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EL PASO WATER UTILITIES

Description of Piezometers and Ground-Water-Quality Characteristics at Three New Sites in the Lower Mesilla Valley, Texas, and New Mexico, 2003

Scientific Investigations Report 2005–5248

U.S. Department of the Interior
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Gale A. Norton, Secretary

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Contents

FIGURES

TABLES

Conversion Factors and Datum

Multiply	By	To obtain
Length		
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
Pressure		
atmosphere, standard (atm)	101.3	kilopascal (kPa)
Radioactivity		
picocurie per liter (pCi/L)	0.037	becquerel per liter (Bq/L)

Temperature in degrees Celsius (˚C) may be converted to degrees Fahrenheit (˚F) as follows:

˚F = (1.8 x ˚C) + 32

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

$$\delta x = [(R_x/R_{STD}) - 1]\ 1{,}000$$

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

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

Altitude, as used in this report, refers to distance above the vertical datum.

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µ S/cm at 25˚C).

Concentrations of chemical constituents in water are given in milligrams per liter (mg/L), micrograms per liter (µ g/L), parts per thousand (per mil), picocuries per liter (pCi/L), and percent modern carbon (pmC).

Description of Piezometers and Ground-Water-Quality Characteristics at Three New Sites in the Lower Mesilla Valley, Texas, and New Mexico, 2003

By Edward L. Nickerson

Abstract

In 2003, El Paso Water Utilities installed six deep piezometers at three sites in the lower Mesilla Valley. This report, which was written in cooperation with El Paso Water Utilities, presents the results of an investigation to describe piezometers and ground-water-quality characteristics at these new sites. The report presents piezometer-location and completion information, selected borehole-geophysical logs, water-level data, water-quality data, and water-quality characteristics, including the interpretation of isotope data to estimate the source and apparent age of ground water. Methods of investigation included collection of drilling and piezometer-construction information and analysis of ground-water-quality data collected by the El Paso Water Utilities and the U.S. Geological Survey.

The LMV-1 site is located approximately 1 mile east-southeast of Vinton, Texas, along the eastern margin of the lower Mesilla Valley. Piezometer LMV-1A (JL-49-04-498) is completed in the middle Santa Fe Group hydrostratigraphic unit; the screened interval is from 280 to 290 feet below land surface. Piezometer LMV-1B (JL-49-04-499) is completed in the lower Santa Fe Group hydrostratigraphic unit; the screened interval is from 640 to 650 feet below land surface. The freshwater zone, with dissolved-solids concentrations of 1,000 milligrams per liter or less, is estimated to extend from about 430 to 660 feet below land surface.

The LMV-2 site is located in the lower Mesilla Valley approximately 3 miles northwest of Anthony, New Mexico. Piezometer LMV-2A (26S.03E.20.423A) is completed in the middle Santa Fe Group hydrostratigraphic unit; the screened interval is from 680 to 690 feet below land surface. Piezometer LMV-2B (26S.03E.20.423B) is completed in the lower Santa Fe Group hydrostratigraphic unit; the screened interval is from 1,860 to 1,870 feet below land surface. The freshwater zone is estimated to extend from the water table to about 1,900 feet below land surface. Dissolved arsenic concentrations in LMV-2A and LMV-2B exceeded the proposed U.S. Environmental Protection Agency primary drinking-water standard.

The LMV-3 site is located on the west side of the lower Mesilla Valley approximately 0.8 mile southeast of La Union, New Mexico. Piezometer LMV-3B (27S.03E.20.432D) is completed in the lower Santa Fe Group hydrostratigraphic unit; the screened interval is from 1,745 to 1,755 feet below land surface. The freshwater zone is estimated to extend from less than 190 feet to about 1,320 feet below land surface. The concentration of dissolved arsenic in LMV-3B also exceeded the proposed U.S. Environmental Protection Agency primary drinking-water standard.

Water-quality samples collected by the U.S. Geological Survey from the LMV piezometers were analyzed for the stable isotope ratios δ^2H, δ^{18}O, and δ^{13}C. Sample LMV-1A plots slightly above the Global Meteoric Water Line, and its isotopic composition may represent source water from precipitation as mountain-front recharge along the Franklin Mountains. The δ^{13}C compositions in samples from LMV-1A, LMV-2A, LMV-2B, and LMV-3B ranged from –13.71 to –4.99 per mil. The wide range in values indicates that different processes have affected the carbon compositions and may represent differences in recharge origin and chemical reactions along the ground-water flow path.

Analytical results for the radioactive isotopes tritium (^{3}H) and carbon-14 (^{14}C) were used to estimate the age of ground water in the LMV piezometers. The small tritium values (less than 0.5 picocurie per liter) are indicative of ground water that was isolated from the atmosphere prior to 1954 atmospheric nuclear weapons testing and that has received no post-1954 contribution from recharge. The ^{14}C values ranged from 2.61 to 28.42 percent modern carbon and were used to calculate the apparent age of ground water at the LMV sites. Uncorrected apparent ages ranged from 10,400 to 30,100 years before present and represent maximum calculated ages. Corrected apparent ages ranged from 4,670 to 24,400 years before present and represent minimum calculated ages assuming maximum carbonate dissolution.

Introduction

The Cañutillo well field, located in the lower Mesilla Valley near El Paso, Texas, is an important municipal water supply for the City of El Paso and nearby communities. El Paso Water Utilities (EPWU) is developing a ground-water flow and solute-transport model of the Cañutillo well field and surrounding areas in and near the lower Mesilla Valley. Piezometer sites in Texas and New Mexico were selected by EPWU and the U.S. Geological Survey (USGS) to identify hydrogeologic characteristics including ground-water quality in areas of the aquifer for which little information is available. In 2003, the EPWU installed six new piezometers at three sites (fig. 1) to aid in the design and calibration of the Cañutillo well-field model. The piezometers were incorporated into the USGS Mesilla Basin Monitoring Program and will provide long-term hydrologic data for the lower Mesilla Valley. The USGS, in cooperation with the EPWU, conducted a study to describe deep piezometer installation and identify water-quality characteristics at the new piezometer sites. Results of the study will help define water-quality characteristics in the lower Mesilla Valley and provide improved ground-water resources information to water-management agencies in Texas and New Mexico.

Purpose and Scope

This report describes deep piezometers and ground-water-quality characteristics at three new sites in the lower Mesilla Valley. The report presents piezometer-location and completion information, selected borehole-geophysical logs, water-level data, water-quality data, and water-quality characteristics including the interpretation of isotope data to estimate the source and apparent age of ground water.

Hydrogeologic Setting

The lower Mesilla Valley ground-water system consists primarily of a basin-fill aquifer with two main geologic units: the Santa Fe Group of Quaternary and Tertiary age and the Rio Grande flood-plain alluvium of Quaternary age (King and others, 1971). The Santa Fe Group is an intermontane basin-fill unit that extends throughout the Mesilla Basin and includes alluvial, eolian, and lucustrine deposits (Hawley and Lozinsky, 1992, p. 4). These clay, silt, sand, and gravel deposits can reach depths of more than 2,000 feet in the lower Mesilla Valley. The Rio Grande flood-plain alluvium overlies the Santa Fe Group in the Mesilla Valley and consists of channel and flood-plain deposits of clay, silt, sand, and gravel that generally are less than 125 feet thick (Wilson and others, 1981, p. 27).

The hydrogeologic framework of the Mesilla Basin was established in Hawley and Lozinsky (1992). Their basinwide conceptual model delineated three hydrogeologic features: (1) bedrock and structural boundaries, (2) lithofacies assemblages, and (3) hydrostratigraphic units. Santa Fe Group basin fill is divided into the informal upper, middle, and lower hydrostratigraphic units based on depositional environment and age. The upper Santa Fe hydrostratigraphic unit (USF) consists primarily of ancestral Rio Grande deposits of coarse to medium sand and gravel. The USF includes the Camp Rice and upper Fort Hancock Formations. The middle Santa Fe hydrostratigraphic unit (MSF) consists primarily of alluvial deposits with eolian and playa-lake facies. Basin-floor sediments of interbedded sand and silty clay are common. The MSF includes the Fort Hancock and Rincon Valley Formations. The lower Santa Fe hydrostratigraphic unit (LSF) consists primarily of eolian, playa-lake, and alluvial facies. Basin-floor sediments include thick-bedded dune sand. The LSF includes the Hayner Ranch and the lower Rincon Valley Formations. Detailed descriptions of the hydrostratigraphic units and associated lithofacies can be found in Hawley and Lozinsky (1992). The Mesilla Basin hydrogeologic framework was recently updated and integrated into a digital format by Hawley and Kennedy (2004).

Methods of Investigation

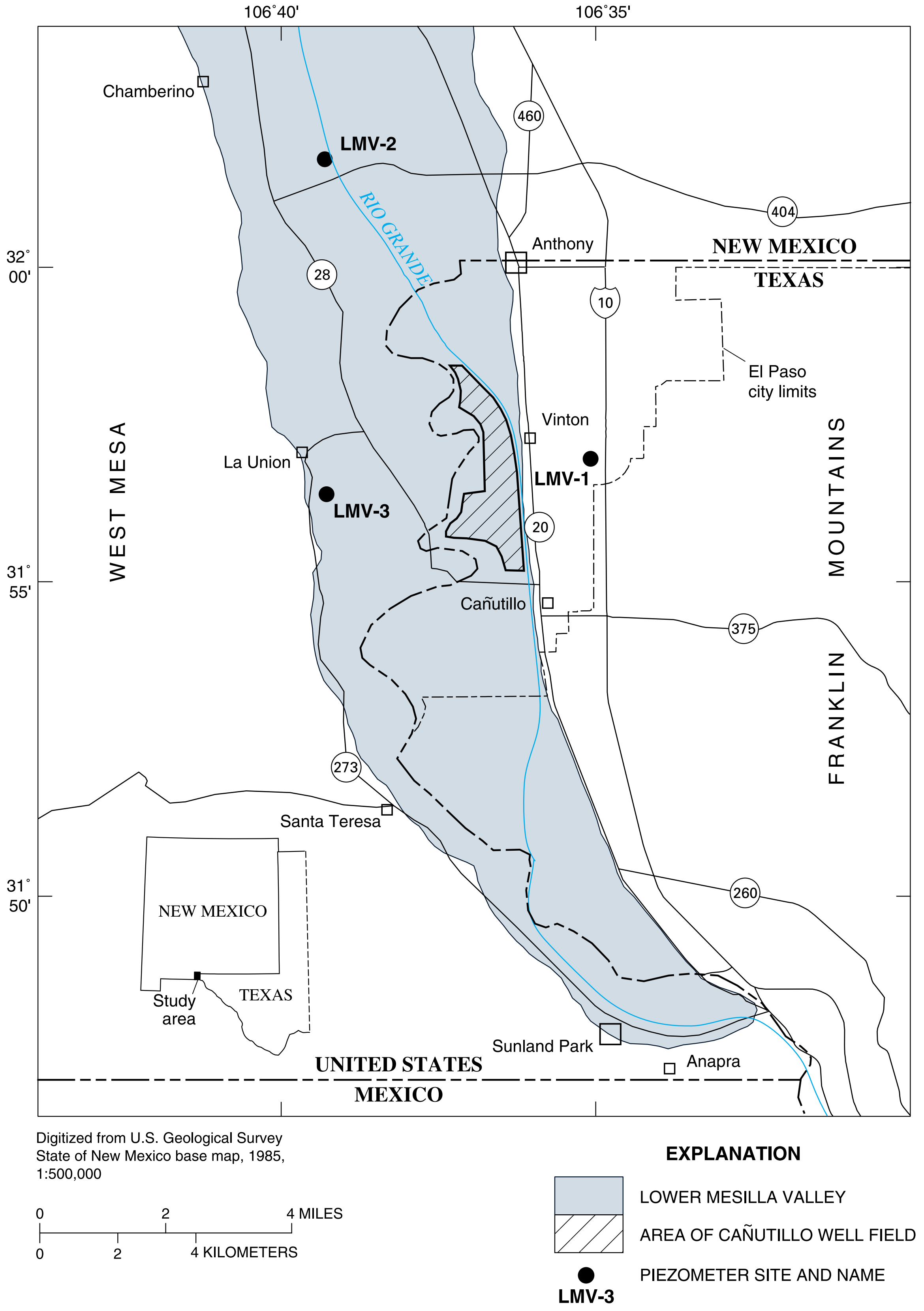
In 2003, the EPWU drilled and installed six piezometers at three sites. Methods of this investigation included collection of drilling and piezometer-construction information and analysis of ground-water-quality data collected by EPWU and USGS. Individual piezometer records are presented by site in the "Description of piezometers and ground-water-quality characteristics" section. Tables 1, 2, and 3 are in the Appendix at the end of the report.

Drilling and Piezometer Construction

One borehole was drilled at each site by the EPWU contractor using a hydraulic rotary drill rig. Drill cuttings were collected by the driller at 10-foot intervals. Geophysical logs were run in the mud-filled borehole, including a caliper log, natural gamma log, electric logs (long-short normal resistivity, single-point resistivity, and spontaneous-potential conductivity), neutron log, induction log, and sonic log. Selected borehole-geophysical logs provided by EPWU and presented in this report include natural gamma logs, long-short normal resistivity logs (16 inch and 64 inch), and single-point resistivity logs. These selected log types are consistent with and allow for comparison with previously published borehole-geophysical logs for the lower Mesilla Valley presented by Hawley and Lozinsky (1992).

Water-quality samples were collected from each borehole at selected intervals using the gravel envelope method. This method is commonly used by local drillers to identify water quality at depth. A 20-foot section of well screen was attached to the bottom of the drill stem and lowered down the borehole to the deepest sample interval. The borehole was then packed with gravel around the screen, extending about 40 feet above the top of the screen. By using the air-lift method (Driscoll, 1986), the screened interval was developed and a water sample was collected. The drill stem and screen were then raised to the next selected interval, and the procedure was repeated until all selected intervals were sampled.

Two piezometers were installed in the single borehole (dual completion) at each site. Piezometers were constructed of 2.5-inch-diameter steel casing with a 10-foot section of stainless-steel screen (0.025-inch slot size) and a bottom 10-foot section of blank casing known as a sump. A gravel filter pack was emplaced adjacent to the screen, and bentonite annular seals were set at about 10 feet above and below the screened interval using a tremie pipe. The completed piezometers were developed and water-quality samples were collected using the air-lift method. The dual-completion piezometers are contained in a 12-inch steel surface casing.



Digitized from U.S. Geological Survey State of New Mexico base map, 1985, 1:500,000

Figure 1. Location of piezometer sites in the lower Mesilla Valley area, Texas and New Mexico, 2003.

Ground-Water Sample Collection and Analysis

The EPWU collected water-quality samples from selected borehole intervals and piezometers using the air-lift method during the drilling program from February through April 2003. Air pressure from the drill-rig compressor was used to air-jet the water samples. The air-lift method may have a significant effect on water temperature, pH, and pH-sensitive constituents such as dissolved trace metals (Driscoll, 1986).

The USGS collected water-quality samples from selected piezometers in October and November 2003. At least three volumes of water were purged from each piezometer using a small-diameter submersible pump. Specific conductance, pH, water temperature, and dissolved oxygen were monitored in a flow-through chamber, and samples were collected only after these field properties had stabilized. Field measurements of pH, specific conductance, temperature, dissolved oxygen, and alkalinity were conducted according to standard USGS procedures (Wilde and Radtke, 1998), and ground-water-quality samples were collected and processed according to the USGS parts per billion protocol (Wilde and others, 1999). The USGS National Water Quality Laboratory in Denver, Colorado, and the USGS Stable Isotope Laboratory in Reston, Virginia, analyzed the water samples for concentrations of major ions, nutrients, trace elements, radioactivity, and selected isotopes. The National Water Quality Laboratory and the Stable Isotope Laboratory use published methods with extensive quality-assurance and quality-control procedures (Pirkey and Glodt, 1998).

Acknowledgments

Site access and land-use permits would not have been possible without cooperation from the Elephant Butte Irrigation District and the International Boundary and Water Commission--U.S. Section. The author expresses appreciation to Scott Reinert and Eric Bangs of EPWU for special cooperation and assistance in the collection of drilling information, borehole-geophysical logs, and EPWU water-quality data. The author also thanks Scott Anderholm of the USGS for assistance with the interpretation of isotope data.

Description of Piezometers and Ground-Water-Quality Characteristics

Site locations, construction information, and initial water-level data for six piezometers installed by the EPWU at three sites are listed in table 1. Selected borehole-geophysical logs for sites LMV-1, LMV-2, and LMV-3 include natural gamma logs, long-short normal resistivity logs, and single-point resistivity logs (figs. 2, 4, and 6). Selected water-quality data reported by the EPWU for sampled borehole intervals and piezometers are listed in table 2. Water-quality data for selected piezometers sampled by the USGS are listed in table 3.

In this report, freshwater is defined as water with a dissolved-solids concentration of 1,000 milligrams per liter (mg/L) or less, slightly saline or brackish water is defined as water with a dissolved-solids concentration between 1,000 and 3,000 mg/L, and saline water is defined as water with a dissolved-solids concentration equal to or greater than 3,000 mg/L. The description of piezometers and water-quality characteristics are discussed by site in the following sections.

LMV-1 Site

The LMV-1 site is located approximately 1 mile east-southeast of Vinton, Texas (fig. 1), along the eastern margin of the lower Mesilla Valley. This upland site is situated on the lower piedmont slope about 130 feet above the adjacent valley floor. The LMV-1 borehole was drilled to a total depth of about 857 feet (table 1); selected borehole-geophysical logs are shown in figure 2. The top of the MSF unit at LMV-1 is estimated to be about 190 feet below land surface or at an altitude of 3,710 feet. The top of the LSF unit is estimated to be about 430 feet below land surface or at an altitude of 3,470 feet. Estimated hydrostratigraphic unit depths in LMV-1 are based on the correlation of borehole-geophysical logs (fig. 2) and the projected unit depths in Hawley and Lozinsky (1992, pl. 5).

Piezometers LMV-1A and LMV-1B are contained in a 12-inch-diameter steel surface casing that extends 52 feet below land surface. Piezometer LMV-1A (JL-49-04-498) is completed in the MSF unit at a total depth of about 300 feet; the screened interval is from 280 to 290 feet below land surface. The initial static water level was measured at 163.07 feet below land surface on March 16, 2003 (table 1). Piezometer LMV-1B (JL-49-04-499) is completed in the LSF at a total depth of 660 feet; the screened interval is from 640 to 650 feet below land surface. The initial static water level was measured at 170.96 feet below land surface on March 16, 2003 (table 1).

Dissolved-solids concentrations in water samples from the LMV-1 site (borehole and piezometers) range from 868 mg/L at 640 to 650 feet below land surface to 1,910 mg/L at 830 to 850 feet below land surface (table 2; fig. 2). The freshwater zone with dissolved-solids concentrations of 1,000 mg/L or less is estimated to extend from about 430 to 660 feet below land surface (fig. 2). Slightly saline water appears to extend from the water table to the top of the freshwater zone and from the base of the freshwater zone to the bottom of the borehole (fig. 2).

The distribution of major constituents as a percentage of total ions, in milliequivalents per liter, for ground-water samples from selected depth intervals in LMV-1 is shown in figure 3. The dominant water type is sodium chloride sulfate, which may represent mixing with geothermal water along the eastern margin of the Mesilla Valley (Witcher and others, 2004, p. 103). Geothermal water may be a substantial component of ground water at depth. Sodium (Na) is the predominant cation in all samples, and water from the slightly saline zones trends

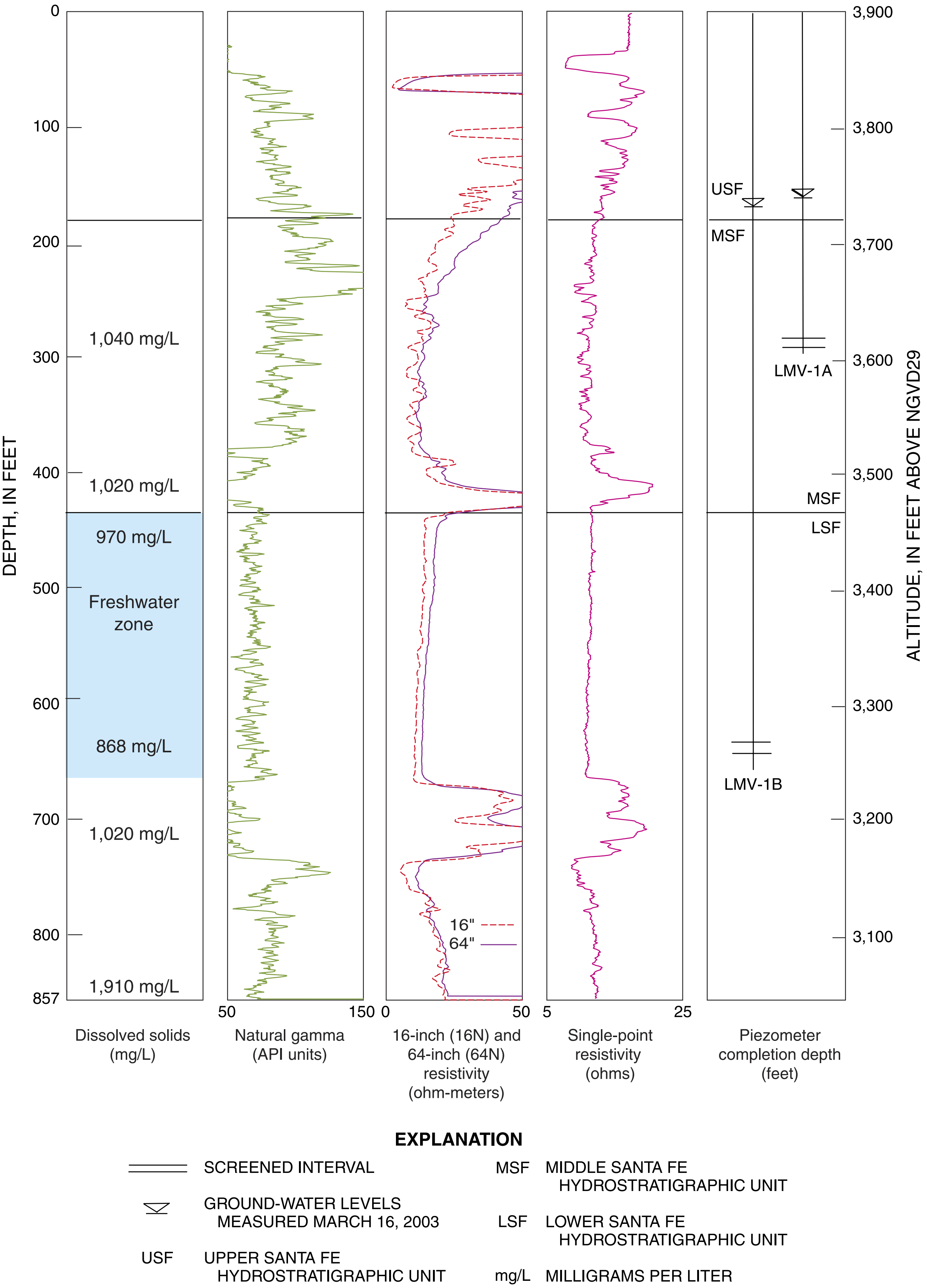
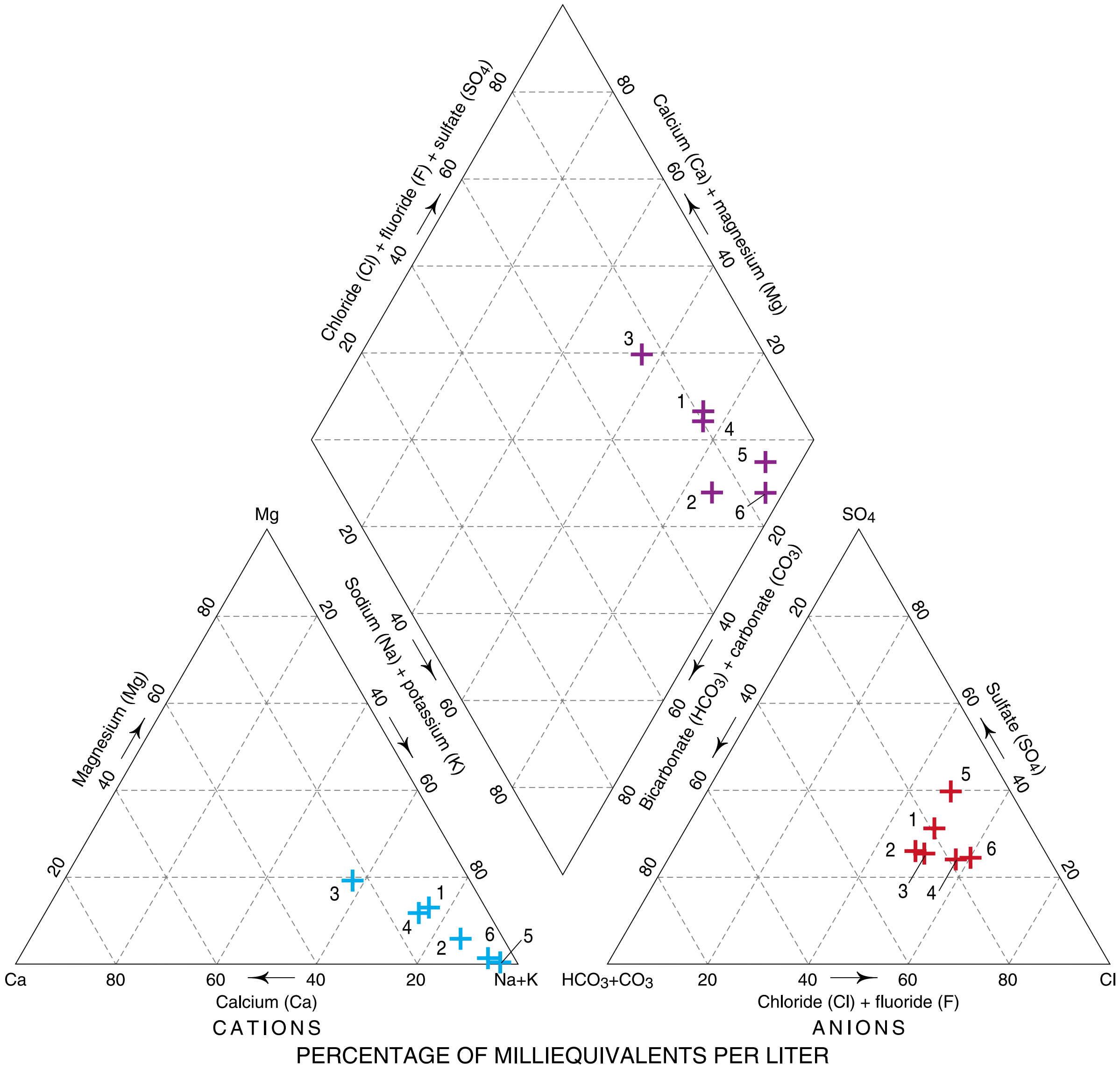


Figure 2. Selected borehole-geophysical logs and piezometer-completion depths at the LMV-1 site (modified from Eric Bangs, El Paso Water Utilities, written commun., 2004).



EXPLANATION

Plot number	Sample interval (feet below land surface)	Dissolved-solids concentration (milligrams per liter)	Sample type	Analyzing agency
1	280-290	1,040	Piezometer	USGS
2	400-420	1,020	Borehole	EPWU
3	450-470	970	Borehole	EPWU
4	640-650	868	Piezometer	EPWU
5	700-720	1,020	Borehole	EPWU
6	830-850	1,910	Borehole	EPWU

Figure 3. Distribution of major constituents in ground-water-quality samples from selected depth intervals at the LMV-1 site.

toward the sodium apex with increased sample depth. The predominant anions are chloride (Cl) and sulfate (SO_4). The 26.5-˚C water temperature in piezometer LMV-1A (table 3) indicates thermal water (greater than 26 ˚C as defined in Witcher and others, 2004) at a shallow depth of 280 feet below land surface.

Water-quality data for LMV-1A sampled by the USGS on October 28, 2003, are listed in table 3. Results of USGS water-quality analyses were compared with current (2004) U.S. Environmental Protection Agency (USEPA) drinking-water standards (U.S. Environmental Protection Agency, 2004) for sampled constituents; exceedances are marked in bold in table 3. No USEPA primary drinking-water standards, which pertain to human health, were exceeded. Secondary drinking-water standards pertain to aesthetic qualities of water, such as taste or color. The dissolved chloride concentration of 284 mg/L exceeded the secondary drinking-water standard of 250 mg/L. The 251-mg/L dissolved sulfate concentration exceeded the secondary drinking-water standard of 250 mg/L. The dissolved-solids concentration of 1,040 mg/L exceeded the secondary drinking-water standard of 500 mg/L. A manganese concentration of 382 µg/L (0.382 mg/L) exceeded the secondary drinking-water standard of 0.05 mg/L.

Total radon-222 radioactivity in sampled water from piezometer LMV-1A was 470 picocuries per liter (pCi/L). Naturally occurring minerals in aquifer sediment that contains uranium may be the source of the radon-222 (Levings and others, 1998). The USEPA previously proposed a radon-222 primary drinking-water standard of 300 pCi/L. This standard was withdrawn by the USEPA in 1996, however, for further evaluation. No USEPA drinking-water standards for radon currently exist.

The USGS was unable to sample piezometer LMV-1B on October 29, 2003, because water-level drawdown to the maximum pump setting at 235 feet and sluggish recovery did not allow adequate purging of the piezometer. A substantial amount of sand was observed in the discharge water during purging attempts.

LMV-2 Site

The LMV-2 site is located in the lower Mesilla Valley approximately 3 miles northwest of Anthony, New Mexico (fig. 1). This site is adjacent to the Rio Grande inside the west levee. The LMV-2 borehole was drilled to a total depth of about 2,300 feet (table 1); selected borehole-geophysical logs are shown in figure 4. The top of the LSF unit is estimated to be about 1,230 feet below land surface or at an altitude of 2,566 feet. The estimated depth to the LSF unit in LMV-2 is based on the borehole-geophysical logs (fig. 4) and the projected unit depths in Hawley and Lozinsky (1992, pls. 11 and 4).

Piezometers LMV-2A and LMV-2B are contained in a 12-inch-diameter steel surface casing that extends 98 feet below land surface. Piezometer LMV-2A (26S.03E.20.423A) is completed in the MSF unit at a total depth of about 700 feet; the screened interval is from 680 to 690 feet below land surface. The initial static water level in LMV-2A was measured at 12.03 feet below land surface on July 2, 2003 (table 1). Piezometer LMV-2B (26S.03E.20.423B) is completed in the LSF unit at a total depth of 1,880 feet; the screened interval is from 1,860 to 1,870 feet below land surface. The initial static water level measured July 2, 2003, was 21.20 feet below land surface.

The dissolved-solids concentrations in water samples from the LMV-2 site range from 362 mg/L at 1,080 to 1,100 feet below land surface to 5,900 mg/L at 1,990 to 2,010 feet below land surface (tables 2 and 3). Dissolved-solids concentrations (salinity) at depth are shown in figure 4. The freshwater zone is estimated to extend from the water table to about 1,900 feet below land surface. Slightly saline to saline water extends from the base of the freshwater zone to the bottom of the borehole (fig. 4).

The distribution of major constituents as a percentage of total ions, in milliequivalents per liter, for ground-water samples from selected depth intervals in LMV-2 is shown in figure 5. Water type varies with aquifer depth from shallow sodium bicarbonate water to deep sodium sulfate water. In two water samples collected at about 380 to 400 feet and 680 to 690 feet below land surface, bicarbonate (HCO_3) was the predominant anion. Sulfate, bicarbonate, and chloride ($SO_4/HCO_3/Cl$) were the predominant anions in three of six water samples at depths ranging from 1,080 to 1,870 feet below land surface. Sulfate (SO_4) was the predominant anion in the deep saline water sample at 1,990 to 2,010 feet below land surface. The predominant cation in all samples was sodium (Na). Cation exchange of dissolved calcium for sodium is a common process in the Mesilla Valley aquifer system and may increase with ground-water travel time from north to south and with aquifer depth (Witcher and others, 2004, p. 110).

Water-quality data for piezometers LMV-2A and LMV-2B sampled by the USGS on October 30 and November 4, 2003, are listed in table 3. Water-quality analyses were compared with current (2004) USEPA drinking-water standards (U.S. Environmental Protection Agency, 2004); exceedances are marked in bold in table 3. The dissolved fluoride concentration of 5.1 mg/L in LMV-2B exceeded the primary drinking-water standard of 4.0 mg/L. The 16.5-µg/L (0.0165 mg/L) concentration of dissolved arsenic in LMV-2A and the 35.1-µg/L (0.0351 mg/L) concentration in LMV-2B exceeded the proposed primary drinking-water standard of 0.010 mg/L. In LMV-2B, a pH of 8.7 standard units exceeded the secondary drinking-water standard of 6.5 to 8.5 units. The dissolved sulfate concentration of 261 mg/L in LMV-2B exceeded the secondary drinking-water standard of 250 mg/L. The dissolved-solids concentration of 535 mg/L in LMV-2A and of 970 mg/L in LMV-2B exceeded the secondary drinking-water standard of 500 mg/L. The dissolved iron concentration of 522 µg/L (0.522 mg/L) in LMV-2A exceeded the secondary drinking-water standard of 0.3 mg/L. Total radon-222 radioactivity in sampled water from piezometer LMV-2B was 700 pCi/L.

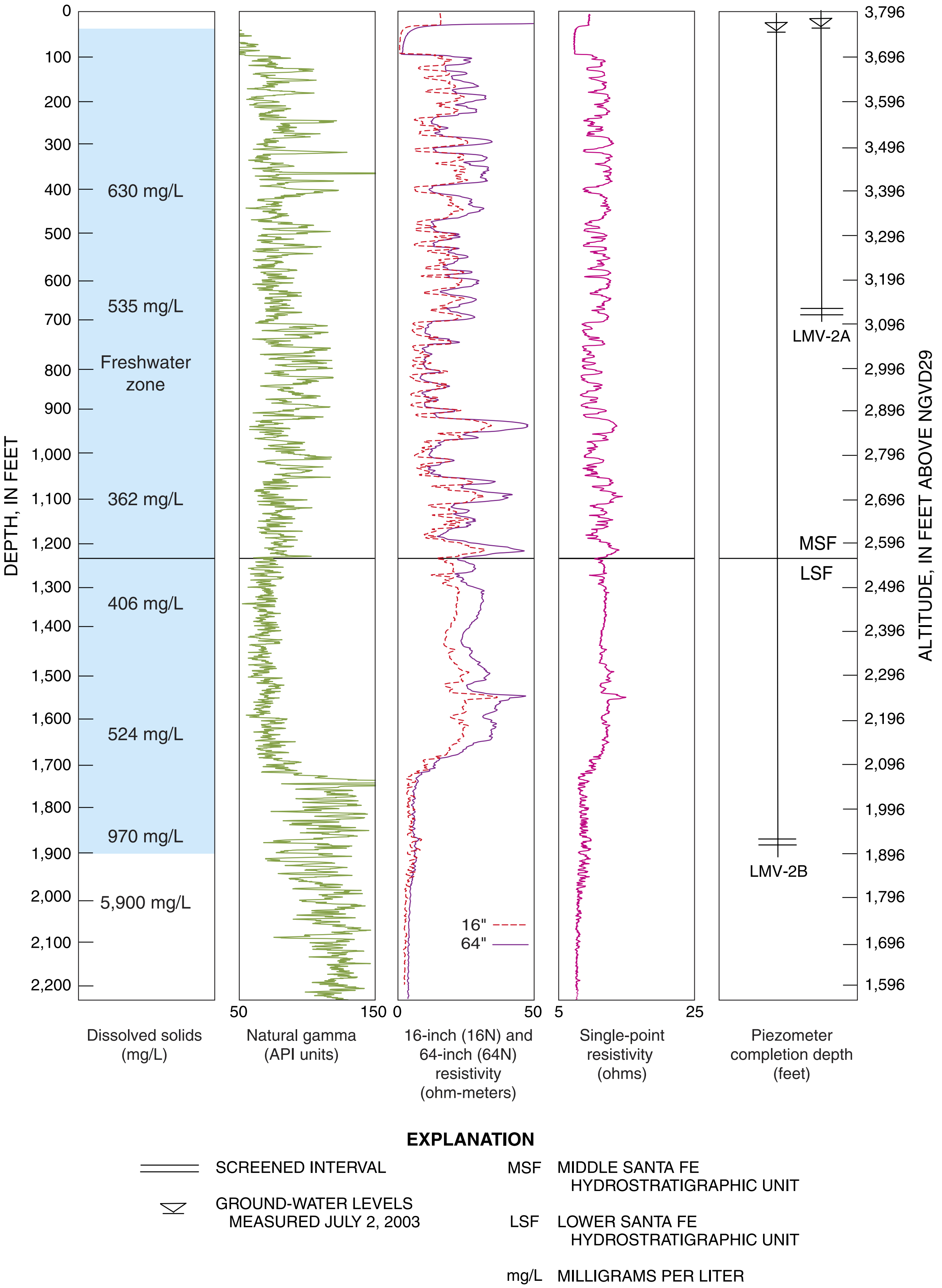
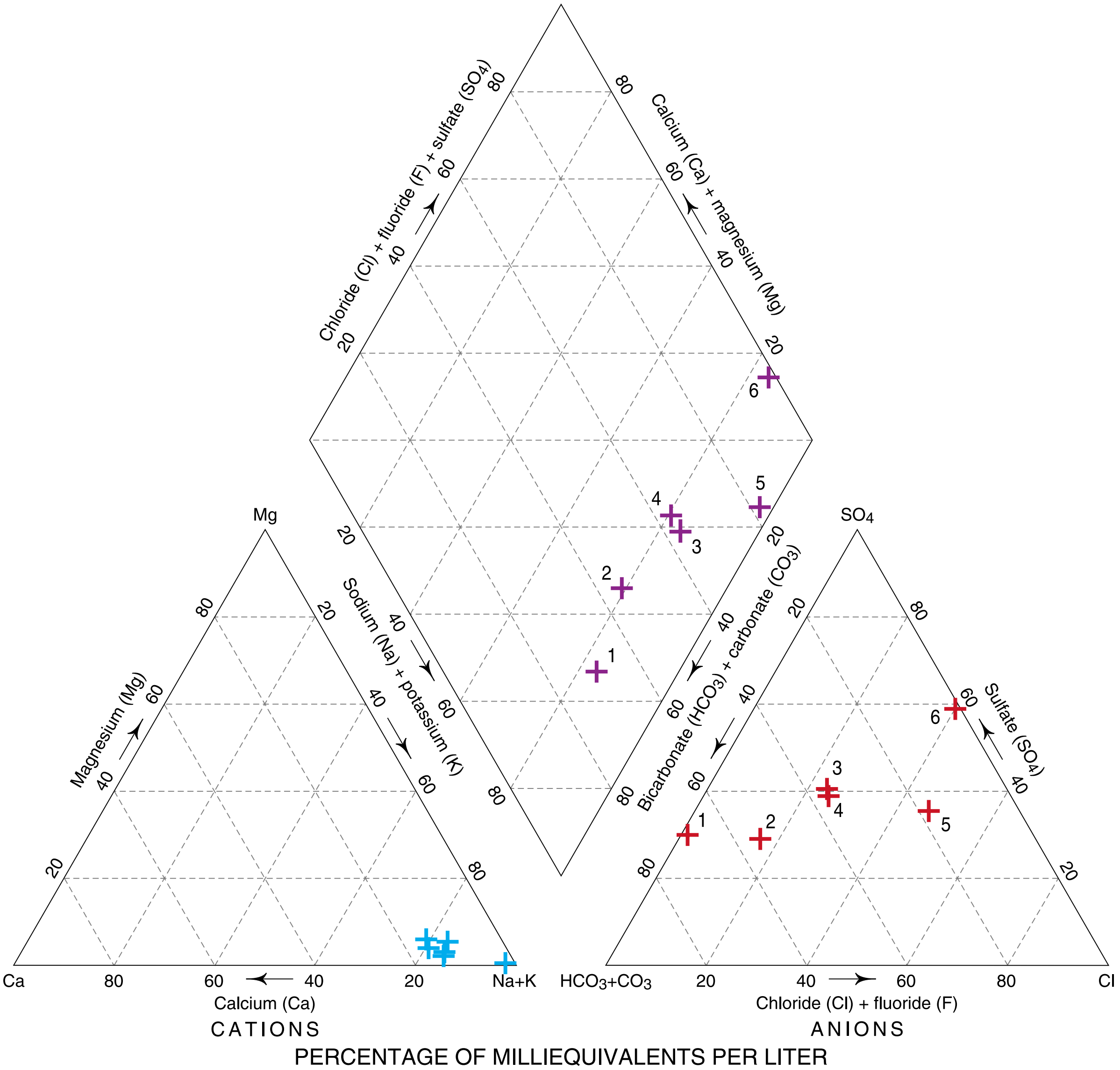


Figure 4. Selected borehole-geophysical logs and piezometer-completion depths at the LMV-2 site (modified from Eric Bangs, El Paso Water Utilities, written commun., 2004).



EXPLANATION

Plot number	Sample interval (feet below land surface)	Dissolved-solids concentration (milligrams per liter)	Sample type	Analyzing agency
1	380-400	630	Borehole	EPWU
2	680-690	535	Piezometer	USGS
3	1,080-1,100	362	Borehole	EPWU
4	1,310-1,330	406	Borehole	EPWU
5	1,860-1,870	970	Piezometer	USGS
6	1,990-2,010	5,900	Borehole	EPWU

Figure 5. Distribution of major constituents in ground-water-quality samples from selected depth intervals at the LMV-2 site.

LMV-3 Site

The LMV-3 site is located on the west side of the lower Mesilla Valley approximately 0.8 mile southeast of La Union, New Mexico (fig. 1). The LMV-3 borehole was drilled to a total depth of about 1,820 feet (table 1); selected borehole-geophysical logs are shown in figure 6. The top of the LSF unit is estimated to be about 1,130 feet below land surface or at an altitude of 2,650 feet. The estimated depth to the LSF unit is based on the correlation of borehole-geophysical logs in Hawley and Lozinsky (1992, pl. 5) and the characteristic response in resistivity logs at the MSF/LSF contact shown in figure 6.

Piezometers LMV-3A and LMV-3B are contained in a 12-inch-diameter steel surface casing that extends 52 feet below land surface. Piezometer LMV-3A (27S.03E.20.432C) was completed in the MSF unit at a total depth of 900 feet; the screened interval is from 880 to 890 feet below land surface. Because the driller was unable to develop piezometer LMV-3A, no water-level data or water-quality samples were obtained. Piezometer LMV-3B (27S.03E.20.432D) is completed in the LSF unit at a total depth of 1,765 feet; the screened interval is from 1,745 to 1,755 feet below land surface. The initial static water level in LMV-3B was measured at 33.45 feet below land surface on April 29, 2003 (table 1).

The dissolved-solids concentrations in water samples from the LMV-3 site range from 378 mg/L at 640 to 660 feet below land surface to 6,100 mg/L at 1,745 to 1,755 feet below land surface (tables 2 and 3). Dissolved-solids concentrations (salinity) at depth are shown in figure 6. The freshwater zone is estimated to extend from less than 190 to about 1,320 feet below land surface. Slightly saline and saline water extends from the base of the freshwater zone to the bottom of the borehole (fig. 6).

The distribution of major constituents as a percentage of total ions, in milliequivalents per liter, for ground-water samples from selected depth intervals in LMV-3 is shown in figure 7. Water type varies with aquifer depth from shallow sodium bicarbonate water to deep sodium chloride sulfate water. Bicarbonate (HCO_3) was the predominant anion in the shallow water sample at 190 to 210 feet below land surface. Sulfate, bicarbonate, and chloride ($SO_4/HCO_3/Cl$) were the predominant anions in five of nine water samples at depths ranging from 450 to 1,150 feet below land surface. Chloride was the predominant anion in two deep water samples at 1,250 to 1,270 feet and 1,470 to 1,490 feet below land surface. Sulfate and chloride were the predominant anions in the deep saline water sample at 1,745 to 1,755 feet below land surface. In all water samples, sodium was the predominant cation. The water temperature of 34.0 ˚C (table 3) in piezometer LMV-3B is indicative of a thermal influence at depth.

Water-quality data for piezometer LMV-3B sampled by the USGS on November 5, 2003, are listed in table 3. Water-quality analyses were compared with current (2004) USEPA drinking-water standards (U.S. Environmental Protection Agency, 2004) for sampled constituents; exceedances are marked in bold in table 3. The 43.6-µg/L (0.0436 mg/L) concentration of dissolved arsenic in LMV-3B exceeded the proposed primary drinking-water standard of 0.010 mg/L. The 1,610-mg/L dissolved chloride concentration and 2.8-mg/L dissolved fluoride concentration exceeded the secondary drinking-water standards of 250 mg/L and 2.0 mg/L, respectively. The dissolved sulfate concentration of 2,180 mg/L exceeded the secondary drinking-water standard of 250 mg/L. The dissolved-solids concentration of 6,100 mg/L exceeded the secondary drinking-water standard of 500 mg/L. The dissolved iron concentration of 527 µg/L (0.527 mg/L) exceeded the secondary drinking-water standard of 0.3 mg/L. The dissolved manganese concentration of 283 µg/L (0.283 mg/L) exceeded the secondary drinking-water standard of 0.05 mg/L. Total radon-222 radioactivity in sampled water from piezometer LMV-3B was 670 pCi/L.

Stable Isotopes and Source of Ground Water

Water-quality samples collected by the USGS from LMV-1A, LMV-2A, LMV-2B, and LMV-3B were analyzed for the stable isotopes of hydrogen (^2H and ^1H), oxygen (^{18}O and ^{16}O), and carbon (^{13}C and ^{12}C). The ratios of heavy to light isotopes for each element are expressed as δ (delta) values in percent differences relative to a reference standard. The δ^2H values and $\delta^{18}O$ values are reported in parts per thousand (per mil) relative to the Vienna Standard Mean Ocean Water (VSMOW) reference (Plummer and others, 2004). The $\delta^{13}C$ values are reported in per mil relative to the Vienna Pee Dee Belemnite (VPDB) reference standard. Analytical results for these stable isotope ratios are listed in table 3.

Values of δ^2H as a function of $\delta^{18}O$ in the four ground-water samples and the Mean Global Meteoric Water Line (GMWL) are plotted in figure 8. The GMWL (Craig, 1961) is a line that represents the global mean composition of meteoric water (precipitation). Deviation below the GMWL in both surface-water and ground-water samples is typically a function of fractionation processes associated with evaporation and variations in origin (Witchers and others, 2004, p. 91). Mixing with non-meteoric water and isotopic exchange at temperatures higher than 30 ˚C also can affect the isotopic composition of ground water (Anderholm and Heywood, 2003, p. 11).

Sample LMV-1A plots slightly above the GMWL (fig. 8), and its isotopic composition may represent source water from precipitation as mountain-front recharge along the Franklin Mountains (fig. 1). The deeper inner-valley samples from LMV-2A, LMV-2B, and LMV-3B are isotopically lighter (hydrogen depleted) and plot below the GMWL (fig. 8). The sources of recharge water to these deep piezometers are unknown, but their isotopic compositions are consistent with those detected in ground-water samples collected by Witcher and others (2004) in the Mesilla Basin at depths generally greater than 200 feet. The isotopic compositions of the samples from LMV-2A, LMV-2B, and LMV-3B also were substantially lighter than values reported for surface-water samples by Witchers and others (2004). This suggests that water in these

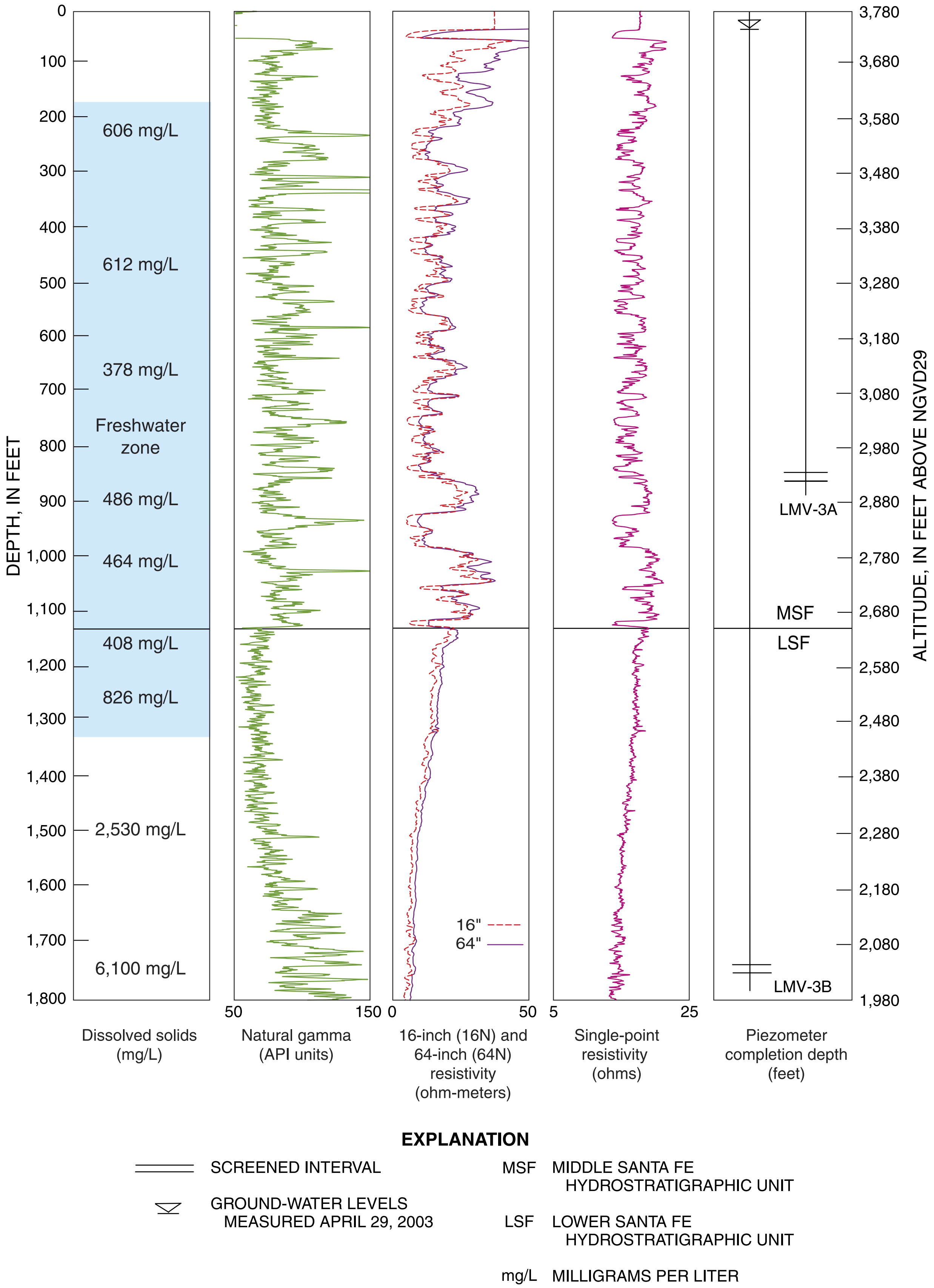
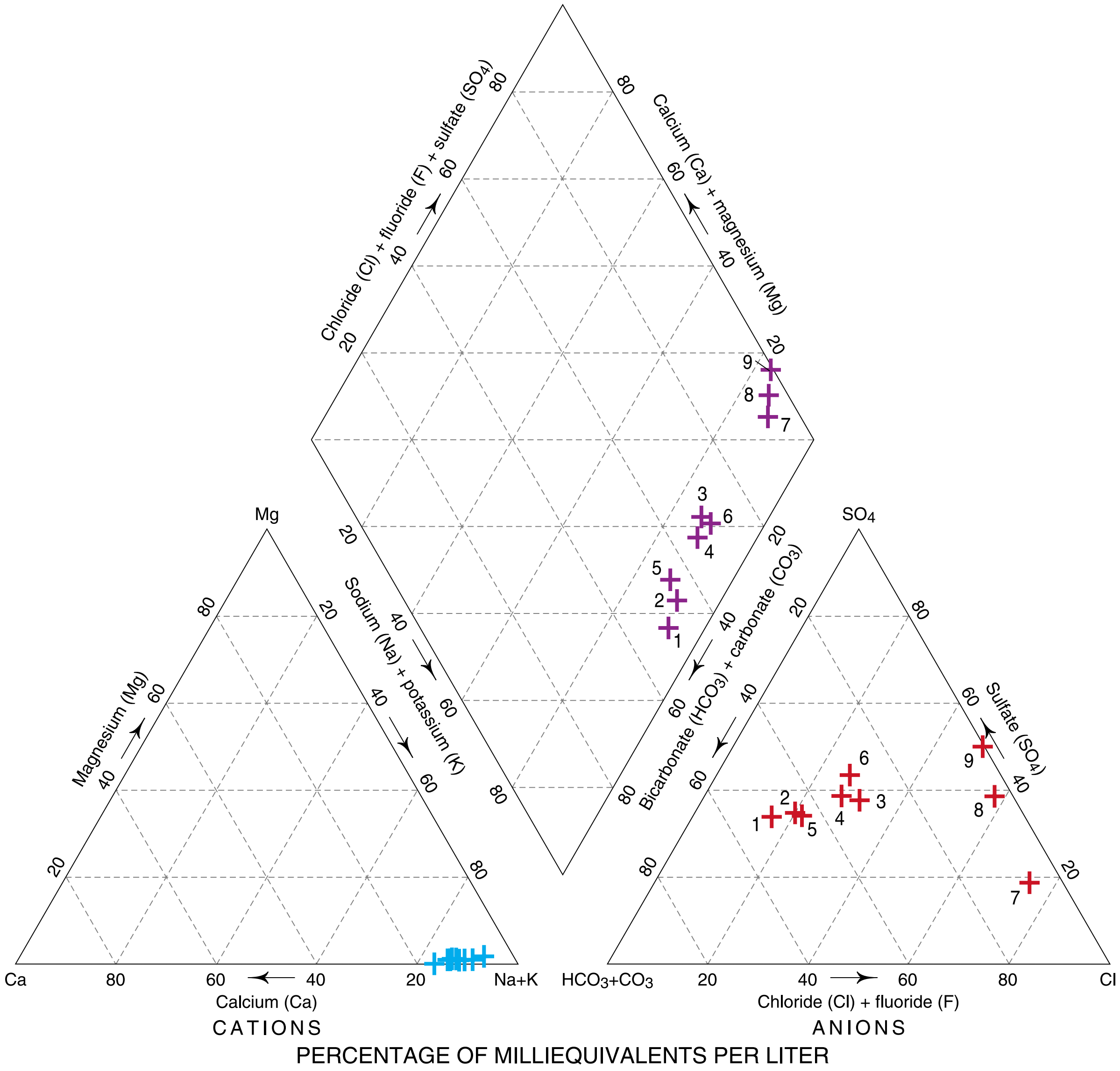


Figure 6. Selected borehole-geophysical logs and piezometer-completion depths at the LMV-3 site (modified from Eric Bangs, El Paso Water Utilities, written commun., 2004).



EXPLANATION

Plot number	Sample interval (feet below land surface)	Dissolved-solids concentration (milligrams per liter)	Sample type	Analyzing agency
1	190-210	606	Borehole	EPWU
2	450-470	612	Borehole	EPWU
3	640-660	378	Borehole	EPWU
4	870-890	486	Borehole	EPWU
5	990-1,010	464	Borehole	EPWU
6	1,130-1,150	408	Borehole	EPWU
7	1,250-1,270	826	Borehole	EPWU
8	1,470-1,490	2,530	Borehole	EPWU
9	1,745-1,755	6,100	Piezometer	USGS

Figure 7. Distribution of major constituents in ground-water-quality samples from selected depth intervals at the LMV-3 site.

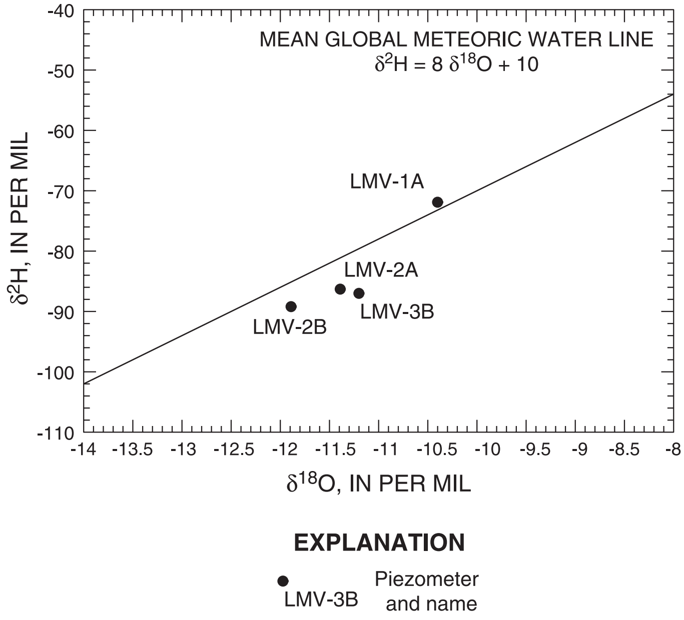


Figure 8. Relation between $\delta^{18}O$ and δ^2H in ground water from selected piezometers in the lower Mesilla Valley, 2003.

three piezometers did not evolve from recent precipitation or modern Rio Grande water of Holocene age (last 10,000 years). The $\delta^{13}C$ composition in samples from LMV-1A, LMV-2A, LMV-2B, and LMV-3B ranged from –13.71 to –4.99 per mil (table 3). The $\delta^{13}C$ composition in piezometer LMV-1A, which is located on the west flank of the Franklin Mountains (fig. 1), is –8.43 per mil. This $\delta^{13}C$ value is consistent with $\delta^{13}C$ compositions (–9.33 to –7.19) in wells that represent mountain-front recharge along the east flank of the Franklin Mountains in the adjacent Hueco Bolson (Anderholm and Heywood, 2003, p. 12). Compositions of $\delta^{13}C$ in the deep inner-valley piezometers LMV-2A, LMV-2B, and LMV-3B were –6.41, –4.99, and –13.71 per mil, respectively. The range in values indicates that different processes have affected carbon compositions (Anderholm and Heywood, 2003, p. 12) and may represent differences in recharge origin and chemical reactions along the ground-water flow path.

Radioactive Isotopes and Age of Ground Water

Analytical results for the radioactive isotopes tritium (^3H) and carbon-14 (^{14}C) (table 3) were used to estimate the age of ground water in the LMV piezometers. Tritium activity in the ground-water samples ranged from 0.1 to 0.3 pCi/L. The small tritium values (less than 0.5 pCi/L) are indicative of ground water that was isolated from the atmosphere prior to 1954 atmospheric nuclear weapons testing and that has received no post-1954 contribution from recharge. The ^{14}C values, which ranged from 2.61 to 28.42 percent modern carbon (pmC), were used to calculate the apparent age of ground water at the LMV sites. The apparent age of ground water since isolation from the atmosphere can be calculated as a function of the ^{14}C radioactive decay rate with a half-life of about 5,730 years using the following equation (Anderholm and Heywood, 2003, p. 14):

$$t = (5{,}730/\ln 2)\ \ln\,(Ao/As) \qquad (1)$$

where t = apparent age, in years;
Ao = ^{14}C composition of water prior to radioactive decay and after chemical reactions, in percent modern carbon; and
As = ^{14}C composition measured in the sample, in percent modern carbon.

The initial ^{14}C composition of ground-water recharge at isolation (Ao) is about 100 pmC. However, geochemical reactions, including dissolution of carbonate minerals and carbon isotopic exchange, can substantially decrease the carbon composition in ground water (Anderholm and Heywood, 2003, p. 14). Cation exchange accompanied by additional calcite dissolution (Plummer and others, 2004, p. 170) also can be an important process affecting carbon composition. The extent of these chemical reactions in the lower Mesilla Valley and the degree to which they affect carbon composition as Ao are unknown. Witcher and others (2004, p. 61) included cation exchange with clay minerals and diagenetic alterations of sediments including dissolution and precipitation of calcite as major hydrochemical processes in the Mesilla Basin. The calculated saturation indexes for calcite in the LMV samples (Scott Anderholm, U.S. Geological Survey, written commun., 2004) using PHREEQE (Parkhurst and others, 1980) are listed in table 4 and indicate that ground-water samples were saturated to oversaturated with calcite. Several models have been proposed to correct carbon composition (Ao) for the dissolution of carbonate minerals or isotopic exchange. Huff (2002, p. 305) noted that a number of these approaches converge to a corrected Ao value of about 53 pmC. Plummer and others (2004, p. 167) also suggested a minimum Ao value of about 50 pmC for mature "closed-system" evolution with respect to maximum carbonate dissolution.

Two sets of apparent ages were calculated for each LMV sample and are listed in table 4. Uncorrected apparent ages in the first set represent maximum calculated ages assuming Ao equals 100 pmC. Uncorrected apparent ages ranged from 10,400 to 30,100 years before present. Corrected apparent ages in the second set represent minimum calculated ages assuming that Ao equals 50 pmC (maximum carbonate dissolution). The corrected apparent ages (table 4) ranged from 4,670 to 24,400 years before present.

The larger ^{14}C composition in the LMV-3B sample of 28.42 pmC (table 4) resulted in a younger corrected apparent age of 4,670 years. The low tritium activity of 0.1 pCi/L (table 3) in the sample indicates no mixing with pre-1954 water and no atmospheric contamination of the sample. A second laboratory analysis of the archived replicate sample indicated a ^{14}C composition of 27.34 pmC, confirming the original sample value (28.42 pmC). Piezometer LMV-3B is completed in the deep, fine-grained basin-floor sediments at 1,745 to 1,755 feet below land surface. The younger apparent age of ground water calculated from LMV-3B sample results is not consistent with the conceptual model of the ground-water flow system.

Summary

This report presents the results of an investigation to describe deep piezometers and ground-water-quality characteristics at three new sites in the lower Mesilla Valley. Methods of investigation included the collection of drilling and piezometer-construction information and analysis of ground-water-quality data collected by El Paso Water Utilities (EPWU) and the U.S. Geological Survey (USGS).

The LMV-1 site is located approximately 1 mile east-southeast of Vinton, Texas, along the eastern margin of the lower Mesilla Valley. The borehole was drilled to a total depth of about 857 feet below land surface. Piezometer LMV-1A is completed in the middle Santa Fe Group (MSF) hydrostratigraphic unit; the screened interval is from 280 to 290 feet below land surface. Piezometer LMV-1B is completed in the lower Santa Fe Group (LSF) hydrostratigraphic unit; the screened interval is from 640 to 650 feet below land surface. Dissolved-solids concentrations in water samples from the LMV-1 site range from 868 mg/L at 640 to 650 feet below land surface to 1,910 mg/L at 830 to 850 feet below land surface. The freshwater zone with dissolved-solids concentrations of 1,000 mg/L or less is estimated to extend from about 430 to 660 feet below land surface. Slightly saline water appears to extend from the water table to the top of the freshwater zone and from the base of the freshwater zone to the bottom of the borehole. The predominant water type is sodium chloride sulfate, which may represent mixing with geothermal water along the eastern margin of the Mesilla Valley. No USEPA primary drinking-water standards were exceeded for sampled constituents in piezometer LMV-1A. The USGS was unable to sample piezometer LMV-1B.

Table 4. Measured ^{14}C composition, partial pressure of carbon dioxide, saturation index for calcite, and apparent age of ground water, lower Mesilla Valley area, 2003.

[pmC, percent modern carbon]

Piezometer name (fig. 1)	^{14}C, in pmC	Partial pressure of carbon dioxide, in atmospheres	Saturation index, calcite	Uncorrected apparent age assuming Ao equals 100 pmC, in years before present	Corrected apparent age assuming Ao equals 50 pmC, in years before present
LMV-1A	6.74	-2.43	-0.03	22,300	16,600
LMV-2A	15.54	-2.53	0.17	15,400	9,660
LMV-2B	2.61	-3.54	0.09	30,100	24,400
LMV-3B	28.42	-3.90	0.39	10,400	4,670

The LMV-2 site is located in the lower Mesilla Valley approximately 3 miles northwest of Anthony, New Mexico. The borehole was drilled to a total depth of 2,300 feet below land surface. Piezometer LMV-2A is completed in the MSF unit; the screened interval is from 680 to 690 feet below land surface. Piezometer LMV-2B is completed in the LSF unit; the screened interval is from 1,860 to 1,870 feet below land surface. Dissolved-solids concentrations in water samples from the LMV-2 site range from 362 mg/L at 1,080 to 1,100 feet below land surface to 5,900 mg/L at 1,990 to 2,010 feet below land surface. The freshwater zone is estimated to extend from the water table to about 1,900 feet below land surface. Slightly saline to saline water extends from the base of the freshwater zone to the bottom of the borehole. Water type varies with aquifer depth from shallow sodium bicarbonate water to deep sodium sulfate water. The dissolved fluoride concentration in LMV-2B exceeded the USEPA primary drinking-water standard. Dissolved arsenic concentrations in LMV-2A and LMV-2B exceeded the proposed USEPA primary drinking-water standard.

The LMV-3 site is located on the west side of the lower Mesilla Valley approximately 0.8 mile southeast of La Union, New Mexico. The borehole was drilled to a total depth of 1,820 feet below land surface. Piezometer LMV-3A is completed in the MSF unit; the screened interval is from 880 to 890 feet below land surface. Because the driller was unable to develop piezometer LMV-3A, no water-level data or water-quality samples were obtained. Piezometer LMV-3B is completed in the LSF unit; the screened interval is from 1,745 to 1,755 feet below land surface. Dissolved-solids concentrations in water samples from the LMV-3 site range from 378 mg/L at 640 to 660 feet below land surface to 6,100 mg/L at 1,745 to 1,755 feet below land surface. The freshwater zone is estimated to extend from less than 190 to about 1,320 feet below land surface. Slightly saline to saline water extends from the base of the freshwater zone to the bottom of the borehole. Water type varies with aquifer depth from shallow sodium bicarbonate water to deep sodium chloride sulfate water. The concentration of dissolved arsenic in LMV-3B exceeded the proposed USEPA primary drinking-water standard.

Water-quality samples collected by the USGS from the LMV piezometers were analyzed for the stable isotopic ratios of $\delta^{2}H$, $\delta^{18}O$, and $\delta^{13}C$. The isotopic composition of sample LMV-1A may represent source water from precipitation as mountain-front recharge along the Franklin Mountains. The deep inner-valley samples from LMV-2A, LMV-2B, and LMV-3B are isotopically lighter (hydrogen depleted). The sources of recharge water to these piezometers are unknown. The $\delta^{13}C$ compositions in samples from LMV-1A, LMV-2A, LMV-2B, and LMV-3B ranged from –13.71 to –4.99 per mil. The range in values indicates that different processes have affected carbon compositions and may represent differences in recharge origin and chemical reactions along the ground-water flow path.

Analytical results for the radioactive isotopes tritium (^{3}H) and carbon-14 (^{14}C) were used to estimate the age of ground water in the LMV piezometers. The small tritium values (less than 0.5 pCi/L) are indicative of ground water that was isolated from the atmosphere prior to 1954 atmospheric nuclear weapons testing and that has received no post-1954 contribution from recharge. The ^{14}C values ranged from 2.61 to 28.42 pmC. Geochemical reactions, including the dissolution of carbonate minerals and carbon isotopic exchange, can substantially decrease carbon composition in ground water. The extent of these chemical reactions in the lower Mesilla Valley and the degree to which they affect carbon composition are unknown. The uncorrected apparent ages ranged from 10,400 to 30,100 years before present and represent maximum calculated ages. The corrected apparent ages ranged from 4,670 to 24,400 years before present and represent minimum calculated ages (maximum carbonate dissolution). The larger ^{14}C composition of 28.42 pmC in the LMV-3B sample resulted in a younger corrected apparent age of 4,670 years, which is inconsistent with the conceptual model of the ground-water flow system.

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Appendix

Table 1. Site location, construction information, and initial water-level data for piezometers installed by El Paso Water Utilities, lower Mesilla Valley area, 2003.

[NGVD29, National Geodetic Vertical Datum of 1929; Do., ditto; --, no data]

Site name and piezometer (fig. 1)	U.S. Geological Survey site identification number	State well number	Latitude	Longitude	Land-surface altitude (feet above NGVD29)	Date completed	Borehole depth (feet)	Screened interval of piezometer (feet below land surface)	Initial water level (feet below land surface)	Date water level measured
LMV-1										
LMV-1A	315656106350701	JL-49-04-498	31°56’56”	106°35’07”	3,900	03/11/2003	857	280-290	163.07	03/16/2003
LMV-1B	315656106350702	JL-49-04-499	Do.	Do.	Do.	Do.	Do.	640-650	170.96	Do.
LMV-2										
LMV-2A	320141106390601	26S.03E.20.423A	32°01’41”	106°39’06”	3,796	04/29/2003	2,300	680-690	12.03	07/02/2003
LMV-2B	320141106390602	26S.03E.20.423B	Do.	Do.	Do.	Do.	Do.	1,860-1,870	21.20	Do.
LMV-3										
[1]LMV-3A	315622106391704	27S.03E.20.432C	31°56’22”	106°39’17”	3,780	04/02/2003	1,820	880-890	--	04/29/2003
LMV-3B	315622106391705	27S.03E.20.432D	Do.	Do.	Do.	Do.	Do.	1,745-1,755	33.45	Do.

[1] Driller unable to develop piezometer. No water-level data or water-quality samples were obtained.

Table 2. Selected water-quality data for sampled borehole intervals and piezometers reported by El Paso Water Utilities, lower Mesilla Valley area, 2003

[NGVD29, National Geodetic Vertical Datum of 1929; µS/cm, microsiemens per centimeter at 25 degrees Celsius (deg C); mg/L, milligrams per liter; --, not determined; <, less than]

Borehole or piezometer name (fig. 1)	Sampled interval (feet below land surface)	Sample type	Date	Time	Land-surface altitude (feet above NGVD29)	pH water, whole, lab (standard units)
LMV-1	250-270	Borehole	02/27/2003	2000	3,900	8.8
LMV-1	400-420	Borehole	02/27/2003	1000	3,900	8.7
LMV-1	450-470	Borehole	02/27/2003	1100	3,900	8.5
LMV-1	700-720	Borehole	02/26/2003	1900	3,900	8.2
LMV-1	830-850	Borehole	02/26/2003	1700	3,900	8.9
LMV-1A	280-290	Piezometer	03/05/2003	1705	3,900	8.6
LMV-1B	640-650	Piezometer	03/05/2003	1800	3,900	8.2
LMV-2	380-400	Borehole	04/23/2003	0045	3,796	8.6
LMV-2	675-695	Borehole	04/18/2003	1700	3,796	8.9
LMV-2	1,080-1,100	Borehole	04/18/2003	0930	3,796	9.4
LMV-2	1,310-1,330	Borehole	04/17/2003	2315	3,796	9.0
LMV-2	1,620-1,640	Borehole	04/16/2003	--	3,796	9.1
LMV-2	1,860-1,880	Borehole	04/16/2003	1200	3,796	--
LMV-2	1,990-2,010	Borehole	04/16/2003	0230	3,796	8.9
LMV-2A	680-690	Piezometer	04/30/2003	1800	3,796	8.1
LMV-2B	1,860-1,870	Piezometer	04/29/2003	1400	3,796	8.3
LMV-3	190-210	Borehole	03/20/2003	0600	3,780	8.6
LMV-3	450-470	Borehole	03/19/2003	2245	3,780	--
LMV-3	640-660	Borehole	03/19/2003	--	3,780	--
LMV-3	870-890	Borehole	03/19/2003	1000	3,780	--
LMV-3	990-1,010	Borehole	03/19/2003	0530	3,780	--
LMV-3	1,130-1,150	Borehole	03/18/2003	2345	3,780	--
LMV-3	1,250-1,270	Borehole	03/18/2003	1730	3,780	8.6
LMV-3	1,470-1,490	Borehole	03/18/2003	1100	3,780	8.7
LMV-3	1,770-1,790	Borehole	03/18/2003	0030	3,780	8.4
LMV-3B	1,745-1,755	Piezometer	04/01/2003	1730	3,780	8.6

Table 2. Selected water-quality data for sampled borehole intervals and piezometers reported by El Paso Water Utilities, lower Mesilla Valley area, 2003--Continued.

Borehole or piezometer name (fig. 1)	Sampled interval (feet below land surface)	Specific conductance, lab (μS/cm)	Hardness, total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Potassium, dissolved (mg/L as K)
LMV-1	250-270	2,250	365	52.9	56.5	18.5
LMV-1	400-420	1,600	97.8	24.6	10.7	10.8
LMV-1	450-470	1,600	336	74.7	37.4	11.6
LMV-1	700-720	1,730	46.3	15.8	2.88	12.2
LMV-1	830-850	2,840	44.0	16.1	2.08	10.4
LMV-1A	280-290	2,000	258	48.5	33.7	14.1
LMV-1B	640-650	1,580	163	35.9	19.0	12.6
LMV-2	380-400	955	71.1	22.5	6.61	3.26
LMV-2	675-695	1,080	85.8	28.4	5.90	4.80
LMV-2	1,080-1,100	595	33.3	15.8	1.41	3.50
LMV-2	1,310-1,330	667	55.1	20.5	3.01	4.96
LMV-2	1,620-1,640	773	30.1	13.1	<10.0	<10.0
LMV-2	1,860-1,880	2,830	105	42.1	5.01	7.03
LMV-2	1,990-2,010	8,320	710	246	30.6	14.8
LMV-2A	680-690	857	90.5	31.2	6.50	3.73
LMV-2B	1,860-1,870	1,680	23.1	14.2	2.11	3.62
LMV-3	190-210	955	21.7	10.8	2.19	1.85
LMV-3	450-470	866	26.9	14.3	1.13	1.51
LMV-3	640-660	556	22.2	13.2	<1.00	1.37
LMV-3	870-890	659	25.7	14.1	<1.00	<1.00
LMV-3	990-1,010	573	26.3	13.0	<1.00	<1.00
LMV-3	1,130-1,150	626	22.6	11.7	<1.00	<1.00
LMV-3	1,250-1,270	1,520	70.3	30.0	1.32	2.25
LMV-3	1,470-1,490	4,120	244	106	5.25	6.23
LMV-3	1,770-1,790	7,420	526	208	10.7	10.8
LMV-3B	1,745-1,755	6,750	435	169	<5.00	10.1

Table 2. Selected water-quality data for sampled borehole intervals and piezometers reported by El Paso Water Utilities, lower Mesilla Valley area, 2003--Continued.

Borehole or piezometer name (fig. 1)	Sampled interval (feet below land surface)	Sodium, dissolved (mg/L as Na)	Alkalinity, total, lab (mg/L as $CaCO_3$)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)
LMV-1	250-270	346	399	326	1.06	13.9
LMV-1	400-420	297	201	258	1.55	21.3
LMV-1	450-470	207	200	277	1.69	24.1
LMV-1	700-720	336	154	323	1.14	17.9
LMV-1	830-850	--	163	454	1.80	28.7
LMV-1A	280-290	286	177	308	1.93	15.6
LMV-1B	640-650	221	116	308	1.12	6.4
LMV-2	380-400	190	299	<50.0	0.56	50.0
LMV-2	675-695	202	211	65.3	0.55	38.8
LMV-2	1,080-1,100	109	90.3	<50.0	<0.50	15.3
LMV-2	1,310-1,330	119	112	52.3	0.52	31.7
LMV-2	1,620-1,640	134	133	<250	1.36	33.5
LMV-2	1,860-1,880	572	217	345	5.19	15.3
LMV-2	1,990-2,010	1,760	78.4	1,280	1.14	16.7
LMV-2A	680-690	144	235	<50.0	0.48	43.5
LMV-2B	1,860-1,870	342	148	236	4.86	15.6
LMV-3	190-210	205	244	<50.0	1.89	43.6
LMV-3	450-470	182	185	53.8	2.18	44.7
LMV-3	640-660	108	85.3	<50.0	1.49	44.0
LMV-3	870-890	132	112	<50.0	1.47	44.6
LMV-3	990-1,010	114	127	<50.0	1.70	43.8
LMV-3	1,130-1,150	123	85.5	50.3	1.34	30.1
LMV-3	1,250-1,270	272	46.2	350	0.82	22.5
LMV-3	1,470-1,490	798	79.4	798	1.45	29.5
LMV-3	1,770-1,790	1,510	64.6	1,400	<0.10	31.9
LMV-3B	1,745-1,755	1,370	33.3	1,350	2.76	45.6

Table 2. Selected water-quality data for sampled borehole intervals and piezometers reported by El Paso Water Utilities, lower Mesilla Valley area, 2003--Concluded.

Borehole or piezometer name (fig. 1)	Sampled interval (feet below land surface)	Sulfate, dissolved (mg/L as SO_4)	Dissolved solids (mg/L)
LMV-1	250-270	289	1,380
LMV-1	400-420	192	1,020
LMV-1	450-470	192	970
LMV-1	700-720	183	1,020
LMV-1	830-850	507	1,910
LMV-1A	280-290	339	1,200
LMV-1B	640-650	173	868
LMV-2	380-400	123	630
LMV-2	675-695	211	710
LMV-2	1,080-1,100	94.9	362
LMV-2	1,310-1,330	114	406
LMV-2	1,620-1,640	<250	524
LMV-2	1,860-1,880	582	1,830
LMV-2	1,990-2,010	2,570	5,900
LMV-2A	680-690	120	548
LMV-2B	1,860-1,870	253	982
LMV-3	190-210	156	606
LMV-3	450-470	135	612
LMV-3	640-660	98.6	378
LMV-3	870-890	121	486
LMV-3	990-1,010	92.9	464
LMV-3	1,130-1,150	117	408
LMV-3	1,250-1,270	119	826
LMV-3	1,470-1,490	717	2,530
LMV-3	1,770-1,790	1,790	4,850
LMV-3B	1,745-1,755	1,450	4,410

Table 3. Water-quality data for selected piezometers sampled by the U.S. Geological Survey, lower Mesilla Valley area, 2003.

[NGVD29, National Geodetic Vertical Datum of 1929; mm, millimeters; µS/cm, microsiemens per centimeter at 25 degrees Celsius (deg C); mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; E, estimated value; --, not determined; bold numbers, exceedances of U.S. Environmental Protection Agency (USEPA) (2004) drinking-water standards; ti, titration; dis it, dissolved incremental titration; pCi/L, picocuries per liter]

Piezometer name (fig. 1)	Station number	Date	Time	Depth of well, total (feet)	Depth to top of screened interval (feet)	Depth to bottom of screened interval (feet)
JL-49-04-498 LMV-1A	315656106350701	10/28/2003	1230	300	280	290
26S.03E.20.423A LMV-2A	320141106390601	10/30/2003	0900	700	680	690
26S.03E.20.423B LMV-2B	320141106390602	11/04/2003	1030	1,880	1,860	1,870
27S.03E.20.432D LMV-3B	315622106391705	11/05/2003	1400	1,765	1,745	1,755

Piezometer name (fig. 1)	Water level (feet below land surface)	Altitude (feet above NGVD29)	Barometric pressure (mm of Hg)	Carbon dioxide, total (mg/L)	Oxygen, dissolved (mg/L)	pH water whole, field[1] (standard units)
JL-49-04-498 LMV-1A	165.38	3,900	662	6.5	0.1	7.7
26S.03E.20.423A LMV-2A	13.30	3,796	663	5.6	0.1	7.9
26S.03E.20.423B LMV-2B	21.66	3,796	666	0.5	0.1	**8.7**
27S.03E.20.432D LMV-3B	43.57	3,780	668	0.3	<0.1	8.3

Piezometer name (fig. 1)	pH water whole, lab (standard units)	Specific conductance, lab (µS/cm)	Specific conductance, field (µS/cm)	Temperature water (deg C)	Hardness, total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)
JL-49-04-498 LMV-1A	7.9	1,660	1,420	26.5	200	36.3
26S.03E.20.423A LMV-2A	8.0	777	783	23.5	92	26.6
26S.03E.20.423B LMV-2B	8.5	1,580	1,620	24.5	22	6.61
27S.03E.20.432D LMV-3B	7.8	8,240	8,540	34.0	760	295

Table 3. Water-quality data for selected piezometers sampled by the U.S. Geological Survey, lower Mesilla Valley area, 2003.—Continued.

Piezometer name (fig. 1)	Magnesium, dissolved (mg/L as Mg)	Potassium, dissolved (mg/L as K)	Sodium, dissolved (mg/L as Na)	Acid neutralizing capacity, total titration 4.5, lab (mg/L as $CaCO_3$)	Alkalinity, water, dis it, field (mg/L as $CaCO_3$)	Bicarbonate water, dis it, field (mg/L as as HCO_3)
JL-49-04-498 LMV-1A	25.8	9.91	283	167	164	200
26S.03E.20.423A LMV-2A	6.05	3.56	155	232	230	281
26S.03E.20.423B LMV-2B	1.14	3.52	333	146	140	160
27S.03E.20.432D LMV-3B	3.21	11.2	1,740	30	E28	E32

Piezometer name (fig. 1)	Carbonate, water dis it, field (mg/L as as CO_3)	Chloride, dissolved[2] (mg/L as Cl	Fluoride, dissolved[3] (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Sulfate, dissolved[4] (mg/L as SO_4)	Solids, sum of constituents, dissolved (mg/L)
JL-49-04-498 LMV-1A	0	**284**	1.8	28.4	**251**	1,020
26S.03E.20.423A LMV-2A	0	46.4	0.5	44.3	117	539
26S.03E.20.423B LMV-2B	5	240	**5.1**	19.4	**261**	955
27S.03E.20.432D LMV-3B	0	**1,610**	**2.8**	36.9	**2,180**	5,900

Piezometer name (fig. 1)	Solids, residue at 180 deg C, dissolved[5] (mg/L)	Ammonia, dissolved (mg/L as N)	Nitrite+ nitrate, dissolved (mg/L as N)	Nitrite, dissolved (mg/L as N)	Orthophosphate, dissolved (mg/L as P)	Phosphorus, dissolved (mg/L as P)
JL-49-04-498 LMV-1A	**1,040**	0.48	<0.06	<0.008	0.013	0.015
26S.03E.20.423A LMV-2A	**535**	E0.04	<0.06	<0.008	0.008	0.009
26S.03E.20.423B LMV-2B	**970**	0.12	<0.06	<0.008	0.010	0.015
27S.03E.20.432D LMV-3B	**6,100**	0.49	<0.06	<0.008	0.008	0.014

Table 3. Water-quality data for selected piezometers sampled by the U.S. Geological Survey, lower Mesilla Valley area, 2003.—Continued.

Piezometer name (fig. 1)	Dissolved organic carbon (mg/L as C)	Aluminum, dissolved (μg/L as Al)	Arsenic, dissolved[6] (μg/L as As)	Barium, dissolved (μg/L as Ba)	Boron, dissolved (μg/L as B)	Cadmium, dissolved (μg/L as Cd)
JL-49-04-498 LMV-1A	4.4	4	3.9	26	240	0.04
26S.03E.20.423A LMV-2A	0.7	<2	**16.5**	32	170	E0.03
26S.03E.20.423B LMV-2B	1.2	3	**35.1**	27	790	E0.03
27S.03E.20.432D LMV-3B	2.9	<6	**43.6**	86	3,320	0.49

Piezometer name (fig. 1)	Chromium, dissolved (μg/L as Cr)	Cobalt, dissolved (μg/L as Co)	Copper, dissolved (μg/L as Cu)	Iron, dissolved[7] (μg/L as Fe)	Lead, dissolved (μg/L as Pb)	Lithium, dissolved (μg/L as Li)
JL-49-04-498 LMV-1A	<0.8	1.30	1.9	220	E0.05	--
26S.03E.20.423A LMV-2A	E0.4	0.10	0.9	**522**	<0.08	128
26S.03E.20.423B LMV-2B	<0.8	0.07	0.9	141	<0.08	--
27S.03E.20.432D LMV-3B	<0.8	1.10	6.1	**527**	<0.32	--

Piezometer name (fig. 1)	Manganese, dissolved[8] (μg/L as Mn)	Mercury, dissolved (μg/L as Hg)	Molybdenum, dissolved (μg/L as Mo)	Nickel, dissolved (μg/L as Ni)	Selenium, dissolved (μg/L as Se)	Silver, dissolved (μg/L as Ag)
JL-49-04-498 LMV-1A	**382**	<0.02	13.4	3.65	E0.3	<0.20
26S.03E.20.423A LMV-2A	34.6	<0.02	12.8	0.63	<0.4	<0.20
26S.03E.20.423B LMV-2B	38.4	<0.02	16.4	0.70	<0.4	<0.20
27S.03E.20.432D LMV-3B	**283**	<0.02	257	2.61	E1.1	<0.80

Piezometer name (fig. 1)	Strontium, dissolved (μg/L as Sr)	Uranium, dissolved (μg/L as U)	Vanadium, dissolved (μg/L as V)	Zinc, dissolved (μg/L as Zn)	Gross alpha, total (pCi/L as Th-230)	Gross beta, total (pCi/L as Cs-137)
JL-49-04-498 LMV-1A	2,860	12.9	<5	1	12	14
26S.03E.20.423A LMV-2A	529	0.35	<5	<1	6	4
26S.03E.20.423B LMV-2B	395	0.06	<5	<1	6	5
27S.03E.20.432D LMV-3B	6,280	<0.16	<5	4	6	10

Table 3. Water-quality data for selected piezometers sampled by the U.S. Geological Survey, lower Mesilla Valley area, 2003.—Concluded.

Piezometer name (fig. 1)	Radium-226, total (pCi/L)	Radium-228, total (pCi/L)	Radon-222, total (pCi/L)	Radon-222, count, 2 sigma (pCi/L)	δ^{2}H stable isotope ratio per mil	δ^{18}O stable isotope ratio per mil
JL-49-04-498 LMV-1A	0.10	<1	470	27	-71.90	-10.40
26S.03E.20.423A LMV-2A	0.07	<1	190	20	-86.30	-11.39
26S.03E.20.423B LMV-2B	0.17	<1	700	29	-89.20	-11.89
27S.03E.20.432D LMV-3B	0.27	1	670	30	-87.00	-11.20

Piezometer name (fig. 1)	Tritium, total (pCi/L)	δ^{13}C stable isotope ratio per mil	^{14}C water, filtered (percent modern)	^{14}C counting error water, filtered (percent)
JL-49-04-498 LMV-1A	0.1	-8.43	6.74	0.12
26S.03E.20.423A LMV-2A	0.3	-6.41	15.54	0.17
26S.03E.20.423B LMV-2B	0.2	-4.99	2.61	0.08
27S.03E.20.432D LMV-3B	0.1	-13.71	28.42	0.26

Exceedances of drinking-water standards established by the USEPA (2004):

[1] pH secondary standard of 6.5 to 8.5 units

[2] Chloride secondary standard of 250 mg/L

[3] Fluoride primary standard of 4.0 mg/L; secondary standard of 2.0 mg/L

[4] Sulfate secondary standard of 250 mg/L

[5] Total dissolved solids secondary standard of 500 mg/L

[6] Arsenic proposed primary standard of 0.010 mg/L (10 µg/L) (effective Jan. 23, 2006)

[7] Iron secondary standard of 0.3 mg/L (300 µg/L)

[8] Manganese secondary standard of 0.05 mg/L (50 µg/L)