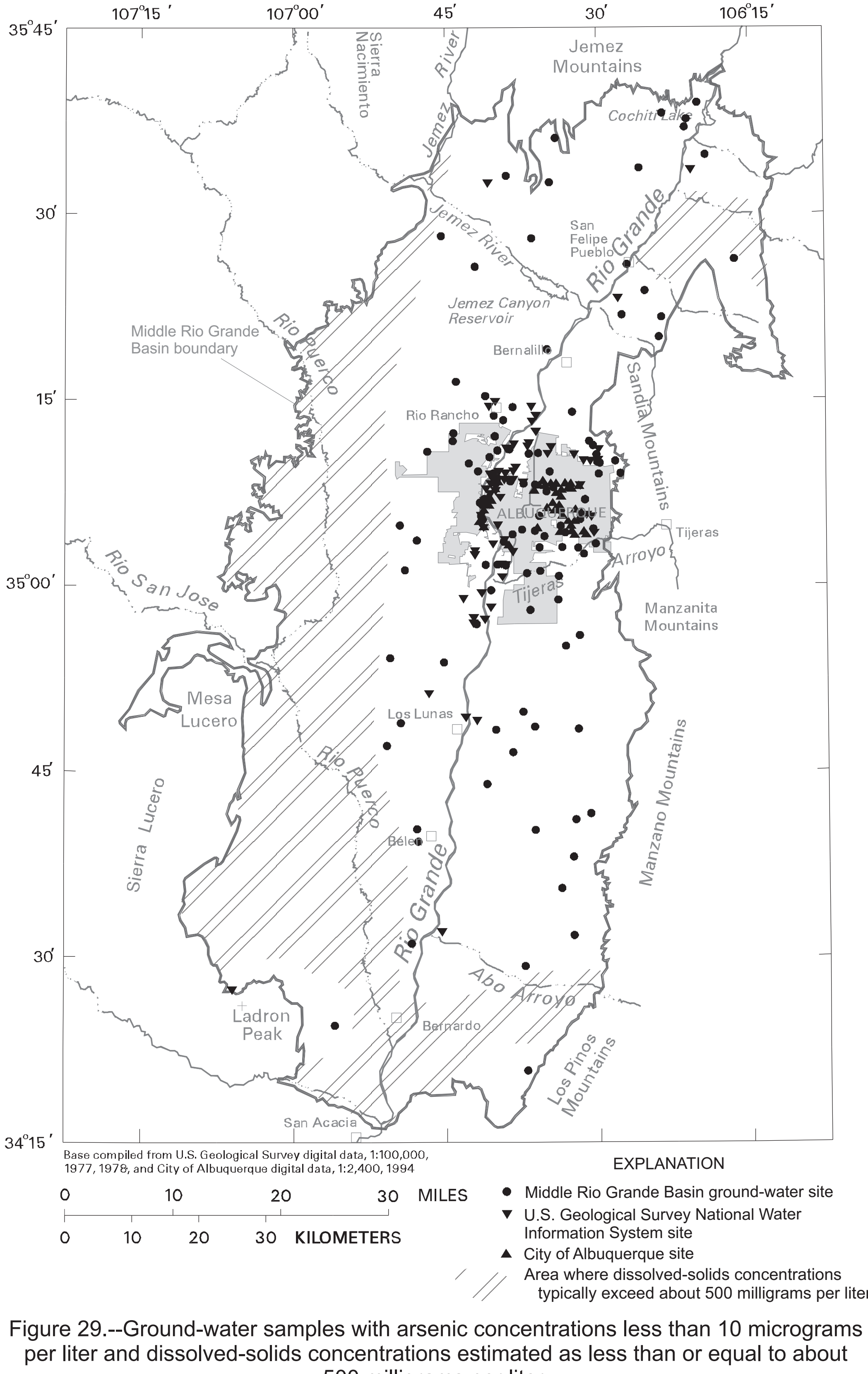


Figure 29.--Ground-water samples with arsenic concentrations less than 10 micrograms per liter and dissolved-solids concentrations estimated as less than or equal to about 500 milligrams per liter.

relatively close to recharge sources that have been shown to have generally low As. These include areas receiving mountain-front recharge along the eastern margin of the basin or in the eastern part of the Jemez Mountains to the north, as well as areas receiving recharge through the Rio Grande. In particular, such areas typically include the region east of the Rio Grande between the north end of the Sandia Mountains on the north and Abo Arroyo on the south and the region at the far northern end of the basin. However, even within these regions, caution should be taken to avoid areas that are affected by upwelling of deep, mineralized water along major structural features or mixing (typically at depth) with waters sourced in the western Jemez Mountains. Large Cl concentrations, elevated temperatures, and/or proximity to major faults that have been indicated to facilitate upwelling along at least part of their lengths can be useful in identifying areas that might be affected by upwelling of deep waters. Near the Rio Grande, large Na concentrations and high pH values (exceeding about 8.0) can help identify mixing with waters sourced in the western Jemez Mountains. In regions where recharge through the western part of the Jemez Mountains is the primary source of recharge, identification of likely areas of low-As waters may not be possible. As stated above, deepening of wells in any area is unlikely to produce water having smaller As concentrations. In the vicinity of Albuquerque, surface water from the Rio Grande, which the City of Albuquerque has proposed to use as its primary source of drinking-water supply beginning in about the year 2005, should meet the new U.S. EPA standard under most conditions.

Primary controls on arsenic occurrence

This investigation of the distribution and sources of As in ground water of the MRGB indicates that variations in As concentration in the basin are associated more closely with the source and geochemical origin of the ground water than with processes occurring within the basin. The sources of arsenic to the basin appear to fall into two major categories: high-As recharge water from the silicic volcanic terrain of the western Jemez Mountains, where As may desorb from hydrothermally-altered rocks, and mineralized water of deep origin that upwells in association with major structural features. However, sorption/desorption processes occurring within the basin also appear to play a role in elevating As concentrations in areas where anion-exchangeable As is available on sediments and pH values are sufficiently high. Appendix II summarizes the likely sources/controls on As levels in ground-water samples having concentrations exceeding 5 μg/L.

Recharge through volcanic rocks in the western Jemez Mountains is the primary source of ground water to the Northwestern and West-Central water-quality zones of the MRGB and contains substantial dissolved As upon entering the basin. Based on SNORM results, most waters of these zones are classified in the dominant salt group of burkeite plus trona, which typically indicates weathering of siliceous crystalline or clastic rocks. By contrast, ground water along basin margins in the Northern Mountain Front zone is low in As and is classified in the dominant salt group of calcite plus pirssonite, despite also receiving recharge through the volcanic terrain of the Jemez Mountains. This contrast indicates that unaltered Tertiary and Quaternary volcanic rocks that blanket the Jemez Mountains may not be the primary source of As for the northwest part of the basin. Investigation of the relations between minor-element and Cl concentrations appears to indicate that mixing with the geothermal fluids that exist in the western part of the Jemez Mountains also generally cannot account for the entire As content of ground water of the

Northwestern and West-Central zones. Elevation of As concentrations as water recharges through volcanic rocks whose trace-element concentrations have been increased by hydrothermal alteration appears most consistent with the chemistry of ground water observed in these zones. Additional research is necessary to investigate compositional differences between volcanic rocks in the eastern and western parts of the Jemez Mountains.

Mixing with mineralized water of deep origin appears to elevate As concentrations in parts of the Northern Mountain Front, Northeastern, Eastern Mountain Front, and Central zones. In these zones, areas of elevated As concentrations are nearly coincident with areas of elevated Cl concentrations. These areas tend to cluster near significant structural features of the basin—particularly, major faults and structural highs. Major faults could provide conduits for vertical movement of deep, mineralized water into shallower parts of the aquifer, whereas structural highs also could force deep water upward by means of a reduction in the thickness of Santa Fe Group sediments. Parameters with which As concentrations in the Northern Mountain Front, Eastern Mountain Front, and eastern Central zones are strongly correlated include Cl, carbon-14 age, temperature, Na, B, Li, and Mo. All of these associations appear consistent with mixing with old, deep water that has elevated concentrations of Cl, Na, and several trace elements; increasing concentrations of these constituents with depth in deep piezometers also appear consistent with this conclusion. Ground-water samples from these zones that are classified with halite as the dominant salt (indicating those samples with large fractions of mineralized water) all have As concentrations between 6 and 54 μg/L. Unfortunately, the exact composition of this deep, mineralized water is not necessarily consistent throughout the basin, which makes determination of its origin difficult. Additional research is required to determine whether the elevated As concentrations associated with these deep waters might be the result of long contact times, high-temperature processes, limited sorption associated with the reduced form of As, or other processes.

Adsorption/desorption processes within the aquifer of the MRGB appear to affect As concentrations in some parts of the basin. Desorption seems to elevate As concentrations primarily in the West-Central zone, where samples with the largest As concentrations typically have pH values of 8.5 or higher, although desorption may also occur in the Northwestern zone. The conclusion that As is desorbing from metal oxides at elevated pH values is supported by data from a core studied by Stanton and others (2001a and b), which indicate that the most likely source of soluble As from aquifer sediments is the “anion-exchangeable” fraction associated with clay and secondary Fe oxide surfaces. It is not entirely clear whether the source of As available on sediments of the Arroyo Ojito and Cochiti Formations in the West-Central zone is weathering of the aquifer sediments after deposition or transport of As in ground water sourced in the western Jemez Mountains. However, the lack of elevated As concentrations in several ground-water samples of similar redox conditions from wells in the Northern Mountain Front and Central zones that are also completed in sediments of the Arroyo Ojito and Cochiti Formations implies that source water plays a major role in the availability of As on sediments of the northwestern part of the basin (i.e., that water recharging through hydrothermally-altered rocks in the source area carries As into the basin, where it can undergo cycles of adsorption/desorption). Additional investigation of the availability of anion-exchangeable As on sediments from different lithostratigraphic units throughout the basin is needed to confirm the role of source water as opposed to sediment composition alone (in particular, the abundance and composition of volcanic material).

Ground waters that have not been affected by mixing with water sourced in the western part of the Jemez Mountains or with deep mineralized water typically have relatively low As concentrations (generally less than 5 μg/L). Possible exceptions are the Discharge zone, which represents the drain for older, more evolved waters from a variety of upgradient water-quality zones, and localized waters of elevated pH in other zones where anion-exchangeable As may be available on aquifer sediments. Low levels of As occur throughout the Western Boundary, Rio Puerco, Southwestern Mountain Front, Tijeras Fault Zone, and Tijeras Arroyo water-quality zones. Small As concentrations also occur near basin margins in the Northern Mountain Front, Eastern Mountain Front, Abo Arroyo, and Northeastern zones, and in parts of the Central zone that are unaffected by upwelling. Based on SNORM results, the low-As waters of these zones tend to be classified with dominant salts of anhydrite plus glauberite (indicating dissolution of evaporitic $CaSO_4$ or sulfatic weathering of calcic rocks), dolomite (indicating dissolution or hydrolysis of mixed calcium-magnesium silicates), or calcite (indicating carbonate acid hydrolysis of rock-forming minerals and the importance of calcium-plagioclase), although halite waters sourced from Paleozoic rocks west of the basin also are low in As.

Applications to other ground-water basins

This investigation of As in ground water of the MRGB indicates the types of sources and geochemical controls that can be important in determining the occurrence of As in ground water of alluvial basins in the southwestern United States. Mountain-front recharge through Precambrian metamorphic and plutonic rocks appears generally to have very low concentrations of As, as does recharge through evaporitic $CaSO_4$ or carbonate rocks. Surface water also tends to be a source of low-As recharge, when contributions of water (particularly geothermal water) from volcanic terrains are limited. Elevated As concentrations are more commonly associated with waters sourced in silicic volcanic terrains, and particularly with waters that have mixed with geothermal fluids or contacted geothermally-altered rocks present in areas of volcanism. Arsenic concentrations can also be elevated in old, mineralized waters present at depth. Unfortunately, the exact origins of mineralized waters at depth in the MRGB are not evident. Therefore, it is not known whether elevated As concentrations are likely to exist in such waters in other alluvial basins, or whether elevated As is unique to the deep waters of basins such as the MRGB as a result of local volcanism, the depositional environments (such as playa lakes) represented by sediments at depth, or other factors. However, where such high-As waters do exist at depth, they appear most likely to affect shallower depths of the aquifer along structural features that can facilitate upwelling. Such features may include major faults and/or structural highs. Another process that can elevate As concentrations in ground waters of alluvial basins is desorption of anion-exchangeable As from Fe oxide or clay surfaces; this process appears to be of most significance in areas where pH values exceed about 8.5. Knowledge of such sources and processes that result in elevated As concentrations can aid in delineating areas where ground water is most likely to meet the new U.S. EPA drinking-water standard of 10 μg/L.

APPENDICES

Appendix I.--Selected water-quality data and construction information for ground-water sites in the Middle Rio Grande Basin, by water-quality zone (as defined by Plummer and others, 2001a) [Samples having reference numbers starting with "NM" are from the MRGB study (Plummer and others, in prep.) (fig. 10), with "DB" are from the USGS NWIS database (fig. 11), and with any other letter combination are median data from the City of Albuquerque (fig. 12). Superscripts on sample reference numbers indicate samples from deep piezometer nests and correspond to IDs shown in figures 10 and 20; all samples having the same superscript are from the same nest. Samples shown in bold script are those referred to on p. 117 of the text. dms, degrees-minutes-seconds; --, no data; <, less than; na, not applicable; µS/cm, microsiemens per centimeter at 25 degrees Celsius; deg. C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter]

Sample reference number	Latitude (dms)	Longitude (dms)	Sample date	Elevation of land surface datum (feet above sea level)	Depth of well, total (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	Casing material	Specific conductance (µS/cm)	pH, field (standard units)	Water temperature (deg. C)	Dissolved oxygen (mg/L)	Calcium (mg/L as Ca)	Magnesium (mg/L as Mg)	Sodium (mg/L as Na)	Potassium (mg/L as K)
Northern Mountain Front zone																			
NM026	353443	1061913	8/28/1996	5,362	300	250	300	160.	5/25/1967	production	steel	323	7.37	15.6	6.15	41.3	6.6	19.8	2.8
NM027	353657	1062116	8/28/1996	5,298	250	--	--	190.	--	production	steel	226	7.73	18.5	5.70	24.6	3.9	15.8	4.2
NM055	351901	1063458	8/17/1996	5,172	330	320	330	160.	9/2/1994	domestic	PVC	774	7.72	18.9	4.87	61.9	8.7	68.1	7.1
NM131	351915	1063529	8/13/1996	5,240	1,487	800	1,435	226.	1994	production	steel	772	7.85	26.7	2.50	42.2	2.6	107.3	6.1
NM143	352759	1063627	8/27/1996	5,725	637	--	--	585.	6/10/1958	windmill	steel	357	7.80	20.1	5.36	42.5	7.0	16.1	6.3
NM168	353856	1062000	8/28/1996	5,525	690	356	690	265.		production	steel	174	7.12	18.4	6.79	16.9	3.3	12.0	2.4
NM486	353736	1062104	8/3/1998	5,335	320	270	315	121.13	8/3/1998	monitoring	PVC	250	7.58	19.8	3.47	28.6	3.7	16.4	4.3
NM487	353805	1062329	7/31/1998	5,533	290	--	--	150.	--	windmill	steel	211	7.20	17.7	7.04	26.5	3.9	6.5	3.8
NM510	352556	1062929	8/3/1998	5,542	535	--	--	460.58	2/9/1995	windmill	steel	409	7.99	25.5	6.21	22.0	6.7	57.3	8.2
NM514	353458	1063037	8/6/1998	6,107	260	--	--	--	--	windmill	steel	784	6.63	17.1	1.27	81.8	9.7	69.6	12.9
NM525	353338	1063228	7/28/1998	5,946	100	--	--	36.6	4/21/1998	windmill	steel	429	7.35	19.4	4.69	53.3	8.5	20.2	5.2
NM527	353605	1063404	7/28/1998	6,275	56	--	--	13.18	1/11/1984	windmill	steel	255	6.97	18.5	--	35.6	5.6	8.8	4.3
NM528	353230	1063440	7/28/1998	6,281	1,109	--	--	990.99	11/7/1994	windmill	steel	286	7.79	20.7	2.61	26.4	2.2	30.9	4.5
NM530	353340	1062547	8/20/1998	5,632	555	--	--	--	--	windmill	steel	550	7.10	20.4	5.50	64.0	10.3	39.0	7.0
Northwestern zone																			
NM128	351625	1064357	8/13/1996	5,827	1,618	982	1,599	880.	8/21/1978	production	steel	395	8. 0	26.4	4.89	17.7	3.5	57.2	4.2
NM133	352117	1064057	8/13/1996	5,794	1,310	820	1,290	775.	8/8/1993	production	steel	777	7.56	25.2	6.13	37.3	3.8	116.6	5.7
NM179	353302	1063856	8/27/1996	5,970	727	715	725	667.	6/4/1981	windmill	steel	250	8.14	17.2	11.65	33.7	1.6	15.3	3.9
NM180	352811	1064523	8/27/1996	5,554	240	125	135	116.	4/18/1957	windmill	steel	381	7.87	18.6	7.80	47.5	6.1	17.5	6.5
NM184	353106	1064214	8/26/1996	5,615	572	392	552	242.	10/16/1995	production	steel	331	7.78	20.4	7.94	34.0	4.7	32.3	4.6
NM185	353041	1064255	8/26/1996	5,525	320	260	320	150.	4/11/1983	production	steel	400	7.69	20.3	7.68	28.1	4.3	54.3	7.0
NM326	351459	1064034	6/20/1997	5,415	990	670	990	396.	9/1/1969	production	steel	415	8.14	20.9	3.83	19.11	3.0	58.5	5.9
NM497[A]	351515	1064104	7/23/1998	5,450	1,260	1,200	1,240	495.5	9/2/1997	monitoring	steel	400	7.43	21.8	4.05	21.4	2.6	60.0	6.6

Sample reference number	Latitude (dms)	Longitude (dms)	Sample date	Elevation of land surface datum (feet above sea level)	Depth of well, total (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	Casing material	Specific conductance (µS/cm)	pH, field (standard units)	Water temperature (deg. C)	Dissolved oxygen (mg/L)	Calcium (mg/L as Ca)	Magnesium (mg/L as Mg)	Sodium (mg/L as Na)	Potassium (mg/L as K)
NM498[A]	351515	1064104	7/23/1998	5,450	835	810	830	494.3	9/2/1997	monitoring	steel	318	8.05	21.1	6.52	19.0	3.0	43.0	6.7
NM499[A]	351515	1064104	7/23/1998	5,450	595	490	590	485.5	9/10/1997	monitoring	steel	293	7.80	20.8	6.68	28.9	5.0	21.8	7.4
NM526	352542	1064203	7/29/1998	5,618	448	--	--	373.3	1/23/1984	windmill	steel	456	7.68	19.5	6.85	40.2	5.3	49.9	4.7
DB436	353226	1064045	4/4/1974	--	503	--	--	376.27	12/18/1951	well	--	490	7.90	17.0	--	49.0	1.5	56.0	5.5
DB447	353454	1063847	6/8/1973	--	na	na	na	na	na	spring	na	367	7.50	--	--	31.0	4.0	46.0	3.3
West-Central zone																			
NM003	350336	1064751	8/12/1996	5,725	1,292	1,078	1,272	834.	10/31/1987	production	steel	474	8.22	30.1	3.98	13.4	0.8	82.6	3.4
NM007	343917	1064747	8/16/1996	4,920	504	150	504	150.	12/1/1967	production	steel	762	7.69	21.9	3.26	38.0	13.4	96.3	7.2
NM008	344017	1064754	8/16/1996	4,930	600	435	600	144.	--	production	steel	693	7.80	21.8	3.90	29.7	10.8	94.9	7.1
NM015	350121	1065208	8/12/1996	5,830	1,661	1,355	1,655	898.	5/3/1990	production	steel	1,018	7.42	31.0	2.35	35.5	4.2	149.0	7.5
NM056	350641	1064232	6/20/1996	5,111	970	350	950	167.2	11/1/1992	production	steel	460	8.33	23.2	3.02	14.1	2.5	72.1	5.8
NM076	344915	1064528	8/14/1996	4,965	605	332	562	182.	--	production	steel	470	8.17	20.8	0.31	10.1	3.2	86.4	6.3
NM077	345009	1064503	8/14/1996	4,981	610	278	582	129.	6/28/1979	production	steel	438	8.08	20.0	0.48	11.0	3.4	75.7	6.2
NM107	344851	1064928	8/14/1996	5,358	985	965	980	530.	3/14/1991	domestic	steel	582	8.30	26.7	0.86	10.2	2.8	105.3	4.0
NM109	350137	1064105	6/17/1996	4,931	149	139	144	11.31	1/24/1996	monitoring	steel	694	8.52	20.9	0.12	13.1	1.4	129.0	4.3
NM110	350137	1064105	6/17/1996	4,931	104	94	99	11.21	1/24/1996	monitoring	steel	620	8.48	18.8	0.08	13.6	2.0	115.0	4.6
NM129	351923	1064707	8/13/1996	6,054	1,540	1,120	1,520	1,082.	10/31/1984	production	steel	359	8.50	26.1	7.33	4.25	0.1	72.8	2.0
NM130	351623	1063946	8/13/1996	5,504	1,470	825	1,450	556.	1994	production	steel	622	7.71	25.7	6.27	25.5	1.8	102.0	5.1
NM132	351630	1064812	8/13/1996	6,055	1,920	1,343	1,721	1,101.15	12/20/1989	production	steel	424	8.73	28.0	6.45	2.97	0.1	88.1	1.7
NM135	345406	1065030	8/21/1996	5,470	620	--	--	598.9	5/11/1993	windmill	steel	503	7.73	24.7	2.96	9.3	3.2	90.3	4.3
NM139	343103	1064827	8/29/1996	4,840	249	224	249	92.	7/3/1984	production	steel	689	8. 0	21.4	0.20	19.7	7.0	111.0	5.6
NM144[B]	352710	1063945	8/22/1996	5,322	750	730	750	6.35	8/16/1985	monitoring	steel	444	8.96	18.0	2.68	4.43	0.3	92.8	3.3
NM145[B]	352710	1063945	8/22/1996	5,322	492	472	492	15.96	8/16/1985	monitoring	steel	412	8.52	17.4	3.89	6.27	0.4	85.3	3.4
NM146[B]	352710	1063945	8/22/1996	5,322	210	190	210	31.22	8/16/1985	monitoring	steel	472	8.25	18.1	4.79	12.0	0.7	92.4	4.1
NM155	350855	1064928	8/12/1996	5,866	1,463	1,116	1,429	922.11	4/25/1988	production	steel	700	8.22	29.4	4.92	13.5	0.9	129.0	3.9
NM181[C]	353000	1064350	8/26/1996	5,397	770	750	770	14.36	8/16/1985	monitoring	steel	614	8.34	19.4	5.28	8.27	1.0	125.4	5.6
NM182[C]	353000	1064350	8/26/1996	5,397	506	486	506	15.11	9/9/1985	monitoring	steel	598	8.61	18.6	3.89	7.79	1.3	124.3	5.6
NM183[C]	353000	1064350	8/26/1996	5,397	300	280	300	19.21	8/16/1985	monitoring	steel	1,509	8.10	17.4	4.52	65.2	10.0	237.6	9.2
NM186	353208	1064059	8/27/1996	5,740	800	750	800	--	--	monitoring	steel	789	8.47	20.1	0.30	10.0	0.7	162.0	4.0

Sample reference number	Latitude (dms)	Longitude (dms)	Sample date	Elevation of land surface datum (feet above sea level)	Depth of well, total (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	Casing material	Specific conductance (µS/cm)	pH, field (standard units)	Water temperature (deg. C)	Dissolved oxygen (mg/L)	Calcium (mg/L as Ca)	Magnesium (mg/L as Mg)	Sodium (mg/L as Na)	Potassium (mg/L as K)
NM255	350112	1064902	6/23/1997	5,688	1,300	1,242	1,294	781.	6/4/1965	production	steel	485	8.89	20.6	5.11	7.06	0.8	89.3	3.8
NM260	344701	1065050	6/26/1997	5,305	660	640	660	475.	10/14/1983	domestic	PVC	649	8.08	25.7	5.26	19.36	7.6	106.0	6.1
NM264	350647	1064400	6/19/1997	5,226	1,605	550	1,564	329.	1993	production	steel	482	8.90	31.9	4.98	3.79	0.4	100.1	1.4
NM294	350310	1064350	6/26/1997	5,076	1,140	288	1,128	193.	1993	production	steel	464	8.62	24.2	4.90	7.43	1.2	100.0	2.2
NM308	351137	1064417	6/18/1997	5,390	1,050	648	1,050	533.	1992	production	steel	351	8. 0	23.6	4.98	24.68	7.2	33.8	5.3
NM310	351302	1064247	6/18/1997	5,460	1,364	650	1,351	489.	4/1/1980	production	steel	453	8.23	24.4	2.22	15.12	2.6	75.7	7.1
NM311	351215	1064413	6/18/1997	5,455	1,357	692	1,339	539.	9/30/1994	production	steel	389	8.14	25.7	3.84	21.0	5.7	51.6	4.1
NM322[D]	350140	1064016	7/4/1997	4,958	515	500	510	12.1	12/2/1992	monitoring	PVC	674	8.84	21.7	0.04	10.4	0.2	114.0	2.1
NM346	350935	1064343	6/19/1997	5,335	1,200	528	1,056	458.	1993	production	steel	381	8.08	23.7	3.89	20.7	4.3	49.1	7.7
NM347[E]	350638	1064137	6/23/1997	5,100	1,095	1,085	1,090	173.11	10/24/1996	monitoring	PVC	780	8.67	26.0	0.14	7.0	0.2	147.0	2.4
NM353	350444	1064354	6/19/1997	5,145	1,365	405	1,353	239.	4/1/1974	production	steel	460	8.75	25.8	4.74	5.2	0.6	92.9	2.3
NM481[F]	350530	1064452	8/4/1998	5,320	1,544	1,534	1,539	421.46	4/21/1997	monitoring	PVC	1,695	7.98	26.3	0.03	5.58	1.1	360.0	3.5
NM482[F]	350530	1064452	8/4/1998	5,320	1,112	1,102	1,107	422.69	4/21/1997	monitoring	PVC	622	8.35	27.6	0.04	1.8	0.1	139.7	1.2
NM483[F]	350530	1064452	8/4/1998	5,320	749	739	744	416.	4/21/1997	monitoring	PVC	714	7.75	27.2	0.05	5.25	0.7	161.6	2.8
NM484[F]	350530	1064452	8/5/1998	5,320	438	388	433	391.3	4/21/1997	monitoring	PVC	500	8.96	23.2	2.97	8.49	0.1	99.9	2.4
NM492[G]	345650	1064159	7/29/1998	4,900	1,340	1,330	1,335	17.89	12/18/1997	monitoring	PVC	548	8.42	22.5	0.14	3.57	0.3	113.1	1.6
NM509	353534	1064251	8/4/1998	5,655	608	353	603	102.27	36011	monitoring	PVC	858	7.35	21.2	3.58	36.4	7.0	159.9	8.9
NM516[H]	350910	1064148	7/22/1998	5,110	1,644	1,634	1,639	178.75	8/8/1997	monitoring	PVC	858	8.71	24.8	0.03	6.19	0.5	171.6	1.6
NM519	350449	1064931	8/5/1998	5,796	1,179	1,139	1,179	884.95	4/12/1994	monitoring	PVC	1,239	7.76	29.3	0.91	28.9	3.9	225.7	8.8
NM520	350449	1064931	8/1/1998	5,796	1,121	980	1,121	886.8	4/12/1994	monitoring	PVC	589	8.38	28.5	2. 0	6.83	0.4	117.1	3.3
NM521	351046	1064648	8/7/1998	5,730	1,805	1,525	1,795	796.97	4/12/1994	monitoring	PVC	322	8.14	21.8	4. 0	15.2	2.3	52.6	4.3
DB031	342753	1064855	4/11/1995	4,746	210	200	210	9.74	4/11/1995	well	--	874	8.05	20.2	<0.10	28.0	11.0	140.0	7.3
DB073	344500	1064603	4/9/1995	4,830	355	345	355	7.22	4/9/1995	well	--	648	8.58	18.1	2.20	7.1	1.7	130.0	3.2
DB074	344522	1064320	4/6/1995	4,829	160	150	160	8.88	4/6/1995	well	--	479	8.39	17.5	0.30	11.0	3.7	86.0	5.1
DB108	345111	1064641	3/12/1975	--	--	--	--	--	--	well	--	511	7.70	18.5	--	17.0	6.4	84.0	5.0
DB109	345113	1064641	7/16/1975	--	--	--	--	--	--	well	--	688	8.60	29.0	5.60	13.0	1.0	130.0	6.0
DB189	350256	1063909	2/27/1974	--	765	189	765	30.24	5/20/1982	well	--	514	8. 0	20.5	--	23.0	5.4	77.0	8.3
DB191	350308	1064334	8/25/1973	--	--	--	--	--	--	well	--	524	8.90	30.0	--	6.1	0.4	110.0	2.0
DB232	350449	1064931	1/17/1983	5,790	1,179	980	1,179	881.	1/25/1982	well	--	1,250	7.78	32.0	--	22.0	5.2	240.0	7.4

Sample reference number	Latitude (dms)	Longitude (dms)	Sample date	Elevation of land surface datum (feet above sea level)	Depth of well, total (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	Casing material	Specific conductance (µS/cm)	pH, field (standard units)	Water temperature (deg. C)	Dissolved oxygen (mg/L)	Calcium (mg/L as Ca)	Magnesium (mg/L as Mg)	Sodium (mg/L as Na)	Potassium (mg/L as K)
DB234	350453	1064454	6/28/1972	--	--	--	--	--	--	well	--	657	8.60	30.0	--	--	--	--	--
DB253	350612	1064409	12/1/1978	--	--	--	--	--	--	well	--	440	8.50	30.0	--	2.5	0.2	100.0	1.4
DB453	353533	1064253	4/4/1974	--	220	--	--	101.98	1/24/1984	well	--	704	8.10	15.0	--	64.0	9.2	69.0	9.6
ATI01	350418	1064124	na	4,945	1,295	280	1,283	47.	3/19/1996	production	--	570	8.77	31.5	--	7.98	1.3	107.4	1.5
COL01	350646	1064433	na	5,336	1,662	660	1,650	434.8	2/19/1998	production	--	484	8.65	28.0	--	3.6	0.4	104.2	1.1
COL03	350723	1064233	na	5,180	1,490	432	1,440	--	--	production	--	474	8.17	24.6	--	11.9	2.2	88.9	4.7
LEV02	350248	1064340	na	5,073	1,133	281	1,121	162.6	1/7/1998	production	--	503	8.70	23.9	--	4.4	0.5	105.5	1.2
LEV03	350228	1064358	na	5,080	1,520	514	1,500	244.	1/23/1996	production	--	695	9. 0	33.4	--	2.45	0.1	140.4	<1.0
VC02	350912	1064341	na	5,328	900	528	876	460.	3/21/1996	production	--	361	8. 0	24.0	--	20.98	4.7	48.8	6.6
VC03	351000	1064345	na	5,345	1,315	659	1,302	468.	3/21/1996	production	--	387	8.08	24.4	--	16.08	3.5	61.5	5.8
WM01	350428	1064418	na	5,175	1,176	504	1,176	299.	3/30/1996	production	--	501	8.99	29.5	--	1.92	0.1	108.1	<1.0
WM02	350508	1064356	na	5,165	1,402	394	1,402	279.	4/8/1993	production	--	444	8.60	25.0	--	5.12	0.8	91.9	1.5
WM04	350449	1064320	na	5,105	1,287	387	1,275	226.	3/30/1996	production	--	486	8.88	29.8	--	3.26	0.3	112.1	<1.0
ZAM01	350919	1064251	na	5,168	970	450	950	233.4	1/28/1998	production	--	416	7.92	24.2	--	20.33	3.7	59.9	7.2
								Western Boundary zone											
NM167	343649	1065738	8/29/1996	5,188	428	388	428	370.5	10/18/1993	windmill	PVC	1,598	7.84	22.2	5.79	32.9	13.4	269.5	10.0
NM263	342924	1065505	6/24/1997	4,850	143	--	--	112.47	2/9/1995	windmill	steel	3,091	7.67	29.5	3.21	72.82	31.5	526.0	15.4
NM266	343539	1070055	6/21/1997	5,249	439	--	--	--	--	windmill	steel	4,738	7.56	19.8	3.40	60.05	21.3	1,075.8	41.5
NM278	343907	1065729	6/23/1997	5,190	395	390	395	349.	3/24/1963	windmill	steel	3,735	7.37	23.5	7.35	302.82	99.0	364.0	13.4
NM285	343841	1070244	6/21/1997	5,434	620	--	--	545.49	5/24/1956	windmill	steel	4,405	7.30	16.5	2.30	125.66	45.3	809.0	30.7
NM320	341841	1065317	6/30/1997	4,905	212	173	212	164.08	10/31/1995	production	steel	2,766	7.62	20.3	12.32	135.0	50.0	375.0	9.9
NM329	342934	1070604	7/2/1997	5,654	630	--	--	--	--	windmill	steel	1,783	7.83	23.1	4.77	226.6	56.4	165.0	5.3
NM345	343230	1065707	6/25/1997	5,004	281	269	279	207.33	5/8/1956	windmill	steel	3,510	7.78	27.6	2.90	68.5	28.6	651.0	16.4
DB032	342802	1065724	10/22/1982	5,125	405	--	--	352.	5/28/1980	well	--	1,810	7.60	22.0	--	93.0	41.0	220.0	9.3
DB036	342947	1070649	3/18/1981	--	--	--	--	--	--	well	--	1,850	8.10	18.5	--	200.0	57.0	200.0	3.7
								Rio Puerco zone											
NM058	343748	1065021	8/16/1996	5,191	590	590	590	385.	10/31/1995	domestic	steel	1,379	7.40	25.8	4.24	142.0	42.3	124.3	8.7
NM062	343447	1065545	8/16/1996	5,035	268	--	--	224.79	5/9/1956	windmill	steel	3,234	7.34	22.2	5.01	307.0	101.0	327.8	13.2
NM079	343634	1064951	8/16/1996	5,169	657	637	657	400.	7/27/1994	domestic	PVC	1,893	7.46	26.0	0.04	193.0	65.4	154.0	12.6

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NM137	345218	1070018	8/21/1996	5,125	212	--	--	133.6	1/26/1993	windmill	steel	5,420	7.07	19.5	0.38	372.0	149.0	830.5	15.2
NM262	342707	1065325	6/24/1997	4,771	61	--	--	34.44	2/2/1993	windmill	steel	3,804	7.62	25.0	4.27	153.47	64.2	610.0	15.0
NM324	350204	1065623	6/16/1997	5,280	150	--	--	75.25	10/30/1995	domestic	PVC	2,378	7.34	18.0	0.16	298.0	88.6	290.0	8.3
NM335	352136	1065622	7/1/1997	5,860	na	na	na	na	na	spring	na	1,120	7.47	21.3	1.20	60.26	16.9	165.0	3.3
NM341	343053	1065518	6/24/1997	5,010	440	--	--	--	--	windmill	steel	2,502	7.70	19.0	4.67	150.38	53.5	279.0	14.4
NM342	343146	1065340	6/24/1997	4,849	90	--	--	52.1	11/21/1949	windmill	steel	3,457	7.20	21.5	4.06	338.87	105.0	341.0	18.0
NM408	345132	1065452	9/10/1997	5,423	700	--	--	580.2	1/25/1993	windmill	steel	1,275	6.50	22.0	6.50	80.8	36.1	133.0	7.2
NM409	345231	1065617	9/10/1997	5,570	720	--	--	599.2	5/11/1993	windmill	steel	2,250	7.76	20.0	2.00	316.0	70.3	131.0	10.4
Southwestern Mountain Front zone																			
NM009	342426	1065559	8/19/1996	5,080	316	--	--	--	--	windmill	steel	447	8.31	30.7	4.43	37.1	12.0	36.6	2.5
Abo Arroyo zone																			
NM011	342914	1063719	8/17/1996	5,181	400	--	--	--	--	domestic	steel	819	7.15	22.1	6.98	91.0	32.2	43.6	2.5
NM064	342516	1064260	8/19/1996	5,032	360	320	360	280.	3/12/1996	domestic	PVC	922	7.45	23.6	6.82	90.1	33.7	49.2	3.4
NM067	343024	1064431	8/15/1996	4,910	350	340	350	150.	7/26/1992	domestic	PVC	400	7.95	22.8	3.88	31.9	6.0	39.8	6.2
NM261	342732	1063133	6/23/1997	5,373	192	--	--	170.95	6/23/1997	stock	steel	1,583	7.37	18.5	5.64	181.28	71.7	84.4	2.4
Eastern Mountain Front zone																			
NM002	350900	1062746	6/21/1996	6,490	55	--	--	30.49	6/21/1996	domestic	PVC	401	7.52	12.0	9.20	71.0	14.8	13.9	2.7
NM006	344132	1063050	8/24/1996	5,634	42	--	--	13.02	1957	windmill	steel	273	7.72	18.1	7.65	35.7	5.6	14.6	0.6
NM016	350559	1063339	6/22/1996	5,324	1,055	456	1,032	386.	1968	production	steel	381	7.71	20.5	4.02	44.1	3.5	30.4	2.6
NM031	344451	1063734	8/14/1996	5,067	480	460	480	350.	--	domestic	PVC	254	7.85	22.8	4.19	27.0	5.3	17.5	2.4
NM042	351000	1062816	6/25/1996	6,455	95	20	95	28.	6/3/1983	production	--	543	7.35	17.0	6.20	84.8	13.2	17.6	2.3
NM043	350804	1062829	7/2/1996	6,440	na	na	na	na	na	spring	na	884	7.27	17.7	3.40	127.0	30.8	22.1	6.0
NM060	350955	1063003	6/19/1996	5,988	600	570	590	392.	7/24/1993	domestic	PVC	402	7.43	17.8	8.65	66.5	7.2	12.5	1.8
NM068	350302	1063332	6/25/1996	5,383	1,199	550	800	427.	8/1/1949	production	steel	392	7.59	21.4	7.20	49.0	7.4	22.4	3.0
NM078	350517	1063145	6/22/1996	5,462	1,170	596	1,096	589.	1993	production	steel	288	7.46	24.2	5.65	29.9	2.2	29.3	2.4
NM080	343323	1063826	8/15/1996	5,055	352	337	352	240.	1/3/1991	domestic	PVC	284	8.06	25.8	3.60	16.2	5.7	36.4	1.7
NM095	344822	1063160	8/14/1996	5,510	150	--	--	80.	--	production	steel	264	7.71	18.0	7.80	36.3	2.5	16.7	1.4
NM106	350931	1063156	6/20/1996	5,647	1,800	964	1,693	754.	1993	production	steel	562	7.55	27.0	1.63	60.5	2.7	47.4	5.0
NM108	350413	1063313	6/22/1996	5,385	1,475	620	1,436	472.	11/15/1974	production	steel	329	7.75	22.7	4.64	38.6	4.4	22.1	3.4

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NM134	344832	1063618	8/14/1996	5,176	600	580	600	320.	2/15/1996	domestic	PVC	317	7.77	23.1	3.22	31.4	7.4	20.4	2.2
NM138	345504	1063313	8/23/1996	5,350	44	--	--	23.1	1/27/1993	windmill	steel	532	7.59	18.0	--	74.2	12.6	21.2	1.4
NM141	351031	1063007	6/26/1996	5,978	800	560	760	361.	7/17/1988	production	steel	314	7.51	21.2	7.57	49.3	5.3	16.0	1.4
NM142	351031	1063007	6/26/1996	5,978	603	383	583	360.	7/8/1988	production	steel	379	7.39	20.3	7.75	58.2	6.7	18.7	1.7
NM148	351903	1062917	8/23/1996	5,462	580	560	580	324.	12/14/1994	domestic	PVC	385	7.48	20.6	4.29	61.1	6.5	14.7	1.8
NM153	351838	1063052	8/23/1996	5,338	400	375	395	225.	11/24/1993	domestic	PVC	543	7.30	25.6	1.88	65.2	4.8	44.1	4.5
NM156	352001	1062353	8/17/1996	6,080	300	260	300	225.	6/16/1982	domestic	PVC	490	7.06	17.4	6.78	60.7	13.4	31.6	2.0
NM157	351115	1063027	6/19/1996	5,943	550	510	530	400.	8/6/1992	domestic	PVC	288	7.62	21.4	8.02	42.2	2.6	17.6	1.5
NM161	343142	1063232	8/15/1996	5,380	640	598	638	390.	8/29/1994	domestic	PVC	371	8.47	25.9	5.75	4.53	0.2	78.8	1.4
NM162	350720	1063305	6/21/1996	5,408	1,536	760	1,520	536.	1993	production	steel	521	7.63	22.9	1.36	58.2	4.7	37.0	3.3
NM174	351025	1063140	6/18/1996	5,699	1,723	991	1,711	802.	1993	production	steel	448	7.69	26.8	2.50	50.4	2.5	34.7	3.1
NM177	344629	1063827	8/15/1996	5,050	368	348	368	220.	11/5/1993	domestic	PVC	445	7.53	21.2	4.86	46.1	11.6	27.7	4.5
NM256	344103	1063218	6/24/1997	5,450	270	260	270	220.	5/17/1995	windmill	PVC	128	9.75	17.8	0.15	7.4	5.5	8.4	1.1
NM257	352148	1062733	6/19/1997	5,320	360	310	360	240.	6/21/1983	production	--	455	7.52	19.1	8.16	74.26	4.3	10.4	1.3
NM295	343236	1064605	6/26/1997	4,781	160	150	160	8.	6/24/1991	domestic	PVC	413	8. 0	19.0	0.59	25.96	5.9	55.6	6.2
NM298	350857	1062954	6/17/1997	5,985	447	439	445	373.	2/22/1972	domestic	steel	390	7.62	17.4	7.95	59.43	8.7	14.9	1.6
NM299	342047	1063708	6/27/1997	5,512	196	--	--	114.65	7/26/1949	windmill	steel	479	8.06	20.8	6.98	40.79	16.6	34.7	1.3
NM300	352137	1062338	6/19/1997	5,760	150	--	--	70.		domestic	steel	714	7.30	16.1	5.83	84.42	16.7	54.2	2.6
NM306	345848	1063357	7/5/1997	5,304	607	547	587	417.46	7/5/1997	monitoring	steel	515	7.39	21.3	5.63	58.8	15.3	22.9	4.6
NM312[I]	351114	1063306	7/3/1997	5,460	1,525	1,515	1,520	538.48	6/6/1997	monitoring	PVC	816	8.10	22.8	0.23	27.9	5.0	118.0	5.4
NM313[I]	351114	1063306	7/2/1997	5,460	1,193	1,183	1,188	540.22	6/6/1997	monitoring	PVC	843	7.84	22.5	0.28	41.5	8.0	102.0	8.0
NM317	343530	1063343	6/30/1997	5,320	460	--	--	--	--	stock	steel	214	8.06	23.1	7.18	22.58	3.0	17.3	1.0
NM318	350042	1063353	7/7/1997	5,330	617	577	597	451.16	7/7/1997	monitoring	steel	416	7.56	20.5	5.16	48.41	7.9	23.4	3.4
NM319	343338	1063553	6/27/1997	5,137	400	390	400	290.	7/16/1988	domestic	PVC	224	8.47	21.9	5.24	12.6	2.7	29.9	0.9
NM328	343802	1063233	6/24/1997	5,440	420	--	--	335.	1962	windmill	steel	368	8.55	20.3	1.79	9.06	1.9	65.5	1.2
NM336	343524	1064120	6/27/1997	4,970	480	460	480	320.	6/8/1996	domestic	PVC	383	7.89	23.6	0.15	27.4	5.4	40.0	3.6
NM343	344012	1063617	6/24/1997	5,160	380	--	--	--	--	windmill	steel	388	7.85	25.0	5.83	42.44	4.1	29.5	2.2
NM407	344945	1063726	9/10/1997	5,142	440	--	--	313.1	5/18/1993	windmill	steel	517	7.65	21.5	4.70	55.8	9.3	34.4	3.1
NM500[J]	350653	1063116	7/31/1998	5,575	1,520	1,460	1,500	727.44	7/18/1997	monitoring	steel	264	7.23	21.9	1.25	26.2	1.0	29.3	2.4

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NM501[J]	350653	1063116	8/1/1998	5,575	1,045	1,020	1,040	720.38	7/18/1997	monitoring	steel	322	7.38	21.1	2.86	20.9	1.4	49.3	2.5
NM502[J]	350653	1063116	8/1/1998	5,575	705	600	700	582.64	7/18/1997	monitoring	steel	311	7.28	20.7	5.45	40.1	3.6	20.8	2.1
NM505[K]	345758	1063642	7/25/1998	5,326	525	420	520	406.76	6/20/1997	monitoring	steel	357	7.35	23.1	1.97	30.8	7.5	30.8	5.0
NM515	350950	1062948	7/28/1998	6,060	495	420	490	445.16	7/28/1998	monitoring	PVC	437	7.05	16.6	8.78	67.0	8.0	13.1	1.6
NM523	351136	1063050	7/30/1998	5,880	1,100	698	1,098	474.	1/19/1966	production	steel	295	7.56	22.6	5.56	48.2	4.6	24.7	1.8
DB040	343158	1064529	6/12/1980	--	--	--	--	22.75	6/12/1980	well	--	281	8.30	22.0	--	29.0	9.0	23.0	4.6
DB244	350529	1063038	10/4/1973	--	--	--	--	--	--	well	--	339	8. 0	24.5	--	37.0	3.3	28.0	2.4
DB247	350537	1063106	11/14/1973	5,575	--	--	--	--	--	well	--	283	8.20	25.0	--	19.0	0.9	41.0	1.9
DB282	350800	1063145	2/14/1974	--	--	--	--	--	--	well	--	275	7.90	25.5	--	30.0	1.4	26.0	2.0
DB328	350957	1063043	3/16/1995	--	655	645	655	475.	8/11/1989	well	--	376	7.67	18.0	--	50.0	3.8	17.0	1.3
DB329	351001	1063124	3/15/1995	--	930	877	882	830.	7/21/1986	well	--	317	7.62	13.6	--	43.0	3.4	19.0	1.3
DB330	351004	1062957	3/24/1995	--	515	495	505	--	--	well	--	454	7.47	17.0	--	71.0	8.2	14.0	1.7
DB338	351029	1063220	3/15/1995	--	670	640	670	535.	2/13/1987	well	--	604	7.37	15.4	--	59.0	5.2	54.0	2.4
DB345	351055	1062954	3/22/1995	--	632	495	505	--	--	well	--	416	7.31	18.0	--	53.0	7.1	20.0	1.5
LOM05	350421	1063124	na	5,494	1,670	830	1,658	644.22	12/30/1997	production	--	333	7.90	26.7	--	28.81	3.9	39.6	2.5
LOM06	350408	1063110	na	5,529	1,704	880	1,692	676.77	12/30/1997	production	--	421	7.68	25.0	--	45.93	6.8	39.1	2.8
LOV03	350512	1063218	na	5,405	1,260	600	1,260	553.	4/29/1996	production	--	309	7.80	23.2	--	36.7	1.8	26.9	2.4
LOV04	350512	1063257	na	5,370	1,284	600	1,284	540.	4/12/1996	production	--	364	7.70	22.7	--	46.45	2.6	27.6	2.7
LOV05	350450	1063240	na	5,390	1,248	660	1,248	552.03	4/14/1997	production	--	325	7.75	22.6	--	38.84	3.0	26.5	2.7
LOV06	350553	1063138	na	5,505	1,521	753	1,509	651.33	1/8/1997	production	--	260	7.91	25.3	--	24.45	1.0	33.1	1.6
LOV07	350608	1063213	na	5,440	1,485	645	1,473	581.	4/5/1994	production	--	326	7.71	24.0	--	40.3	1.6	26.4	2.2
LOV08	350539	1063330	na	5,316	1,455	640	1,440	463.3	1/12/1998	production	--	440	7.67	21.7	--	49.77	4.6	33.7	3.0
PON02	350802	1063152	na	5,600	1,581	801	1,569	735.64	2/9/1998	production	--	328	7.75	25.4	--	42.56	1.7	27.0	1.9
PON03	350821	1063210	na	5,527	1,602	870	1,590	667.	2/27/1996	production	--	630	7.56	28.1	--	58.08	5.9	54.6	4.9
PON04	350836	1063148	na	5,629	1,549	936	1,738	766.5	12/29/1997	production	--	352	7.75	26.3	--	42.0	1.6	35.0	1.9
PON05	350916	1063151	na	5,630	1,626	939	1,613	746.33	1/9/1997	production	--	445	7.69	25.8	--	52.06	2.1	35.7	2.2
PON06	350852	1063220	na	5,558	1,675	852	1,662	672.42	12/29/1997	production	--	634	7.59	27.8	--	48.82	7.1	65.1	5.4
RIG01	350405	1063219	na	5,442	1,260	636	1,260	277.	4/10/1996	production	--	400	7.53	22.7	--	52.4	7.6	29.0	2.5
RIG02	350424	1063235	na	5,416	1,512	730	1,500	566.42	1/12/1998	production	--	328	7.84	23.8	--	33.61	3.3	27.7	2.7

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TOM01	350753	1063256	na	5,445	1,092	624	1,092	595.	4/9/1996	production	--	472	7.60	22.2	--	55.4	3.7	37.9	2.1
TOM02	350749	1063235	na	5,490	1,224	696	1,224	629.	4/9/1996	production	--	443	7.62	24.5	--	52.01	3.3	40.7	2.1
TOM03	350816	1063313	na	5,415	1,200	672	1,200	551.	7/18/1994	production	--	473	7.58	21.4	--	54.3	4.6	43.7	2.0
TOM04	350813	1063241	na	5,485	1,020	672	1,020	622.	12/18/1995	production	--	500	7.61	24.0	--	60.09	4.2	52.0	2.3
TOM08	350712	1063231	na	5,462	1,655	835	1,635	605.77	2/23/1998	production	--	579	7.58	26.0	--	69.62	4.3	39.5	3.4
WLK02	351024	1063212	na	5,596	1,786	852	1,773	694.	4/11/1996	production	--	631	7.70	28.8	--	39.11	5.8	79.2	5.1
									Tijeras Fault Zone zone										
NM029	345957	1062812	6/28/1996	5,840	na	na	na	na	na	spring	na	3,500	6.46	17.5	2.77	322.0	70.3	382.0	43.7
NM061	345555	1063151	8/23/1996	5,437	na	na	na	na	na	spring	na	849	7.54	18.2	4.77	77.3	31.2	58.3	1.9
NM071	345757	1062905	6/28/1996	5,790	114	79	104	85.8	12/6/1993	monitoring	steel	1,360	7.34	19.4	4.54	156.0	27.7	100.0	9.1
NM136	345335	1062932	8/23/1996	5,725	295	--	--	203.6	5/18/1993	windmill	steel	1,405	8.18	20.3	0.25	22.1	14.0	259.6	3.2
NM151	345650	1063122	8/24/1996	5,494	362	312	352	162.61	11/3/1995	monitoring	PVC	1,407	6.64	19.8	5.66	171.0	39.6	90.1	6.7
NM152	345650	1063122	8/24/1996	5,494	222	182	212	163.5	11/3/1995	monitoring	PVC	1,189	6.94	20.7	5.46	127.0	30.6	84.7	5.4
									Tijeras Arroyo zone										
NM001	350340	1062940	6/29/1996	5,669	70	25	65	57.25	1994	monitoring	PVC	1,214	7.27	16.4	4.97	146.0	49.1	45.1	4.9
NM069	350230	1063124	6/25/1996	5,466	1,327	670	1,327	545.	2/27/1972	production	steel	517	7.37	23.4	6.97	67.8	12.2	29.3	3.2
NM075	350431	1063028	6/22/1996	5,595	1,300	700	1,300	731.	1993	production	steel	507	7.33	22.2	7.43	63.1	13.1	28.4	3.8
NM250	350319	1063014	7/3/1997	5,647	1,200	650	1,180	616.17	9/30/1957	production	steel	717	7.47	15.8	14.66	98.88	31.3	26.5	2.7
NM277	350259	1063158	7/4/1997	5,457	615	550	610	566.33	5/10/1964	monitoring	steel	474	7.69	19.7	6.35	56.4	10.0	23.8	1.8
DB202	350337	1062912	5/20/1992	--	8	--	--	2.36	5/26/1992	well	--	1,080	7.24	15.7	--	130.0	30.0	55.0	4.1
DB203	350337	1062940	5/20/1992	--	12	--	--	9.26	5/26/1992	well	--	980	7.51	16.0	--	110.0	27.0	52.0	5.0
DB205	350338	1062928	5/20/1992	--	12	--	--	5.25	5/26/1992	well	--	980	7.40	16.2	--	120.0	28.0	53.0	4.2
DB213	350410	1063023	9/19/1973	--	--	--	--	--	--	well	--	630	7.60	15.5	--	80.0	19.0	27.0	3.7
									Northeastern zone										
NM097	352713	1062056	8/28/1996	5,496	800	520	760	347.2	4/8/1993	production	steel	1,284	7.37	20.9	0.18	135.0	35.2	94.0	9.4
NM258	352633	1062018	6/18/1997	5,520	55	--	--	25.08	1979	windmill	steel	1,252	8.35	18.7	10.61	24.93	4.7	236.0	3.8
NM259	352617	1061624	6/18/1997	5,780	300	--	--	240.	--	windmill	steel	528	8.19	19.4	6.58	28.43	2.8	76.3	1.8
NM276	353025	1062122	6/25/1997	5,382	--	--	--	--	--	production	--	1,282	7.15	16.8	2.80	146.26	31.8	91.4	5.8
NM332	352345	1062516	7/3/1997	5,320	175	--	--	115.	1/1/1956	windmill	steel	538	7.57	19.5	14.40	71.07	14.5	27.3	3.0

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NM334	352506	1062400	7/3/1997	5,260	286	268	286	130.	10/31/1979	production	steel	1,579	7.32	19.3	6.73	279.13	57.1	87.3	4.4
NM338	352820	1061559	6/25/1997	5,594	292	--	--	--	--	windmill	steel	1,079	7.58	18.6	6.29	104.03	30.0	73.7	5.1
DB410	352257	1062753	9/25/1974	--	--	--	--	--	--	well	--	1,050	--	19.5	--	150.0	22.0	50.0	3.0
DB411	352303	1062746	9/25/1974	--	--	--	--	--	--	well	--	1,880	6.40	21.5	--	210.0	51.0	180.0	11.0
DB442	353329	1062040	3/7/1995	5,225	138	131	138	24.28	3/7/1995	well	--	724	7.33	17.1	2.20	69.0	18.0	58.0	6.1
									Central zone										
NM004	350533	1064131	6/22/1996	4,960	31	26	31	12.55	1994	monitoring	steel	390	7.60	19.3	0.12	42.8	7.0	26.3	4.7
NM005	350516	1064121	6/20/1996	4,950	813	180	804	13.	1993	production	steel	450	8.04	18.6	0.15	29.6	5.4	56.7	7.3
NM012	350421	1063613	6/19/1996	5,284	857	425	845	418.	1993	production	steel	378	7.76	21.2	2.89	40.0	7.5	24.0	5.5
NM013	350355	1063517	6/19/1996	5,275	1,170	550	1,150	415.1	35404	production	steel	361	7.81	21.9	0.41	37.7	7.3	23.6	4.8
NM025	345205	1063942	8/21/1996	4,974	182	142	172	121.	--	production	steel	859	7.36	17.4	0.79	125.0	14.4	44.9	5.3
NM028	351023	1063418	6/18/1996	5,288	1,186	479	1,184	384.	1993	production	steel	558	7.90	22.8	0.72	36.0	7.8	62.1	7.9
NM032	350641	1064006	6/20/1996	4,960	1,000	204	924	34.	1993	production	steel	593	7.61	20.2	0.03	45.0	9.6	59.1	10.6
NM057	350811	1064003	6/21/1996	4,968	916	260	916	20.	1993	production	steel	399	6.84	19.4	0.17	34.9	6.3	37.9	7.7
NM063	345345	1064513	8/21/1996	5,016	167	147	167	150.1	1/26/1996	windmill	steel	451	7.49	18.0	3.20	32.2	6.8	52.0	7.5
NM066	350404	1063825	6/28/1996	4,997	163	148	158	114.67	1994	monitoring	PVC	653	7.60	19.8	0.03	76.1	15.3	35.5	7.9
NM070	350301	1063546	6/25/1996	5,322	1,000	380	1,000	360.	1969	production	steel	336	7.79	21.7	0.66	37.9	6.8	20.5	4.0
NM073	351038	1063552	6/29/1996	5,093	233	218	228	145.64	1994	monitoring	PVC	715	7.69	16.1	0.07	115.0	13.4	26.7	6.6
NM074	350752	1063423	6/21/1996	5,285	1,000	468	996	413.	1993	production	steel	311	7.87	19.1	0.93	43.4	3.6	18.3	2.6
NM081	350810	1063719	6/27/1996	5,018	200	185	195	116.21	1994	monitoring	PVC	500	7.82	17.6	0.01	69.4	14.4	20.0	5.5
NM082	350836	1063956	6/19/1996	4,970	147	138	143	20.7	1/24/1996	monitoring	steel	477	7.61	16.7	0.08	56.6	14.9	18.2	9.1
NM083	350836	1063956	6/19/1996	4,970	99	90	95	17.1	1/24/1996	monitoring	steel	629	7.54	15.4	0.03	75.2	19.8	21.2	12.0
NM084	350836	1063956	6/19/1996	4,970	40	30	35	14.28	1/24/1996	monitoring	steel	673	7.50	15.7	0.02	92.3	12.9	37.9	7.9
NM085	350821	1063837	6/20/1996	4,975	132	123	128	45.33	1/24/1996	monitoring	steel	429	7.73	17.3	0.09	50.8	11.4	18.3	8.2
NM086	350821	1063837	6/19/1996	4,974	94	85	90	42.8	1/24/1996	monitoring	steel	914	7.24	17.4	0.06	123.0	26.6	45.6	9.8
NM088	350859	1064019	6/24/1996	4,977	150	135	145	9.79	12/17/1992	monitoring	PVC	417	7.63	18.1	0.06	41.7	9.8	26.7	7.8
NM089	350859	1064019	6/24/1996	4,977	75	60	70	7.39	12/17/1992	monitoring	PVC	378	7.69	14.3	0.08	44.8	7.4	20.5	3.5
NM090	350859	1064019	6/24/1996	4,977	25	10	20	7.46	12/17/1992	monitoring	PVC	370	7.35	22.4	0.08	41.2	7.6	21.8	4.2
NM091[L]	**350834**	**1063958**	**6/18/1996**	**4,970**	**983**	**972**	**978**	**31.**	**11/10/1994**	**monitoring**	**PVC**	**374**	**7.87**	**18.4**	**0.05**	**33.5**	**6.4**	**35.8**	**8.7**

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NM092[L]	**350834**	**1063958**	**6/18/1996**	**4,970**	**836**	**826**	**831**	**30.01**	**11/10/1994**	**monitoring**	**PVC**	**311**	**8.81**	**20.5**	**0.08**	**32.0**	**5.7**	**24.4**	**9.2**
NM093[L]	**350834**	**1063958**	**6/18/1996**	**4,970**	**568**	**558**	**563**	**28.25**	**11/10/1994**	**monitoring**	**PVC**	**311**	**8.82**	**18.2**	**0.05**	**37.2**	**7.6**	**17.0**	**7.9**
NM094[L]	**350834**	**1063958**	**6/18/1996**	**4,970**	**182**	**172**	**177**	**20.62**	**11/10/1994**	**monitoring**	**PVC**	**393**	**8.26**	**16.8**	**0.08**	**44.2**	**12.3**	**17.5**	**8.1**
NM099	350329	1063917	6/27/1996	4,940	51	46	51	17.65	1994	monitoring	steel	331	7.98	18.1	0.02	41.2	7.4	22.8	6.6
NM100	351057	1063842	6/26/1996	4,989	150	135	145	16.42	12/17/1992	monitoring	PVC	354	8.20	16.0	0.03	42.9	7.2	14.8	4.1
NM101	351057	1063842	6/26/1996	4,989	95	80	90	11.63	12/17/1992	monitoring	PVC	461	7.94	16.5	0.01	60.9	8.6	18.7	3.2
NM102	351057	1063842	6/26/1996	4,989	45	30	40	11.81	12/17/1992	monitoring	PVC	487	7.96	18.0	0.01	59.1	7.9	30.6	4.1
NM103	351057	1063842	6/26/1996	4,990	23	13	23	10.6	8/2/1993	monitoring	PVC	673	7.74	17.8	0.01	89.8	12.1	33.3	6.7
NM104[M]	351035	1063647	6/21/1996	5,006	544	539	544	69.95	8/24/1993	monitoring	PVC	268	6.83	18.1	0.17	32.1	6.8	14.4	3.8
NM105[M]	351035	1063647	6/21/1996	5,006	144	139	144	53.2	8/24/1993	monitoring	PVC	812	6.84	17.7	0.11	121.0	16.0	39.4	7.2
NM111	350137	1064105	6/17/1996	4,931	38	28	33	10.5	4/4/1995	monitoring	steel	596	7.34	20.2	0.10	85.8	10.9	27.9	5.8
NM112	350138	1063955	6/25/1996	4,929	154	144	149	12.23	1/24/1996	monitoring	steel	429	8.14	19.0	0.06	26.9	6.5	49.1	10.7
NM113	350138	1063955	6/25/1996	4,929	91	81	86	11.47	1/24/1996	monitoring	steel	619	7.81	19.9	0.05	56.5	13.6	48.0	12.0
NM114	350138	1063955	6/25/1996	4,929	49	39	44	11.31	1/24/1996	monitoring	steel	610	7.70	20.7	0.06	59.7	12.4	47.8	9.9
NM115	350135	1063906	6/25/1996	4,933	149	139	144	22.55	1/24/1996	monitoring	steel	339	7.97	21.7	0.04	39.7	7.9	14.5	6.8
NM116	350135	1063906	6/25/1996	4,933	124	114	119	23.79	1/24/1996	monitoring	steel	819	7.38	20.4	0.04	96.3	19.8	22.5	10.5
NM126	343940	1064238	8/15/1996	4,958	670	290	660	158.	5/14/1984	production	steel	467	7.65	26.1	0.62	32.1	8.0	50.1	8.0
NM127	344355	1064060	8/15/1996	5,010	602	330	590	190.5	8/31/1985	production	steel	316	7.73	22.8	0.05	30.8	8.6	17.7	5.6
NM140	350338	1063832	6/20/1996	4,992	1,000	264	996	96.	1993	production	steel	418	7.91	27.0	0.61	30.7	6.6	41.4	9.5
NM147	350648	1063625	6/19/1996	5,139	1,000	312	984	257.	1993	production	steel	313	7.85	20.4	0.33	34.4	4.7	22.4	4.2
NM158	**351051**	**1063953**	**7/1/1996**	**4,995**	**840**	**710**	**790**	**41.9**	**6/28/1996**	**monitoring**	**PVC**	**250**	**8.99**	**16.5**	**0.02**	**16.0**	**1.7**	**32.7**	**3.2**
NM159	**351051**	**1063953**	**7/1/1996**	**4,995**	**1,055**	**870**	**1,050**	**43.71**	**6/28/1996**	**monitoring**	**PVC**	**208**	**8.67**	**16.5**	**0.02**	**17.0**	**3.5**	**19.3**	**6.2**
NM171	350030	1064221	6/27/1996	4,923	64	59	64	8.24	1994	monitoring	steel	951	7.48	18.1	0.02	125.0	17.8	50.2	9.1
NM172	350732	1063504	6/21/1996	5,208	1,016	360	852	332.	1993	production	steel	300	7.92	19.6	0.58	42.0	4.2	15.9	2.4
NM173	350805	1063611	6/18/1996	5,112	1,020	260	900	222.	1993	production	steel	371	7.90	18.0	0.26	48.6	5.8	17.7	3.0
NM175	351029	1063320	6/18/1996	5,436	1,484	620	1,345	530.	1993	production	steel	441	7.83	22.1	1.05	32.8	5.7	48.2	5.9
NM178	350427	1063729	6/19/1996	5,159	1,000	336	960	267.	1993	production	steel	376	7.77	22.0	1.62	41.7	7.3	24.3	6.0
NM270	350656	1064112	6/26/1997	4,954	950	144	950	4.	5/6/1905	production	steel	415	7.86	17.7	0.21	32.55	6.3	42.1	7.8
NM271	350628	1064122	7/5/1997	5,100	105	95	100	6.62	2/27/1997	monitoring	PVC	385	7.84	15.8	0.08	40.17	7.7	23.3	6.8

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NM272	350628	1064122	7/5/1997	5,100	75	65	70	7.07	2/27/1997	monitoring	PVC	388	7.83	17.2	0.06	41.61	6.7	24.8	5.6
NM273	350628	1064122	7/5/1997	5,100	50	40	45	6.78	2/27/1997	monitoring	PVC	408	7.75	16.4	0.08	45.94	7.7	22.4	5.2
NM274	350628	1064122	7/5/1997	5,100	30	20	25	7.09	2/27/1997	monitoring	PVC	424	7.72	14.9	0.04	49.96	8.0	23.5	3.7
NM275	350628	1064122	7/5/1997	5,100	25	15	20	7.21	2/27/1997	monitoring	PVC	414	7.70	15.9	0.01	47.59	7.8	22.2	3.5
NM279[N]	350706	1063903	6/19/1997	4,964	1,020	995	1,010	49.44	10/24/1996	monitoring	PVC	425	8.14	26.7	0.21	14.63	2.3	67.5	6.4
NM280[N]	350706	1063903	6/19/1997	4,964	582	552	572	48.28	10/24/1996	monitoring	PVC	368	7.96	22.9	0.18	21.01	5.0	45.4	8.2
NM283	351421	1063822	6/20/1997	5,230	315	300	315	221.5	6/20/1997	domestic	PVC	498	7.66	17.8	0.05	54.08	9.1	23.1	7.2
NM286[O]	**351200**	**1064008**	**6/20/1997**	**5,110**	**1,518**	**1,508**	**1,513**	**162.73**	**10/24/1996**	**monitoring**	**PVC**	**423**	**8.02**	**23.1**	**0.22**	**19.26**	**3.0**	**69.7**	**6.4**
NM287[O]	**351200**	**1064008**	**6/21/1997**	**5,110**	**855**	**845**	**850**	**158.61**	**10/24/1996**	**monitoring**	**PVC**	**354**	**7.71**	**20.6**	**0.15**	**42.75**	**7.3**	**18.3**	**8.0**
NM288[O]	**351200**	**1064008**	**6/20/1997**	**5,110**	**238**	**148**	**228**	**146.11**	**10/24/1996**	**monitoring**	**PVC**	**652**	**7.65**	**19.8**	**3.11**	**67.26**	**15.6**	**40.5**	**6.7**
NM289[O]	**351200**	**1064008**	**6/21/1997**	**5,110**	**359**	**349**	**354**	**150.65**	**10/24/1996**	**monitoring**	**PVC**	**446**	**7.79**	**19.5**	**0.20**	**48.93**	**8.3**	**28.1**	**6.5**
NM290[O]	**351200**	**1064008**	**6/21/1997**	**5,110**	**305**	**295**	**300**	**147.95**	**10/24/1996**	**monitoring**	**PVC**	**483**	**7.67**	**18.6**	**0.07**	**57.06**	**11.4**	**26.3**	**5.7**
NM291[O]	351200	1064008	6/21/1997	5,110	268	238	258	147.39	10/24/1996	monitoring	PVC	589	7.64	18.7	1.11	72.2	15.3	29.2	6.1
NM292	351318	1063918	7/2/1997	5,227	2,020	730	2,000	269.	4/26/1994	production	steel	378	7.78	20.3	0.26	39.66	5.9	29.7	7.3
NM305	350949	1064242	6/17/1997	5,197	326	--	--	264.49	6/17/1997	domestic	steel	377	7.71	23.8	1.15	37.38	7.7	26.1	9.2
NM307	351019	1064040	6/17/1997	5,064	275	259	274	103.05	10/30/1995	domestic	PVC	500	7.79	18.6	1. 0	61.74	9.3	20.0	9.3
NM309	351215	1064216	6/18/1997	5,280	1,000	350	800	302.	10/5/1963	production	steel	391	7.89	21.7	0.98	31.19	5.5	38.5	7.8
NM315	350107	1063543	6/17/1997	5,145	462	305	410	262.	1/6/1982	production	steel	289	8. 0	20.4	--	35.81	3.8	17.9	2.2
NM316	344818	1064007	6/27/1997	4,895	210	200	210	55.4	4/3/1995	domestic	PVC	357	7.76	19.2	0.05	40.22	9.5	16.6	2.7
NM321	350445	1063341	6/26/1997	5,344	1,424	572	1,412	431.	12/11/1974	production	steel	393	7.84	21.4	1.45	44.94	5.6	24.8	3.5
NM323[D]	350140	1064016	7/4/1997	4,958	150	135	145	7.3	1/9/1992	monitoring	PVC	439	8.17	15.5	0.03	18.17	4.2	69.5	6.9
NM325	351340	1064014	6/20/1997	5,266	751	508	751	295.	7/1/1963	production	steel	472	7.74	17.8	1.57	58.6	9.2	20.2	6.5
NM331	352552	1062701	7/3/1997	5,050	110	65	100	23.	7/15/1977	production	steel	527	7.62	16.0	1.06	81.8	12.8	27.2	4.7
NM333	352552	1062701	7/3/1997	5,050	557	517	547	14.8	12/5/1986	production	steel	298	7.43	17.1	0.06	38.11	7.1	12.1	3.9
NM339[P]	350908	1063444	6/30/1997	5,340	1,308	1,298	1,303	348.09	10/24/1996	monitoring	PVC	544	7.70	20.5	0.74	29.46	8.2	62.3	9.2
NM340[P]	350908	1063444	6/27/1997	5,340	799	789	794	348.34	10/24/1996	monitoring	PVC	289	7.78	18.6	0.14	32.55	5.0	17.0	2.8
NM344	345934	1064033	6/17/1997	4,920	109	--	--	12.25	12/18/1980	domestic	PVC	688	7.44	16.0	0.11	77.46	12.6	48.6	9.1
NM348[E]	350638	1064137	6/23/1997	5,100	689	679	684	161.91	10/24/1996	monitoring	PVC	412	7.81	24.4	0.19	25.44	4.1	50.5	8.8

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NM349[E]	**350638**	**1064137**	**6/24/1997**	**5,100**	**437**	**422**	**427**	**155.32**	**10/24/1996**	**monitoring**	**PVC**	**400**	**7.88**	**20.0**	**0.21**	**30.49**	**4.9**	**42.5**	**9.0**
NM350[E]	**350638**	**1064137**	**6/24/1997**	**5,100**	**328**	**318**	**323**	**155.25**	**10/24/1996**	**monitoring**	**PVC**	**461**	**7.80**	**18.7**	**0.14**	**39.45**	**7.1**	**40.8**	**9.1**
NM351[E]	**350638**	**1064137**	**6/24/1997**	**5,100**	**254**	**244**	**249**	**155.57**	**10/24/1996**	**monitoring**	**PVC**	**430**	**7.75**	**17.0**	**0.24**	**43.88**	**8.2**	**31.9**	**8.4**
NM352[E]	350638	1064137	6/24/1997	5,100	173	143	163	155.51	10/24/1996	monitoring	PVC	447	7.41	16.4	1.41	53.7	8.6	24.6	4.5
NM488[Q]	350534	1063547	7/21/1998	5,210	1,567	1,557	1,562	336.69	10/24/1996	monitoring	PVC	489	7.73	21.1	0.50	22.0	5.3	75.6	7.3
NM489[Q]	350534	1063547	7/21/1998	5,210	842	832	837	345.61	10/24/1996	monitoring	PVC	516	7.42	21.2	0.45	48.9	7.6	46.6	5.6
NM490[Q]	350534	1063547	7/21/1998	5,210	425	315	415	348.66	10/24/1996	monitoring	PVC	753	7.39	18.6	3.26	90.2	16.4	25.3	5.6
NM491[N]	350706	1063903	7/28/1998	4,964	93	43	83	43.51	10/24/1996	monitoring	PVC	881	6.78	17.8	0.06	122.9	21.3	43.2	6.7
NM493[G]	345650	1064159	7/29/1998	4,900	815	805	810	7.26	12/18/1997	monitoring	PVC	425	7.79	20.2	0.03	10.8	1.6	85.3	5.1
NM494[G]	345650	1064159	7/29/1998	4,900	185	175	180	6.08	12/18/1997	monitoring	PVC	291	7.56	18.4	0.03	30.2	4.7	22.0	5.1
NM495[G]	345650	1064159	7/29/1998	4,900	50	10	40	6.42	12/18/1997	monitoring	PVC	875	7.21	17.4	0.04	118.5	16.1	59.2	7.5
NM503[K]	345758	1063642	8/2/1998	5,326	1,630	1,580	1,620	400.56	6/20/1997	monitoring	steel	458	8.44	27.9	0.03	3.49	0.1	95.3	1.1
NM504[K]	345758	1063642	7/25/1998	5,326	1,015	990	1,010	412.48	6/20/1997	monitoring	steel	428	8.10	23.6	0.04	4.51	0.2	86.2	1.0
NM506[R]	350056	1063701	7/27/1998	5,100	708	698	703	216.06	10/2/1997	monitoring	PVC	359	7.51	23.8	0.04	30.8	7.2	26.7	8.0
NM507[R]	350056	1063701	7/27/1998	5,100	330	260	320	211.22	10/2/1997	monitoring	PVC	315	7.52	20.9	1.59	31.6	4.3	26.0	4.2
NM508[I]	351114	1063306	7/20/1998	5,460	608	538	598	540.73	6/6/1997	monitoring	PVC	373	7.74	21.0	0.41	26.1	4.2	48.7	4.5
NM511[S]	351357	1063230	7/30/1998	5,440	1,305	1,295	1,300	485.77	6/26/1998	monitoring	PVC	622	7.43	21.1	1.14	24.1	6.8	92.9	7.4
NM513[S]	351357	1063230	7/30/1998	5,440	535	485	525	479.12	6/26/1998	monitoring	PVC	735	8.53	18.6	0.14	79.5	12.6	51.9	8.6
NM517[H]	350910	1064148	7/22/1998	5,110	928	918	923	153.04	8/8/1997	monitoring	PVC	416	8.39	22.4	0.05	7.95	1.1	83.8	5.9
NM518[H]	350910	1064148	7/22/1998	5,110	210	140	200	148.79	8/8/1997	monitoring	PVC	462	7.56	19.2	4.55	30.4	5.6	62.2	6.5
NM522	344431	1063934	8/6/1998	5,020	1,200	1,185	1,195	195.98	8/6/1998	monitoring	PVC	478	7.51	27.6	0.02	20.2	5.3	69.4	5.8
DB093	344900	1064158	4/9/1995	4,852	187	177	187	5.78	4/9/1995	well	--	317	8. 0	15.8	0.10	31.0	9.7	17.0	6.7
DB094	344916	1064304	4/12/1995	4,853	178	173	178	3.53	4/12/1995	well	--	309	8.13	14.8	0.10	31.0	7.5	16.0	8.1
DB133	345653	1064218	8/6/1985	--	65	--	--	--	--	well	--	670	7.70	16.2	--	88.0	10.0	44.0	5.3
DB135	345711	1064110	8/5/1993	--	17	6	16	4.08	8/5/1993	well	--	400	8.04	16.0	0.10	41.0	5.5	32.0	3.5
DB136	345718	1064215	8/9/1985	--	119	--	--	--	--	well	--	520	7.70	17.5	--	75.0	10.0	23.0	7.2
DB139	345810	1064034	4/23/1995	4,907	220	210	220	8.99	4/23/1995	well	--	373	7.97	16.2	0.10	33.0	6.5	28.0	5.9
DB140	345851	1064316	8/16/1985	--	176	--	--	--	--	well	--	450	8. 0	18.0	--	50.0	11.0	20.0	7.4
DB141	345919	1064128	8/13/1993	--	19	9	19	6.25	8/13/1993	well	--	800	7.25	18.1	0.10	120.0	17.0	47.0	10.0

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DB145	345956	1063908	8/5/1985	--	305	--	--	--	--	well	--	350	7.70	23.8	--	34.0	6.5	28.0	8.0
DB148	350003	1064040	8/8/1985	--	58	--	--	--	--	well	--	500	8. 0	15.5	--	30.0	6.1	66.0	6.6
DB150	350005	1064054	8/8/1985	--	50	--	--	--	--	well	--	420	7.70	15.0	--	42.0	6.5	42.0	4.5
DB151	350029	1064221	8/17/1993	--	13	7	12	7.29	8/17/1993	well	--	982	7.27	23.4	0.91	110.0	13.0	76.0	8.8
DB153	350037	1063927	8/5/1985	--	103	--	--	--	--	well	--	580	7.60	20.5	--	82.0	13.0	24.0	7.8
DB162	350135	1063906	11/9/1993	--	149	139	144	--	--	well	--	350	7.18	19.5	--	36.0	7.0	17.0	6.9
DB168	350138	1063932	11/8/1993	--	148	138	143	--	--	well	--	400	7.92	18.5	--	35.0	2.9	21.0	12.0
DB169	350138	1063932	11/8/1993	--	101	91	96	--	--	well	--	370	8.18	18.5	--	30.0	6.4	28.0	8.8
DB170	350138	1063932	11/8/1993	--	49	39	44	--	--	well	--	640	8.19	18.0	--	51.0	13.0	60.0	11.0
DB176	350204	1064112	9/15/1985	--	18	--	--	--	--	well	--	925	7.30	16.8	--	130.0	14.0	75.0	6.9
DB180	350223	1064208	9/19/1985	--	70	--	--	--	--	well	--	825	7.60	16.8	--	85.0	13.0	88.0	6.3
DB181	350223	1064208	9/19/1985	--	24	--	--	--	--	well	--	760	7.50	16.9	--	97.0	14.0	70.0	7.5
DB185	350238	1063824	6/25/1980	--	--	--	--	--	--	well	--	595	7.10	23.5	--	84.0	14.0	30.0	6.2
DB186	350241	1064207	9/28/1993	--	28	18	28	9.57	9/28/1993	well	--	479	7.72	18.1	2.65	51.0	7.9	35.0	5.4
DB188	350255	1063844	6/25/1980	--	--	--	--	--	--	well	--	465	7.40	26.0	--	34.0	7.3	48.0	8.1
DB190	350301	1063837	6/25/1980	--	503	360	503	59.1	6/30/1982	well	--	400	7.60	26.0	--	28.0	6.7	40.0	8.8
DB194	350313	1063747	6/25/1980	--	--	--	--	--	--	well	--	400	7.50	25.0	--	34.0	7.2	33.0	6.9
DB197	350316	1064020	8/16/1993	--	20	10	20	10.46	8/16/1993	well	--	711	7.27	16.5	0.05	89.0	12.0	40.0	5.4
DB207	350336	1063912	8/11/1993	--	29	14	29	12.1	8/11/1993	well	--	420	7.60	17.2	0.05	48.0	6.9	25.0	3.4
DB228	350436	1064117	8/10/1993	--	28	18	28	9.96	8/10/1993	well	--	750	7.23	18.6	0.20	85.0	11.0	61.0	7.4
DB230	350447	1063952	8/4/1993	--	18	8	18	7.69	8/4/1993	well	--	490	7.47	17.7	0.10	61.0	8.8	29.0	4.1
DB246	350534	1064131	8/17/1993	--	16	11	16	11.24	8/17/1993	well	--	574	7.51	18.9	0.20	68.0	10.0	30.0	4.5
DB259	350639	1063805	8/29/1984	--	--	--	--	--	--	well	--	870	7.20	17.5	4.70	97.0	15.0	79.0	7.3
DB260	350639	1064100	8/4/1993	--	27	16	26	14.7	8/4/1993	well	--	500	7.75	16.0	0.10	60.0	8.0	35.0	4.9
DB262	350647	1064110	8/17/1984	--	--	--	--	--	--	well	--	350	7.90	15.0	0.20	44.0	5.9	25.0	3.7
DB265	350702	1063937	8/27/1984	--	--	--	--	--	--	well	--	790	7.30	16.0	0.20	99.0	17.0	43.0	9.5
DB269	350706	1064013	8/22/1984	--	--	--	--	--	--	well	--	900	7.40	16.0	0.10	120.0	18.0	68.0	8.9
DB270	350718	1064036	8/21/1984	--	--	--	--	--	--	well	--	530	7.80	17.5	0.30	71.0	12.0	30.0	7.6
DB273	350734	1064004	8/10/1984	--	--	--	--	--	--	well	--	790	7.60	17.0	0.20	80.0	13.0	80.0	8.1

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DB275	350743	1064101	8/14/1984	--	--	--	--	--	--	well	--	420	7.80	15.0	0.10	50.0	6.8	28.0	4.2
DB283	350807	1064033	8/22/1984	--	--	--	--	--	--	well	--	630	7.40	14.0	0.20	71.0	13.0	44.0	5.7
DB286	350815	1063722	8/9/1984	--	--	--	--	--	--	well	--	590	7.90	17.5	0.20	63.0	11.0	23.0	4.3
DB288	350821	1063837	8/13/1985	--	132	123	128	--	--	well	--	270	7.92	17.5	--	30.0	6.7	17.0	6.2
DB292	350825	1064017	8/13/1984	--	--	--	--	--	--	well	--	487	7.80	16.0	0.20	51.0	7.2	41.0	3.5
DB294	350827	1063913	9/13/1985	--	150	140	145	--	--	well	--	700	7.24	16.5	--	98.0	29.0	30.0	15.0
DB295	350827	1063913	9/13/1985	--	99	90	95	--	--	well	--	800	7.35	15.5	--	88.0	24.0	65.0	14.0
DB296	350827	1063913	9/13/1985	--	50	40	45	--	--	well	--	910	7.25	15.5	--	130.0	22.0	55.0	7.3
DB299	350828	1063820	8/20/1984	--	--	--	--	--	--	well	--	610	7.70	17.0	0.20	81.0	16.0	27.0	5.5
DB308	350854	1064037	8/14/1985	--	152	140	145	--	--	well	--	419	7.90	17.0	--	51.0	10.0	31.0	6.5
DB309	350854	1064037	8/14/1985	--	93	83	88	--	--	well	--	315	8.14	16.0	--	30.0	6.2	31.0	6.5
DB310	350854	1064037	8/14/1985	--	48	40	45	--	--	well	--	430	7.94	15.0	--	47.0	8.7	31.0	6.9
DB312	350859	1063906	8/17/1984	--	--	--	--	--	--	well	--	570	7.60	16.0	0.40	73.0	19.0	25.0	8.2
DB317	350907	1063945	8/14/1984	--	--	--	--	--	--	well	--	700	7.40	15.0	0.10	100.0	13.0	42.0	5.4
DB318	350908	1063820	8/20/1984	--	--	--	--	--	--	well	--	760	7.40	17.0	0.20	110.0	27.0	31.0	7.1
DB320	350928	1063805	8/27/1984	--	--	--	--	--	--	well	--	380	7.80	18.0	0. 0	43.0	9.6	17.0	4.2
DB340	351034	1063456	3/13/1995	--	--	--	--	261.2	2/24/1993	well	--	600	7.52	16.6	--	83.0	13.0	23.0	3.6
DB350[T]	351059	1063859	1/5/1994	--	150	135	145	19.56	2/14/1992	well	--	430	8.04	12.5	--	55.0	9.1	18.0	4.7
DB351[T]	351059	1063859	1/4/1994	--	25	10	20	6.76	12/3/1992	well	--	386	7.95	8.5	--	46.0	7.3	22.0	2.9
DB352[T]	351059	1063859	1/5/1994	--	600	545	555	37.71	12/3/1992	well	--	323	8.02	15.3	--	37.0	6.9	16.0	6.4
DB353	351106	1063436	3/14/1995	--	364	352	362	275.	10/9/1980	well	--	527	8.09	15.3	--	73.0	13.0	21.0	3.6
DB354	351108	1063336	3/15/1995	--	575	--	--	--	--	well	--	344	7.65	17.5	--	27.0	6.7	32.0	6.1
DB355	351109	1063655	8/1/1993	--	27	17	27	17.36	8/1/1993	well	--	800	7.20	19.7	1.80	130.0	12.0	36.0	6.1
DB357	351120	1063816	5/4/1995	4,993	300	260	280	29.26	5/4/1995	well	--	280	8.05	14.3	0.10	31.0	5.8	14.0	4.5
DB358	351125	1063646	8/1/1993	--	31	21	31	15.17	8/1/1993	well	--	700	7.28	18.3	0.20	95.0	12.0	35.0	5.1
DB362	351221	1063606	8/18/1993	--	16	10	15	11.15	8/18/1993	well	--	765	7.12	17.5	0.20	110.0	14.0	33.0	5.1
DB367	351311	1063628	8/12/1993	--	17	7	17	5.9	8/12/1993	well	--	420	7.77	16.0	0.05	48.0	6.8	28.0	3.3
DB372	351338	1063605	3/6/1995	5,011	250	240	250	40.	5/7/1993	well	--	317	8. 0	15.0	<0.05	32.0	11.0	14.0	5.7
DB373	351347	1063706	8/12/1993	--	29	18	28	17.94	8/12/1993	well	--	900	7.17	16.0	3.80	130.0	27.0	34.0	1.5

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DB375	351421	1063632	9/27/1993	--	40	25	40	20.63	9/23/1993	well	--	751	7.24	17.1	4.10	100.0	12.0	28.0	4.1
DB376	351422	1064042	12/12/1974	5,370	--	--	--	--	--	well	--	352	7.40	13.0	--	28.0	5.0	36.0	7.6
DB379	351446	1064006	12/12/1974	5,356	--	--	--	--	--	well	--	348	7.50	16.0	--	31.0	5.9	30.0	6.4
DB413	352307	1062756	9/25/1974	--	550	--	--	24.	1/15/1956	well	--	749	6.60	25.5	--	65.0	15.0	77.0	11.0
ATI02	350445	1064115	na	4,945	544	108	250	15.	11/30/1996	production	--	584	7.50	18.3	--	44.44	9.3	66.0	8.7
ATI04	350509	1064142	na	4,950	500	98	475	12.32	2/9/1998	production	--	465	7.79	21.5	--	27.67	5.8	61.6	6.6
BUR01	350359	1063624	na	5,315	1,312	676	1,292	447.03	12/29/1997	production	--	411	7.84	24.5	--	30.99	7.0	39.8	6.0
BUR03	350439	1063559	na	5,215	994	358	994	360.	3/19/1996	production	--	391	7.70	20.6	--	42.68	7.8	26.0	4.1
BUR04	350343	1063634	na	5,275	1,276	636	1,276	440.	3/27/1996	production	--	440	7.86	26.2	--	28.37	6.6	48.2	6.8
CHW01	350628	1063348	na	5,315	1,056	456	1,032	477.	4/23/1996	production	--	346	7.80	19.6	--	38.1	3.0	31.4	2.0
CHW02	350605	1063415	na	5,262	1,020	432	996	411.18	1/26/1998	production	--	314	7.76	19.0	--	39.9	3.5	21.8	1.9
CHW03	350640	1063427	na	5,275	1,020	420	996	405.	5/27/1990	production	--	305	7.83	18.4	--	39.39	3.6	19.7	1.8
CHW05	350615	1063460	na	5,222	1,400	625	1,385	357.62	1/12/1998	production	--	337	7.75	19.4	--	40.55	4.3	24.2	2.5
COR02	351007	1063439	na	5,242	1,390	590	1,390	330.05	12/18/1998	production	--	451	7.76	20.8	--	31.55	7.8	49.2	5.3
DUR02	350711	1064047	na	4,970	804	180	804	22.11	12/29/1997	production	--	418	7.88	19.1	--	27.59	5.6	49.0	6.6
DUR03	350630	1064043	na	4,962	950	132	950	23.72	12/29/1997	production	--	505	7.67	19.0	--	39.54	8.0	54.2	7.4
DUR04	350628	1064115	na	4,960	950	144	950	13.75	2/9/1998	production	--	441	7.97	19.6	--	20.4	4.0	67.4	6.5
DUR05	350606	1064116	na	4,960	950	152	950	10.85	2/9/1998	production	--	436	7.90	20.4	--	23.69	4.5	60.7	6.2
DUR06	350653	1064030	na	4,962	500	260	500	32.6	12/29/1997	production	--	511	7.39	19.0	--	52.57	12.3	42.3	9.7
GON02	350635	1064150	na	5,100	1,115	400	1,100	152.28	12/30/1997	production	--	432	7.89	25.3	--	22.21	4.2	62.1	6.9
GRG01	350823	1063950	na	4,972	802	232	802	30.56	1/27/1998	production	--	405	7.56	17.9	--	41.17	11.5	23.6	8.2
GRG02	350749	1064007	na	4,965	820	164	820	29.	6/8/1994	production	--	482	7.57	18.5	--	47.01	11.8	34.3	8.6
GRG04	350824	1063902	na	4,975	804	218	804	48.	3/13/1996	production	--	344	7.70	18.6	--	29.37	8.1	36.0	7.5
LYN02	350729	1063407	na	5,298	996	468	996	436.15	12/16/1997	production	--	324	7.71	18.9	--	42.21	3.5	22.8	2.4
LYN03	350815	1063438	na	5,265	996	456	996	393.4	12/16/1997	production	--	301	7.84	18.0	--	40.05	4.2	17.3	2.1
LYN04	350814	1063407	na	5,325	996	480	996	455.	12/5/1996	production	--	338	7.67	19.2	--	42.91	4.3	23.7	2.0
MIL01	350307	1063748	na	5,154	1,165	404	1,153	260.7	12/15/1997	production	--	424	7.88	25.5	--	34.95	7.5	41.0	7.4
RIG05	350420	1063345	na	5,355	1,470	636	1,260	418.98	2/10/1998	production	--	378	7.72	22.3	--	41.42	5.7	24.4	2.9
SJ01	350316	1063848	na	4,950	600	--	--	41.13	12/15/1997	production	--	570	7.34	19.0	--	56.53	13.4	36.2	9.2

Sample reference number	Latitude (dms)	Longitude (dms)	Sample date	Elevation of land surface datum (feet above sea level)	Depth of well, total (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	Casing material	Specific conductance (µS/cm)	pH, field (standard units)	Water temperature (deg. C)	Dissolved oxygen (mg/L)	Calcium (mg/L as Ca)	Magnesium (mg/L as Mg)	Sodium (mg/L as Na)	Potassium (mg/L as K)
SJ03	350343	1063901	na	4,952	1,032	192	1,032	41.3	12/15/1997	production	--	433	8.09	24.3	--	17.56	4.1	65.4	6.1
TOM05	350744	1063335	na	5,356	1,450	722	1,450	489.79	2/23/1998	production	--	384	7.56	21.3	--	40.31	3.7	36.9	2.4
TOM07	350712	1063339	na	5,347	1,475	659	1,460	481.96	2/23/1998	production	--	399	7.63	21.3	--	42.75	3.9	35.8	2.7
VAN01	350805	1063548	na	5,144	972	300	972	262.99	1/12/1998	production	--	375	7.85	17.2	--	54.7	6.6	21.2	2.3
VAN03	350741	1063616	na	5,110	900	264	900	230.01	1/8/1997	production	--	375	7.86	18.0	--	51.24	6.6	21.1	2.9
VAN04	350803	1063512	na	5,200	876	372	876	327.37	12/29/1997	production	--	313	7.88	17.0	--	43.01	4.8	16.9	1.9
VAN06	350826	1063525	na	5,178	984	324	984	294.95	12/29/1997	production	--	315	7.82	16.7	--	40.86	5.1	17.7	2.2
WEB02	351012	1063335	na	5,387	1,346	608	1,334	490.	12/14/1995	production	--	412	7.80	21.2	--	29.96	7.4	44.1	6.3
YAL02	350358	1063729	na	5,128	1,191	351	1,179	249.95	1/26/1998	production	--	420	7.70	23.1	--	37.1	8.0	33.1	6.9
YAL03	350435	1063800	na	5,080	1,004	320	992	204.	4/24/1989	production	--	471	7.63	24.7	--	44.28	9.2	38.6	7.8
									Discharge zone										
NM096	342608	1064647	8/19/1996	4,755	258	238	258	20.	12/7/1995	production	PVC	1,157	7.74	23.0	0.05	64.5	21.1	124.3	19.3
NM150	342104	1065301	8/19/1996	4,860	223	210	220	136.64	10/31/1995	domestic	PVC	3,076	7.70	20.6	0.06	93.0	49.0	495.0	8.5
NM327	342010	1065043	6/30/1997	4,730	130	120	130	20.	7/26/1983	domestic	PVC	2,452	7.57	20.9	1.84	237.93	53.2	212.3	10.5
DB009	342041	1065046	4/11/1995	4,725	89	84	88	21.45	4/11/1995	well	--	1,771	7.67	17.2	0.10	130.0	36.0	190.0	8.9
DB025	342650	1064303	5/30/1980	--	320	--	--	177.95	5/30/1980	well	--	3,400	7.60	17.5	--	98.0	31.0	770.0	8.6
DB029	342740	1064323	5/30/1980	--	380	--	--	120.6	5/30/1980	well	--	975	7.90	17.0	--	48.0	17.0	140.0	22.0
									Samples not included in final data set										
NM014[1]	350020	1065308	8/12/1996	5,488	746	555	616	570.	11/10/1988	monitoring	steel	11,700	6.18	25.4	0.82	561.0	108.0	2,190.0	135.0
NM041[1]	343030	1064046	8/17/1996	5,065	390	--	--	--	--	domestic	PVC	8,200	7.04	27.0	0.08	185.0	25.7	1,530.0	107.0
NM297[1]	343020	1063825	6/21/1997	5,131	560	540	560	460.	5/19/1997	domestic	PVC	1,075	7.01	53.8	--	97.85	33.4	63.1	8.6
NM524	353822	1064104	8/4/1998	5,840	na	na	na	na	na	spring	na	463	6.94	17.4	--	45.9	9.1	39.2	10.7
DB178	350312	1064040	8/16/1993	--	18	8	18	8.67	8/16/1993	well	--	2,400	7.24	17.6	0.10	180.0	35.0	300.0	3.0
DB403	351948	1063147	3/3/1995	5,092	80	65	75	35.06	3/3/1995	well	--	1,219	7.59	19.2	3.60	130.0	21.0	91.0	16.0

Sample reference number	Alkalinity (mg/L as HCO_3)	Sulfate (mg/L as SO_4)	Chloride (mg/L as Cl)	Fluoride (mg/L as F)	Bromide (mg/L as Br)	Silica (mg/L as SiO_2)	Nitrate (mg/L as N)	Arsenic (µg/L as As)	Boron (mg/L as B)	Iron (mg/L as Fe)	Lithium (mg/L as Li)	Manganese (mg/L as Mn)	Molybdenum (µg/L as Mo)	Strontium (mg/L as Sr)	Uranium (µg/L as U)	Vanadium (µg/L as V)	Zinc (µg/L as Zn)
Northern Mountain Front zone																	
NM026	178	17.6	4.1	0.33	0.08	29.7	0.88	1.8	0.032	0.024	0.008	<0.004	1.8	0.256	3.3	7.0	4.0
NM027	112	14.1	4.4	0.46	0.09	65.2	0.83	1.7	0.023	0.033	0.026	<0.004	1.8	0.161	0.8	5.8	2.0
NM055	102	20.9	178.3	0.96	0.46	41.9	0.96	7.6	0.197	0.057	0.289	<0.004	6.6	0.547	0.7	10.3	3.0
NM131	104	56.1	151.7	0.36	0.36	31.0	0.52	45.1	0.159	0.052	0.180	<0.004	1.0	0.801	1.0	17.0	2.8
NM143	128	52.1	11.6	0.65	0.17	60.1	0.91	5.6	0.076	0.060	0.059	0.015	2.3	0.511	3.1	9.3	700.0
NM168	91	7.3	3.2	0.28	<0.05	53.7	0.62	1.7	0.019	0.028	0.016	<0.004	0.7	0.082	0.3	6.3	18.0
NM486	124	16.5	5.0	0.76	0.07	65.7	0.59	4.5	0.024	0.025	0.030	<0.001	1.6	0.168	0.8	9.0	2.0
NM487	104	17.8	1.7	0.18	0.02	52.8	0.26	1.1	0.011	0.063	0.004	0.008	1.1	0.093	0.1	3.6	4,340.0
NM510	197	38.1	7.4	0.55	0.10	61.2	2.16	28.9	0.113	0.130	0.062	0.005	3.1	0.361	1.0	29.6	4,230.0
NM514	339	84.7	33.5	0.34	0.10	35.9	0.04	14.6	0.173	3.180	0.208	0.193	6.9	1.130	4.1	<1.0	1,140.0
NM525	203	28.5	14.1	0.29	0.08	38.3	3.03	24.2	0.050	0.089	0.060	0.005	1.0	0.630	2.0	1.4	349.0
NM527	146	11.1	2.4	0.18	0.02	54.3	<0.02	1.7	0.021	0.154	0.006	0.009	0.5	0.152	0.2	6.4	330.0
NM528	160	9.3	4.9	0.28	0.08	26.5	0.38	1.7	0.035	0.169	0.102	0.004	1.8	0.737	2.6	3.1	186.0
NM530	304	29.1	13.4	0.15	0.07	76.4	0.53	1.7	0.118	0.108	0.058	0.028	1.0	0.247	3.5	2.8	388.0
Northwestern zone																	
NM128	127	66.2	9.3	0.67	0.13	20.3	2.53	5.0	0.174	0.051	0.054	<0.004	4.8	0.656	6.9	15.3	4.0
NM133	202	100.1	78.2	1.08	0.22	30.2	1.36	11.0	0.365	0.064	0.266	<0.004	9.1	0.549	3.0	12.5	3.0
NM179	108	10.4	3.9	0.14	0.07	24.4	5.80	9.3	0.025	0.027	0.009	<0.004	0.3	0.684	0.9	15.6	816.0
NM180	139	28.6	4.7	0.35	0.05	24.0	11.51	4.8	0.088	0.033	0.022	0.005	1.5	1.150	2.5	7.4	255.0
NM184	160	24.7	2.7	0.37	<0.05	27.2	5.60	15.0	0.059	<0.010	0.029	<0.004	1.6	0.482	2.3	21.0	89.0
NM185	181	40.4	10.4	0.77	0.08	28.2	2.35	19.0	0.161	<0.010	0.088	<0.004	4.9	0.421	1.4	32.0	9.0
NM326	157	58.4	10.1	0.82	0.10	55.4	1.58	14.0	0.230	0.093	0.111	0.006	10.8	0.696	3.7	21.0	10.6
NM497[A]	155	42.5	7.7	0.99	0.11	57.1	4.72	10.0	0.166	0.023	0.089	0.003	8.4	0.566	2.7	17.6	5.0

Sample reference number	Alkalinity (mg/L as HCO_3)	Sulfate (mg/L as SO_4)	Chloride (mg/L as Cl)	Fluoride (mg/L as F)	Bromide (mg/L as Br)	Silica (mg/L as SiO_2)	Nitrate (mg/L as N)	Arsenic (μg/L as As)	Boron (mg/L as B)	Iron (mg/L as Fe)	Lithium (mg/L as Li)	Manganese (mg/L as Mn)	Molybdenum (μg/L as Mo)	Strontium (mg/L as Sr)	Uranium (μg/L as U)	Vanadium (μg/L as V)	Zinc (μg/L as Zn)
NM498[A]	123	28.7	4.4	0.76	0.07	70.6	5.81	9.8	0.118	0.021	0.068	<0.001	3.2	0.531	1.7	23.4	5.0
NM499[A]	123	17.2	4.6	0.61	0.06	65.9	5.60	5.4	0.080	0.023	0.057	<0.001	1.8	0.850	2.8	13.4	8.0
NM526	184	60.6	12.8	0.77	0.07	22.5	1.35	3.2	0.177	0.042	0.168	0.004	3.4	0.571	4.6	7.4	2,080.0
DB436	228	57.0	4.2	0.40	0.10	36.0	--	4.0	0.110	1.700	--	<0.010	--	--	--	--	--
DB447	211	20.0	3.0	0.40	0.03	33.0	--	15.0	0.050	0.020	--	<0.010	--	--	--	--	--
West-Central zone																	
NM003	134	96.5	9.9	0.81	<0.05	32.1	1.61	10.3	0.142	0.049	0.015	<0.004	8.7	0.340	2.6	26.5	12.0
NM007	176	193.2	26.2	0.98	0.02	35.7	1.65	2.7	0.227	<0.010	0.105	<0.004	8.6	0.831	3.8	8.7	2.0
NM008	171	170.7	19.4	1.11	0.14	42.1	1.76	3.4	0.222	0.045	0.096	<0.004	10.6	0.649	3.6	10.0	2.0
NM015	162	260.2	36.9	0.52	0.11	26.3	1.57	7.5	0.117	<0.010	0.042	<0.004	12.8	1.130	4.1	12.8	2.0
NM056	157	78.8	11.2	1.15	0.09	53.5	1.27	25.0	0.214	0.019	0.053	<0.004	4.3	0.221	4.2	46.0	--
NM076	184	71.8	11.3	0.94	0.07	57.3	0.02	18.0	0.181	0.023	0.022	<0.004	5.0	0.196	8.0	52.2	3.0
NM077	179	56.9	13.0	0.79	0.08	59.7	0.03	13.0	0.130	0.027	0.034	<0.004	4.2	0.182	9.3	41.0	<1.0
NM107	147	144.3	7.6	0.78	0.08	32.5	0.98	9.8	0.224	0.030	0.026	<0.004	15.9	0.213	5.0	42.9	18.2
NM109	124	166.7	32.7	1.45	0.20	31.2	1.10	31.0	0.442	0.051	0.049	0.004	11.3	0.140	4.3	40.0	--
NM110	119	151.6	27.1	1.57	0.17	36.4	1.00	40.0	0.330	0.028	0.052	<0.004	9.5	0.161	4.0	48.1	--
NM129	137	47.8	6.0	0.54	0.07	21.0	2.11	39.1	0.183	0.011	0.031	<0.004	6.2	0.109	1.9	42.3	<1.0
NM130	217	94.8	22.0	0.93	0.15	29.1	1.71	18.2	0.355	0.033	0.207	<0.004	8.0	0.713	4.7	13.0	6.0
NM132	143	75.2	4.6	0.90	0.08	21.8	1.50	45.4	0.217	0.046	0.030	<0.004	7.4	0.081	1.7	72.3	1.0
NM135	148	97.4	14.1	0.82	0.09	41.1	1.49	4.3	0.175	0.181	0.024	0.025	16.9	0.213	2.3	9.6	75.7
NM139	150	186.0	18.6	0.77	0.15	35.1	1.24	9.8	0.237	0.032	0.063	<0.004	11.2	0.566	6.3	22.9	16.0
NM144[B]	227	41.1	2.8	0.67	<0.05	15.8	1.24	111.0	0.209	0.039	0.090	<0.004	1.7	0.147	1.6	26.3	179.0
NM145[B]	226	29.7	1.6	0.71	<0.05	22.5	1.56	264.0	0.241	0.041	0.115	<0.004	1.0	0.207	1.3	119.0	218.0
NM146[B]	230	36.3	15.8	0.80	<0.05	23.3	0.69	230.0	0.249	0.049	0.147	<0.004	1.2	0.326	2.6	38.8	147.0
NM155	119	209.4	8.7	0.53	0.08	17.5	0.86	11.0	0.122	0.108	0.026	<0.004	11.6	0.386	2.3	26.0	2.3
NM181[C]	273	66.0	6.8	6.14	0.06	24.4	2.32	13.0	0.697	0.016	0.410	0.005	22.8	0.094	0.4	22.0	515.0
NM182[C]	270	61.8	7.2	5.70	0.06	23.7	2.28	21.0	0.619	0.024	0.397	<0.004	18.3	0.118	0.6	24.0	132.0
NM183[C]	279	207.7	204.7	3.09	0.46	25.9	2.35	17.0	0.621	0.085	0.649	<0.004	8.4	0.993	0.4	17.0	434.0
NM186	311	133.0	9.1	0.64	0.14	19.4	0.33	100.0	0.211	0.035	0.105	<0.004	5.8	0.258	1.2	16.0	<1.0

Sample reference number	Alkalinity (mg/L as HCO_3)	Sulfate (mg/L as SO_4)	Chloride (mg/L as Cl)	Fluoride (mg/L as F)	Bromide (mg/L as Br)	Silica (mg/L as SiO_2)	Nitrate (mg/L as N)	Arsenic (µg/L as As)	Boron (mg/L as B)	Iron (mg/L as Fe)	Lithium (mg/L as Li)	Manganese (mg/L as Mn)	Molybdenum (µg/L as Mo)	Strontium (mg/L as Sr)	Uranium (µg/L as U)	Vanadium (µg/L as V)	Zinc (µg/L as Zn)
NM255	121	114.4	8.6	0.71	0.09	12.7	0.02	2.9	0.128	0.120	0.010	0.007	7.3	0.317	1.0	4.5	20.1
NM260	178	144.7	15.8	1.02	0.12	57.1	2.04	8.3	0.268	0.046	0.000	0.000	14.9	0.462	4.9	28.1	49.6
NM264	184	62.4	6.6	0.99	0.11	30.6	2.30	33.3	0.292	0.020	0.000	0.000	6.2	0.073	5.5	84.8	10.1
NM294	176	70.5	12.9	1.19	0.14	33.4	2.78	37.3	0.212	0.021	0.033	0.001	4.5	0.091	6.6	66.0	2.4
NM308	138	38.7	9.6	0.73	0.10	65.0	2.88	7.9	0.111	0.052	0.032	0.005	2.8	0.424	8.2	19.9	4.8
NM310	165	67.8	10.4	0.94	0.08	68.7	1.10	28.0	0.190	0.045	0.052	0.005	4.0	0.274	3.7	50.3	7.4
NM311	149	53.0	6.5	0.81	0.07	56.7	2.90	10.3	0.178	0.057	0.037	0.005	5.9	0.334	8.6	22.5	8.1
NM322[D]	76	140.6	54.9	1.78	0.24	18.0	<0.01	23.6	0.411	0.054	0.051	0.006	12.5	0.142	1.2	17.3	1.9
NM346	147	50.8	8.4	0.95	0.08	62.3	1.27	13.6	0.151	0.071	0.042	0.009	3.3	0.371	4.4	26.3	15.8
NM347[E]	131	168.9	50.8	1.29	0.28	19.1	0.76	36.0	0.457	0.036	0.023	0.007	2.8	0.144	2.7	<1.0	<1.0
NM353	190	53.4	8.8	1.33	0.09	31.0	2.38	38.9	0.234	0.024	0.027	0.006	2.2	0.066	7.5	<1.0	<1.0
NM481[F]	363	242.9	194.4	2.10	0.27	27.4	0.04	38.9	0.843	0.023	0.264	0.005	15.4	0.525	15.2	53.0	<1.0
NM482[F]	252	87.8	12.7	1.11	0.08	20.2	0.04	51.8	0.296	0.014	0.078	0.009	5.8	0.065	86.3	12.0	<1.0
NM483[F]	331	95.7	4.0	2.08	0.05	16.5	0.01	11.9	0.368	0.023	0.048	0.039	10.0	0.198	6.0	<1.0	<1.0
NM484[F]	182	66.2	8.4	1.14	0.11	33.4	3.14	21.7	0.218	0.014	0.033	<0.001	8.0	0.181	3.7	50.2	<1.0
NM492[G]	122	114.7	22.1	1.96	0.13	22.9	1.17	95.8	0.505	0.015	0.018	0.004	11.5	0.037	1.4	173.2	2.0
NM509	445	90.9	13.4	0.58	0.12	25.5	1.83	22.9	0.857	0.038	0.464	<0.001	31.4	0.821	3.2	57.4	6.0
NM516[H]	181	183.4	39.3	0.89	0.23	18.5	<0.02	23.7	0.464	0.016	0.099	0.008	8.2	0.140	2.3	<1.0	2.0
NM519	244	258.5	96.3	0.89	0.22	46.9	0.19	25.4	0.343	0.041	0.118	0.120	33.3	0.661	1.2	3.3	6.0
NM520	155	118.8	17.9	0.60	0.09	18.6	0.93	7.2	0.134	0.021	0.027	0.012	8.2	0.105	1.3	9.1	19.0
NM521	136	33.9	6.0	0.83	0.08	17.8	3.61	2.1	0.108	0.274	0.035	0.024	4.7	0.485	4.7	4.0	10.0
DB031	163	200.0	58.0	1. 0	0.18	35.0	--	5.0	--	<0.003	--	<0.001	10.0	--	--	--	--
DB073	168	130.0	16.0	1.30	0.13	45.0	--	22.0	--	0.012	--	<0.001	12.0	--	--	--	--
DB074	174	69.0	16.0	1. 0	0.09	45.0	--	19.0	--	<0.003	--	<0.001	4.0	--	--	--	--
DB108	180	90.0	12.0	1.10	--	39.0	0.30	7.0	0.150	0.020		<0.010	--	--	--	--	--
DB109	146	160.0	13.0	1.20	--	68.0	0.83	24.0	0.450	0.070		<0.010	--	--	--	--	--
DB189	169	79.0	22.0	0.80	--	75.0	--	29.0	0.200	0.030	--	<0.010	--	--	--	--	--
DB191	165	84.0	13.0	1.10	--	40.0	--	45.0	0.260	0.030	--	0.020	--	--	--	--	--
DB232	252	220.0	100.0	0.80	--	49.0	--	31.0	--	0.500	--	0.088	--	--	--	--	--

Sample reference number	Alkalinity (mg/L as HCO_3)	Sulfate (mg/L as SO_4)	Chloride (mg/L as Cl)	Fluoride (mg/L as F)	Bromide (mg/L as Br)	Silica (mg/L as SiO_2)	Nitrate (mg/L as N)	Arsenic (µg/L as As)	Boron (mg/L as B)	Iron (mg/L as Fe)	Lithium (mg/L as Li)	Manganese (mg/L as Mn)	Molybdenum (µg/L as Mo)	Strontium (mg/L as Sr)	Uranium (µg/L as U)	Vanadium (µg/L as V)	Zinc (µg/L as Zn)
DB234	--	--	--	2.20	--	--	--	70.0	0.360	0.020	--	0.010	--	--	--	--	--
DB253	171	62.0	6.9	1. 0	--	30.0	--	28.0	--	0.030	--	0.005	--	--	--	--	--
DB453	185	190.0	4.9	0.50	0.10	30.0	--	12.0	0.240	3.700	--	0.020	--	--	--	--	--
ATI01	143	110.0	19.8	0.92	0.50	46.9	1.53	21.7	0.352	<0.010	0.150	<0.002	--	0.097	--	45.500	<5.0
COL01	200	55.3	5.5	1.50	0.50	28.7	2.91	48.9	0.317	0.011	0.040	<0.002	--	0.064	--	98.550	<5.0
COL03	157	79.2	11.4	1.22	0.50	49.9	1.19	24.7	0.251	<0.010	0.060	<0.002	--	0.203	--	43.400	<5.0
LEV02	183	68.1	18.8	1.46	0.50	29.8	1.31	34.0	0.269	<0.010	0.040	<0.002	--	0.059	--	70.900	<5.0
LEV03	160	133.0	31.6	1.02	0.50	38.6	1.78	34.6	0.322	<0.010	0.080	<0.002	--	0.052	--	74.200	<5.0
VC02	144	45.8	7.8	0.99	0.50	70.3	1.68	11.4	0.157	<0.010	0.050	<0.002	--	0.351	--	21.060	<5.0
VC03	152	47.7	7.4	1.00	0.50	65.2	1.91	15.0	0.181	<0.010	0.050	<0.002	--	0.266	--	27.750	<5.0
WM01	194	67.9	6.3	1.10	0.50	36.2	1.71	27.2	0.282	<0.010	0.040	<0.002	--	0.059	--	48.900	<5.0
WM02	184	49.4	7.3	1.33	--	32.4	--	39.5	0.229	<0.010	0.040	<0.002	--	0.079	--	60.000	<5.0
WM04	174	87.0	14.8	1.08	0.50	35.8	1.71	35.9	0.262	<0.010	0.040	<0.002	--	0.063	--	62.000	<5.0
ZAM01	157	57.4	9.2	0.78	0.50	70.8	0.86	14.4	0.173	<0.010	--	<0.002	--	0.317	--	27.300	<5.0
Western Boundary zone																	
NM167	240	413.9	94.9	1.64	0.43	18.4	1.09	1.7	0.555	<0.010	0.190	0.008	25.2	0.835	4.1	4.3	12.0
NM263	259	554.3	532.6	2.15	0.57	20.1	1.41	<1.0	0.382	0.158	0.174	0.066	6.2	2.090	2.3	2.2	25.5
NM266	924	919.2	649.8	3.92	0.38	64.2	0.59	<10.0	1.590	0.556	0.629	0.047	16.6	1.620	3.2	15.8	643.9
NM278	144	792.9	797.5	--	0.69	29.3	0.67	<1.0	0.366	0.463	0.312	0.027	2.2	4.850	4.8	5.4	210.7
NM285	632	583.4	880.6	2.05	0.38	23.1	1.55	<1.0	1.280	0.900	0.550	0.141	4.8	2.090	5.5	6.6	1,176.0
NM320	179	571.4	408.3	1.20	0.05	27.0	6.87	1.8	0.351	0.302	0.251	0.015	8.1	3.520	6.0	7.7	5.9
NM329	148	935.6	38.9	1.07	0.22	18.5	0.01	6.6	0.439	1.070	0.102	0.074	17.5	12.000	0.5	1.2	18.8
NM345	433	672.1	519.3	2.12	0.31	22.0	1.04	<10.0	1.110	0.205	0.433	0.036	11.7	1.400	10.0	6.0	275.2
DB032	246	290.0	300.0	0.80	--	23.0	--	<1	--	0.016	--	0.064	--	--	--	--	--
DB036	122	1,000.0	13.0	1.00	--	17.0	--	3.0	0.510	0.590	--	0.060	--	--	--	--	--
Rio Puerco zone																	
NM058	142	490.0	108.2	0.44	0.31	24.6	1.96	0.9	0.222	0.230	0.191	0.033	2.1	2.530	3.1	3.3	49.3
NM062	203	1,060.0	442.4	0.38	0.70	21.8	2.62	0.8	0.394	0.510	0.295	0.033	1.9	4.700	9.0	3.1	1,480.0
NM079	102	702.3	171.6	0.41	0.35	27.0	1.55	1.0	0.213	0.270	0.253	0.050	3.2	3.610	2.6	4.0	7.5

Sample reference number	Alkalinity (mg/L as HCO_3)	Sulfate (mg/L as SO_4)	Chloride (mg/L as Cl)	Fluoride (mg/L as F)	Bromide (mg/L as Br)	Silica (mg/L as SiO_2)	Nitrate (mg/L as N)	Arsenic (µg/L as As)	Boron (mg/L as B)	Iron (mg/L as Fe)	Lithium (mg/L as Li)	Manganese (mg/L as Mn)	Molybdenum (µg/L as Mo)	Strontium (mg/L as Sr)	Uranium (µg/L as U)	Vanadium (µg/L as V)	Zinc (µg/L as Zn)
NM137	351	2,130.0	590.7	0.63	1.19	21.8	1.10	6.2	1.110	1.570	0.767	0.121	18.0	6.180	37.0	18.0	180.0
NM262	309	902.6	582.1	1.68	0.60	26.3	1.64	1.3	0.881	0.261	0.327	0.028	7.2	4.180	12.5	4.1	51.3
NM324	486	1,107.0	117.9	1.03	0.28	22.7	0.11	<1.0	0.267	0.690	0.074	1.560	7.0	3.850	1.5	1.5	9.1
NM335	355	291.3	11.5	1.44	0.09	30.6	0.09	1.6	0.210	0.172	0.067	0.047	7.5	0.819	10.9	3.7	18.4
NM341	102	490.2	486.4	1.22	0.73	22.9	1.72	<1.0	0.344	0.310	0.253	0.031	9.3	3.920	2.1	3.4	649.8
NM342	257	1,303.0	346.2	0.41	0.68	29.7	1.48	<1.0	0.315	0.496	0.289	0.036	0.8	6.180	13.0	3.2	116.7
NM408	65	543.3	20.3	0.54	0.13	28.9	0.34	1.5	0.139	0.130	0.069	0.007	8.1	2.040	1.0	10.5	886.2
NM409	118	1,180.0	38.9	0.22	0.17	28.0	0.42	1.2	0.095	0.395	0.041	0.033	0.7	5.130	6.0	3.3	3,561.1
Southwestern Mountain Front zone																	
NM009	135	70.9	23.0	0.73	0.21	9.2	1.12	0.4	0.177	0.049	0.041	0.004	3.0	0.861	0.9	1.0	252.0
Abo Arroyo zone																	
NM011	171	263.6	23.8	0.48	0.18	21.8	1.38	2.6	0.073	0.105	0.020	0.010	3.7	1.200	2.9	10.0	49.0
NM064	147	311.1	22.2	1.27	0.16	23.5	1.48	7.7	0.160	0.131	0.049	<0.004	6.5	1.750	7.9	8.9	3.6
NM067	115	78.0	8.9	0.51	0.12	42.8	3.32	23.0	0.063	0.024	0.034	<0.004	3.0	0.505	1.2	18.0	2.0
NM261	198	687.4	42.1	0.89	0.29	16.2	0.99	1.3	0.148	0.369	0.028	0.036	3.0	2.130	9.1	3.9	12.7
Eastern Mountain Front zone																	
NM002	270	42.3	6.5	1.30	0.07	23.3	1.00	<1.0	0.014	0.075	0.015	0.006	1.6	0.176	6.1	2.0	--
NM006	130	26.8	6.0	0.19	0.08	18.5	<0.01	0.8	0.022	0.119	0.008	0.005	1.2	0.195	1.0	2.4	28.0
NM016	150	27.4	33.4	0.33	0.12	29.5	0.27	1.0	0.085	0.041	0.016	<0.004	1.0	0.287	2.1	4.0	--
NM031	121	20.1	6.7	0.45	0.09	40.9	0.46	16.0	0.031	0.030	0.009	<0.004	3.6	0.323	2.2	9.3	5.4
NM042	304	43.9	7.0	1.97	0.09	23.5	0.16	<2.0	0.030	0.052	0.023	0.005	1.0	0.225	21.0	2.0	--
NM043	468	98.6	10.3	0.98	0.23	32.7	0.44	<2.0	0.047	0.139	0.036	0.021	<1.0	0.342	10.7	3.0	--
NM060	224	20.2	6.0	1.62	0.10	21.6	2.80	<1.0	0.022	0.041	0.011	<0.004	0.7	0.151	5.6	1.0	--
NM068	172	52.8	9.1	0.51	0.12	27.2	0.77	1.0	0.036	0.036	0.017	<0.004	1.8	0.360	1.9	6.0	--
NM078	133	24.3	7.7	0.70	0.10	30.2	0.66	1.0	0.029	0.026	0.016	<0.004	1.7	0.257	1.4	7.0	--
NM080	125	34.7	4.8	0.78	0.06	26.1	0.31	14.0	0.080	0.050	0.018	<0.004	2.6	0.393	3.6	35.6	2.0
NM095	140	12.1	3.3	0.17	0.06	16.5	2.07	0.7	0.044	0.028	0.003	<0.004	0.7	0.138	0.8	3.7	3.0
NM106	151	33.8	79.3	0.53	0.24	35.1	0.12	17.0	0.126	0.048	0.053	0.006	3.2	0.688	7.0	2.7	--
NM108	132	22.1	24.9	0.50	0.11	31.0	0.40	2.0	0.030	0.026	0.015	<0.004	1.2	0.387	1.6	8.0	--

Sample reference number	Alkalinity (mg/L as HCO_3)	Sulfate (mg/L as SO_4)	Chloride (mg/L as Cl)	Fluoride (mg/L as F)	Bromide (mg/L as Br)	Silica (mg/L as SiO_2)	Nitrate (mg/L as N)	Arsenic (µg/L as As)	Boron (mg/L as B)	Iron (mg/L as Fe)	Lithium (mg/L as Li)	Manganese (mg/L as Mn)	Molybdenum (µg/L as Mo)	Strontium (mg/L as Sr)	Uranium (µg/L as U)	Vanadium (µg/L as V)	Zinc (µg/L as Zn)
NM134	124	30.8	17.2	0.35	0.17	48.8	1.37	3.8	0.038	0.045	0.010	<0.004	2.9	0.402	3.1	20.5	3.0
NM138	196	80.7	22.4	0.31	0.25	23.7	1.48	1.7	0.034	0.060	0.013	<0.004	1.4	0.550	15.7	3.9	1,140.0
NM141	189	14.3	4.8	0.52	0.07	28.7	0.28	<1.0	0.022	0.033	0.014	<0.004	0.8	0.162	2.1	1.0	--
NM142	202	30.4	7.4	1.18	0.12	25.9	0.79	<1.0	0.029	0.031	0.016	<0.004	0.8	0.197	4.4	1.3	--
NM148	213	31.3	3.5	0.39	<0.05	35.1	0.27	12.2	0.029	0.063	0.011	<0.004	2.3	0.444	2.1	3.8	165.0
NM153	254	42.6	22.8	0.30	0.10	56.5	0.35	18.4	0.121	0.068	0.066	<0.004	2.8	0.476	4.3	6.7	7.6
NM156	267	35.9	7.5	0.78	0.08	26.1	0.26	2.4	0.052	0.045	0.023	<0.004	3.1	0.680	4.4	2.8	6.5
NM157	163	14.3	5.2	0.49	0.07	28.7	0.23	<1.0	0.019	0.036	0.015	<0.004	0.5	0.144	3.2	1.9	--
NM161	177	35.7	7.6	0.49	0.09	25.5	0.67	5.2	0.134	0.011	0.010	<0.004	4.5	0.078	6.7	35.1	<1.0
NM162	155	31.1	67.0	0.49	0.20	34.8	0.12	6.0	0.103	0.042	0.024	0.011	3.7	0.407	4.3	3.0	1.8
NM174	123	24.6	64.7	0.71	0.20	31.4	0.16	19.0	0.040	0.036	0.041	0.004	1.4	0.370	2.3	2.7	1.0
NM177	182	43.6	23.6	0.34	0.21	45.1	1.24	4.5	0.084	0.034	0.026	<0.004	2.2	0.552	3.7	8.2	1.5
NM256	51	10.7	4.5	0.13	0.09	0.3	<0.01	<1.0	0.055	0.017	0.008	0.000	0.4	0.019	0.1	0.4	88.5
NM257	202	58.4	7.5	0.25	0.09	27.0	0.75	1.0	0.025	0.043	0.000	0.004	1.0	0.299	3.3	1.4	54.8
NM295	154	49.4	23.9	0.41	0.11	64.0	0.24	16.2	0.113	0.046	0.042	0.003	4.2	0.383	12.3	9.6	7.2
NM298	210	27.9	6.3	1.15	0.07	21.4	2.69	<1.0	0.022	0.033	0.007	0.000	2.0	0.192	7.5	1.4	12.2
NM299	153	55.0	31.2	2.34	0.33	23.7	3.87	1.1	0.103	0.066	0.020	0.000	1.4	0.518	4.5	3.9	753.7
NM300	332	92.6	20.1	1.21	0.19	21.2	0.33	<1.0	0.064	0.237	0.052	0.008	4.6	0.704	6.1	1.8	21.1
NM306	196	70.2	15.1	0.42	0.17	29.1	3.78	1.6	0.043	0.084	0.037	0.006	4.2	0.846	4.7	6.8	29.0
NM312[I]	110	66.4	152.7	1.46	0.38	34.0	0.14	54.0	0.405	0.039	0.185	0.104	8.6	0.241	2.0	35.1	4.9
NM313[I]	98	44.1	177.6	0.55	0.35	44.1	0.10	38.2	0.262	0.052	0.320	0.054	3.7	0.342	1.4	26.4	20.5
NM317	100	13.2	5.9	0.24	0.09	23.1	0.55	<1.0	0.017	0.035	0.000	0.004	0.4	0.118	0.6	7.0	22.2
NM318	169	55.6	10.7	0.48	0.14	26.3	0.80	1.1	0.033	0.054	0.000	0.004	3.2	0.462	2.7	6.3	32.3
NM319	86	29.5	8.3	0.55	0.13	15.9	0.52	11.3	0.039	0.023	0.000	0.000	2.1	0.320	1.2	44.4	8.0
NM328	137	52.6	11.5	0.61	0.17	26.7	0.74	3.1	0.104	1.450	0.015	0.018	3.7	0.186	8.1	17.6	101.6
NM336	125	51.0	26.4	0.48	0.12	41.1	0.05	13.7	0.118	0.038	0.029	0.006	5.9	0.188	12.8	4.0	13.3
NM343	123	70.8	9.8	0.17	0.16	25.9	1.51	<1.0	0.049	0.111	0.000	0.008	1.1	0.519	1.3	3.6	238.5
NM407	206	55.0	27.0	0.41	0.20	36.2	0.22	7.7	0.097	0.048	0.027	0.006	5.9	0.512	4.1	8.0	556.6
NM500[J]	131	19.5	4.8	0.83	0.08	28.7	<0.02	1.9	0.02	0.028	0.019	0.181	5.8	0.294	0.8	1.0	7.0

Sample reference number	Alkalinity (mg/L as HCO_3)	Sulfate (mg/L as SO_4)	Chloride (mg/L as Cl)	Fluoride (mg/L as F)	Bromide (mg/L as Br)	Silica (mg/L as SiO_2)	Nitrate (mg/L as N)	Arsenic (µg/L as As)	Boron (mg/L as B)	Iron (mg/L as Fe)	Lithium (mg/L as Li)	Manganese (mg/L as Mn)	Molybdenum (µg/L as Mo)	Strontium (mg/L as Sr)	Uranium (µg/L as U)	Vanadium (µg/L as V)	Zinc (µg/L as Zn)
NM501[J]	169	19.6	5.5	0.71	0.05	25.5	<0.02	1.9	0.03	0.019	0.017	0.017	6.5	0.152	4.0	4.6	6.0
NM502[J]	164	17.6	4.7	0.52	0.10	23.7	0.67	0.8	0.021	0.017	0.013	0.004	1.7	0.197	2.3	3.1	5.0
NM505[K]	153	26.1	18.5	0.67	0.08	61.4	0.24	8.8	0.040	0.030	0.042	0.058	6.9	0.305	7.2	13.5	4.0
NM515	231	31.2	5.1	1.68	0.09	19.8	1.39	0.5	0.020	0.034	0.009	<0.001	2.0	0.166	14.8	1.2	3.0
NM523	157	16.8	6.0	0.91	0.07	26.3	0.27	0.7	0.022	0.030	0.033	0.004	1.5	0.268	3.2	1.9	63.0
DB040	146	30.0	13.0	0.40	--	56.0	--	8.0	0.010	0.030		<0.001	--	--	--	--	--
DB244	151	33.0	6.9	0.70	--	24.0	--	2.0	0.030	0.040	--	<0.010	--	--	--	--	--
DB247	139	21.0	5.4	1.00	--	34.0	--	<1	0.006	0.040	--	<0.010	--	--	--	--	--
DB282	139	15.0	6.8	0.90	--	32.0	--	4.0	0.030	0.030	--	0.050	--	--	--	--	--
DB328	183	15.0	4.8	0.60	--	26.0	--	<1	0.020	0.008	--	0.001	--	--	--	--	--
DB329	163	17.0	5.1	0.50	--	26.0	--	<1	0.020	0.007	--	0.003	--	--	--	--	--
DB330	232	26.0	6.5	1.80	--	23.0	--	<1	0.020	0.012	--	0.001	--	--	--	--	--
DB338	168	32.0	84.0	0.80	--	32.0	--	2.0	0.220	0.006	--	<0.001	--	--	--	--	--
DB345	176	33.0	10.0	1.50	--	26.0	--	<1	0.020	0.013	--	<0.001	--	--	--	--	--
LOM05	152	31.7	6.5	1.31	0.50	26.6	0.54	4.0	<0.050	<0.010	0.020	<0.002	--	0.203	--	<10.0	<5.0
LOM06	175	56.2	9.6	0.87	0.50	25.8	0.94	<2.0	<0.050	0.016	0.020	0.005	--	0.259	--	<10.0	6.000
LOV03	130	19.0	17.3	0.67	0.50	30.2	0.31	<2.0	<0.050	0.012	0.020	<0.002	--	0.363	--	<10.0	8.000
LOV04	137	21.2	35.0	0.48	0.50	29.8	0.31	<2.0	0.051	<0.010	0.020	<0.002	--	0.466	--	<10.0	<5.0
LOV05	133	19.6	22.1	0.56	0.50	28.1	0.33	<2.0	<0.050	0.013	0.020	<0.002	--	0.368	--	<10.0	<5.0
LOV06	133	16.8	4.8	0.87	0.50	29.1	0.43	<2.0	<0.050	0.011	0.020	<0.002	--	0.202	--	<10.0	<5.0
LOV07	129	19.1	25.0	0.60	0.50	30.6	0.25	4.0	<0.050	0.013	0.020	0.006	--	0.400	--	<10.0	<5.0
LOV08	139	25.7	49.0	0.37	0.50	33.9	0.17	<2.0	0.093	0.016	0.020	0.002	--	0.397	--	<10.0	13.000
PON02	133	19.6	23.5	0.79	0.50	30.4	0.19	6.0	<0.050	<0.010	0.030	0.003	--	0.287	--	<10.0	6.000
PON03	162	35.1	90.2	0.63	0.50	39.7	<0.05	23.2	0.226	0.019	0.070	0.029	--	0.539	--	<10.0	7.000
PON04	136	19.0	33.3	0.98	0.50	30.1	0.16	14.0	<0.050	<0.010	0.030	0.007	--	0.268	--	<10.0	7.000
PON05	133	23.3	55.8	0.78	0.50	31.1	0.18	25.4	0.051	<0.010	0.030	0.003	--	0.350	--	<10.0	<5.0
PON06	168	36.7	87.8	0.97	0.50	42.9	<0.05	33.9	0.232	0.037	0.100	0.056	--	0.415	--	<10.0	6.000
RIG01	178	51.8	11.4	0.69	0.50	27.0	0.88	<2.0	<0.050	0.011	0.020	<0.002	--	0.279	--	<10.0	7.000
RIG02	122	19.8	27.0	0.69	0.50	28.0	0.28	<2.0	<0.050	<0.010	0.020	<0.002	--	0.359	--	<10.0	6.000

Sample reference number	Alkalinity (mg/L as HCO_3)	Sulfate (mg/L as SO_4)	Chloride (mg/L as Cl)	Fluoride (mg/L as F)	Bromide (mg/L as Br)	Silica (mg/L as SiO_2)	Nitrate (mg/L as N)	Arsenic (µg/L as As)	Boron (mg/L as B)	Iron (mg/L as Fe)	Lithium (mg/L as Li)	Manganese (mg/L as Mn)	Molybdenum (µg/L as Mo)	Strontium (mg/L as Sr)	Uranium (µg/L as U)	Vanadium (µg/L as V)	Zinc (µg/L as Zn)
TOM01	162	30.3	46.2	0.46	0.50	30.7	0.55	<2.0	0.074	0.010	0.020	<0.002	--	0.320	--	<10.0	<5.0
TOM02	160	26.7	53.6	0.48	0.50	30.9	0.21	<2.0	0.103	0.020	0.020	0.002	--	0.282	--	<10.0	<5.0
TOM03	171	36.0	41.9	0.63	0.50	36.4	0.11	6.2	0.114	0.033	0.020	0.003	--	0.327	--	<10.0	<5.0
TOM04	170	30.0	64.0	0.52	0.50	34.6	0.19	<2.0	0.120	0.027	0.020	0.003	--	0.328	--	<10.0	8.000
TOM08	145	28.4	86.2	0.47	0.50	32.0	<0.05	12.9	0.184	0.059	0.000	0.044	--	0.508	--	<10.0	9.000
WLK02	171	35.9	83.7	1.23	0.50	41.6	<0.05	35.5	0.224	0.018	0.120	0.021	--	0.266	--	<10.0	<5.0
Tijeras Fault Zone zone																	
NM029	1,305	139.5	581.3	1.90	2.45	16.9	0.28	<5.0	1.230	0.347	2.52	1.390	<2.0	1.610	6.6	2.0	--
NM061	230	211.1	35.1	0.79	0.36	27.0	0.87	3.7	0.126	0.103	0.036	0.006	8.5	1.110	6.4	14.4	117.2
NM071	278	292.1	82.7	3.01	0.71	19.7	1.13	<2.0	0.418	0.118	0.223	0.031	16.0	0.869	8.0	<1.0	--
NM136	270	326.3	90.9	1.23	1.19	12.4	0.14	2.3	0.426	0.224	0.079	0.034	1.5	0.717	2.7	7.8	112.0
NM151	599	92.6	139.9	1.41	0.66	29.1	1.09	1.6	0.276	0.160	0.341	<0.008	2.8	1.290	18.9	5.8	9.1
NM152	426	90.2	139.2	1.31	0.65	27.6	0.90	1.7	0.270	0.120	0.230	0.015	4.6	1.110	15.5	6.8	11.1
Tijeras Arroyo zone																	
NM001	240	286.6	107.6	0.98	0.73	18.5	4.16	<2.0	0.082	0.139	0.027	0.011	2.0	0.951	7.8	1.0	--
NM069	205	83.1	17.1	0.55	0.21	27.4	4.16	<1.0	0.061	0.067	0.025	0.004	1.9	0.473	3.3	5.0	--
NM075	184	94.3	35.6	0.43	0.35	22.9	3.80	<1.0	0.030	0.050	0.017	0.005	0.4	0.390	2.7	3.0	--
NM250	240	130.1	77.6	0.52	0.35	18.5	2.86	<1.0	0.054	0.103	0.000	0.006	1.2	0.601	4.5	1.8	2.2
NM277	156	85.1	12.2	0.39	0.16	22.2	2.21	<1.0	0.041	0.060	0.013	0.003	2.0	0.296	3.7	3.9	6.7
DB202	298	150.0	130.0	0.70	--	19.0	--	<1.0	0.100	0.004	--	--	--	--	--	--	--
DB203	260	130.0	120.0	0.60	--	19.0	0.62	<1.0	0.070	0.006	--	--	--	--	--	--	--
DB205	269	140.0	120.0	0.60	--	17.0	--	<1.0	0.060	0.011	--	--	--	--	--	--	--
DB213	254	100.0	17.0	0.70	--	20.0	--	<1.0	0.050	<0.010	--	<0.010	--	--	--	--	--
Northeastern zone																	
NM097	240	475.8	22.0	0.51	0.22	46.6	0.11	7.5	0.074	0.457	0.178	0.030	7.7	1.860	13.6	6.1	86.2
NM258	290	283.5	66.1	1.25	0.67	40.2	0.64	154.6	0.439	0.178	0.070	0.006	30.9	0.500	8.5	30.2	258.8
NM259	160	97.9	15.9	1.16	0.25	16.6	2.36	1.0	0.473	0.059	0.000	0.011	11.6	0.904	12.0	1.5	441.6
NM276	163	540.0	16.4	0.75	0.12	38.1	1.80	1.9	0.143	0.182	0.044	0.010	5.7	1.720	3.2	3.3	41.2
NM332	202	103.5	10.3	1.12	0.09	26.3	2.30	2.0	0.060	0.066	0.000	0.006	9.4	0.846	2.9	3.0	262.7

Sample reference number	Alkalinity (mg/L as HCO_3)	Sulfate (mg/L as SO_4)	Chloride (mg/L as Cl)	Fluoride (mg/L as F)	Bromide (mg/L as Br)	Silica (mg/L as SiO_2)	Nitrate (mg/L as N)	Arsenic (µg/L as As)	Boron (mg/L as B)	Iron (mg/L as Fe)	Lithium (mg/L as Li)	Manganese (mg/L as Mn)	Molybdenum (µg/L as Mo)	Strontium (mg/L as Sr)	Uranium (µg/L as U)	Vanadium (µg/L as V)	Zinc (µg/L as Zn)
NM334	174	877.0	21.5	0.35	0.15	30.6	1.89	2.3	0.117	0.244	0.040	0.020	4.7	1.960	4.2	3.8	21.8
NM338	147	399.2	23.4	0.60	0.27	26.7	2.73	2.2	0.215	0.250	0.033	0.013	4.7	2.860	9.0	9.2	99.5
DB410	193	350.0	24.0	0.40	--	39.0	--	3.0	0.360	0.030	--	<0.010	--	--	--	--	--
DB411	514	580.0	53.0	0.40	--	78.0	--	4.0	0.270	3.000	--	0.070	--	--	--	--	--
DB442	213	190.0	9.2	0.40	0.11	63.0	--	4.0	--	<0.003	--	<0.001	5.0	--	--	--	--
									Central zone								
NM004	150	63.6	12.2	0.38	0.06	30.4	0.03	5.0	0.064	0.062	0.042	0.538	4.4	0.419	1.3	<1.0	--
NM005	155	80.7	14.5	0.81	0.07	58.8	0.16	9.0	0.149	0.039	0.064	0.022	5.1	0.459	4.7	19.0	--
NM012	131	38.7	32.7	0.44	0.13	55.6	0.44	4.0	0.088	0.034	0.270	0.006	3.4	0.399	3.8	8.0	--
NM013	129	28.7	32.2	0.43	0.10	55.4	0.09	6.0	0.085	0.032	0.036	0.005	3.7	0.388	2.8	8.0	--
NM025	290	149.4	33.6	0.32	0.19	44.1	5.44	3.4	0.098	0.088	0.017	0.085	2.7	0.703	6.9	5.2	3.0
NM028	146	44.3	72.7	0.80	0.22	60.8	0.36	27.0	0.201	0.045	0.256	<0.004	4.4	0.372	1.4	26.0	--
NM032	187	117.0	19.7	0.55	0.09	70.9	0.09	16.0	0.126	0.068	0.135	0.015	2.2	0.682	10.0	24.0	--
NM057	143	69.7	12.2	0.41	0.06	68.5	0.03	6.0	0.089	0.036	0.074	<0.004	3.4	0.466	4.1	14.0	--
NM063	184	57.4	18.0	0.46	0.10	65.5	0.24	3.5	0.089	0.167	0.048	0.006	4.6	0.460	12.0	12.1	376.9
NM066	228	123.2	24.1	0.24	0.11	59.0	0.20	2.0	0.094	0.057	0.044	0.011	0.7	0.649	10.7	5.0	--
NM070	128	26.8	25.8	0.40	0.08	49.8	0.33	4.0	0.079	0.031	0.021	0.006	2.3	0.341	2.2	10.0	--
NM073	297	119.7	20.5	--	0.09	31.7	<0.01	2.0	0.107	0.102	0.042	0.216	4.0	0.618	8.0	<1.0	--
NM074	133	32.0	10.9	0.45	0.07	34.0	0.79	5.0	0.049	0.022	0.029	<0.004	4.1	0.259	2.4	4.0	--
NM081	120	139.5	33.9	0.27	0.17	40.9	0.06	4.0	0.072	0.053	0.027	0.012	1.7	0.728	5.1	6.0	--
NM082	195	74.0	19.0	0.24	0.08	60.5	0.05	4.0	0.067	0.078	0.051	0.014	6.6	0.689	6.0	7.0	--
NM083	258	101.3	21.6	0.18	0.09	58.2	0.03	3.0	0.086	0.074	0.056	0.140	8.5	0.865	10.2	5.0	--
NM084	301	97.7	16.9	0.45	0.08	34.2	0.02	4.0	0.081	0.810	0.057	1.520	7.2	0.638	0.4	<1.0	--
NM085	167	63.3	19.2	0.26	0.10	55.8	0.04	5.0	0.062	0.031	0.033	0.008	3.9	0.517	6.4	6.0	--
NM086	346	172.5	14.8	0.38	0.10	48.6	0.02	3.0	0.140	0.117	0.067	0.072	11.0	0.940	19.0	3.0	--
NM088	166	67.5	10.4	0.38	0.06	59.5	0.02	4.0	0.063	0.043	0.044	0.020	6.8	0.477	2.3	6.0	--
NM089	157	57.1	8.3	0.31	0.05	18.5	0.05	4.0	0.055	0.064	0.031	0.195	4.5	0.339	5.5	0.5	--
NM090	139	67.3	6.4	0.39	0.04	22.9	0.50	2.9	0.048	0.031	0.023	<0.004	3.5	0.331	1.9	4.5	--
NM091[L]	**150**	**57.1**	**10.0**	**0.45**	**0.04**	**62.5**	**0.19**	**4.4**	**0.120**	**0.111**	**0.110**	**0.486**	**5.6**	**0.460**	**4.2**	**<1.0**	**--**

Sample reference number	Alkalinity (mg/L as HCO_3)	Sulfate (mg/L as SO_4)	Chloride (mg/L as Cl)	Fluoride (mg/L as F)	Bromide (mg/L as Br)	Silica (mg/L as SiO_2)	Nitrate (mg/L as N)	Arsenic (µg/L as As)	Boron (mg/L as B)	Iron (mg/L as Fe)	Lithium (mg/L as Li)	Manganese (mg/L as Mn)	Molybdenum (µg/L as Mo)	Strontium (mg/L as Sr)	Uranium (µg/L as U)	Vanadium (µg/L as V)	Zinc (µg/L as Zn)
NM092[L]	**125**	**44.9**	**8.8**	**0.40**	**0.04**	**87.7**	**<0.01**	**6.0**	**0.070**	**0.034**	**0.058**	**<0.004**	**1.8**	**0.533**	**3.3**	**10.9**	**--**
NM093[L]	**117**	**49.8**	**12.9**	**0.36**	**0.05**	**67.2**	**<0.01**	**6.0**	**0.044**	**0.055**	**0.040**	**0.016**	**3.4**	**0.531**	**2.3**	**9.6**	**--**
NM094[L]	**144**	**73.9**	**15.1**	**0.23**	**0.07**	**60.1**	**0.04**	**3.8**	**0.068**	**0.050**	**0.040**	**0.009**	**11.3**	**0.652**	**5.4**	**4.8**	**--**
NM099	154	53.7	8.7	0.39	0.05	38.3	0.05	8.0	0.066	0.044	0.048	0.099	3.6	0.371	3.2	5.3	--
NM100	120	59.1	16.1	0.27	0.06	34.4	<0.01	3.1	0.063	0.041	0.034	0.051	2.0	0.386	2.1	2.7	--
NM101	166	85.9	13.4	0.23	0.06	27.2	<0.01	3.8	0.068	0.042	0.041	0.449	4.7	0.444	1.3	<1.0	--
NM102	196	81.9	13.1	0.54	0.06	31.4	0.05	6.8	0.094	0.395	0.058	1.150	6.4	0.348	0.2	<1.0	--
NM103	284	102.5	17.4	0.60	0.07	24.2	0.82	2.0	0.098	0.058	0.065	0.940	2.0	0.492	10.0	2.0	--
NM104[M]	124	26.8	7.3	0.32	0.03	39.4	0.00	5.0	0.050	0.039	0.030	0.058	3.5	0.321	1.6	2.0	--
NM105[M]	360	124.6	25.4	0.29	0.10	45.1	0.47	<2.0	0.101	0.078	0.061	1.890	8.0	0.935	7.6	2.0	--
NM111	239	99.4	20.6	0.40	0.08	31.4	<0.01	7.0	0.058	0.217	0.041	0.646	7.0	0.575	1.4	<1.0	--
NM112	163	70.4	13.1	0.99	0.06	78.7	0.10	23.0	0.210	0.045	0.098	0.015	4.2	0.342	3.3	17.0	--
NM113	187	106.6	42.2	0.38	0.14	83.0	0.06	10.1	0.237	0.061	0.130	0.018	2.1	0.749	10.0	10.7	--
NM114	230	100.9	22.1	0.76	0.09	60.5	<0.01	9.5	0.137	0.063	0.072	0.160	10.7	0.520	7.8	6.7	--
NM115	135	29.4	22.9	0.45	0.07	60.8	0.05	7.4	0.060	0.113	0.026	0.488	2.3	0.375	2.7	1.0	--
NM116	123	136.6	97.1	0.36	0.28	61.0	3.09	4.7	0.084	0.091	0.033	0.048	1.0	0.887	3.9	6.3	--
NM126	161	63.1	28.3	0.50	0.11	73.2	0.16	15.4	0.131	0.031	0.039	<0.004	5.8	0.394	5.6	12.1	2.0
NM127	144	31.8	8.0	0.38	<0.05	58.6	<0.01	6.8	0.059	0.035	0.026	<0.004	3.3	0.412	3.1	12.2	2.0
NM140	134	58.4	26.4	0.68	0.09	76.0	0.68	21.0	0.175	0.029	0.107	<0.004	4.6	0.386	2.8	21.1	--
NM147	129	36.8	10.7	0.49	0.06	46.4	0.17	11.0	0.061	0.031	0.047	<0.004	4.0	0.294	2.4	8.2	--
NM158	**125**	**13.3**	**11.7**	**0.15**	**0.07**	**30.0**	**0.27**	**7.0**	**0.074**	**0.059**	**0.021**	**0.031**	**10.5**	**0.146**	**1.0**	**<1.0**	**--**
NM159	**110**	**6.3**	**9.1**	**0.52**	**0.05**	**39.6**	**<0.01**	**5.0**	**0.068**	**0.063**	**0.020**	**0.049**	**10.5**	**0.217**	**0.2**	**<1.0**	**--**
NM171	355	166.8	21.0	0.39	0.11	39.6	0.16	7.0	0.142	0.522	0.071	1.210	7.0	0.897	5.3	<1.0	--
NM172	121	34.0	10.4	0.41	0.07	33.6	1.12	6.0	0.047	0.025	0.022	<0.004	3.3	0.270	2.1	4.3	3.0
NM173	124	67.0	16.1	0.40	0.08	33.4	0.31	7.0	0.045	0.037	0.029	0.005	3.4	0.403	2.9	5.7	2.0
NM175	155	38.3	43.1	0.77	0.11	57.1	0.14	35.0	0.157	0.038	0.150	0.006	5.5	0.328	2.3	22.3	2.0
NM178	128	47.2	24.9	0.45	0.12	61.0	0.63	7.0	0.080	0.044	0.035	0.005	4.5	0.372	2.8	7.8	15.0
NM270	156	66.5	10.2	0.63	0.07	63.3	0.04	7.3	0.086	0.047	0.050	0.012	4.0	0.518	6.0	13.7	20.6
NM271	142	62.2	10.4	0.47	0.05	56.7	<0.01	4.6	0.069	0.048	0.034	0.247	5.6	0.516	4.3	5.1	6.1

Sample reference number	Alkalinity (mg/L as HCO_3)	Sulfate (mg/L as SO_4)	Chloride (mg/L as Cl)	Fluoride (mg/L as F)	Bromide (mg/L as Br)	Silica (mg/L as SiO_2)	Nitrate (mg/L as N)	Arsenic (µg/L as As)	Boron (mg/L as B)	Iron (mg/L as Fe)	Lithium (mg/L as Li)	Manganese (mg/L as Mn)	Molybdenum (µg/L as Mo)	Strontium (mg/L as Sr)	Uranium (µg/L as U)	Vanadium (µg/L as V)	Zinc (µg/L as Zn)
NM272	148	60.8	11.1	0.35	0.06	43.4	<0.01	3.2	0.070	0.053	0.036	0.704	4.2	0.460	2.8	0.6	6.4
NM273	155	70.7	9.6	0.32	0.06	24.8	0.01	4.5	0.063	0.054	0.032	0.724	4.0	0.458	3.9	0.9	5.9
NM274	163	67.9	14.0	0.29	0.07	19.1	<0.01	5.3	0.059	0.054	0.032	0.577	3.8	0.391	6.2	2.9	5.7
NM275	153	62.7	16.5	0.31	0.07	19.8	<0.01	5.5	0.063	0.046	0.028	0.053	4.2	0.354	1.6	1.8	10.3
NM279[N]	169	60.8	8.6	0.97	0.06	50.9	0.16	50.7	0.261	0.035	0.000	0.025	3.0	0.210	3.6	37.4	2.0
NM280[N]	163	43.1	8.0	0.97	0.03	75.9	0.07	22.2	0.171	0.062	0.000	0.117	5.0	0.333	2.9	12.0	17.8
NM283	169	81.6	15.7	0.35	0.09	52.2	1.08	4.5	0.052	0.069	0.033	0.007	4.0	0.565	4.1	7.6	16.3
NM286[O]	**178**	**65.1**	**11.3**	**0.59**	**0.06**	**61.4**	**0.08**	**5.9**	**0.378**	**0.050**	**0.000**	**0.016**	**15.1**	**0.564**	**8.5**	**17.2**	**5.1**
NM287[O]	**163**	**40.6**	**7.3**	**0.32**	**0.05**	**63.1**	**0.01**	**4.0**	**0.056**	**0.120**	**0.030**	**0.045**	**4.4**	**0.371**	**4.4**	**7.4**	**9.6**
NM288[O]	**169**	**155.7**	**20.5**	**0.42**	**0.17**	**43.2**	**0.78**	**3.6**	**0.101**	**0.094**	**0.000**	**0.016**	**8.3**	**0.599**	**3.9**	**6.2**	**6.3**
NM289[O]	**156**	**84.6**	**9.0**	**0.37**	**0.06**	**47.9**	**<0.01**	**2.7**	**0.080**	**0.070**	**0.000**	**0.085**	**9.0**	**0.371**	**2.8**	**3.7**	**9.3**
NM290[O]	**165**	**93.5**	**12.5**	**0.39**	**0.11**	**44.1**	**0.07**	**2.8**	**0.085**	**0.080**	**0.000**	**0.017**	**8.5**	**0.495**	**2.0**	**4.5**	**3.7**
NM291[O]	165	136.5	19.8	0.39	0.19	42.8	0.29	3.1	0.087	0.090	0.000	0.012	4.3	0.570	2.4	5.1	3.0
NM292	160	44.4	11.9	0.30	0.08	66.5	0.27	4.6	0.079	0.056	0.049	0.002	5.1	0.497	4.0	10.0	10.8
NM305	165	45.2	8.9	0.95	0.05	76.8	0.10	6.1	0.086	0.055	0.035	0.006	2.7	0.493	7.5	12.3	26.3
NM307	130	105.2	24.5	0.24	0.14	64.2	<0.01	3.7	0.049	0.071	0.000	0.007	4.4	0.590	2.4	7.4	41.9
NM309	164	42.2	13.5	0.65	0.10	72.1	0.63	11.0	0.064	0.056	0.042	0.006	2.6	0.299	3.2	17.7	8.8
NM315	127	31.6	6.8	0.41	0. 0	35.9	0.35	2.0	0.042	0.085	0.000	0.008	3.5	0.163	0.7	5.3	19.7
NM316	134	48.3	16.1	0.32	0.55	36.4	0.01	4.5	0.047	0.061	0.000	0.007	3.0	0.450	1.9	9.0	3.9
NM321	133	31.6	39.5	0.34	0.12	33.8	0.12	2.6	0.072	0.057	0.000	0.005	1.6	0.400	2.8	6.8	1.3
NM323[D]	163	69.1	11.9	0.69	0.06	70.0	<0.01	21.4	0.095	0.043	0.071	0.007	9.9	0.280	4.3	14.8	4.6
NM325	139	59.2	36.0	0.42	0.31	49.4	0.82	5.3	0.052	0.082	0.000	0.011	3.6	0.545	2.5	5.2	1.5
NM331	227	120.8	13.2	0.28	0.09	27.4	2.08	2.9	0.064	0.061	0.018	0.133	3.5	0.579	6.3	3.2	22.6
NM333	140	37.4	4.4	0.48	0.03	67.6	<0.01	11.6	0.024	0.170	0.000	0.012	4.3	0.143	0.8	16.0	2.3
NM339[P]	177	52.8	47.7	0.95	0.14	74.0	0.77	29.2	0.324	0.027	0.172	0.011	7.9	0.387	2.9	25.3	8.7
NM340[P]	137	22.0	7.0	0.47	0.03	29.7	<0.01	8.5	0.046	0.049	0.000	0.081	5.1	0.371	2.6	4.5	1.1
NM344	259	92.7	31.5	0.43	0.16	52.6	2.27	8.7	0.175	0.110	0.057	0.062	2.1	0.596	6.0	9.6	11.6
NM348[E]	161	56.8	11.1	1.04	0.06	67.2	0.06	12.5	0.111	0.033	0.042	0.009	0.3	0.335	4.2	<1.0	<1.0

Sample reference number	Alkalinity (mg/L as HCO_3)	Sulfate (mg/L as SO_4)	Chloride (mg/L as Cl)	Fluoride (mg/L as F)	Bromide (mg/L as Br)	Silica (mg/L as SiO_2)	Nitrate (mg/L as N)	Arsenic (µg/L as As)	Boron (mg/L as B)	Iron (mg/L as Fe)	Lithium (mg/L as Li)	Manganese (mg/L as Mn)	Molybdenum (µg/L as Mo)	Strontium (mg/L as Sr)	Uranium (µg/L as U)	Vanadium (µg/L as V)	Zinc (µg/L as Zn)
NM349[E]	**157**	**55.5**	**10.8**	**1.08**	**0.05**	**68.0**	**0.05**	**6.8**	**0.080**	**0.037**	**0.028**	**0.010**	**0.3**	**0.466**	**4.0**	**0.2**	**<1.0**
NM350[E]	**140**	**91.9**	**14.1**	**0.74**	**0.07**	**62.3**	**<0.01**	**5.4**	**0.067**	**0.075**	**0.027**	**0.109**	**0.1**	**0.523**	**4.3**	**0.2**	**<1.0**
NM351[E]	**150**	**79.9**	**11.9**	**0.81**	**0.07**	**59.7**	**<0.01**	**4.7**	**0.058**	**0.050**	**0.000**	**0.015**	**0.3**	**0.463**	**4.3**	**<1.0**	**<1.0**
NM352[E]	175	60.4	14.3	0.31	0.09	23.1	0.28	3.3	0.059	0.046	0.000	0.225	0.7	0.437	2.8	0.2	<1.0
NM488[Q]	155	41.7	48.6	1.00	0.11	74.4	0.53	38.5	0.164	0.030	0.127	<0.001	4.9	0.286	4.5	28.5	2.0
NM489[Q]	160	42.6	55.5	0.56	0.13	55.0	0.48	9.5	0.191	0.056	0.070	0.081	6.6	0.484	13.5	4.1	1.0
NM490[Q]	95	109.2	107.7	0.31	1.25	38.3	4.11	3.8	0.039	0.059	0.028	0.001	2.0	0.746	1.8	3.8	3.0
NM491[N]	306	208.3	17.5	0.54	0.08	37.2	<0.02	4.9	0.090	2.230	0.065	2.840	4.8	0.881	11.8	<1.0	3.0
NM493[G]	190	46.2	11.8	1.18	0.06	59.9	0.28	43.1	0.142	0.026	0.045	0.049	7.0	0.144	8.9	40.5	1.0
NM494[G]	128	30.0	8.8	0.45	0.02	37.9	<0.02	5.8	0.056	0.033	0.030	0.074	4.6	0.293	1.5	4.9	2.0
NM495[G]	357	139.5	33.7	0.40	0.14	38.7	<0.02	3.2	0.126	0.434	0.069	1.260	7.6	0.907	1.9	<1.0	3.0
NM503[K]	143	65.6	21.3	2.12	0.11	50.7	<0.02	44.5	0.351	0.015	0.039	0.004	9.9	0.009	0.2	<1.0	2.0
NM504[K]	150	32.5	34.6	1.34	0.11	37.2	<0.02	27.1	0.349	0.027	0.069	0.008	4.4	0.015	0.6	<1.0	1.0
NM506[R]	130	31.2	26.2	0.60	0.08	72.1	0.09	16.3	0.090	0.032	0.087	0.062	4.0	0.363	2.1	10.4	3.0
NM507[R]	136	30.7	11.9	0.46	0.02	49.2	0.07	2.8	0.054	0.025	0.014	0.002	5.1	0.296	1.6	7.3	9.0
NM508[I]	166	37.6	9.5	0.67	0.06	46.4	<0.02	22.3	0.118	0.095	0.100	0.177	17.5	0.298	5.0	10.5	2.0
NM511[S]	181	58.3	62.0	1.03	0.16	55.0	0.23	26.9	0.150	0.031	0.119	0.104	19.8	0.305	5.3	13.9	3.0
NM513[S]	188	78.8	97.5	0.31	0.24	39.6	0.04	6.0	0.056	0.059	0.061	0.038	6.6	0.926	4.7	4.4	6.0
NM517[H]	179	49.4	8.1	1.10	0.05	73.2	0.06	23.3	0.105	0.016	0.080	0.034	5.1	0.142	3.7	28.5	3.0
NM518[H]	199	61.2	17.7	0.63	0.15	53.7	0.45	5.9	0.076	0.025	0.042	0.077	15.0	0.414	6.7	6.8	3.0
NM522	156	43.7	41.3	0.88	0.11	58.2	<0.02	15.6	0.117	0.022	0.091	0.036	9.3	0.280	5.7	6.8	6.0
DB093	144	32.0	7.1	0.50	0.05	46.0	--	6.0	--	0.037	--	<0.001	4.0	--	--	--	--
DB094	118	42.0	10.0	0.30	0.05	48.0	--	6.0	--	<0.003	--	0.008	3.0	--	--	--	--
DB133	293	92.0	11.0	0.40	0.06	34.0	--	5.0	0.090	0.340	--	1.000	<10	--	--	--	--
DB135	148	65.0	<0.1	0.40	0.03	25.0	--	2.0	--	0.260	--	0.600	5.0	--	--	--	--
DB136	162	99.0	24.0	0.30	0.09	51.0	--	3.0	0.060	0.072	--	0.850	<10	--	--	--	--
DB139	141	36.0	22.0	0.50	0.08	57.0	--	10.0	--	0.003	--	0.002	3.0	--	--	--	--
DB140	105	110.0	11.0	0.40	0.08	60.0	--	7.0	0.060	0.005	--	0.007	<10	--	--	--	--
DB141	376	130.0	28.0	0.70	0.11	31.0	1.65	3.0	--	0.009	--	2.400	6.0	--	--	--	--

Sample reference number	Alkalinity (mg/L as HCO_3)	Sulfate (mg/L as SO_4)	Chloride (mg/L as Cl)	Fluoride (mg/L as F)	Bromide (mg/L as Br)	Silica (mg/L as SiO_2)	Nitrate (mg/L as N)	Arsenic (µg/L as As)	Boron (mg/L as B)	Iron (mg/L as Fe)	Lithium (mg/L as Li)	Manganese (mg/L as Mn)	Molybdenum (µg/L as Mo)	Strontium (mg/L as Sr)	Uranium (µg/L as U)	Vanadium (µg/L as V)	Zinc (µg/L as Zn)
DB145	133	30.0	20.0	0.60	0.07	74.0	0.19	15.0	0.060	0.021	--	0.003	<10	--	--	--	--
DB148	162	80.0	20.0	0.70	0.08	55.0	--	18.0	0.190	0.005	--	0.180	<10	--	--	--	--
DB150	166	56.0	16.0	0.50	0.03	36.0	--	18.0	0.110	0.005	--	0.520	<10	--	--	--	--
DB151	356	180.0	30.0	0.80	0.14	37.0	--	10.0	--	0.100	--	0.230	11.0	--	--	--	--
DB153	190	78.0	47.0	0.40	0.17	63.0	--	3.0	0.080	0.042	--	0.004	<10	--	--	--	--
DB162	139	31.0	21.0	0.50	--	66.0	--	6.0	--	--	--	--	--	--	--	--	--
DB168	77	70.0	17.0	0.10	--	17.0	--	8.0	--	--	--	--	--	--	--	--	--
DB169	141	34.0	27.0	0.50	--	82.0	--	15.0	--	--	--	--	--	--	--	--	--
DB170	224	110.0	19.0	0.70	--	66.0	--	9.0	--	--	--	--	--	--	--	--	--
DB176	341	220.0	37.0	0.60	0.10	27.0	1.09	2.0	0.190	0.210	--	0.840	20.0	--	--	--	--
DB180	339	160.0	29.0	0.60	0.10	38.0	--	7.0	0.200	0.210	--	0.870	10.0	--	--	--	--
DB181	294	160.0	29.0	0.70	0.09	32.0	--	5.0	0.150	<0.003	--	0.680	<10	--	--	--	--
DB185	232	110.0	38.0	0.30	--	50.0	0.01	3.0	0.120	0.050	--	--	--	--	--	--	--
DB186	190	79.0	8.6	0.60	0.12	36.0	--	4.0	--	0.110	--	0.570	5.0	--	--	--	--
DB188	115	65.0	36.0	0.70	--	71.0	0.39	21.0	0.170	<0.010	--	--	--	--	--	--	--
DB190	115	47.0	33.0	0.00	--	78.0	0.41	21.0	0.110	<0.010	--	--	--	--	--	--	--
DB194	134	34.0	35.0	0.50	--	71.0	0.26	13.0	0.120	<0.010	--	--	--	--	--	--	--
DB197	324	100.0	14.0	0.70	0.08	34.0	--	9.0	--	2.160	--	1.010	6.0	--	--	--	--
DB207	166	67.0	10.0	0.40	0.04	26.0	--	6.0	--	0.210	--	0.230	7.0	--	--	--	--
DB228	274	150.0	24.0	0.80	0.17	31.0	0.08	10.0	--	0.032	--	0.410	10.0	--	--	--	--
DB230	210	69.0	14.0	0.40	0.04	25.0	--	4.0	--	0.120	--	0.810	4.0	--	--	--	--
DB246	226	99.0	12.0	0.40	0.05	24.0	--	5.0	--	0.009	--	1.200	4.0	--	--	--	--
DB259	341	190.0	19.0	0.10	--	49.0	--	3.0	--	0.008	--	0.001	--	--	--	--	--
DB260	201	83.0	<0.1	0.40	0.05	23.0	2.78	4.0	--	0.011	--	0.710	5.0	--	--	--	--
DB262	134	65.0	9.4	0.40	--	--	--	2.0	--	0.170	--	0.910	--	--	--	--	--
DB265	268	200.0	15.0	0.50	--	47.0	--	5.0	--	0.480	--	2.300	--	--	--	--	--
DB269	354	210.0	22.0	0.40	--	40.0	--	3.0	--	0.960	--	2.800	--	--	--	--	--
DB270	220	110.0	11.0	0.30	--	57.0	--	4.0	--	0.047	--	1.400	--	--	--	--	--
DB273	354	130.0	13.0	0.50	--	34.0	--	4.0	--	0.341	--	1.600	--	--	--	--	--

Sample reference number	Alkalinity (mg/L as HCO_3)	Sulfate (mg/L as SO_4)	Chloride (mg/L as Cl)	Fluoride (mg/L as F)	Bromide (mg/L as Br)	Silica (mg/L as SiO_2)	Nitrate (mg/L as N)	Arsenic (µg/L as As)	Boron (mg/L as B)	Iron (mg/L as Fe)	Lithium (mg/L as Li)	Manganese (mg/L as Mn)	Molybdenum (µg/L as Mo)	Strontium (mg/L as Sr)	Uranium (µg/L as U)	Vanadium (µg/L as V)	Zinc (µg/L as Zn)
DB275	146	73.0	8.1	0.40	--	34.0	--	3.0	--	0.110	--	0.690	--	--	--	--	--
DB283	220	110.0	20.0	0.50	--	37.0	--	3.0	--	0.230	--	0.880	--	--	--	--	--
DB286	93	110.0	55.0	0.30	--	35.0	--	3.0	--	0.000	--	0.003	--	--	--	--	--
DB288	121	30.0	9.8	0.40	0.05	55.0	--	7.0	0.050	0.003	--	0.013	<10	--	--	--	--
DB292	171	68.0	26.0	0.60	--	27.0	--	3.0	--	0.300	--	1.100	--	--	--	--	--
DB294	355	120.0	15.0	0.20	0.07	63.0	--	3.0	0.150	0.004	--	0.057	<10	--	--	--	--
DB295	371	150.0	13.0	0.20	0.07	64.0	--	4.0	0.150	<0.003	--	0.049	20.0	--	--	--	--
DB296	422	190.0	13.0	0.60	0.07	42.0	--	5.0	0.110	0.770	--	3.200	10.0	--	--	--	--
DB299	207	86.0	62.0	0.20	--	47.0	--	2.0	--	0.017	--	0.090	--	--	--	--	--
DB308	157	89.0	14.0	0.30	0.08	57.0	--	5.0	0.050	<0.003	--	0.037	<10	--	--	--	--
DB309	126	53.0	10.0	0.50	0.05	61.0	--	7.0	0.060	0.003	--	0.009	10.0	--	--	--	--
DB310	172	72.0	11.0	0.40	0.03	46.0	--	4.0	0.080	0.025	--	0.470	10.0	--	--	--	--
DB312	220	110.0	25.0	0.30	--	51.0	--	2.0	--	0.036	--	0.074	--	--	--	--	--
DB317	341	110.0	7.2	0.60	--	35.0	--	4.0	--	0.740	--	2.400	--	--	--	--	--
DB318	341	150.0	25.0	0.10	--	37.0	--	<1	--	0.120	--	0.073	--	--	--	--	--
DB320	110	70.0	22.0	0.30	--	29.0	--	2.0	--	0.081	--	0.036	--	--	--	--	--
DB340	220	92.0	17.0	0.30	--	27.0	--	1.0	0.040	0.004	--	0.200	--	--	--	--	--
DB350[T]	155	73.0	12.0	0.20	--	38.0	--	2.0	--	--	--	--	--	--	--	--	--
DB351[T]	151	58.0	8.2	0.30	--	17.0	--	3.0	--	--	--	--	--	--	--	--	--
DB352[T]	146	33.0	7.2	0.30	--	65.0	--	4.0	--	--	--	--	--	--	--	--	--
DB353	198	83.0	17.0	0.20	--	29.0	--	4.0	0.050	0.023	--	0.094	--	--	--	--	--
DB354	151	31.0	9.9	0.70	--	64.0	--	18.0	0.090	0.340	--	0.012	--	--	--	--	--
DB355	339	160.0	22.0	0.70	0.08	22.0	--	1.0	--	0.005	--	0.130	9.0	--	--	--	--
DB357	126	26.0	7.4	0.30	0.04	49.0	--	4.0	--	<0.003	--	0.002	3.0	--	--	--	--
DB358	244	160.0	21.0	0.50	0.09	32.0	--	2.0	--	1.400	--	1.100	6.0	--	--	--	--
DB362	362	66.0	44.0	0.50	0.12	33.0	--	3.0	--	0.045	--	2.300	8.0	--	--	--	--
DB367	170	59.0	11.0	--	0.01	22.0	--	3.0	--	0.470	--	0.280	4.0	--	--	--	--
DB372	148	30.0	7.9	0.50	0.03	57.0	--	6.0	--	<0.003	--	0.009	4.0	--	--	--	--
DB373	513	85.0	7.5	--	0.22	59.0	--	6.0	--	0.004	--	0.004	11.0	--	--	--	--

Sample reference number	Alkalinity (mg/L as HCO_3)	Sulfate (mg/L as SO_4)	Chloride (mg/L as Cl)	Fluoride (mg/L as F)	Bromide (mg/L as Br)	Silica (mg/L as SiO_2)	Nitrate (mg/L as N)	Arsenic (µg/L as As)	Boron (mg/L as B)	Iron (mg/L as Fe)	Lithium (mg/L as Li)	Manganese (mg/L as Mn)	Molybdenum (µg/L as Mo)	Strontium (mg/L as Sr)	Uranium (µg/L as U)	Vanadium (µg/L as V)	Zinc (µg/L as Zn)
DB375	324	95.0	8.9	0.50	0.07	30.0	--	3.0	--	0.004	--	<0.001	5.0	--	--	--	--
DB376	156	35.0	7.3	0.30	--	70.0	--	7.0	0.080	0.080	--	<0.010	--	--	--	--	--
DB379	142	37.0	7.4	0.40	--	60.0	--	9.0	0.080	0.070	--	<0.010	--	--	--	--	--
DB413	394	29.0	35.0	0.30	--	100.0	--	9.0	0.380	0.200	--	<0.010	--	--	--	--	--
ATI02	201	111.0	16.6	0.72	0.50	65.9	<0.05	6.5	0.139	0.011	0.070	0.017	--	0.697	--	12.2	6.000
ATI04	165	77.1	12.2	1.01	0.50	65.8	0.37	9.7	0.147	<0.010	0.070	<0.002	--	0.406	--	19.9	<5.0
BUR01	134	34.4	36.1	0.63	0.50	64.5	0.18	15.0	0.134	<0.010	0.080	<0.002	--	0.332	--	10.5	<5.0
BUR03	130	41.9	30.5	0.51	0.50	49.7	0.42	5.0	0.092	<0.010	0.030	<0.002	--	0.359	--	<10.0	<5.0
BUR04	137	35.8	41.6	0.71	0.50	70.2	0.24	20.8	0.155	<0.010	0.100	<0.002	--	0.297	--	14.0	7.000
CHW01	145	31.3	18.0	0.51	0.50	26.8	0.25	<2.0	0.094	<0.010	0.020	<0.002	--	0.185	--	<10.0	<5.0
CHW02	135	34.4	11.5	0.53	0.50	29.0	0.36	<2.0	0.052	0.013	0.010	<0.002	--	0.207	--	<10.0	5.000
CHW03	131	30.7	9.5	0.54	0.50	33.1	0.49	2.0	0.054	<0.010	0.020	<0.002	--	0.192	--	<10.0	7.000
CHW05	128	28.9	19.9	0.54	0.50	40.4	0.10	4.0	0.067	<0.010	0.030	<0.002	--	0.293	--	<10.0	9.000
COR02	169	48.2	24.6	0.79	0.50	52.3	0.13	15.6	0.168	0.011	0.000	<0.002	--	0.344	--	11.0	<5.0
DUR02	152	67.5	10.5	0.65	0.50	63.7	<0.05	7.6	0.099	<0.010	0.070	0.003	--	0.379	--	13.6	<5.0
DUR03	181	88.2	12.7	0.56	0.50	62.4	<0.05	6.2	0.126	0.015	0.080	0.114	--	0.504	--	12.0	6.000
DUR04	155	70.8	12.4	1.03	0.50	63.6	<0.05	12.9	0.124	<0.010	0.070	<0.002	--	0.319	--	21.1	<5.0
DUR05	158	67.7	12.2	0.98	0.50	63.0	0.13	10.0	0.141	<0.010	0.060	0.004	--	0.353	--	16.7	<5.0
DUR06	204	93.4	14.4	0.41	0.50	69.5	<0.05	4.3	0.110	0.021	0.100	0.003	--	0.869	--	<10.0	<5.0
GON02	158	63.5	10.0	0.98	0.50	68.8	0.32	12.8	0.160	<0.010	0.000	<0.002	--	0.329	--	24.5	5.000
GRG01	156	60.7	12.1	0.41	0.50	64.4	<0.05	6.1	0.068	0.014	0.070	<0.002	--	0.638	--	<10.0	5.000
GRG02	196	79.2	12.4	0.40	0.50	68.5	<0.05	5.0	0.073	0.014	0.080	0.016	--	0.710	--	<10.0	8.000
GRG04	157	45.3	9.4	0.68	0.50	64.7	<0.05	13.0	0.074	0.014	0.090	<0.002	--	0.422	--	15.7	6.000
LYN02	139	32.7	10.2	0.56	0.50	32.0	0.37	3.0	0.057	<0.010	0.030	<0.002	--	0.201	--	<10.0	<5.0
LYN03	133	29.9	8.0	0.50	0.50	31.6	0.45	6.0	<0.050	<0.010	0.030	<0.002	--	0.241	--	<10.0	<5.0
LYN04	149	33.9	11.1	0.58	0.50	32.9	0.43	5.0	0.064	<0.010	0.040	<0.002	--	0.230	--	<10.0	<5.0
MIL01	132	39.0	38.6	0.69	0.50	71.0	0.29	16.1	0.130	0.011	0.060	<0.002	--	0.399	--	15.0	7.000
RIG05	133	26.6	32.6	0.45	0.50	37.1	0.13	5.0	0.088	0.018	0.030	0.004	--	0.348	--	<10.0	<5.0
SJ01	205	108.5	16.3	0.33	0.50	69.4	<0.05	6.4	0.133	<0.010	0.080	<0.002	--	0.675	--	<10.0	<5.0

Sample reference number	Alkalinity (mg/L as HCO_3)	Sulfate (mg/L as SO_4)	Chloride (mg/L as Cl)	Fluoride (mg/L as F)	Bromide (mg/L as Br)	Silica (mg/L as SiO_2)	Nitrate (mg/L as N)	Arsenic (µg/L as As)	Boron (mg/L as B)	Iron (mg/L as Fe)	Lithium (mg/L as Li)	Manganese (mg/L as Mn)	Molybdenum (µg/L as Mo)	Strontium (mg/L as Sr)	Uranium (µg/L as U)	Vanadium (µg/L as V)	Zinc (µg/L as Zn)
SJ03	141	69.3	14.7	0.95	0.50	66.7	0.33	32.7	0.230	<0.010	0.110	<0.002	--	0.259	--	28.7	<5.0
TOM05	161	36.1	18.1	0.67	0.50	36.2	<0.05	8.6	0.113	0.011	0.040	0.003	--	0.277	--	<10.0	9.000
TOM07	155	34.5	26.9	0.65	0.50	35.0	0.12	6.1	0.123	0.010	0.030	0.004	--	0.303	--	<10.0	8.000
VAN01	134	51.7	13.5	0.45	0.50	31.6	0.88	7.0	0.051	<0.010	0.030	0.002	--	0.423	--	<10.0	5.000
VAN03	123	56.7	17.8	0.49	0.50	37.3	0.42	6.8	0.058	<0.010	0.030	<0.002	--	0.403	--	<10.0	<5.0
VAN04	132	35.6	9.5	0.45	0.50	30.9	0.91	8.0	<0.050	<0.010	0.030	<0.002	--	0.278	--	<10.0	<5.0
VAN06	133	36.7	8.8	0.44	0.50	30.9	0.62	7.9	0.052	0.010	0.030	0.003	--	0.303	--	<10.0	6.000
WEB02	160	38.6	25.2	0.75	0.50	61.8	<0.05	27.0	0.144	<0.010	0.140	<0.002	--	0.312	--	16.9	6.000
YAL02	131	40.1	34.8	0.60	0.50	66.5	0.46	10.8	0.115	<0.010	0.060	<0.002	--	0.382	--	<10.0	<5.0
YAL03	150	67.1	29.5	0.54	0.50	73.2	0.56	13.0	0.170	0.015	0.090	<0.002	--	0.470	--	<10.0	13.000
Discharge zone																	
NM096	136	202.8	151.9	1.59	0.37	39.6	0.01	12.0	0.560	0.072	0.326	0.009	11.3	1.460	1.3	6.9	16.2
NM150	188	450.4	692.2	1.12	0.53	24.2	0.42	2.6	0.700	0.200	0.400	<0.012	9.3	3.020	5.2	11.4	42.0
NM327	61	290.3	684.6	0.54	0.59	29.1	0.82	7.9	0.280	0.297	0.152	0.017	4.2	3.020	3.9	7.1	4.4
DB009	202	340.0	280.0	1.10	0.40	39.0	--	18.0	--	0.550	--	0.260	12.0	--	--	--	--
DB025	180	330.0	1,100.0	2.90	--	30.0	--	4.0	0.860	0.040	--	0.010	--	--	--	--	--
DB029	140	170.0	150.0	1.70	--	44.0	--	17.0	0.220	0.010	--	0.020	--	--	--	--	--
Samples not included in final data set																	
NM014[1]	862	2,190.0	2,680.0	0.73	3.09	22.2	0.01	610.0	1.650	2.740	1.700	1.010	20.5	13.000	5.5	36.4	76.1
NM041[1]	182	296.2	2,520.0	6.40	1.78	43.4	<0.01	33.0	5.000	0.240	5.70	0.390	<1.0	5.770	0.1	17.4	<5.0
NM297[1]	175	246.7	95.6	0.43	0.20	43.0	0.04	51.9	0.144	0.307	0.147	0.056	60.9	1.260	0.1	0.6	585.8
NM524	249	35.4	6.0	1.29	0.08	11.2	0.05	23.2	0.167	0.067	0.164	0.143	7.6	0.345	0.3	0.2	165.0
DB178	--	610.0	140.0	1.20	0.47	42.0	--	18.0	--	0.120	--	1.600	17.0	--	--	--	--
DB403	--	320.0	99.0	0.60	0.34	77.0	--	28.0	--	0.000	--	0.000	2.0	--	--	--	--

[1]Mineralized water

Appendix II.--Apparent arsenic sources and controls and selected constituent ratios for ground-water samples with arsenic concentrations greater than 5 micrograms per liter [Ratios were calculated using concentrations in milligrams per liter. mineralized water, sample with an arsenic concentration affected by mixing with deep, mineralized water; desorption, sample with an arsenic concentration affected by source water from the western Jemez Mountains and/or desorption of arsenic from aquifer materials; μg/L, micrograms per liter; --, no data]

Sample reference number	Water-quality zone	Arsenic source/control	Arsenic concentration (μg/L)	Chloride/ arsenic	Chloride/ barium	Chloride/ boron	Chloride/ bromide	Chloride/ fluoride	Chloride/ lithium	Chloride/ molybdenum	Chloride/ uranium	Chloride/ vanadium
NM055	Northern Mountain Front	mineralized water	7.6	2.3E+04	1.1E+03	9.1E+02	3.9E+02	1.9E+02	6.2E+02	2.7E+04	2.4E+05	1.7E+04
NM131	Northern Mountain Front	mineralized water	45.1	3.4E+03	1.3E+03	9.5E+02	4.3E+02	4.2E+02	8.4E+02	1.5E+05	1.5E+05	8.9E+03
NM143	Northern Mountain Front	desorption	5.6	2.1E+03	2.2E+02	1.5E+02	7.0E+01	1.8E+01	2.0E+02	5.0E+03	3.7E+03	1.2E+03
NM510	Northern Mountain Front	desorption	28.9	2.6E+02	1.0E+02	6.6E+01	7.4E+01	1.3E+01	1.2E+02	2.4E+03	7.1E+03	2.5E+02
NM514	Northern Mountain Front	mineralized water	14.6	2.3E+03	3.7E+03	1.9E+02	3.4E+02	9.9E+01	1.6E+02	4.9E+03	8.3E+03	3.4E+05
NM525	Northern Mountain Front	mineralized water	24.2	5.8E+02	7.1E+03	2.8E+02	1.8E+02	4.9E+01	2.4E+02	1.4E+04	7.1E+03	1.0E+04
NM133	Northwestern	mineralized water	11.	7.1E+03	2.0E+03	2.1E+02	3.6E+02	7.2E+01	2.9E+02	8.6E+03	2.6E+04	6.3E+03
NM179	Northwestern	desorption	9.3	4.2E+02	8.2E+01	1.6E+02	5.6E+01	2.8E+01	4.4E+02	1.3E+04	4.6E+03	2.5E+02
NM184	Northwestern	desorption	15.	1.8E+02	2.9E+01	4.6E+01	5.5E+01	7.4E+00	9.4E+01	1.7E+03	1.2E+03	1.3E+02
NM185	Northwestern	desorption	19.	5.5E+02	1.9E+02	6.5E+01	1.2E+02	1.4E+01	1.2E+02	2.1E+03	7.4E+03	3.3E+02
NM326	Northwestern	desorption	14.	7.2E+02	2.0E+02	4.4E+01	1.0E+02	1.2E+01	9.1E+01	9.4E+02	2.8E+03	4.8E+02
NM497	Northwestern	desorption	10.	7.7E+02	9.4E+01	4.6E+01	7.0E+01	7.8E+00	8.6E+01	9.1E+02	2.9E+03	4.4E+02
NM498	Northwestern	desorption	9.8	4.4E+02	7.8E+01	3.7E+01	6.2E+01	5.7E+00	6.4E+01	1.4E+03	2.5E+03	1.9E+02
NM499	Northwestern	desorption	5.4	8.5E+02	6.9E+01	5.8E+01	7.7E+01	7.6E+00	8.1E+01	2.6E+03	1.7E+03	3.5E+02
DB447	Northwestern	desorption	15.	2.0E+02	--	6.0E+01	1.0E+02	7.5E+00	--	--	--	--
NM003	West-Central	desorption	10.3	9.6E+02	2.8E+02	7.0E+01	2.0E+02	1.2E+01	6.4E+02	1.1E+03	3.8E+03	3.7E+02
NM015	West-Central	mineralized water	7.5	4.9E+03	1.0E+03	3.2E+02	3.4E+02	7.1E+01	8.7E+02	2.9E+03	9.0E+03	2.9E+03
NM056	West-Central	desorption	25.	4.5E+02	3.2E+02	5.2E+01	1.3E+02	9.7E+00	2.1E+02	2.6E+03	2.7E+03	2.4E+02
NM076	West-Central	desorption	18.	6.3E+02	3.7E+02	6.2E+01	1.6E+02	1.2E+01	5.2E+02	2.3E+03	1.4E+03	--
NM077	West-Central	desorption	13.	1.0E+03	3.4E+02	1.0E+02	1.7E+02	1.6E+01	3.9E+02	3.1E+03	1.4E+03	3.2E+02
NM107	West-Central	desorption	9.8	7.8E+02	5.4E+02	3.4E+01	9.8E+01	9.8E+00	3.0E+02	4.8E+02	1.5E+03	1.8E+02
NM109	West-Central	desorption	31.	1.1E+03	9.9E+02	7.4E+01	1.6E+02	2.3E+01	6.7E+02	2.9E+03	7.6E+03	8.2E+02

Sample reference number	Water-quality zone	Arsenic source/control	Arsenic concentration (μg/L)	Chloride/ arsenic	Chloride/ barium	Chloride/ boron	Chloride/ bromide	Chloride/ fluoride	Chloride/ lithium	Chloride/ molybdenum	Chloride/ uranium	Chloride/ vanadium
NM110	West-Central	desorption	40.	6.8E+02	1.6E+03	8.2E+01	1.6E+02	1.7E+01	5.2E+02	2.8E+03	6.8E+03	5.6E+02
NM129	West-Central	desorption	39.1	1.5E+02	1.5E+02	3.3E+01	8.2E+01	1.1E+01	1.9E+02	9.7E+02	3.2E+03	1.4E+02
NM130	West-Central	both	18.2	1.2E+03	6.9E+02	6.2E+01	1.5E+02	2.4E+01	1.1E+02	2.8E+03	4.7E+03	1.7E+03
NM132	West-Central	desorption	45.4	1.0E+02	2.0E+02	2.1E+01	5.5E+01	5.2E+00	1.5E+02	6.3E+02	2.7E+03	6.4E+01
NM139	West-Central	desorption	9.8	1.9E+03	9.4E+02	7.8E+01	1.3E+02	2.4E+01	3.0E+02	1.7E+03	3.0E+03	8.1E+02
NM144	West-Central	desorption	111.	2.5E+01	5.5E+01	1.3E+01	5.5E+01	4.1E+00	3.1E+01	1.6E+03	1.7E+03	1.0E+02
NM145	West-Central	desorption	264.	6.1E+00	2.4E+01	6.7E+00	3.2E+01	2.3E+00	1.4E+01	1.7E+03	1.2E+03	1.4E+01
NM146	West-Central	desorption	230.	6.9E+01	2.4E+02	6.3E+01	3.2E+02	2.0E+01	1.1E+02	1.3E+04	6.1E+03	4.1E+02
NM155	West-Central	desorption	11.	7.9E+02	4.2E+02	7.1E+01	1.1E+02	1.7E+01	3.4E+02	7.5E+02	3.7E+03	3.4E+02
NM181	West-Central	desorption	13.	5.2E+02	1.2E+02	9.8E+00	1.1E+02	1.1E+00	1.7E+01	3.0E+02	1.7E+04	3.1E+02
NM182	West-Central	desorption	21.	3.4E+02	2.1E+02	1.2E+01	1.1E+02	1.3E+00	1.8E+01	4.0E+02	1.2E+04	3.0E+02
NM186	West-Central	desorption	100.	9.1E+01	1.8E+02	4.3E+01	6.4E+01	1.4E+01	8.6E+01	1.6E+03	7.6E+03	5.7E+02
NM260	West-Central	desorption	8.3	1.9E+03	6.4E+02	5.9E+01	1.3E+02	1.6E+01	1.6E+04	1.1E+03	3.2E+03	5.6E+02
NM264	West-Central	desorption	33.3	2.0E+02	3.6E+02	2.3E+01	6.2E+01	6.7E+00	6.6E+03	1.1E+03	1.2E+03	7.8E+01
NM294	West-Central	desorption	37.3	3.5E+02	5.4E+02	6.1E+01	9.5E+01	1.1E+01	4.0E+02	2.9E+03	2.0E+03	2.0E+02
NM308	West-Central	desorption	7.9	1.2E+03	1.4E+02	8.7E+01	9.3E+01	1.3E+01	3.0E+02	3.4E+03	1.2E+03	4.8E+02
NM310	West-Central	desorption	28.	3.7E+02	2.7E+02	5.5E+01	1.3E+02	1.1E+01	2.0E+02	2.6E+03	2.8E+03	2.1E+02
NM311	West-Central	desorption	10.3	6.3E+02	1.1E+02	3.7E+01	8.9E+01	8.0E+00	1.8E+02	1.1E+03	7.6E+02	2.9E+02
NM322	West-Central	both	23.6	2.3E+03	2.3E+03	1.3E+02	2.3E+02	3.1E+01	1.1E+03	4.4E+03	4.5E+04	3.2E+03
NM346	West-Central	desorption	13.6	6.2E+02	1.4E+02	5.6E+01	1.1E+02	8.9E+00	2.0E+02	2.6E+03	1.9E+03	3.2E+02
NM347	West-Central	both	36.	1.4E+03	2.1E+03	1.1E+02	1.8E+02	3.9E+01	2.2E+03	3.4E+03	1.9E+04	8.6E+02
NM353	West-Central	desorption	38.9	2.3E+02	4.6E+02	3.8E+01	9.7E+01	6.7E+00	3.3E+02	1.7E+03	1.2E+03	1.2E+02
NM481	West-Central	mineralized water	38.9	5.0E+03	5.6E+03	2.3E+02	7.2E+02	9.3E+01	7.4E+02	1.3E+04	1.3E+04	3.7E+03
NM482	West-Central	desorption	51.8	2.4E+02	1.1E+03	4.3E+01	1.6E+02	1.1E+01	1.6E+02	2.2E+03	1.5E+02	1.1E+03
NM483	West-Central	desorption	11.9	3.4E+02	1.1E+02	1.1E+01	8.0E+01	1.9E+00	8.3E+01	4.0E+02	6.7E+02	4.0E+04
NM484	West-Central	desorption	21.7	3.9E+02	2.5E+02	3.9E+01	7.6E+01	7.4E+00	2.5E+02	1.0E+03	2.3E+03	1.7E+02

Sample reference number	Water-quality zone	Arsenic source/control	Arsenic concentration (µg/L)	Chloride/ arsenic	Chloride/ barium	Chloride/ boron	Chloride/ bromide	Chloride/ fluoride	Chloride/ lithium	Chloride/ molybdenum	Chloride/ uranium	Chloride/ vanadium
NM492	West-Central	desorption	95.8	2.3E+02	2.2E+03	4.4E+01	1.7E+02	1.1E+01	1.2E+03	1.9E+03	1.6E+04	1.3E+02
NM509	West-Central	desorption	22.9	5.8E+02	2.2E+02	1.6E+01	1.1E+02	2.3E+01	2.9E+01	4.3E+02	4.1E+03	2.3E+02
NM516	West-Central	both	23.7	1.7E+03	1.6E+03	8.5E+01	1.7E+02	4.4E+01	4.0E+02	4.8E+03	1.7E+04	3.9E+05
NM519	West-Central	mineralized water	25.4	3.8E+03	5.3E+02	2.8E+02	4.4E+02	1.1E+02	8.2E+02	2.9E+03	8.0E+04	2.9E+04
NM520	West-Central	desorption	7.2	2.5E+03	3.7E+02	1.3E+02	2.0E+02	3.0E+01	6.6E+02	2.2E+03	1.4E+04	2.0E+03
DB073	West-Central	desorption	22.	7.3E+02	8.9E+02	--	1.2E+02	1.2E+01	--	1.3E+03	--	--
DB074	West-Central	desorption	19.	8.4E+02	6.2E+02	--	1.8E+02	1.6E+01	--	4.0E+03	--	--
DB108	West-Central	desorption	7.	1.7E+03	--	8.0E+01	--	1.1E+01	--	--	--	--
DB109	West-Central	desorption	24.	5.4E+02	--	2.9E+01	--	1.1E+01	--	--	--	--
DB189	West-Central	desorption	29.	7.6E+02	2.2E+02	1.1E+02	--	2.8E+01	--	--	--	--
DB191	West-Central	desorption	45.	2.9E+02	1.3E+02	5.0E+01	--	1.2E+01	--	--	--	--
DB232	West-Central	mineralized water	31.	3.2E+03	5.3E+03	--	--	1.3E+02	--	--	--	--
DB234	West-Central	desorption	70.	--	--	--	--	0.0E+00	--	--	--	--
DB253	West-Central	desorption	28.	2.5E+02	3.5E+02	--	--	6.9E+00	--	--	--	--
DB453	West-Central	desorption	12.	4.1E+02	--	2.0E+01	4.9E+01	9.8E+00	--	--	--	--
ATI01	West-Central	desorption	21.7	9.1E+02	1.9E+03	5.6E+01	4.0E+01	2.2E+01	1.3E+02	--	--	4.4E+02
COL01	West-Central	desorption	48.9	1.1E+02	1.6E+02	1.7E+01	1.1E+01	3.7E+00	1.4E+02	--	--	5.6E+01
COL03	West-Central	desorption	24.7	4.6E+02	3.0E+02	4.5E+01	2.3E+01	9.3E+00	1.9E+02	--	--	2.6E+02
LEV02	West-Central	desorption	34.	5.5E+02	1.1E+03	7.0E+01	3.8E+01	1.3E+01	4.7E+02	--	--	2.7E+02
LEV03	West-Central	desorption	34.6	9.1E+02	4.0E+03	9.8E+01	6.3E+01	3.1E+01	4.0E+02	--	--	4.3E+02
VC02	West-Central	desorption	11.4	6.8E+02	1.3E+02	5.0E+01	1.6E+01	7.9E+00	1.6E+02	--	--	3.7E+02
VC03	West-Central	desorption	15.	4.9E+02	1.4E+02	4.1E+01	1.5E+01	7.4E+00	1.5E+02	--	--	2.7E+02
WM01	West-Central	desorption	27.2	2.3E+02	2.8E+02	2.2E+01	1.3E+01	5.7E+00	1.6E+02	--	--	1.3E+02
WM02	West-Central	desorption	39.5	1.8E+02	3.3E+02	3.2E+01	--	5.5E+00	1.8E+02	--	--	1.2E+02
WM04	West-Central	desorption	35.9	4.1E+02	7.0E+02	5.6E+01	3.0E+01	1.4E+01	3.7E+02	--	--	2.4E+02
ZAM01	West-Central	desorption	14.4	6.4E+02	1.7E+02	5.3E+01	1.8E+01	1.2E+01	--	--	--	--

Sample reference number	Water-quality zone	Arsenic source/control	Arsenic concentration (μg/L)	Chloride/ arsenic	Chloride/ barium	Chloride/ boron	Chloride/ bromide	Chloride/ fluoride	Chloride/ lithium	Chloride/ molybdenum	Chloride/ uranium	Chloride/ vanadium
NM329	Western Boundary	both	6.6	5.9E+03	1.7E+03	8.9E+01	1.8E+02	3.6E+01	3.8E+02	2.2E+03	8.2E+04	3.2E+04
NM137	Rio Puerco	mineralized water	6.2	9.5E+04	8.4E+04	5.3E+02	5.0E+02	9.3E+02	7.7E+02	3.3E+04	1.6E+04	3.3E+04
NM064	Abo Arroyo	mineralized water	7.7	2.9E+03	1.4E+03	1.4E+02	1.4E+02	1.7E+01	4.5E+02	3.4E+03	2.8E+03	2.5E+03
NM067	Abo Arroyo	desorption	23.	3.9E+02	1.1E+02	1.4E+02	7.6E+01	1.7E+01	2.6E+02	3.0E+03	7.4E+03	5.0E+02
NM031	Eastern Mountain Front	desorption	16.	4.2E+02	6.6E+01	2.2E+02	7.7E+01	1.5E+01	7.9E+02	1.9E+03	3.1E+03	7.2E+02
NM080	Eastern Mountain Front	desorption	14.	3.4E+02	1.4E+02	6.0E+01	7.5E+01	6.2E+00	2.7E+02	1.9E+03	1.3E+03	1.4E+02
NM106	Eastern Mountain Front	mineralized water	17.	4.7E+03	4.0E+02	6.3E+02	3.3E+02	1.5E+02	1.5E+03	2.5E+04	1.1E+04	2.9E+04
NM148	Eastern Mountain Front	desorption	12.2	2.9E+02	4.0E+01	1.2E+02	7.0E+01	9.0E+00	3.3E+02	1.5E+03	1.7E+03	9.2E+02
NM153	Eastern Mountain Front	mineralized water	18.4	1.2E+03	2.1E+02	1.9E+02	2.3E+02	7.7E+01	3.5E+02	8.2E+03	5.3E+03	3.4E+03
NM161	Eastern Mountain Front	desorption	5.2	1.5E+03	1.6E+03	5.7E+01	8.2E+01	1.5E+01	7.8E+02	1.7E+03	1.1E+03	2.2E+02
NM162	Eastern Mountain Front	mineralized water	6.	1.1E+04	3.8E+02	6.5E+02	3.4E+02	1.4E+02	2.8E+03	1.8E+04	1.6E+04	2.2E+04
NM174	Eastern Mountain Front	mineralized water	19.	3.4E+03	7.0E+02	1.6E+03	3.2E+02	9.1E+01	1.6E+03	4.6E+04	2.8E+04	2.4E+04
NM295	Eastern Mountain Front	desorption	16.2	1.5E+03	3.3E+02	2.1E+02	2.2E+02	5.8E+01	5.7E+02	5.6E+03	1.9E+03	2.5E+03
NM312	Eastern Mountain Front	mineralized water	54.	2.8E+03	2.7E+03	3.8E+02	4.0E+02	1.0E+02	8.2E+02	1.8E+04	7.7E+04	4.4E+03
NM313	Eastern Mountain Front	mineralized water	38.2	4.6E+03	3.1E+03	6.8E+02	5.0E+02	3.3E+02	5.6E+02	4.8E+04	1.3E+05	6.7E+03
NM319	Eastern Mountain Front	desorption	11.3	7.3E+02	1.9E+02	2.1E+02	6.3E+01	1.5E+01	8.3E+03	4.0E+03	6.7E+03	1.9E+02
NM336	Eastern Mountain Front	both	13.7	1.9E+03	4.3E+02	2.2E+02	2.2E+02	5.5E+01	9.1E+02	4.5E+03	2.1E+03	6.6E+03
NM407	Eastern Mountain Front	mineralized water	7.7	3.5E+03	3.5E+02	2.8E+02	1.4E+02	6.6E+01	1.0E+03	4.6E+03	6.7E+03	3.4E+03
NM505	Eastern Mountain Front	mineralized water	8.8	2.1E+03	3.5E+02	4.6E+02	2.3E+02	2.8E+01	4.4E+02	2.7E+03	2.6E+03	1.4E+03
DB040	Eastern Mountain Front	desorption	8.	1.6E+03	1.4E+02	1.3E+03	--	3.3E+01	--	--	--	--
PON02	Eastern Mountain Front	mineralized water	6.	3.9E+03	1.5E+02	4.7E+02	4.7E+01	3.0E+01	7.8E+02	--	--	2.4E+03
PON03	Eastern Mountain Front	mineralized water	23.2	3.9E+03	4.6E+02	4.0E+02	1.8E+02	1.4E+02	1.3E+03	--	--	9.0E+03
PON04	Eastern Mountain Front	mineralized water	14.	2.4E+03	2.7E+02	6.7E+02	6.7E+01	3.4E+01	1.1E+03	--	--	3.3E+03
PON05	Eastern Mountain Front	mineralized water	25.4	2.2E+03	4.6E+02	1.1E+03	1.1E+02	7.2E+01	1.9E+03	--	--	5.6E+03
PON06	Eastern Mountain Front	mineralized water	33.9	2.6E+03	6.9E+02	3.8E+02	1.8E+02	9.1E+01	8.8E+02	--	--	8.8E+03
TOM03	Eastern Mountain Front	mineralized water	6.2	6.8E+03	3.3E+02	3.7E+02	8.4E+01	6.6E+01	2.1E+03	--	--	4.2E+03

Sample reference number	Water-quality zone	Arsenic source/control	Arsenic concentration ($\mu g/L$)	Chloride/ arsenic	Chloride/ barium	Chloride/ boron	Chloride/ bromide	Chloride/ fluoride	Chloride/ lithium	Chloride/ molybdenum	Chloride/ uranium	Chloride/ vanadium
TOM08	Eastern Mountain Front	mineralized water	12.9	6.7E+03	4.3E+02	4.7E+02	1.7E+02	1.8E+02	--	--	--	--
WLK02	Eastern Mountain Front	mineralized water	35.5	2.4E+03	1.0E+03	3.7E+02	1.7E+02	6.8E+01	7.0E+02	--	--	8.4E+03
NM097	Northeastern	mineralized water	7.5	2.9E+03	1.6E+03	3.0E+02	1.0E+02	4.3E+01	1.2E+02	2.9E+03	1.6E+03	3.6E+03
NM258	Northeastern	both	154.6	4.3E+02	5.1E+03	1.5E+02	9.9E+01	5.3E+01	9.4E+02	2.1E+03	7.8E+03	2.2E+03
NM005	Central	desorption	9.	1.6E+03	3.2E+02	9.8E+01	2.0E+02	1.8E+01	2.3E+02	2.9E+03	3.1E+03	7.7E+02
NM013	Central	both	6.	5.4E+03	2.3E+02	3.8E+02	3.1E+02	7.5E+01	8.9E+02	8.7E+03	1.2E+04	4.0E+03
NM028	Central	mineralized water	27.	2.7E+03	7.7E+02	3.6E+02	3.2E+02	9.1E+01	2.8E+02	1.7E+04	5.2E+04	2.8E+03
NM032	Central	desorption	16.	1.2E+03	2.9E+02	1.6E+02	2.2E+02	3.6E+01	1.5E+02	9.0E+03	2.0E+03	8.2E+02
NM057	Central	desorption	6.	2.0E+03	2.1E+02	1.4E+02	2.1E+02	3.0E+01	1.7E+02	3.6E+03	3.0E+03	8.7E+02
NM092	Central	desorption	6.	1.5E+03	1.4E+02	1.3E+02	2.4E+02	2.2E+01	1.5E+02	4.9E+03	2.7E+03	8.1E+02
NM093	Central	desorption	6.	2.1E+03	1.9E+02	2.9E+02	2.5E+02	3.6E+01	3.2E+02	3.8E+03	5.6E+03	1.3E+03
NM099	Central	desorption	8.	1.1E+03	1.3E+02	1.3E+02	1.7E+02	2.2E+01	1.8E+02	2.4E+03	2.7E+03	1.6E+03
NM102	Central	desorption	6.8	1.9E+03	2.1E+02	1.4E+02	2.1E+02	2.4E+01	2.3E+02	2.1E+03	6.6E+04	1.3E+04
NM111	Central	mineralized water	7.	2.9E+03	1.4E+02	3.5E+02	2.5E+02	5.1E+01	5.0E+02	2.9E+03	1.5E+04	2.1E+04
NM112	Central	desorption	23.	5.7E+02	1.5E+02	6.3E+01	2.2E+02	1.3E+01	1.3E+02	3.1E+03	4.0E+03	7.7E+02
NM113	Central	desorption	10.1	4.2E+03	3.5E+02	1.8E+02	3.0E+02	1.1E+02	3.2E+02	2.0E+04	4.2E+03	3.9E+03
NM114	Central	desorption	9.5	2.3E+03	2.5E+02	1.6E+02	2.5E+02	2.9E+01	3.0E+02	2.1E+03	2.8E+03	3.3E+03
NM115	Central	desorption	7.4	3.1E+03	1.5E+02	3.8E+02	3.3E+02	5.1E+01	8.9E+02	9.9E+03	8.5E+03	2.2E+04
NM126	Central	mineralized water	15.4	1.8E+03	3.5E+02	2.2E+02	2.6E+02	5.6E+01	7.2E+02	4.9E+03	5.1E+03	2.3E+03
NM127	Central	desorption	6.8	1.2E+03	8.8E+01	1.4E+02	1.6E+02	2.1E+01	3.1E+02	2.4E+03	2.6E+03	6.6E+02
NM140	Central	desorption	21.	1.3E+03	3.1E+02	1.5E+02	2.9E+02	3.9E+01	2.5E+02	5.7E+03	9.4E+03	1.2E+03
NM147	Central	desorption	11.	9.7E+02	1.0E+02	1.7E+02	1.9E+02	2.2E+01	2.3E+02	2.7E+03	4.4E+03	1.3E+03
NM158	Central	desorption	7.	1.7E+03	3.8E+02	1.6E+02	1.8E+02	7.8E+01	5.6E+02	1.1E+03	1.2E+04	1.2E+04
NM171	Central	mineralized water	7.	3.0E+03	3.0E+02	1.5E+02	1.9E+02	5.4E+01	3.0E+02	3.0E+03	4.0E+03	2.1E+04
NM172	Central	desorption	6.	1.7E+03	1.2E+02	2.2E+02	1.4E+02	2.5E+01	4.7E+02	3.1E+03	4.9E+03	2.4E+03
NM173	Central	desorption	7.	2.3E+03	1.8E+02	3.6E+02	2.0E+02	4.0E+01	5.5E+02	4.7E+03	5.5E+03	2.8E+03

Sample reference number	Water-quality zone	Arsenic source/control	Arsenic concentration (µg/L)	Chloride/ arsenic	Chloride/ barium	Chloride/ boron	Chloride/ bromide	Chloride/ fluoride	Chloride/ lithium	Chloride/ molybdenum	Chloride/ uranium	Chloride/ vanadium
NM175	Central	both	35.	1.2E+03	5.6E+02	2.7E+02	3.9E+02	5.6E+01	2.9E+02	7.8E+03	1.9E+04	1.9E+03
NM178	Central	both	7.	3.6E+03	2.2E+02	3.1E+02	2.2E+02	5.5E+01	7.1E+02	5.5E+03	8.9E+03	3.2E+03
NM270	Central	desorption	7.3	1.4E+03	2.0E+02	1.2E+02	1.6E+02	1.6E+01	2.0E+02	2.6E+03	1.7E+03	7.4E+02
NM274	Central	desorption	5.3	2.6E+03	1.3E+02	2.4E+02	2.0E+02	4.8E+01	4.4E+02	3.7E+03	2.2E+03	4.9E+03
NM275	Central	desorption	5.5	3.0E+03	2.0E+02	2.6E+02	2.5E+02	5.3E+01	5.9E+02	4.0E+03	1.0E+04	9.0E+03
NM279	Central	desorption	50.7	1.7E+02	2.1E+02	3.3E+01	1.5E+02	8.9E+00	8.6E+03	2.8E+03	2.4E+03	2.3E+02
NM280	Central	desorption	22.2	3.6E+02	1.1E+02	4.6E+01	2.5E+02	8.2E+00	8.0E+03	1.6E+03	2.7E+03	6.7E+02
NM286	Central	desorption	5.9	1.9E+03	2.7E+02	3.0E+01	1.9E+02	1.9E+01	1.1E+04	7.5E+02	1.3E+03	6.6E+02
NM305	Central	desorption	6.1	1.5E+03	1.6E+02	1.0E+02	1.9E+02	9.3E+00	2.5E+02	3.2E+03	1.2E+03	7.2E+02
NM309	Central	desorption	11.	1.2E+03	2.2E+02	2.1E+02	1.3E+02	2.1E+01	3.2E+02	5.2E+03	4.3E+03	7.6E+02
NM323	Central	desorption	21.4	5.6E+02	3.1E+02	1.3E+02	1.9E+02	1.7E+01	1.7E+02	1.2E+03	2.8E+03	8.0E+02
NM325	Central	mineralized water	5.3	6.8E+03	4.2E+02	7.0E+02	1.2E+02	8.6E+01	3.6E+04	9.9E+03	1.4E+04	6.9E+03
NM333	Central	unknown	11.6	3.8E+02	4.0E+01	1.9E+02	1.7E+02	9.2E+00	4.4E+03	1.0E+03	5.4E+03	2.8E+02
NM339	Central	mineralized water	29.2	1.6E+03	4.9E+02	1.5E+02	3.5E+02	5.0E+01	2.8E+02	6.0E+03	1.6E+04	1.9E+03
NM340	Central	desorption	8.5	8.3E+02	8.3E+01	1.5E+02	2.7E+02	1.5E+01	7.0E+03	1.4E+03	2.8E+03	1.6E+03
NM344	Central	mineralized water	8.7	3.6E+03	2.7E+02	1.8E+02	2.0E+02	7.4E+01	5.5E+02	1.5E+04	5.2E+03	3.3E+03
NM348	Central	desorption	12.5	8.9E+02	2.2E+02	1.0E+02	1.9E+02	1.1E+01	2.6E+02	5.1E+03	2.6E+03	5.1E+02
NM349	Central	desorption	6.8	1.6E+03	2.0E+02	1.3E+02	2.1E+02	1.0E+01	3.9E+02	3.8E+03	2.7E+03	8.9E+02
NM350	Central	desorption	5.4	2.6E+03	2.1E+02	2.1E+02	2.2E+02	1.9E+01	5.2E+02	1.9E+03	3.3E+03	1.7E+03
NM488	Central	mineralized water	38.5	1.3E+03	5.2E+02	3.0E+02	4.4E+02	4.9E+01	3.8E+02	1.0E+04	1.1E+04	1.7E+03
NM489	Central	mineralized water	9.5	5.8E+03	5.7E+02	2.9E+02	4.3E+02	9.9E+01	7.9E+02	8.4E+03	4.1E+03	1.4E+04
NM493	Central	desorption	43.1	2.7E+02	4.2E+02	8.3E+01	2.0E+02	1.0E+01	2.6E+02	1.7E+03	1.3E+03	2.9E+02
NM494	Central	desorption	5.8	1.5E+03	1.5E+02	1.6E+02	4.4E+02	2.0E+01	2.9E+02	1.9E+03	5.7E+03	1.8E+03
NM503	Central	both	44.5	4.8E+02	1.1E+04	6.1E+01	1.9E+02	1.0E+01	5.5E+02	2.1E+03	9.4E+04	2.1E+05
NM504	Central	mineralized water	27.1	1.3E+03	1.7E+04	9.9E+01	3.1E+02	2.6E+01	5.0E+02	7.9E+03	5.6E+04	3.5E+05
NM506	Central	mineralized water	16.3	1.6E+03	2.7E+02	2.9E+02	3.3E+02	4.4E+01	3.0E+02	6.6E+03	1.3E+04	2.5E+03

Sample reference number	Water-quality zone	Arsenic source/control	Arsenic concentration (µg/L)	Chloride/ arsenic	Chloride/ barium	Chloride/ boron	Chloride/ bromide	Chloride/ fluoride	Chloride/ lithium	Chloride/ molybdenum	Chloride/ uranium	Chloride/ vanadium
NM508	Central	desorption	22.3	4.2E+02	1.1E+02	8.0E+01	1.6E+02	1.4E+01	9.5E+01	5.4E+02	1.9E+03	9.0E+02
NM511	Central	mineralized water	26.9	2.3E+03	9.7E+02	4.1E+02	3.9E+02	6.0E+01	5.2E+02	3.1E+03	1.2E+04	4.5E+03
NM513	Central	mineralized water	6.	1.6E+04	6.3E+02	1.7E+03	4.1E+02	3.1E+02	1.6E+03	1.5E+04	2.1E+04	2.2E+04
NM517	Central	desorption	23.3	3.5E+02	2.3E+02	7.7E+01	1.6E+02	7.3E+00	1.0E+02	1.6E+03	2.2E+03	2.8E+02
NM518	Central	both	5.9	3.0E+03	2.5E+02	2.3E+02	1.2E+02	2.8E+01	4.2E+02	1.2E+03	2.6E+03	2.6E+03
NM522	Central	mineralized water	15.6	2.7E+03	5.5E+02	3.5E+02	3.8E+02	4.7E+01	4.5E+02	4.4E+03	7.2E+03	6.1E+03
DB093	Central	desorption	6.	1.2E+03	8.6E+01	--	1.4E+02	1.4E+01	--	1.8E+03	--	--
DB094	Central	desorption	6.	1.7E+03	1.4E+02	--	2.0E+02	3.3E+01	--	3.3E+03	--	--
DB139	Central	both	10.	2.2E+03	8.1E+02	--	2.8E+02	4.4E+01	--	7.3E+03	--	--
DB140	Central	desorption	7.	1.6E+03	1.4E+02	1.8E+02	1.3E+02	2.8E+01	--	1.1E+03	--	--
DB145	Central	mineralized water	15.	1.3E+03	1.4E+02	3.3E+02	2.9E+02	3.3E+01	--	2.0E+03	--	--
DB148	Central	both	18.	1.1E+03	2.4E+02	1.1E+02	2.5E+02	2.9E+01	--	2.0E+03	--	--
DB150	Central	desorption	18.	8.9E+02	1.7E+02	1.5E+02	5.7E+02	3.2E+01	--	1.6E+03	--	--
DB151	Central	mineralized water	10.	3.0E+03	2.7E+02	--	2.1E+02	3.8E+01	--	2.7E+03	--	--
DB162	Central	mineralized water	6.	3.5E+03	2.5E+02	--	--	4.2E+01	--	--	--	--
DB168	Central	desorption	8.	2.1E+03	3.2E+02	--	--	1.7E+02	--	--	--	--
DB169	Central	both	15.	1.8E+03	3.9E+02	--	--	5.4E+01	--	--	--	--
DB170	Central	desorption	9.	2.1E+03	3.7E+02	--	--	2.7E+01	--	--	--	--
DB180	Central	mineralized water	7.	4.1E+03	4.0E+02	1.5E+02	3.1E+02	4.8E+01	--	2.9E+03	--	--
DB188	Central	mineralized water	21.	1.7E+03	3.6E+02	2.1E+02	--	5.1E+01	--	--	--	--
DB190	Central	mineralized water	21.	1.6E+03	3.3E+02	3.0E+02	--	--	--	--	--	--
DB194	Central	mineralized water	13.	2.7E+03	3.5E+02	2.9E+02	--	7.0E+01	--	--	--	--
DB197	Central	mineralized water	9.	1.6E+03	2.1E+02	--	1.8E+02	2.0E+01	--	2.3E+03	--	--
DB207	Central	unknown	6.	1.7E+03	1.6E+02	--	2.5E+02	2.5E+01	--	1.4E+03	--	--
DB228	Central	mineralized water	10.	2.4E+03	2.2E+02	--	1.4E+02	3.0E+01	--	2.4E+03	--	--
DB288	Central	desorption	7.	1.4E+03	1.2E+02	2.0E+02	1.8E+02	2.5E+01	--	9.8E+02	--	--

Sample reference number	Water-quality zone	Arsenic source/control	Arsenic concentration ($\mu g/L$)	Chloride/ arsenic	Chloride/ barium	Chloride/ boron	Chloride/ bromide	Chloride/ fluoride	Chloride/ lithium	Chloride/ molybdenum	Chloride/ uranium	Chloride/ vanadium
DB309	Central	desorption	7.	1.4E+03	2.6E+02	1.7E+02	2.0E+02	2.0E+01	--	1.0E+03	--	--
DB354	Central	unknown	18.	5.5E+02	--	1.1E+02	--	1.4E+01	--	--	--	--
DB372	Central	desorption	6.	1.3E+03	1.5E+02	--	2.6E+02	1.6E+01	--	2.0E+03	--	--
DB373	Central	unknown	6.	1.3E+03	1.0E+02	--	3.4E+01	--	--	6.8E+02	--	--
DB376	Central	unknown	7.	1.0E+03	7.3E+01	9.1E+01	--	2.4E+01	--	--	--	--
DB379	Central	unknown	9.	8.2E+02	7.4E+01	9.3E+01	--	1.9E+01	--	--	--	--
DB413	Central	mineralized water	9.	3.9E+03	3.5E+02	9.2E+01	--	1.2E+02	--	--	--	--
ATI02	Central	both	6.5	2.5E+03	3.2E+02	1.2E+02	3.3E+01	2.3E+01	2.4E+02	--	--	1.4E+03
ATI04	Central	desorption	9.7	1.3E+03	2.4E+02	8.3E+01	2.4E+01	1.2E+01	1.7E+02	--	--	6.1E+02
BUR01	Central	mineralized water	15.	2.4E+03	3.0E+02	2.7E+02	7.2E+01	5.7E+01	4.5E+02	--	--	3.4E+03
BUR04	Central	mineralized water	20.8	2.0E+03	4.1E+02	2.7E+02	8.3E+01	5.9E+01	4.2E+02	--	--	3.0E+03
COR02	Central	both	15.6	1.6E+03	3.3E+02	1.5E+02	4.9E+01	3.1E+01	--	--	--	2.2E+03
DUR02	Central	desorption	7.6	1.4E+03	1.9E+02	1.1E+02	2.1E+01	1.6E+01	1.5E+02	--	--	7.7E+02
DUR03	Central	desorption	6.2	2.0E+03	2.5E+02	1.0E+02	2.5E+01	2.3E+01	1.6E+02	--	--	1.1E+03
DUR04	Central	desorption	12.9	9.6E+02	2.7E+02	1.0E+02	2.5E+01	1.2E+01	1.8E+02	--	--	5.9E+02
DUR05	Central	desorption	10.	1.2E+03	2.8E+02	8.6E+01	2.4E+01	1.2E+01	2.0E+02	--	--	7.3E+02
GON02	Central	desorption	12.8	7.8E+02	2.1E+02	6.2E+01	2.0E+01	1.0E+01	--	--	--	--
GRG01	Central	desorption	6.1	2.0E+03	2.0E+02	1.8E+02	2.4E+01	3.0E+01	1.7E+02	--	--	1.2E+03
GRG04	Central	desorption	13.	7.2E+02	1.7E+02	1.3E+02	1.9E+01	1.4E+01	1.0E+02	--	--	6.0E+02
LYN03	Central	desorption	6.	1.3E+03	9.6E+01	1.6E+02	1.6E+01	1.6E+01	2.7E+02	--	--	8.0E+02
MIL01	Central	both	16.1	2.4E+03	4.3E+02	3.0E+02	7.7E+01	5.6E+01	6.4E+02	--	--	2.6E+03
SJ01	Central	mineralized water	6.4	2.5E+03	3.8E+02	1.2E+02	3.3E+01	4.9E+01	2.0E+02	--	--	1.6E+03
SJ03	Central	desorption	32.7	4.5E+02	2.4E+02	6.4E+01	2.9E+01	1.5E+01	1.3E+02	--	--	5.1E+02
TOM05	Central	both	8.6	2.1E+03	2.1E+02	1.6E+02	3.6E+01	2.7E+01	4.5E+02	--	--	1.8E+03
TOM07	Central	mineralized water	6.1	4.4E+03	2.5E+02	2.2E+02	5.4E+01	4.1E+01	9.0E+02	--	--	2.7E+03
VAN01	Central	desorption	7.	1.9E+03	1.1E+02	2.6E+02	2.7E+01	3.0E+01	4.5E+02	--	--	1.4E+03

Sample reference number	Water-quality zone	Arsenic source/control	Arsenic concentration (µg/L)	Chloride/ arsenic	Chloride/ barium	Chloride/ boron	Chloride/ bromide	Chloride/ fluoride	Chloride/ lithium	Chloride/ molybdenum	Chloride/ uranium	Chloride/ vanadium
VAN03	Central	desorption	6.8	2.6E+03	1.8E+02	3.1E+02	3.6E+01	3.6E+01	5.9E+02	--	--	1.8E+03
VAN04	Central	desorption	8.	1.2E+03	1.0E+02	1.9E+02	1.9E+01	2.1E+01	3.2E+02	--	--	9.5E+02
VAN06	Central	desorption	7.9	1.1E+03	7.0E+01	1.7E+02	1.8E+01	2.0E+01	2.9E+02	--	--	8.8E+02
WEB02	Central	both	27.	9.3E+02	3.2E+02	1.8E+02	5.0E+01	3.4E+01	1.8E+02	--	--	1.5E+03
YAL02	Central	mineralized water	10.8	3.2E+03	3.4E+02	3.0E+02	7.0E+01	5.8E+01	5.8E+02	--	--	3.5E+03
YAL03	Central	mineralized water	13.	2.3E+03	3.3E+02	1.7E+02	5.9E+01	5.5E+01	3.3E+02	--	--	3.0E+03
NM096	Discharge	mineralized water	12.	1.3E+04	7.2E+03	2.7E+02	4.1E+02	9.6E+01	4.7E+02	1.3E+04	1.2E+05	2.2E+04
NM327	Discharge	mineralized water	7.9	8.7E+04	2.3E+04	2.4E+03	1.2E+03	1.3E+03	4.5E+03	1.6E+05	1.8E+05	9.6E+04
DB009	Discharge	mineralized water	18.	1.6E+04	8.2E+03	--	7.0E+02	2.5E+02	--	2.3E+04	--	--
DB029	Discharge	mineralized water	17.	8.8E+03	5.0E+03	6.8E+02	--	8.8E+01	--	--	--	--

Appendix III.--Salt assemblage and dominant salt group for MRGB study ground-water samples. [Assemblages are given in percent of salts classified in each group, as determined using SNORM (Bodine and Jones, 1986). a, anhydrite plus glauberite; b, burkeite plus trona; c, calcite plus pirssonite; d, dolomite; h, halite; t, thenardite plus aphthitalite]

Sample reference number	Anhydrite plus glauberite	Burkeite plus trona	Calcite plus pirssonite	Dolomite	Halite	Thenardite plus aphthitalite	Other	Dominant salt group
			Northern Mountain Front zone					
NM026	0.0	0.0	52.6	27.1	3.8	14.9	1.7	c
NM027	0.0	0.0	50.1	23.6	5.9	18.1	2.3	c
NM055	7.4	0.0	11.7	8.3	44.2	0.0	28.4	h
NM131	13.7	0.0	15.2	4.7	59.6	0.0	6.8	h
NM143	26.7	0.0	23.8	26.4	9.5	0.0	13.6	a
NM168	0.0	0.0	51.6	28.0	5.7	12.5	2.2	c
NM486	0.0	0.0	52.4	20.5	6.1	18.9	2.2	c
NM487	2.3	0.0	45.1	27.3	2.5	21.9	1.0	c
NM510	0.0	42.3	22.5	20.3	4.9	7.7	2.4	b
NM514	0.0	0.0	43.2	16.0	11.9	28.1	0.8	c
NM525	0.6	0.0	41.4	27.5	10.0	17.3	3.2	c
NM527	0.0	0.0	53.5	30.1	2.8	13.0	0.6	c
NM528	0.0	0.0	73.1	10.5	5.1	9.7	1.6	c
NM530	0.0	0.0	52.8	25.0	7.0	14.5	0.7	c
			Northwestern zone					
NM128	0.0	25.9	27.3	11.8	6.8	24.8	3.3	c
NM133	0.0	0.0	30.2	6.6	28.5	33.2	1.5	t
NM179	0.0	0.0	64.5	8.6	5.3	12.7	8.9	c
NM180	8.8	0.0	40.0	21.6	4.3	13.5	11.9	c
NM184	0.0	0.0	53.4	18.0	2.4	20.1	6.1	c
NM185	0.0	19.9	44.6	13.5	7.3	11.9	2.9	c
NM326	0.0	34.0	31.6	9.9	7.4	14.2	2.9	b
NM497	0.0	39.4	37.2	8.3	5.8	4.1	5.2	b
NM498	0.0	33.3	38.6	12.2	4.4	3.9	7.7	c
NM499	0.0	0.0	45.3	22.9	5.2	18.3	8.3	c
NM526	0.0	0.0	41.0	14.9	7.9	34.2	2.0	c
			West-Central zone					
NM003	0.0	57.7	23.0	2.2	5.8	9.3	2.0	b
NM007	5.5	0.0	6.3	22.5	9.1	54.8	1.8	t
NM008	0.0	0.0	11.3	20.0	7.5	59.5	1.7	t
NM015	0.0	0.0	16.6	5.7	10.4	66.3	1.1	t
NM056	0.0	57.7	20.3	7.5	6.7	5.7	2.1	b
NM076	0.0	69.5	8.6	8.4	6.2	6.2	1.1	b
NM077	0.0	63.9	10.7	9.9	7.8	6.7	1.0	b
NM107	0.0	74.2	8.5	6.3	3.5	6.2	1.3	b
NM109	0.0	34.9	13.5	2.6	13.0	34.3	1.8	b
NM110	0.0	31.5	14.1	4.0	11.8	36.7	1.8	t
NM129	0.0	81.8	9.8	0.4	4.5	1.0	2.6	b

Sample reference number	Anhydrite plus glauberite	Burkeite plus trona	Calcite plus pirssonite	Dolomite	Halite	Thenardite plus aphthitalite	Other	Dominant salt group
NM130	0.0	48.5	32.6	3.9	9.8	3.2	2.0	b
NM132	0.0	88.2	5.7	0.3	2.9	0.9	2.1	b
NM135	0.0	72.0	7.0	8.3	7.7	3.2	1.8	b
NM139	0.0	16.8	10.2	13.0	7.1	51.6	1.3	t
NM144	0.0	86.2	7.3	0.8	1.5	2.6	1.5	b
NM145	0.0	82.1	11.2	1.2	0.9	2.7	2.0	b
NM146	0.0	65.5	19.1	1.8	8.5	3.6	1.4	b
NM155	0.0	26.5	14.7	1.6	3.3	53.0	0.9	t
NM181	0.0	78.1	9.0	2.0	2.8	3.1	5.0	b
NM182	0.0	78.8	7.7	2.6	3.0	3.2	4.7	b
NM183	0.0	0.0	14.0	8.5	34.1	42.0	1.4	t
NM186	0.0	83.8	9.4	1.1	2.9	2.2	0.6	b
NM255	0.0	77.4	10.8	2.2	4.8	3.9	0.9	b
NM260	0.0	47.3	9.1	14.9	6.6	20.2	1.9	b
NM264	0.0	87.2	5.6	1.0	3.7	0.0	2.5	b
NM294	0.0	77.6	9.2	3.0	7.0	0.4	2.7	b
NM308	0.0	0.0	28.8	28.4	8.3	30.6	4.0	t
NM310	0.0	56.9	20.8	7.4	6.3	6.7	1.9	b
NM311	0.0	33.2	26.9	19.5	4.9	11.9	3.6	b
NM322	0.0	45.3	15.1	0.4	21.3	16.4	1.4	b
NM346	0.0	28.3	32.6	15.2	6.4	15.1	2.5	c
NM347	0.0	62.5	8.0	0.4	18.3	9.4	1.4	b
NM353	0.0	81.8	7.9	1.7	5.0	0.9	2.8	b
NM481	0.0	64.5	1.9	0.8	30.9	1.0	0.9	b
NM482	0.0	91.6	3.8	0.2	2.6	1.4	0.4	b
NM483	0.0	89.9	4.6	1.1	1.4	1.7	1.4	b
NM484	0.0	77.5	14.3	0.3	4.6	0.4	3.0	b
NM492	0.0	79.9	4.9	0.7	11.1	0.8	2.6	b
NM509	0.0	58.7	22.4	9.3	3.9	3.8	2.0	b
NM516	0.0	79.2	5.6	0.8	12.8	0.9	0.8	b
NM519	0.0	26.7	15.8	4.0	21.0	31.7	0.7	t
NM520	0.0	78.4	9.0	0.9	8.4	2.2	1.0	b
NM521	0.0	48.4	29.8	8.9	5.3	2.8	4.9	b
				Western Boundary zone				
NM167	0.0	10.3	6.0	10.9	16.1	55.8	0.9	t
NM263	15.7	0.0	0.0	7.5	46.3	27.2	3.4	h
NM266	0.0	53.9	4.0	5.0	33.0	3.6	0.6	b
NM278	43.3	0.0	0.0	0.0	39.0	0.0	17.7	a
NM285	0.0	0.0	4.7	12.5	51.3	30.9	0.5	h
NM320	31.1	0.0	0.0	0.0	43.3	0.0	25.6	h
NM329	67.7	0.0	0.0	0.0	4.3	0.0	28.1	a
NM345	0.0	0.1	5.2	10.2	38.7	45.3	0.6	t
				Rio Puerco zone				
NM058	54.4	0.0	0.0	0.0	18.2	0.0	27.4	a

Sample reference number	Anhydrite plus glauberite	Burkeite plus trona	Calcite plus pirssonite	Dolomite	Halite	Thenardite plus aphthitalite	Other	Dominant salt group
NM062	42.2	0.0	0.0	0.0	31.0	0.0	26.8	a
NM079	44.0	0.0	0.0	0.0	21.2	0.0	34.8	a
NM137	43.8	0.0	0.0	0.0	23.0	0.0	33.2	a
NM262	43.1	0.0	0.0	0.0	38.4	8.2	10.3	a
NM324	58.5	0.0	0.0	0.0	10.4	0.0	31.1	a
NM335	0.0	0.0	20.0	18.3	2.6	58.5	0.8	t
NM341	34.1	0.0	0.0	0.0	47.8	0.0	18.2	h
NM342	45.3	0.0	0.0	0.0	22.0	0.0	32.6	a
NM408	58.4	0.0	0.0	0.0	3.9	0.0	37.7	a
NM409	61.4	0.0	0.0	0.0	3.5	0.0	35.0	a
			Southwestern Mountain Front zone					
NM009	27.4	0.0	6.3	35.6	15.2	13.7	1.8	d
			Abo Arroyo zone					
NM011	68.3	0.0	0.0	3.4	7.3	0.0	21.0	a
NM064	66.2	0.0	0.0	0.0	6.2	0.0	27.6	a
NM067	5.4	0.0	20.6	19.2	6.4	44.9	3.6	t
NM261	52.2	0.0	0.0	0.0	6.0	0.0	41.8	a
			Eastern Mountain Front zone					
NM002	18.5	0.0	33.4	39.8	3.7	2.9	1.7	d
NM006	6.9	0.0	39.9	27.4	6.4	18.7	0.7	c
NM016	5.2	0.0	42.7	12.5	25.2	13.2	1.2	c
NM031	0.0	0.0	39.8	28.8	7.9	21.7	1.9	c
NM042	11.9	0.0	43.4	31.4	3.6	8.1	1.6	c
NM043	22.8	0.0	24.3	44.5	3.2	0.0	5.1	d
NM060	3.3	0.0	55.6	23.5	4.4	9.6	3.7	c
NM068	16.9	0.0	33.9	24.8	6.5	16.5	1.5	c
NM078	0.0	0.0	57.4	10.1	7.9	22.6	2.0	c
NM080	0.0	42.3	21.6	26.7	4.8	2.6	2.0	b
NM095	0.0	0.0	67.7	12.9	3.8	12.5	3.0	c
NM106	15.5	0.0	34.5	5.6	39.5	0.0	4.9	h
NM108	7.7	0.0	39.6	18.4	22.5	10.2	1.7	c
NM134	13.7	0.0	22.7	33.0	16.2	12.0	2.4	d
NM138	36.5	0.0	19.4	30.2	12.0	0.0	2.0	a
NM141	0.0	0.0	61.3	21.5	4.4	11.8	1.1	c
NM142	0.5	0.0	50.1	22.3	5.5	19.6	2.0	c
NM148	3.5	0.0	54.1	21.9	2.5	16.9	1.1	c
NM153	0.0	0.0	54.5	11.7	12.1	20.8	0.8	c
NM156	0.0	0.0	40.2	35.0	4.4	19.2	1.3	c
NM157	0.0	0.0	68.5	12.0	5.2	13.1	1.1	c
NM161	0.0	82.6	9.3	0.7	5.1	1.2	1.2	b
NM162	15.5	0.0	36.4	8.1	34.2	0.0	5.7	c
NM174	14.3	0.0	39.6	1.8	36.9	0.0	7.4	c
NM177	14.2	0.0	21.6	35.4	15.6	11.4	1.8	d
NM256	0.0	24.0	0.0	53.8	10.5	5.3	6.4	d

Sample reference number	Anhydrite plus glauberite	Burkeite plus trona	Calcite plus pirssonite	Dolomite	Halite	Thenardite plus aphthitalite	Other	Dominant salt group
NM257	30.4	0.0	49.3	13.1	4.7	0.0	2.5	c
NM295	0.0	0.0	33.6	18.0	16.2	31.1	1.0	c
NM298	7.0	0.0	46.2	28.0	4.6	11.0	3.3	c
NM299	30.4	0.0	0.0	43.4	20.0	0.0	6.3	d
NM300	1.9	0.0	31.0	29.0	7.6	29.3	1.2	c
NM306	32.3	0.0	13.4	39.5	8.7	0.0	6.1	d
NM312	1.0	0.0	10.6	9.1	56.6	21.1	1.6	h
NM313	13.6	0.0	9.0	8.8	60.9	0.0	7.8	h
NM317	0.0	0.0	52.4	19.8	8.7	17.5	1.6	c
NM318	19.5	0.0	30.6	25.9	7.5	15.0	1.5	c
NM319	0.0	37.6	34.4	16.8	7.8	1.6	1.8	b
NM328	0.0	46.9	14.4	6.8	12.6	17.3	2.1	b
NM336	0.0	0.0	25.1	19.7	19.6	34.7	0.9	t
NM343	26.7	0.0	30.3	14.0	7.4	19.8	1.9	c
NM407	13.1	0.0	30.8	25.0	15.2	14.5	1.5	c
NM500	0.0	0.0	67.9	5.1	5.4	20.0	1.7	c
NM501	0.0	34.1	50.6	5.6	4.8	3.7	1.1	c
NM502	0.0	0.0	62.3	15.9	4.6	15.6	1.6	c
NM505	0.0	0.0	33.4	29.0	15.5	20.8	1.3	c
NM515	10.9	0.0	50.1	25.2	3.5	7.7	2.6	c
NM523	0.0	0.0	60.0	17.0	6.0	15.3	1.8	c
			Tijeras Fault Zone zone					
NM029	1.9	0.0	21.6	24.7	43.5	3.0	5.4	h
NM061	55.5	0.0	0.0	19.9	10.8	0.0	13.8	a
NM071	49.8	0.0	3.0	24.1	17.6	0.0	5.5	a
NM136	0.0	49.1	0.0	12.1	17.3	20.5	1.0	b
NM151	13.6	0.0	20.2	35.6	27.1	0.0	3.6	d
NM152	18.1	0.0	14.3	33.2	31.4	0.0	3.0	d
			Tijeras Arroyo zone					
NM001	53.6	0.0	0.0	12.4	14.8	0.0	19.3	a
NM069	36.9	0.0	21.8	28.7	8.9	0.0	3.7	a
NM075	37.2	0.0	9.8	31.5	17.1	0.0	4.5	a
NM250	37.4	0.0	0.0	36.9	14.0	0.0	11.7	a
NM277	44.7	0.0	16.9	28.2	7.5	0.0	2.6	a
			Northeastern zone					
NM097	71.7	0.0	0.0	9.7	4.0	0.0	14.6	a
NM258	0.0	54.3	11.9	4.8	14.0	14.1	0.8	b
NM259	0.0	0.0	35.0	7.1	8.4	46.2	3.3	t
NM276	81.9	0.0	0.0	0.0	2.9	0.0	15.2	a
NM332	43.2	0.0	15.1	32.4	5.2	0.0	4.3	a
NM334	71.9	0.0	0.0	0.0	2.5	0.0	25.6	a
NM338	74.9	0.0	0.0	0.0	5.4	0.0	19.8	a
			Central zone					
NM004	20.2	0.0	26.9	23.5	8.6	19.8	1.1	c

Sample reference number	Anhydrite plus glauberite	Burkeite plus trona	Calcite plus pirssonite	Dolomite	Halite	Thenardite plus aphthitalite	Other	Dominant salt group
NM005	0.0	0.0	30.4	15.2	8.7	44.4	1.3	t
NM012	16.4	0.0	20.4	26.9	24.9	0.0	11.4	d
NM013	11.7	0.0	23.0	27.8	26.6	0.0	10.9	d
NM025	40.7	0.0	24.9	20.1	10.8	0.0	3.5	a
NM028	0.6	0.0	18.1	19.5	39.1	20.7	2.0	h
NM032	1.1	0.0	20.1	20.9	9.1	47.5	1.3	t
NM057	0.0	0.0	26.7	20.0	8.4	44.1	0.9	t
NM063	0.0	0.0	35.6	19.7	11.0	32.7	0.9	c
NM066	37.0	0.0	14.5	29.8	10.0	0.0	8.7	a
NM070	13.2	0.0	26.8	27.5	22.9	0.0	9.5	d
NM073	33.1	0.0	30.8	22.2	7.6	0.0	6.2	a
NM074	11.9	0.0	46.2	14.9	10.3	14.8	1.9	c
NM081	53.2	0.0	0.0	20.0	15.1	0.0	11.6	a
NM082	24.3	0.0	11.2	40.1	10.7	0.0	13.8	d
NM083	25.6	0.0	10.6	40.8	9.2	0.0	13.8	d
NM084	22.1	0.0	34.2	23.4	6.7	12.7	0.8	c
NM085	23.3	0.0	15.9	34.6	12.3	0.0	13.9	d
NM086	39.4	0.0	15.2	33.8	4.5	0.0	7.2	a
NM088	14.6	0.0	20.9	30.9	6.8	25.7	1.0	d
NM089	24.0	0.0	29.1	26.3	6.1	13.5	1.0	c
NM090	30.5	0.0	22.2	27.1	4.8	14.2	1.3	a
NM091	0.0	0.0	31.5	21.2	7.3	38.8	1.1	t
NM092	0.0	0.0	31.5	22.5	7.7	37.2	1.1	t
NM093	20.9	0.0	14.0	34.7	11.0	18.0	1.4	d
NM094	30.3	0.0	5.8	39.2	10.1	0.0	14.6	d
NM099	10.3	0.0	29.5	26.2	6.5	26.3	1.1	c
NM100	32.8	0.0	17.6	27.6	12.7	0.0	9.3	a
NM101	39.5	0.0	22.3	24.7	7.9	0.0	5.6	a
NM102	25.1	0.0	30.9	21.1	7.2	14.7	1.0	c
NM103	32.2	0.0	32.0	23.2	7.0	4.3	1.4	a
NM104	4.8	0.0	31.2	33.1	8.0	21.7	1.3	d
NM105	30.0	0.0	32.1	23.6	8.2	0.0	6.2	c
NM111	32.7	0.0	28.6	22.5	9.2	0.0	7.0	a
NM112	0.0	0.0	29.8	19.8	8.1	40.9	1.4	t
NM113	31.6	0.0	10.4	28.0	18.5	6.9	4.6	a
NM114	11.4	0.0	22.5	26.1	9.8	29.2	1.1	t
NM115	8.9	0.0	23.8	32.0	19.7	0.0	15.6	d
NM116	43.3	0.0	0.0	20.8	12.7	0.0	23.3	a
NM126	0.0	0.0	23.8	22.8	17.0	35.3	1.0	t
NM127	0.0	0.0	25.4	38.1	7.5	28.0	1.1	d
NM140	0.0	0.0	22.4	21.0	17.9	37.0	1.6	t
NM147	0.0	0.0	37.3	20.3	9.9	31.3	1.2	c
NM158	0.0	20.8	49.9	9.5	12.6	6.4	0.9	c
NM159	0.0	2.5	50.4	23.2	9.1	9.0	5.9	c

Sample reference number	Anhydrite plus glauberite	Burkeite plus trona	Calcite plus pirssonite	Dolomite	Halite	Thenardite plus aphthitalite	Other	Dominant salt group
NM171	37.5	0.0	26.4	23.5	6.2	1.2	5.2	a
NM172	24.7	0.0	40.1	18.0	10.3	4.8	2.2	c
NM173	37.9	0.0	23.3	20.5	11.9	0.0	6.4	a
NM175	0.0	0.0	30.6	17.7	27.6	23.0	1.2	c
NM178	22.3	0.0	21.5	25.3	19.2	0.0	11.8	d
NM270	0.0	0.0	30.9	19.8	6.9	41.3	1.1	t
NM271	21.7	0.0	23.1	26.8	7.6	19.5	1.3	d
NM272	17.5	0.0	28.2	23.2	8.0	22.0	1.1	c
NM273	31.2	0.0	24.6	25.5	6.5	11.3	1.0	a
NM274	34.0	0.0	25.7	25.2	9.1	5.1	0.9	a
NM275	31.9	0.0	24.1	25.9	11.3	0.0	6.9	a
NM279	0.0	55.3	23.1	7.3	5.4	7.4	1.6	b
NM280	0.0	31.2	31.6	18.3	6.0	11.2	1.7	c
NM283	32.5	0.0	20.9	26.0	9.2	0.0	11.3	a
NM286	0.0	47.6	28.4	8.8	6.8	7.0	1.6	b
NM287	2.5	0.0	36.0	27.0	5.9	27.7	1.0	c
NM288	51.3	0.0	2.4	30.4	8.6	0.0	7.3	a
NM289	31.0	0.0	22.3	24.2	5.6	16.3	0.8	a
NM290	39.7	0.0	14.9	29.7	7.2	0.0	8.6	a
NM291	48.5	0.0	3.7	31.5	9.1	0.0	7.2	a
NM292	0.0	0.0	38.4	20.3	9.0	31.3	1.1	c
NM305	0.0	0.0	32.4	27.1	6.7	32.2	1.6	c
NM307	39.0	0.0	10.0	24.1	13.6	0.0	13.3	a
NM309	0.0	0.0	40.2	19.2	10.0	29.2	1.5	c
NM315	0.4	0.0	45.0	17.9	6.8	28.5	1.3	c
NM316	29.1	0.0	14.7	36.5	13.4	0.0	6.3	d
NM321	11.7	0.0	35.7	20.2	25.0	0.1	7.4	c
NM323	0.0	0.3	21.2	11.7	10.5	55.2	1.2	t
NM325	0.0	0.0	43.3	27.9	11.0	16.9	0.9	c
NM331	42.2	0.0	20.4	26.4	5.7	0.0	5.3	a
NM333	20.1	0.0	31.1	31.9	4.2	11.9	0.9	d
NM339	0.0	0.0	24.5	21.5	25.6	26.7	1.7	t
NM340	0.0	0.0	44.9	24.9	7.4	21.5	1.3	c
NM344	18.7	0.0	27.7	23.4	13.0	15.5	1.8	c
NM348	0.0	0.0	41.2	13.4	7.6	36.3	1.5	c
NM349	0.0	0.0	38.1	16.2	7.6	36.6	1.6	c
NM350	13.0	0.0	20.2	20.0	8.5	37.2	1.2	t
NM351	19.9	0.0	21.4	24.1	7.5	26.0	1.2	t
NM352	26.2	0.0	29.0	25.6	9.3	8.9	0.9	c
NM488	0.0	25.0	23.8	14.0	28.9	6.9	1.5	h
NM489	16.0	0.0	24.8	19.7	32.1	5.9	1.6	h
NM490	38.2	0.0	0.0	17.7	15.6	0.0	28.4	a
NM491	48.1	0.0	13.5	28.1	5.0	0.0	5.3	a
NM493	0.0	66.7	15.3	4.4	7.1	5.1	1.4	b

Sample reference number	Anhydrite plus glauberite	Burkeite plus trona	Calcite plus pirssonite	Dolomite	Halite	Thenardite plus aphthitalite	Other	Dominant salt group
NM494	0.0	0.0	40.3	21.7	8.8	28.1	1.1	c
NM495	29.1	0.0	30.1	21.7	10.2	8.2	0.7	c
NM503	0.0	77.4	6.3	0.3	12.6	1.1	2.3	b
NM504	0.0	65.7	8.7	0.6	22.1	1.1	1.7	b
NM506	0.0	0.0	23.5	28.1	22.0	24.7	1.7	d
NM507	0.0	0.0	42.8	18.7	11.0	26.4	1.1	c
NM508	0.0	15.8	45.4	14.7	7.4	15.5	1.2	c
NM511	0.0	29.1	19.2	15.0	29.7	6.0	1.1	h
NM513	26.1	0.0	18.0	17.4	31.2	0.0	7.3	h
NM517	0.0	72.4	12.0	3.1	5.1	6.3	1.2	b
NM518	0.0	6.0	39.4	15.4	10.2	27.9	1.1	c
NM522	0.0	29.7	22.3	15.2	25.4	6.2	1.1	b
				Discharge zone				
NM096	33.4	0.0	0.0	7.1	38.3	0.0	21.2	h
NM150	23.8	0.0	0.0	0.0	59.4	0.0	16.8	h
NM327	25.5	0.0	0.0	7.4	36.2	0.0	31.0	h
				Samples not included in final data set				
NM014[1]	32.2	0.0	0.0	5.9	53.1	0.3	8.5	h
NM041[1]	8.8	0.0	1.8	1.3	80.8	0.0	7.4	h
NM297[1]	49.8	0.0	0.0	1.4	24.8	0.0	24.0	a
NM485[2]	9.4	0.0	0.0	0.0	68.5	0.0	22.1	h
NM065[3]	0.0	0.0	25.3	2.7	60.5	0.0	11.5	h
NM154[3]	0.0	0.0	23.4	6.9	55.8	0.0	13.9	h

[1]Mineralized water from within the MRGB

[2]Brine from Paleozoic rocks along the western boundary of the MRGB

[3]Geothermal water from the Jemez Mountains

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