U.S. Department of the Interior
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Geohydrology of the Winchester Subbasin, Riverside County, California

Water-Resources Investigations Report 98-4102

Prepared in cooperation with the
EASTERN MUNICIPAL WATER DISTRICT

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GEOHYDROLOGY OF THE WINCHESTER SUBBASIN, RIVERSIDE COUNTY, CALIFORNIA

By Charles A. Kaehler, Carmen A. Burton, Terry F. Rees, *and* Allen H. Christensen

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CONTENTS

FIGURES

TABLES

Conversion Factors, Water-Quality Information, and Abbreviations

Multiply	By	To obtain
acre	0.404	hectare (ha)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year (m^3/yr)
foot (ft)	0.3048	meter (m)
foot per day (ft/d)	0.3048	meter per day (m/d)
square foot (ft^2)	0.09290	square meter (m^2)
foot squared per day (ft^2/d)	0.09290	meter squared per day (m^2/d)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
cubic foot per day (ft^3/d)	0.02832	cubic meter per day (m^3/d)
gallon (gal)	3.785	liter (L)
gallon per minute (gal/min)	0.06308	liter per second (L/s)
gallon per minute per foot [(gal/min)/ft]	0.2069	liter per second per meter [(L/s)m]
inch (in.)	25.4	millimeter (mm)
inch (in.)	2.54	centimenter (cm)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)

Temperature is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation:

$$°F = 1.8\ (°C) + 32$$

VERTICAL DATUM

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

WATER-QUALITY INFORMATION

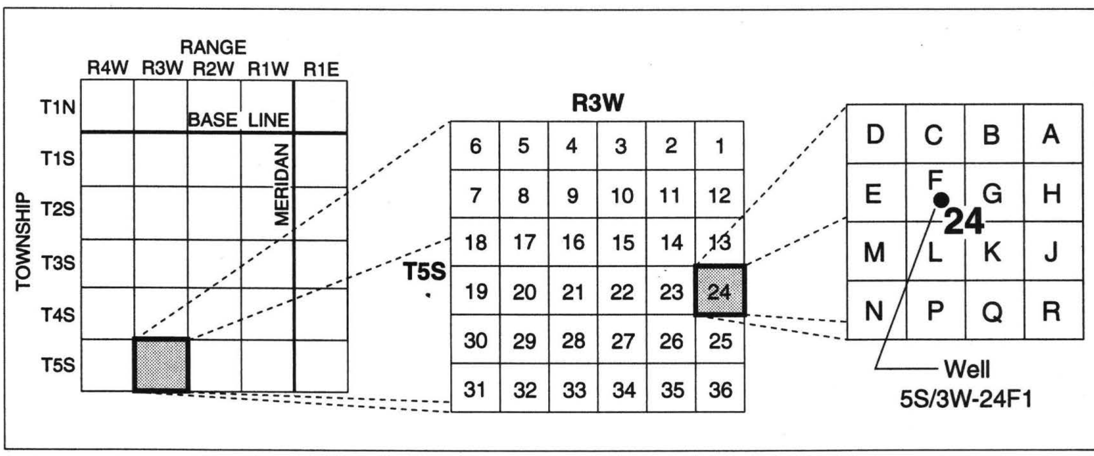
Chemical concentrations are given in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams per liter is approximately equivalent to parts per million. Micrograms per liter is approximately equivalent to parts per billion.

ABBREVIATIONS

DOC	dissolved organic carbon
MCL	maximum contaminant level (U.S. Environmental Protection Agency, 1990)
m	meter
mg/L	milligram per liter
mm	millimeter
µg/L	microgram per liter
µS/cm	microsiemen per centimeter @ 25° Celsius
MEQ/L	milliequivalents per liter
per mil	parts per thousand
EMWD	Eastern Municipal Water District
USGS	U.S. Geological Survey

WELL-NUMBERING SYSTEM

Wells are identified and numbered by the State of California according to their locations in the system for the subdivision of public lands. Identification consists of the township number, north or south; the range number, east or west; and the section number. Each section is divided into sixteen 40-acre tracts lettered consecutively (except I and O), beginning with "A" in the northeast corner of the section and progressing in a sinusoidal manner to "R" in the southeast corner. Within the 40-acre tract, wells are numbered sequentially in the order in which they are inventoried. The final letter refers to the base line and meridian. In California, there are three base lines and meridians: Humboldt (H), Mount Diablo (M), and San Bernardino (S). Because all wells in the study area of this report are referenced to the San Bernardino base line and meridian, the final letter "S" will be omitted. Well numbers consist of 15 characters and follow the format 005S003W024F01S. In this report, well numbers are abbreviated and written 5S/3W-24F1. The following diagram of the well-numbering system shows how well number 5S/3W-24F1 is derived.



Well-numbering diagram

GEOHYDROLOGY OF THE WINCHESTER SUBBASIN, RIVERSIDE COUNTY, CALIFORNIA

By Charles A. Kaehler, Carmen A. Burton, Terry F. Rees, *and* Allen H. Christensen

ABSTRACT

The 20-square-mile Winchester structural subbasin is an alluvium-filled paleocanyon that is as much as 900 feet deep. The alluvial aquifer is composed of detrital material that generally ranges in size from clay to fine gravel; the fine and coarse materials are mixed in some places and interbedded in others. The apparent lenticularity of fine- and coarse-grained materials and differing water quality with depth indicate that the aquifer is partly or locally confined.

A ground-water divide exists east of the town of Winchester. West of the divide, ground water moves toward and into the South Perris and the Menifee subbasins. East of the divide, ground water moves toward and into the Hemet subbasin. The components of flow direction in the Winchester–Hemet subbasins border area are complex: along the border, some water moves from the southwest corner of the Hemet subbasin into the Winchester subbasin and then eastward subparallel to the border before moving back into the Hemet subbasin. The direction of ground-water movement between the Winchester and Hemet subbasins, and the position of the ground-water divide in the central part of the Winchester subbasin, have changed with time. Prior to about 1974, ground water moved both eastward from the divide and westward from the Hemet subbasin toward a local depression of the water table caused by pumping in the eastern part of the Winchester subbasin.

Comparison of spring 1970 and spring 1993 ground-water levels indicates a net rise of as much as 150 feet in the east end of the Winchester subbasin. For this same period, water levels rose about 3 to 20 feet in the western and central parts of the subbasin.

Ground-water chemistry in the Winchester subbasin and adjacent subbasins varies areally and vertically. In general, sodium, calcium, chloride, and sulfate are dominant ions. Water quality is generally poor: dissolved-solids concentration exceeded 2,000 milligrams per liter throughout much of the subbasin and was highest west of the town of Winchester. Eastward along the subbasin axis (toward the Hemet subbasin), the dissolved-solids concentration decreases and the pH increases (generally greater than 7.0). Samples from two multiple-well monitoring sites at the west and east ends of the subbasin indicate that the best quality water (dissolved-solids concentrations of 395 and 483 milligrams per liter) is from the deepest wells (perforated near the alluvium-bedrock contact). Samples from the deeper wells in the eastern part of the Winchester subbasin are similar in water type to a sample from a well in the western part of the Hemet subbasin, which suggests that the water may have flowed from the Hemet subbasin; alternatively, the chemistry may reflect the influence of good-quality water flowing from the fractured bedrock basement to the alluvium in the eastern part of the Winchester subbasin. In addition, the potential problem of poor-quality water moving from the Winchester

subbasin into the Hemet subbasin may not exist at all depths; fair- to good-quality water may be present below a depth of about 450 feet.

Dissolved-solids concentrations in the southwest part of the Hemet subbasin ranged from about 900 milligrams per liter at well 5S/1W-19Q1 about one-quarter mile north of the Winchester–Hemet subbasin boundary to about 3,500 milligrams per liter at well 5S/2W-24C2 near the bedrock outcrops southeast of the Lakeview Mountains. High dissolved-solids concentration in the vicinity of well 5S/2W-24C2 most likely is a result of dissolution of constituents from the aquifer matrix, evaporative processes, and agricultural practices that occur in that vicinity rather than a result of flow from the Winchester subbasin.

Aquifer-test results indicate that the transmissivity is about 950 feet squared per day in the eastern part of the Winchester subbasin near the boundary with the Hemet subbasin and about 72 feet squared per day in the western part of the subbasin near the boundary with the South Perris subbasin. The quantity of extractable ground water available in the alluvial-aquifer system in the Winchester subbasin is estimated to be 230,000 acre-feet using measured water levels, estimated specific yield, and thickness of alluvial basin fill. In 1993, there was about 9,000 acre-feet of unused ground-water storage capacity in the alluvium. On the basis of observed hydraulic gradients and the aquifer properties determined during the aquifer tests, 29 to 423 acre-feet per year of water is moving from the Winchester subbasin into the Hemet subbasin.

INTRODUCTION

The conjunctive use of ground-water basins has become a priority policy for many southern California water agencies. The Eastern Municipal Water District (EMWD) has undertaken extensive studies of the San Jacinto and the Hemet ground-water subbasins (fig. 1) to assess their suitability for storing water during wet years and augmenting supplies during dry years. The results of one of these studies (Rees and others, 1994) indicate that poor-quality ground water from the Winchester subbasin (dissolved-solids concentration as high as 3,300 mg/L) has the potential of moving into, and degrading the water quality in, the southwest part of the adjacent Hemet subbasin, where ground water generally has a dissolved-solids concentration of 600 to 1,900 mg/L. The EMWD is considering various options to control the water-quality degradation.

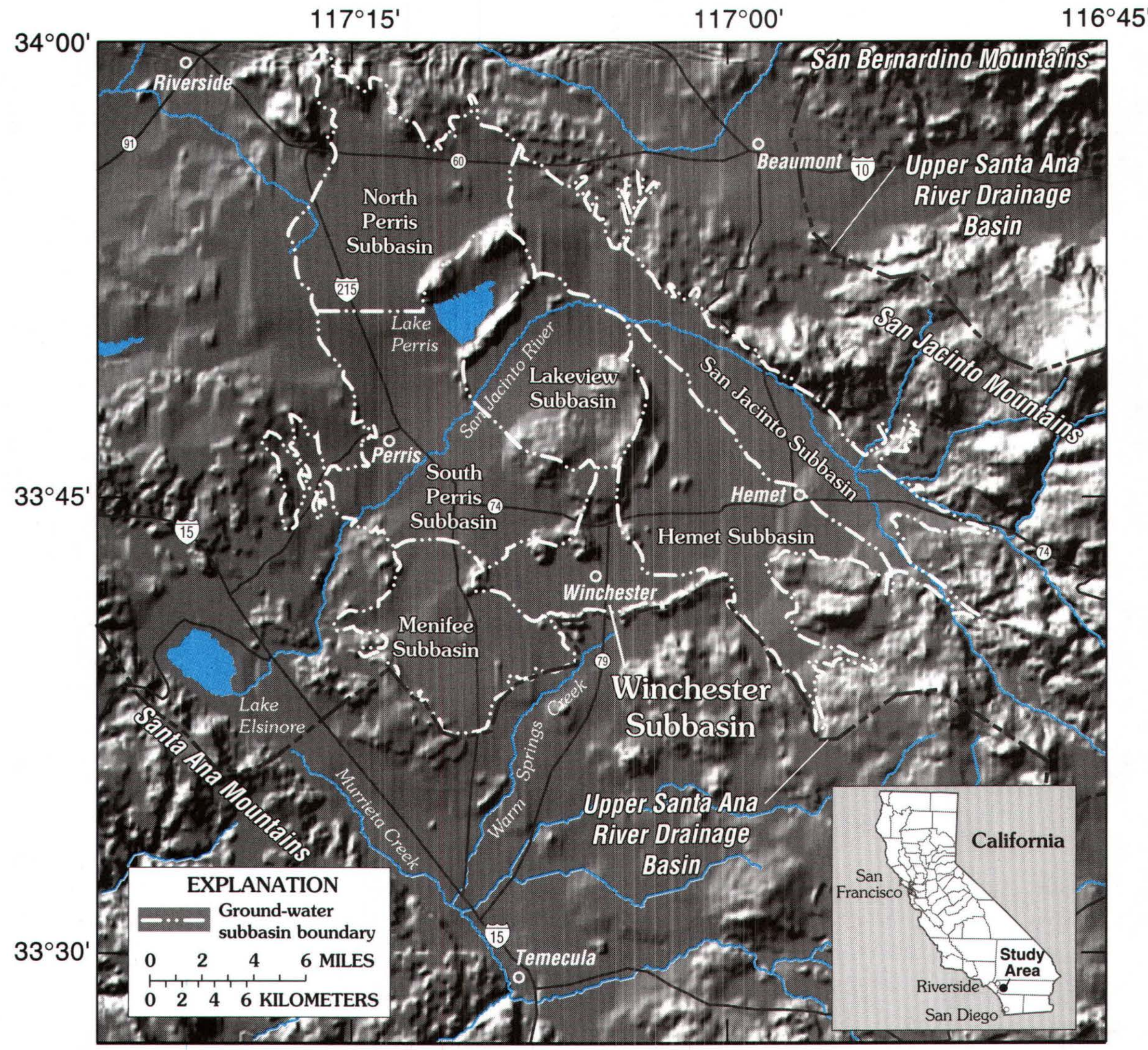
Purpose and Scope

Geohydrologic information about the Winchester subbasin—including knowledge of ground-water quantity, quality, and movement—is needed to formulate and evaluate plans for water-resource management in the area and to predict the hydrologic effects of future management decisions. To address these needs, the U.S. Geological Survey (USGS), in cooperation with EMWD, has completed a ground-water study in the Winchester subbasin. The objectives of the study were to develop a better understanding of the geohydrology of the Winchester subbasin, including the aquifer lithology, the ground-water levels and directions of ground-water flow, the horizontal and vertical variations in ground-water quality, the hydrologic properties of the aquifer at selected sites, the quantity of ground water in storage, and the quantity of ground water that may be moving from the Winchester subbasin into the Hemet subbasin. The scope of the study included compiling historical water-level and water-quality data from several sources, collecting water-level and water-quality data at a number of sites, and performing aquifer tests to determine hydrologic properties of the aquifer at selected locations. The results of the investigation are presented in this report.

Description of the Study Area

The Winchester subbasin is about 25 mi southeast of Riverside, California (fig. 1), in the upper

Santa Ana River drainage basin. The 20-mi^2 subbasin includes about 12 mi^2 of relatively level valley floor. The sides and bottom of the alluvium-filled subbasin are formed principally by granitic rocks of Cretaceous age and by undifferentiated metamorphic rocks (California Department of Water Resources, 1959, plate B-1B). The lateral boundaries of the Winchester subbasin coincide with surface-water-drainage divides, except where alluvium is contiguous with adjacent subbasins (California Department of Water Resources, 1978) (figs. 1, 2). Alluvium-filled constrictions were selected as boundaries between the Winchester subbasin and the Hemet subbasin to the east, the South Perris subbasin to the northwest, and the Menifee subbasin to the southwest (California Department of Water Resources, 1964). Saturated alluvium in the constrictions connects the subbasins hydraulically in the subsurface. Subsurface flow during 1974 from the



Base from U.S. Geological Survey digital elevation data, 1:100,000, 1981-89: Universal Tranverse Mercator Projection, zone 11. Shaded relief base from 1:250,000 scale Digital Elevation Model: sun illumination from northwest at 30 degrees above horizon

Figure 1. Selected subbasins of the upper Santa Ana River drainage basin, California.

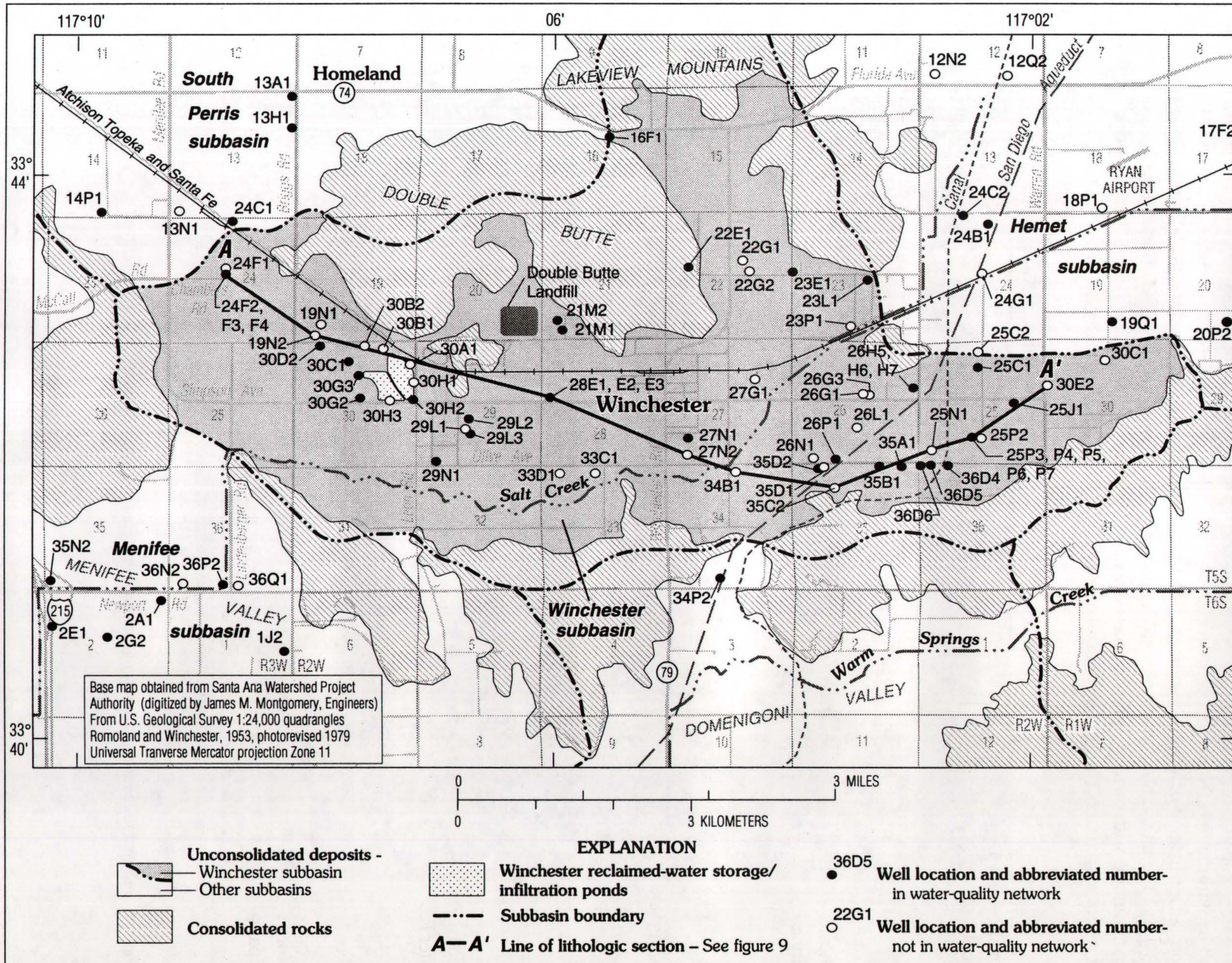


Figure 2. Location of selected wells in and near the Winchester subbasin, California.

Winchester subbasin to the Hemet, the South Perris, and the Menifee subbasins has been estimated to be 300, 100, and 10 acre-ft/yr, respectively (California Department of Water Resources, 1978, fig. 9). Prior to this present study, the amount of subsurface flow under current conditions was unknown, as were the physical characteristics of the subsurface where the Winchester subbasin is connected to the three adjacent subbasins. A bedrock ridge separates the Winchester subbasin from the Domenigoni Valley, which is part of the Santa Margarita River basin, to the south. The two valleys are not considered to be connected hydraulically (Metropolitan Water District of Southern California, 1991), although some seepage may occur through the bedrock ridge that separates the two valleys after the Domenigoni Valley Reservoir, currently under construction, is completed. The geomorphology of the Winchester subbasin and surface geophysical data (gravity and seismic refraction) collected by Biehler and Lee (1994) provide no evidence of active or inactive faults within the subbasin.

Surface water in the Winchester subbasin drains to the ephemeral Salt Creek (fig. 2), which is one of a few well-defined drainages in the upper Santa Ana River drainage basin. Salt Creek flows westward from the Winchester subbasin, through the Menifee subbasin, and into the Railroad Canyon Reservoir (not shown in figure 2).

The thickness of the alluvium in the Winchester subbasin has been estimated to be as much as 900 ft [previously reported as 500 ft (California department of Water Resources, 1978)] on the basis of geophysical data (gravity and seismic refraction, Biehler and Lee, 1994) and borehole data collected as part of this study. Measured depth to water in 1994–95 ranged from 6 to 72 ft in the subbasin, and generally was less than 11 ft for most of the central part of the subbasin. The principal sources of recharge are believed to be infiltration from ephemeral flows in Salt Creek and in small washes draining upland areas at the margins of the subbasin, reclaimed-water storage ponds in the northwest part of the subbasin, and irrigation return flows.

Approach

Existing geohydrologic information was assessed by inventorying wells in and around the Winchester subbasin and by compiling well-construction, water-level-altitude, water-quality, aquifer-test, and subsurface-geologic data from USGS, EMWD, County of Riverside, and California Department of Water Resources files, and from existing reports. The location of the wells used in this study is shown in figure 2.

In addition, four multiple-well monitoring sites were installed as part of this study to provide for more detailed geohydrologic characterization. The choice of sites was restricted to locations where permission for drilling could be obtained from landowners. Multiple-well monitoring site 5S/3W-24F was selected to provide hydrologic information about the boundary between the Winchester and the South Perris subbasins. This site was selected for one of two aquifer tests done for this study (described in the "Hydrologic Properties" section of this report), and has two separate boreholes. The first borehole was drilled to a depth of 729 ft. Caliper, gamma, spontaneous potential, single-point resistivity, 16-inch normal resistivity, and 64-inch normal resistivity geophysical logs were recorded in the open hole prior to piezometer installation. Three individual 2-inch-diameter monitoring wells (24F2, 24F3, and 24F4) were installed in this borehole using the techniques described by Rees and others (1994). Screened intervals were 681–691 ft, 399–404 ft, and 150–155 ft below land surface, respectively. The borehole annulus was sealed using a bentonite-slurry grout between the screened zones, and from the top of the shallowest screen to the land surface. The second borehole (24F1) was drilled 113 ft from the first borehole and to a depth of 680 ft. A 6-inch-diameter casing with screened intervals at 661–680, 622–641, 563–583, 524–544, 388–427, and 310–349 ft below land surface was installed in the second borehole; sand was placed in the borehole annulus from the bottom of the casing to the top of the shallowest screen, and a grout seal was placed from there to the land surface. Geophysical logs, well construction, and generalized lithology of the borehole are shown in figure 3.

Figure 3. Geophysical logs, well-construction diagrams, and generalized lithologic descriptions for multiple-well monitoring site 5S/3W-24F in the Winchester subbasin, California. (Wells F2, F3, and F4 are in one borehole; F1 is in a separate borehole 113 feet to the north.)

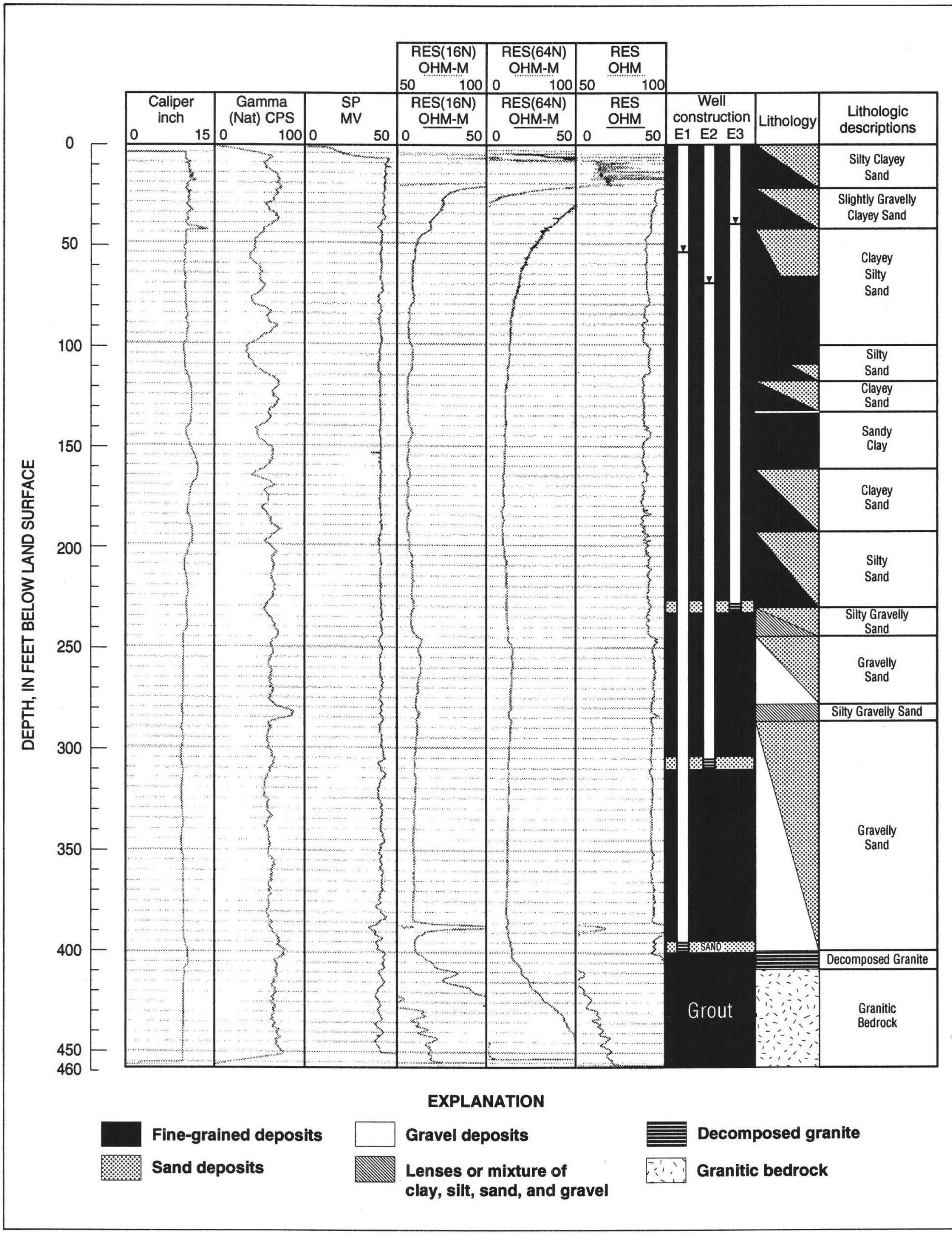


Figure 4. Geophysical logs, well-construction diagrams, and generalized lithologic descriptions for multiple-well monitoring site 5S/2W-28E in the Winchester subbasin, California.

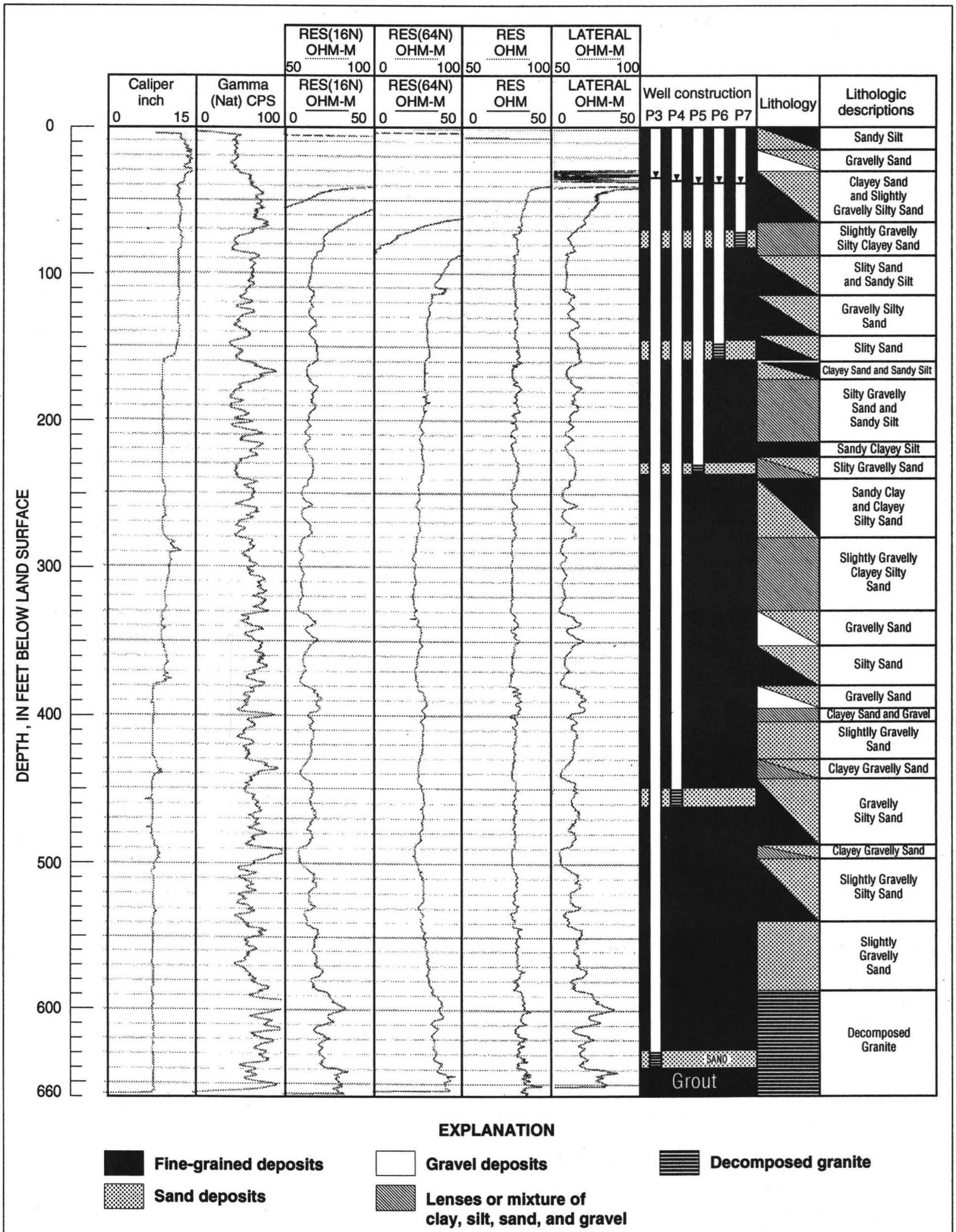


Figure 5. Geophysical logs, well-construction diagrams, and generalized lithologic descriptions for multiple-well monitoring site 5S/2W-25P in the Winchester subbasin, California.

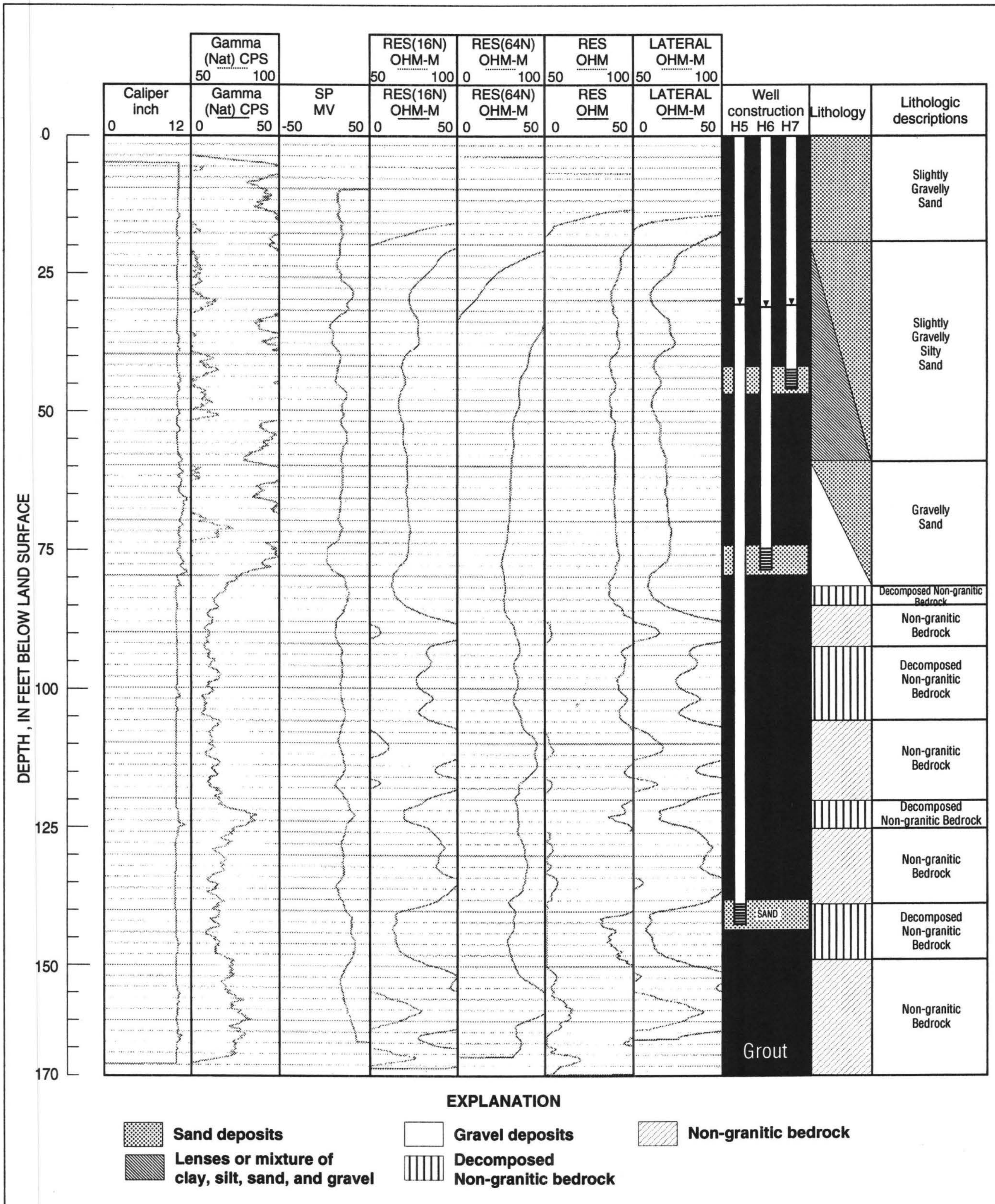


Figure 6. Geophysical logs, well-construction diagrams, and generalized lithologic descriptions for multiple-well monitoring site 5S/2W-26H in the Winchester subbasin, California.

Lithologic description, as determined by microscope examination of drill cuttings, is given in appendix 1.

Site 5S/2W-28E was selected to provide hydrologic information near the center of the Winchester subbasin and consists of a single borehole. This borehole was drilled to a depth of 457 ft, and the same suite of borehole geophysical logs collected at 5S/3W-24F were recorded in the open hole. Three 2-inch-diameter monitoring wells (28E1, 28E2, and 28E3) were installed in the borehole (using the same methods described earlier for site 5S/3W-24F), with screened intervals at 395–400, 306–311, and 228–233 ft, respectively, below land surface. Geophysical logs, well construction, and generalized lithology are shown in figure 4. A detailed description of lithology determined by microscopic examination of drill cuttings is given in appendix 2. Full development (and subsequent water-quality sampling) of monitoring wells 28E2 and 28E3, and the drilling of a test well to be used in an aquifer test, were not completed because the landowner withdrew permission.

Site 5S/2W-25P was selected to provide hydrologic information near the boundary of the Winchester and Hemet subbasins close to the center of the valley floor. This site was selected for observation wells for the second aquifer test (described in the "Hydrologic Properties" section of this report). Because of the availability of a nearby well that was suitable for use as the aquifer-test pumped well (5S/2W-25J1), only one borehole was drilled at the 25P site. This borehole was drilled to 658 ft, and a suite of borehole geophysical logs were recorded in the open hole prior to installation of the monitoring wells. Five individual 2-inch-diameter monitoring wells (25P3, 25P4, 25P5, 25P6, and 25P7) were installed in the borehole as described above, with screened intervals at 630–640, 450–460, 231–236, 148–158 and 72–82 ft below land surface, respectively. Geophysical logs, well construction, and generalized lithology are shown in figure 5. A detailed description of lithology determined by microscopic examination of drill cuttings is given in appendix 3.

Additional hydrologic definition of the Winchester–Hemet subbasin boundary area was provided by drilling a borehole at site 5S/2W-26H near the bedrock outcrop north of Simpson Avenue. This site consisted of a single borehole that was drilled to a depth of 170 ft. The previously mentioned suite of borehole geophysical logs were recorded in the open hole prior to installation of three 2-inch-diameter monitoring wells (26H5, 26H6, and 26H7). These monitoring wells were installed in the borehole (using the same methods as described earlier for site 5S/3W-24F) with screened intervals at 138–143, 74–79, and 40–45 ft below land surface, respectively. Geophysical logs, well construction, and generalized lithology are shown in figure 6. A detailed description of lithology determined by microscope examination of drill cuttings is given in appendix 4.

Water-level altitudes were measured periodically in the piezometers installed for this project and in suitable wells in the Winchester subbasin and in adjacent parts of the Hemet, the Menifee, and the South Perris subbasins. These data were combined with historical water-level data (table 1) to determine directions of ground-water movement, the quantity of ground water available in storage, and the long-term changes in water level. Vertical hydraulic gradients were determined at the multiple-well monitoring sites that were previously described. Water-level data collected for this study (table 1) are discussed in the "Geohydrologic Characterization" section of this report.

Water samples from the USGS-installed piezometers and from selected wells in the Winchester, South Perris, Hemet, and Menifee subbasins were collected for water-quality analysis. Results of these analyses are discussed in the "Ground-Water Quality" section of this report.

Acknowledgments

The authors gratefully acknowledge Jeffrey Hale, Stephen Crombie, and Alfred Javier of EMWD for their help with fieldwork logistics, and Behrooz Mortazavi, Ph.D., and Richard Morton for their review of this report. The authors also thank the many well owners for their cooperation in data-collection efforts.

Table 1. Well-construction and water-level data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California

[Diam., diameter; in., inch; ft blw LSD, feet below land-surface datum; D.G., decomposed granite; R, value is a reported value; >, greater than indicated value; --, no data. Well logs: D, driller's; E, electric; V, video; G, gamma-ray; C, caliper; T, temperature. Well test: SC, specific capacity; gpm/ft, gallons per minute per foot]

Well number	USGS Site identifier	Well depth (ft)		Casing diam. (in.)	Perforations (ft blw LSD)	Well-casing material	Date constructed	Depth to bedrock	Water level		Altitude LSD (± 5 ft)	Available well logs	Well tests
		Drilled	Sounded (date)						(ft blw LSD)	Date			
5S/1W-17F2	334417117002201	–	–	–	–	–	–	–	163.40	4/19/91	1,522	–	–
									168.69	12/24/91			
									173.15	4/30/92			
									164.77	5/15/92			
5S/1W-18P1	334346117012401	–	241 (5/9/91)	12	–	Steel	–	–	105.52	5/9/91	1,507	–	–
5S/1W-19Q1	334300117012101	–	–	12	–	Steel	–	–	–	–	1,510	–	–
5S/1S-20P2	334303117002301	–	–	–	–	–	–	–	151.04	4/19/91	1,528	–	–
									151.38	2/21/92			
									151.72	5/13/92			
									152.26	7/8/92			
5S/1W-30C1	334244117012001	–	149 (5/9/91)	14	–	Steel	–	–	88.90	5/9/91	1,510	–	SC1=18.9 gpm/ft
									88.52	12/23/91			SC2=16.3 gpm/ft
									87.10	4/29/92			SC3=15.7 gpm/ft
									86.95	7/8/92			
5S/1W-30E2	334233117012301	582	–	14	180-582	Steel	10/24/48	604	76.40	5/9/91	1,502	D	–
									75.75	2/4/92			
									75.31	4/30/92			
									73.88	7/7/92			
									69.40	5/13/93			
									65.90	2/10/94			
									72.10	6/16/94			
5S/2W-12N2	334444117025101	–	74.3 (7/3/91)	–	–	–	–	–	33.61	7/3/91	1,508	–	–
									34.78	12/23/91			
									33.93	4/29/92			
									35.00	7/7/92			
5S/2W-12Q2	334440117022501	–	89 (7/3/91)	–	–	–	–	–	36.73	7/3/91	1,499	–	–
									37.60	12/23/91			
									37.04	4/29/92			
									38.90	7/7/92			
5S/2W-16F1	334417117053401	100 R	–	8R	–	Steel	–	–	–	–	1,640	–	–
5S/2W-19N1	333712117080901	358	290.5 (5/3/95)	10	96-312	Steel	7/1/53	350	29.40	9/18/87	1,459	D	–
									31.39	9/15/88			
									32.56	4/21/89			
									34.51	9/6/89			
									34.68	3/19/90			
									40.67	9/28/90			
									38.05	4/15/91			
									40.49	9/17/91			
									37.79	3/18/92			
									42.47	9/3/92			
									37.63	3/30/93			
									34.34	9/10/93			
									40.03	12/29/93			
									33.70	2/10/94			
									33.25	3/15/94			
									32.77	11/18/94			

Table 1. Well-construction and water-level data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

Well number	USGS Site identifier	Well depth (ft) Drilled	Well depth (ft) Sounded (date)	Casing diam. (in.)	Perforations (ft blw LSD)	Well-casing material	Date constructed	Depth to bedrock	Water level (ft blw LSD)	Water level Date	Altitude LSD (± 5 ft)	Available well logs	Well tests
5S/2W-19N2	334251117080201	373	360.35 (5/16/95)	10	127-141, 157-217 231-251,265-365	Steel	8/15/80	>373	33.43	5/16/95	1,458	D	–
5S/2W-21M1	334256117055401	260	–	6	40-260	Steel	1/13/77	–	–	–	1,480	D	–
5S/2W-21M2	334300117055701	260 R	–	4	–	Steel	–	–	–	–	1,490	–	–
5S/2W-22E1	334324117045301	200 R	–	7	–	Steel	–	–	11.11	7/22/93	1,640	–	–
5S/2W-22G1	334320117042101	160 R	–	–	–	–	–	–	–	–	1,505	–	–
5S/2W-22G2	334320117042102	120	–	14	48-104	Steel	3/23/51	>267	49.50	3/23/51	1,506	D	–
									31.25	9/18/87			
									36.05	9/15/88			
									37.59	4/17/89			
									46.00	9/6/89			
									41.90	3/19/90			
									44.61	9/28/90			
									49.29	4/15/91			
									49.80	9/17/91			
									43.77	3/18/92			
									58.34	9/3/92			
									43.95	3/30/93			
									50.48	9/10/93			
									44.50	3/15/94			
5S/2W-23E1	334319117040001	140	–	6	0-140	Steel	1987 R	>140	–	–	1,500	D	–
5S/2W-23L1	334317117032201	120 R	–	6 R	–	Steel	–	–	–	–	1,500	–	–
5S/2W-23P1	334256117033001	140	–	5	40-140	Steel	8/26/78	> 140	–	–	1,490	D	–
5S/2W-24B1	334341117022201	200 R	–	6	–	Steel	–	–	–	–	1,495	–	–
5S/2W-24C2	334344117023501	160 R	–	6	–	Steel	–	–	40.26	4/26/91	1,500	–	–
									41.17	2/26/92			
									40.78	7/7/92			
5S/2W-24G1	334319117022601	30	–	–	–	–	–	–	17.68	4/26/91	1,497	–	–
									16.22	4/29/92			
									16.85	5/15/92			
									19.40	7/7/92			
5S/2W-25C1	334240117022601	–	–	14	–	Steel	–	–	59.61	5/10/91	1,495	–	–
									57.84	3/20/92			
									61.02	7/8/92			
5S/2W-25C2	334248117022601	–	351 (5/9/91)	12	–	Steel	–	–	58.25	5/9/91	1,494	–	–
									58.80	12/23/91			
									56.92	7/8/92			
5S/2W-25J1	334226117020901	525 R	–	14	–	Steel	–	–	70.23	5/9/91	1,498	–	–
									74.69	12/24/91			
									67.44	7/8/92			
5S/2W-25N1		652	–	14	200-530	Steel	1/5/53	630	–	–	–	D	SC=7.7 gpm/ft
5S/2W-25P2	334211117022701	–	287 (5/3/95)	14	–	Steel	–	–	55.49	12/23/91	1,491	V	–
									55.28	4/29/92			
									59.35	7/8/92			
									34.46	5/13/93			
									40.83	2/10/94			
Multiple-well monitoring site													
5S/2W-25P3	334211117022901	640	–	2	630-640	Plastic	5/19/94	600 D.G.	48.84	6/13/94	1,490	C,D,E G, T	–
									40.98	1/27/95			
									41.03	2/2/95			
									40.45	3/9/95			

Table 1. Well-construction and water-level data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

Well number	USGS Site identifier	Well depth (ft) Drilled	Well depth (ft) Sounded (date)	Casing diam. (in.)	Perforations (ft blw LSD)	Well-casing material	Date constructed	Depth to bedrock	Water level (ft blw LSD)	Date	Altitude LSD (± 5 ft)	Available well logs	Well tests
5S/2W-25P4	334211117022902	460	–	2	450-460	Plastic	5/19/94	600 D.G.	39.98	1/27/95	1,490	C, D	–
									40.66	2/2/95		E, G, T	
									40.60	3/9/95			
5S/2W-25P5	334211117022903	236	–	2	231-236	Plastic	5/19/94	600 D.G.	40.16	1/27/95	1,490	C, D, E,	–
									40.25	2/2/95		G, T	
									39.37	3/9/95			
5S/2W-25P6	334211117022904	158	–	2	148-158	Plastic	5/19/94	600 D.G.	38.04	1/30/95	1,490	C,D,E	–
									37.98	2/2/95		G,T	
									36.41	3/9/95			
5S/2W-25P7	334211117022905	82	–	2	72-82	Plastic	5/19/94	600 D.G.	37.60	1/30/94	1,490	C,D,E	–
									37.44	2/2/95		G,T	
									35.97	3/9/95			
5S/2W-26G1		240	–	12	125-240	Steel	2/7/95	245 D.G.	–	–	–	D	SC=0.4 gpm/ft
5S/2W-26G3	334229117032201	60 R	–	10	–	Steel	–	–	39.13	6/20/91	1,484	–	–
									39.13	6/20/91			
									39.46	12/23/91			
									39.46	12/23/91			
									37.55	7/8/92			
									37.55	7/8/92			
Multiple-well monitoring site													
5S/2W-26H5	334232117025901	143	143.3(12/3/93)	2	138-143	Plastic	9/22/93	90	32.58	12/3/93	1,485	C,D,E	–
									32.35	12/28/93		G,T	
									32.03	2/10/94			
									32.25	6/16/94			
									31.71	11/17/94			
5S/2W-26H6	334232117025902	79	79 (12/3/93)	2	74-79	Plastic	9/22/93	90	32.51	12/3/93	1,485	C,D,E	–
									32.28	12/29/93		G,T	
									31.86	2/10/94			
									32.16	6/16/94			
									31.63	11/17/94			
5S/2W-26H7	334232117025903	45	45.1(12/3/93)	2	40-45	Plastic	9/22/93	90	32.44	12/3/93	1,458	C,D,E	–
									32.24	12/28/93		G,T	
									31.84	2/10/94			
									32.15	6/16/94			
									31.75	11/17/94			
5S/2W-26L1		285	–	12	85-136	Steel	3/5/49	262 D.G.	–	–		D	–
5S/2W-26N1	334201117035001	–	–	10	–	Steel	–	–	26.67	6/21/91	1,475	–	–
									26.78	12/23/91			
									19.16	4/29/92			
									22.80	7/8/92			
5S/2W-26P1	334202117033801	300 R	–	8	–	Steel	–	–	34.13	6/21/91	1,477	–	–
									33.12	2/21/92			
									30.15	7/8/92			
5S/2W-27G1		96	–	8	30-90	Steel	6/15/51	>96	–	–	–	D	SC=3 gpm/ft
5S/2W-27N1	334211117045201	105	59 (5/13/93)	6	40-105	Steel	5/13/87	>105	9.27	5/12/93	1,491	D	–
									11.27	12/30/93			
									8.59	6/16/94			
5S/2W-27N2	334202117045101	560	–	14	180-560	Steel	4/25/84	<570	–	–	1,469	D	–
Multiple-well monitoring site													
5S/2W-28E1	334227117060001	400	400.3(12/3/93)	2	395-400	Plastic	10/11/93	400	21.20	2/3/93	1,459	C,D,E,	–
									9.53	2/10/94		G,T	
									9.38	6/16/94			
									9.19	6/21/94			
									9.45	11/17/94			

Table 1. Well-construction and water-level data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

Well number	USGS Site identifier	Well depth (ft) Drilled	Well depth (ft) Sounded (date)	Casing diam. (in.)	Perforations (ft blw LSD)	Well-casing material	Date constructed	Depth to bedrock	Water level (ft blw LSD)	Water level Date	Altitude LSD (± 5 ft)	Available well logs	Well tests
5S/2W-28E2	334227117060002	312	311.5(12/3/93)	2	306-311	Plastic	10/11/93	400	7.08	12/3/93	1,459	C,D,E,	–
									6.87	2/10/94		G,T	
									7.68	6/16/94			
									7.66	6/21/94			
									8.45	11/17/94			
5S/2W-28E3	334227117060003	234	233.8(12/3/93)	2	228-233	Plastic	10/11/93	400	25.67	12/3/93	1,459	C,D,E,	–
									9.94	2/10/94		G,T	
									10.39	6/16/94			
									10.50	6/21/94			
									7.83	11/17/94			
5S/2W-29L2	334219117064101	–	85 R (7/3/94)	6	–	Steel	–	–	14.80	5/16/95	1,455	–	–
5S/2W-29L3	334213117064101	196	–	5.6	50-70	Steel	1/13/93	>200	7.86	5/15/95	1,455	D	–
					100-120								
					160-180								
5S/2W-29N1	334201117065801	–	113 (12/30/92)	4	–	Steel	–	–	15.02	12/30/92	1,450	–	–
									5.64	5/13/93			
									8.00	2/10/94			
									8.57	11/17/94			
									6.39	6/23/95			
									6.83	7/12/95			
									8.16	9/13/95			
5S/2W-30A1	334241117070901	70	71.2(5/23/95)	6	50-70	Plastic	12/21/92	70 D.G.	18.79	5/23/95	1,475	D	–
									23.08	7/6/95			
									30.35	9/13/95			
5S/2W-30B1	334249117072401	70	70.4 (5/23/95)	6	50-70	Plastic	12/21/92	> 70	14.63	5/23/95	1,468	D	–
									16.24	7/6/95			
									20.92	9/13/95			
5S/2W-30B2	334249117073301	70	70.7 (6/2/95)	6	50-70	Plastic	12/21/92	–	10.37	6/2/94	1,457	D	–
									16.64	7/6/95			
									12.37	9/13/95			
5S/2W-30C1	334245117074201	370	355 (5/16/95)	10	270-370	Steel	9/16/80	–	8.50	5/16/95	1,452	D	–
					210-230								
					130-190								
5S/2W-30D2	334250117075601	355	–	14	40-355	Steel	–	–	–	–	1,455	V	–
5S/2W-30G2	334226117073301	70	70.7 (5/23/95)	6	50-70	Plastic	12/21/92	>70	5.65	5/23/95	1,447	D	–
									6.95	7/7/95			
									9.84	9/13/95			
5S/2W-30G3	334236117073301	72	71.4 (5/23/95)	6	52-72	Plastic	12/21/92	>75	6.96	5/23/95	1,449	D	–
									8.00	7/6/95			
									13.33	9/13/95			
5S/2W-30H1	334231117070901	70	69.1 (5/11/95)	6	50-70	Plastic	12/21/92	> 70	9.56	5/11/95	1,463	D	–
									12.56	7/6/95			
									19.53	9/11/95			
5S/2W-30H2	334226117070901	70	69.9(5/11/95)	6	50-70	Plastic	12/21/92	> 70	9.20	5/11/95	1,460	D	–
									16.59	9/11/95			
5S/2W-30H3	334226117072001	70	70.9 (5/23/95)	6	50-70	Plastic	12/21/92	>70	5.10	5/23/95	1,453	D	–
									5.65	7/6/95			
									12.93	9/11/95			
5S/2W-33C1	334158117053501	415	70 (5/16/95)	12	44-54	Steel	11/27/50	283	16.44	12/30/92	1,461	D	–
					62-73				8.59	5/13/93			
					75-85				9.49	2/10/94			
					96-110				10.31	6/16/94			
					124-133				11.52	11/17/94			
					216-240				8.22	5/16/95			
					287-403				10.45	9/13/95			

Table 1. Well-construction and water-level data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

Well number	USGS Site identifier	Well depth (ft) Drilled	Well depth (ft) Sounded (date)	Casing diam. (in.)	Perforations (ft blw LSD)	Well-casing material	Date constructed	Depth to bedrock	Water level (ft blw LSD)	Water level Date	Altitude LSD (± 5 ft)	Available well logs	Well tests
5S/2W-33D1	334157117055301	270	145 (5/16/95)	12	–	Steel	11/1/46	>270	7.32	5/13/93	1,458	D	–
									15.30	12/30/93			
									8.40	2/10/94			
									9.31	6/16/94			
									10.51	11/17/94			
									6.13	5/16/95			
									8.44	9/13/95			
5S/2W-34B1		530	–	14	0-240	Steel	9/30/54	525	–	–	–	D	–
					240-500								
					500-530								
5S/2W-34P2	334112117043401	200 R	–	6	–	Steel	–	–	21.77	7/21/93	1,478	–	–
5S/2W-35A1	334159117030501	–	290 (5/13/93)	12	–	Steel	–	–	23.95	5/13/93	1,485	–	–
									27.70	7/21/93			
									28.90	6/16/94			
									26.63	11/18/94			
5S/2W-35B1	334200117031601	–	168 (7/21/93)	12	–	Steel	–	–	20.10	5/13/93	1,480	–	–
									24.84	11/18/94			
5S/2W-35C2		280	–	10.8	0-282	Steel	3/11/62	>282	–	–	–	D	SC=1.85 gpm/ft
5S/2W-35D1	334159117034401	142	(6/21/91)	–	–	Steel	–	–	30.25	6/21/91	1,476	–	–
									31.40	12/23/91			
									30.35	7/8/92			
									13.30	5/13/93			
									19.57	11/18/94			
5S/2W-36D1		383	–	14	180-383	Steel	10/17/53	380	–	–	–	D	SC=3.2 gpm/ft
5S/2W-35D2	334158117034601	38	(5/6/93)	8	–	Steel	–	–	9.81	5/6/93	1,476	–	–
									10.21	5/13/93			
									18.51	11/18/94			
5S/2W-36D4	334200117024201	–	235 (6/21/91)	14	–	Steel	–	–	46.03	6/21/91	1,487	–	–
									47.42	12/23/91			
									46.27	4/29/92			
									40.65	7/8/92			
									29.83	11/17/94			
5S/2W-36D5	334200117025001	–	31.5 (6/16/94)	14	–	Steel	–	–	36.00	12/29/92	1,485	–	–
									25.45	5/13/93			
									28.20	11/18/94			
5S/2W-36D6	334200117025601	–	283 (12/29/92)1	12	–	Steel	–	–	27.64	11/18/94	1,485	–	–
5S/3W-13A1	334434117080901	431	–	12	231-431	Steel	5/12/77	426	–	–	1,522	D	SC=2.1 gpm/ft
5S/3W-13H1	334420117080901	460	–	12	200-460	Steel	8/17/83	460 D.G.	114.14	7/14/95	1,518	D	–
5S/3W-13N1	334348117085701	433	142.0 (5/22/95)	10.8	250-433	Steel	5/21/77	417	52.02	5/22/95	1,475	D	
5S/3W-14P1	334343117094401	~250R	–	–	–	Steel	–	–	–	–	1,447	–	
5S/3W-24C1	334341117084101	505	–	12.8	265-505	Steel	5/25/77	479	72.56	1/4/94	1,480	D	SC=0.48 gpm/ft
5S/3W-24F1	334318117084301	681	681 (12/3/94)	6	309.5-348.5	Plastic	9/30/93	690	68.34	12/3/93	1,475	C,D,E	Aquifer test
					387.5-426.5				62.86	2/10/94		G,T	Velocity
					524.0-543.5				76.03	11/18/94			(dye injection)
					563.0-582.5				69.21	12/15/94			
					621.5-641.0				92.40	6/23/95			
					660.5-680.0								
Multiple-well monitoring site													
5S/3W-24F2	334317117084301	691	691(12/3/93)	2	686-691	Plastic	9/30/93	695	64.22	12/3/93	1,475	C,D,E	–
									66.58	2/10/94		G,T	
									76.47	11/18/94			
									69.25	12/15/94			
									64.73	1/17/95			
									65.77	6/23/95			
									75.11	9/13/95			

Table 1. Well-construction and water-level data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

Well number	USGS Site identifier	Well depth (ft) Drilled	Sounded (date)	Casing diam. (in.)	Perforations (ft blw LSD)	Well-casing material	Date constructed	Depth to bedrock	Water level (ft blw LSD)	Date	Altitude LSD (± 5 ft)	Available well logs	Well tests
5S/3W-24F3	334317117084302	404	404 (12/3/93)	2	399-404	Plastic	9/30/93	695	69.90	12/3/93	1,475	C,D,E	–
									68.21	2/10/94		G,T	
									83.52	11/18/94			
									72.76	12/15/94			
									68.22	1/17/95			
									108.69	6/23/95			
									99.99	9/13/95			
5S/3W-24F4	334317117084303	155	155 (12/3/93)	2	150-155	Plastic	9/30/93	695	58.06	12/3/93	1,475	C,D,E	–
									57.40	2/10/94		G,T	
									57.44	11/18/94			
									57.06	12/15/94			
									56.31	1/17/95			
									57.00	6/23/95			
									56.86	9/13/95			
5S/3W-35N2	334107117100701	650	587.6 (4/26/95)	6	250-350, 400-440	Stainless	8/7/92	>650	80.85	4/26/95	1,425	D,E,G	–
					480-520, 580-600	steel							
5S/3W-36N2	334107117090301	700	338.6 (4/26/95)	12.7	320-700	Steel	5/24/77	>700	91.98	4/26/95	1,425	D	
5S/3W-36P2	334107117084201	680	684 (7/12/94)	5.5	400-440	Steel	6/3/92	695	104.71	7/12/94	1,430	D	–
					460-500				96.73	9/28/95			
					520-560								
					580-620								
					640-680								
5S/3W-36Q1		604	–	14	92-600	Steel	7/4/52	>604	–	–		D	–
6S/3W-1J2	334036117081101	300R	–	12	–	Steel	–	–	–	–	1,430	–	–
6S/3W-2A1	334105117091201	600	577.0 (4/26/95)	16	180-200, 300-360	Steel	11/19/93	>600	93.97	4/26/95	1,425	D,E,G,C	–
					380-440, 540-560								
6S/3W-2E1	334049117100601	695	651.3 (4/26/95)	16	220-300, 360-400	Steel	11/13/93	>695	89.79	4/26/95	1,425	D,E,G	–
					440-520, 540-600								
					620-640								
6S/3W-2G2	334046117094501	622	–	16	–	Steel	9/1/88	>620	92.74	6/5/95	1,428	D,E,G	–

GEOHYDROLOGIC CHARACTERIZATION

Geologic Structure

Gravity and seismic-refraction surface-geophysical studies by Biehler and Lee (1994) that utilized borehole data collected during this study indicate that the paleocanyon that forms the main part of the Winchester subbasin extends from the South Perris subbasin in the northwest to the Hemet subbasin in the east (fig. 7). The alluvial fill is thickest (about 900 ft) at the northwest end of the Winchester subbasin and extends into the South Perris subbasin.

Lithology and Aquifer-Matrix Description

The surface-geophysical data (Biehler and Lee, 1994) and the drill cuttings collected during this study indicate that the bedrock basement of the Winchester subbasin consists mainly of crystalline granitic and ultramafic intrusive rocks. The alluvial fill is detrital material derived from the local mountains and surrounding areas. This detrital material generally ranges in size from clay to fine gravel, and the fine and coarse materials are mixed in some places and interbedded in others. Sand and gravel grains are angular to subrounded, indicating a short travel distance from source to deposition.

A general texture map (fig. 8) showing the percentage of coarse-grained material within the saturated alluvium (0–500 ft in depth) of the Winchester subbasin was constructed on the basis of 16 driller's logs and the lithologic logs of three monitoring-well sites completed for this study, and on the basis of inferences from the geometry of the basin. The texture map shows the percentage of coarse-grained material at each site and an inferred line of equal abundance of coarse-grained material within the upper 500 ft of saturated alluvium. The percentage of coarse-grained material was calculated for 100-foot intervals for each borehole and then determined for the total depth of the borehole to a maximum depth of 500 ft. If a borehole did not extend at least 80 ft into an interval, no calculation was made for that interval.

Much of the information used to construct figure 8 was interpreted from imprecise lithologic descriptions on drillers' logs. Material described as clayey sand, silty sand, sand-shale, sand, sand and gravel, clayey gravel, silty gravel, and gravel was interpreted to be coarse-grained deposits. Material described as clay, sandy clay, silt, top soil, dirt, and hill formation was interpreted to be fine-grained deposits. Material described as clay and sand was considered to be 50 percent fine grained and 50 percent coarse grained sediment. Material described as being present in streaks or layers was tabulated as 33 percent of the interval to which the description was applied. Material described as decomposed granite was considered to be 50 percent fine grained and 50 percent coarse grained. The calculated percentage of coarse-grained deposits for an interval may not have a direct correlation with permeability because of the effects of grain-size sorting; deposits described as primarily coarse grained may have reduced permeability owing to the plugging of pore spaces between the coarse grains by fine-grained particles.

As would be expected, on the basis of the existence of a paleocanyon (fig. 7) in the Winchester subbasin, the largest percentage of coarse-grained material generally is along the central axis of the subbasin. This distribution probably reflects the depositional influence of ancestral stream channels.

Generalized lithologic logs (fig. 9) along section *A-A′* through the deepest part of the subbasin (fig. 2) depict the thickness and vertical distribution of layers or lenticular units within the alluvium. For this section, the alluvium was divided into four categories: fine-grained deposits, sand deposits, gravel deposits, and mixed deposits. The rocks underlying the alluvium were classified as decomposed granite if significantly weathered, or granitic bedrock if relatively unweathered. No lithologic units, or layers, were traceable from borehole to borehole. Consequently, clay, silt, sand, and gravel deposits within the alluvium of the Winchester subbasin probably should be considered to be lenticular. The apparent lenticularity of fine- and coarse-grained materials supports a conceptualization of the aquifer as partly or locally confined, although probably without a traceable, widespread confining layer. However, some of this apparent lenticularity may be an artifact of the sparse distribution and shallow depth of the available wells, and the generally poor lithologic descriptions from the driller's logs.

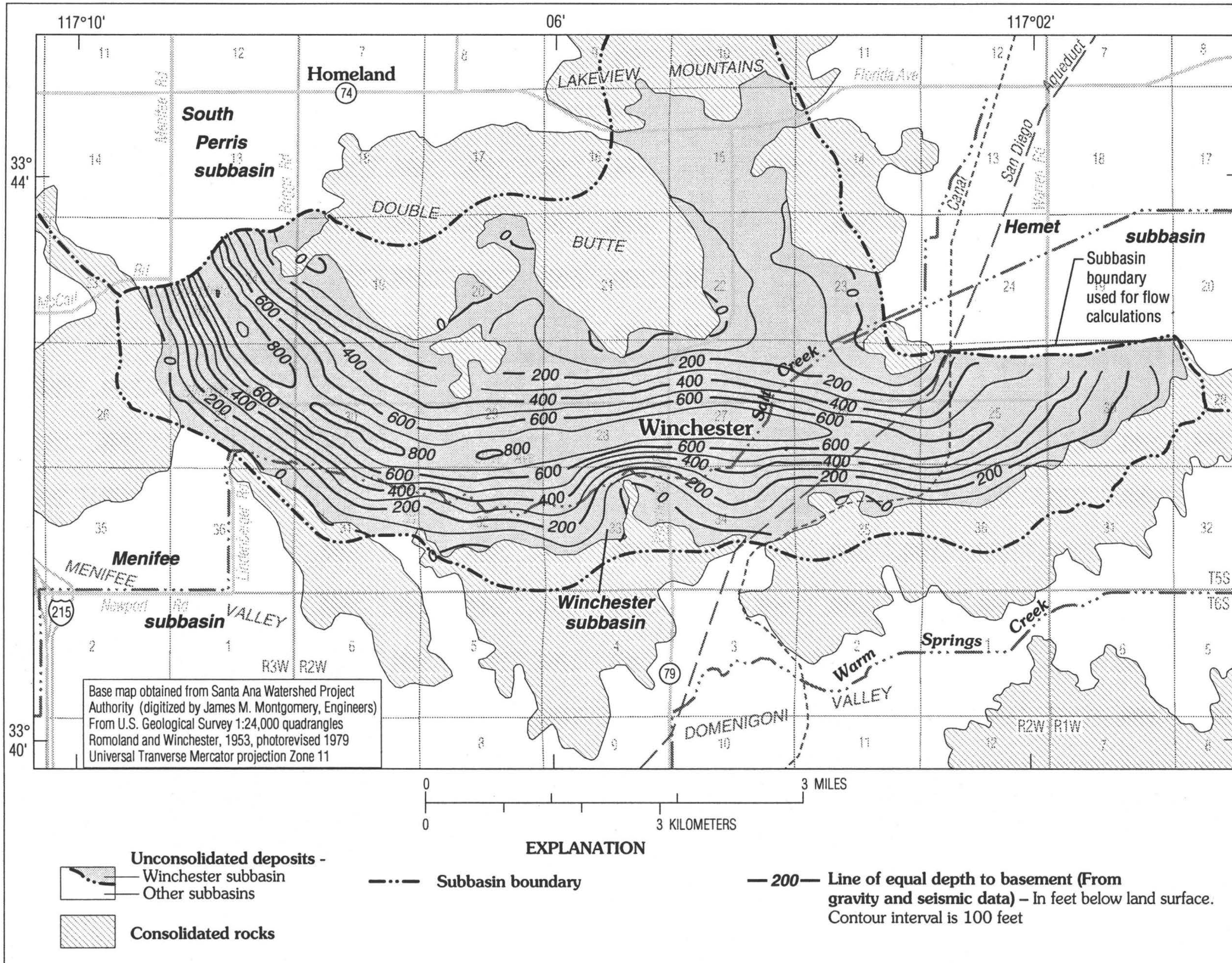


Figure 7. Depth to bedrock basement, in feet below land surface, (thickness of basin fill) in the Winchester subbasin, California. (Contours from Biehler and Lee, 1994, superimposed on base map without modification.)

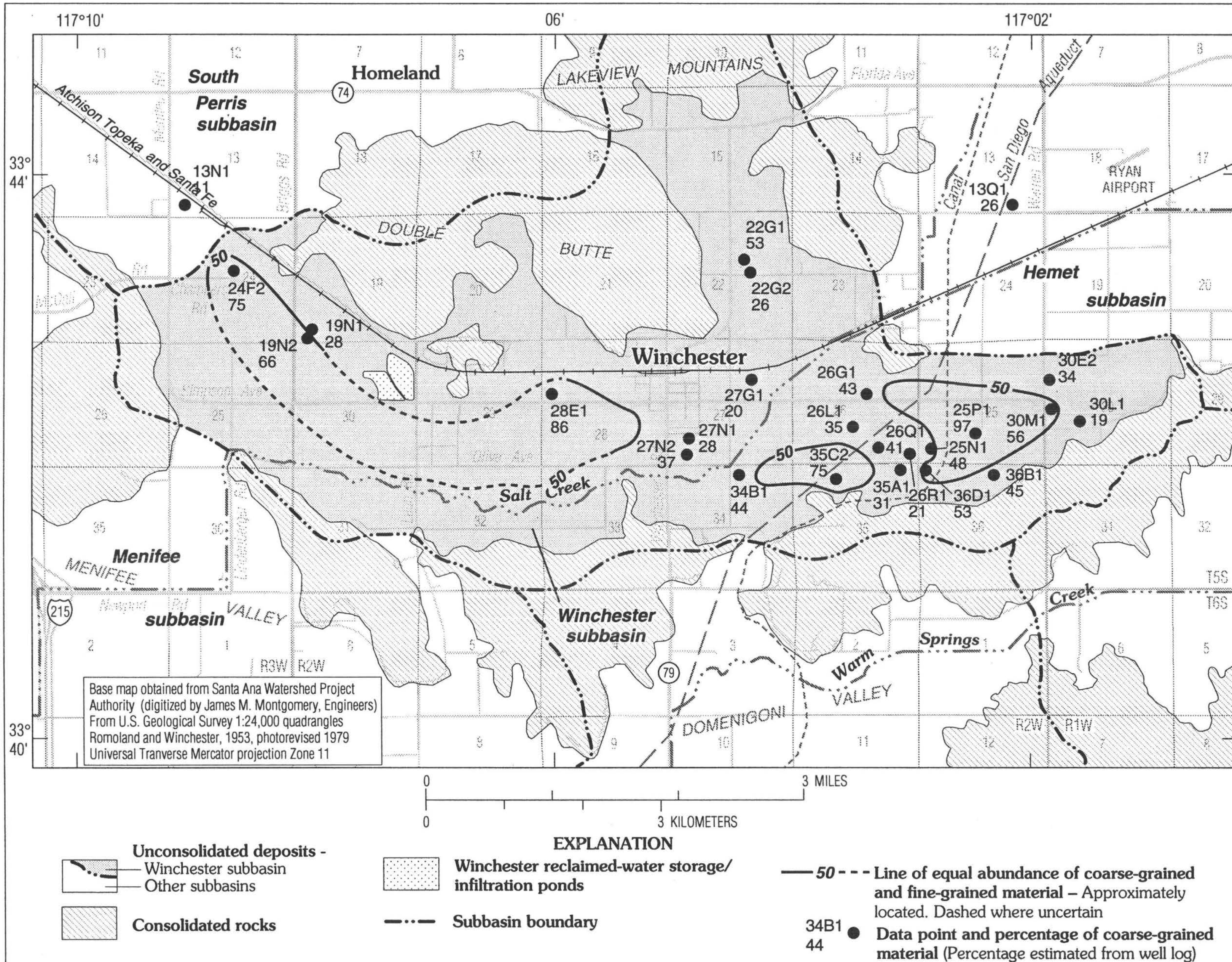


Figure 8. Texture in the 0–500 foot depth interval of the alluvial deposits in the Winchester subbasin, California.

General Ground-Water Levels and Ground-Water Movement

One of the objectives of this study was to investigate the direction of ground-water flow and the quantity of water moving between the Winchester and the Hemet subbasins. Water levels (figs. 10–12) were measured in the Winchester–Hemet border area in April–May 1991 (fig. 10) and July 1992 (fig. 11), and in a more widespread area of the Winchester subbasin in May 1993 (fig. 12). The results show that ground water is moving from the Winchester subbasin into the Hemet subbasin, but the flow-direction components are complex. This movement takes place east of a ground-water divide (best seen in figure 12) that is east of the town of Winchester. Along the border, some water moves from the southwest corner of the Hemet subbasin into the Winchester subbasin, and then eastward subparallel to the border before moving back into the Hemet subbasin (figs. 10–11). On the west side

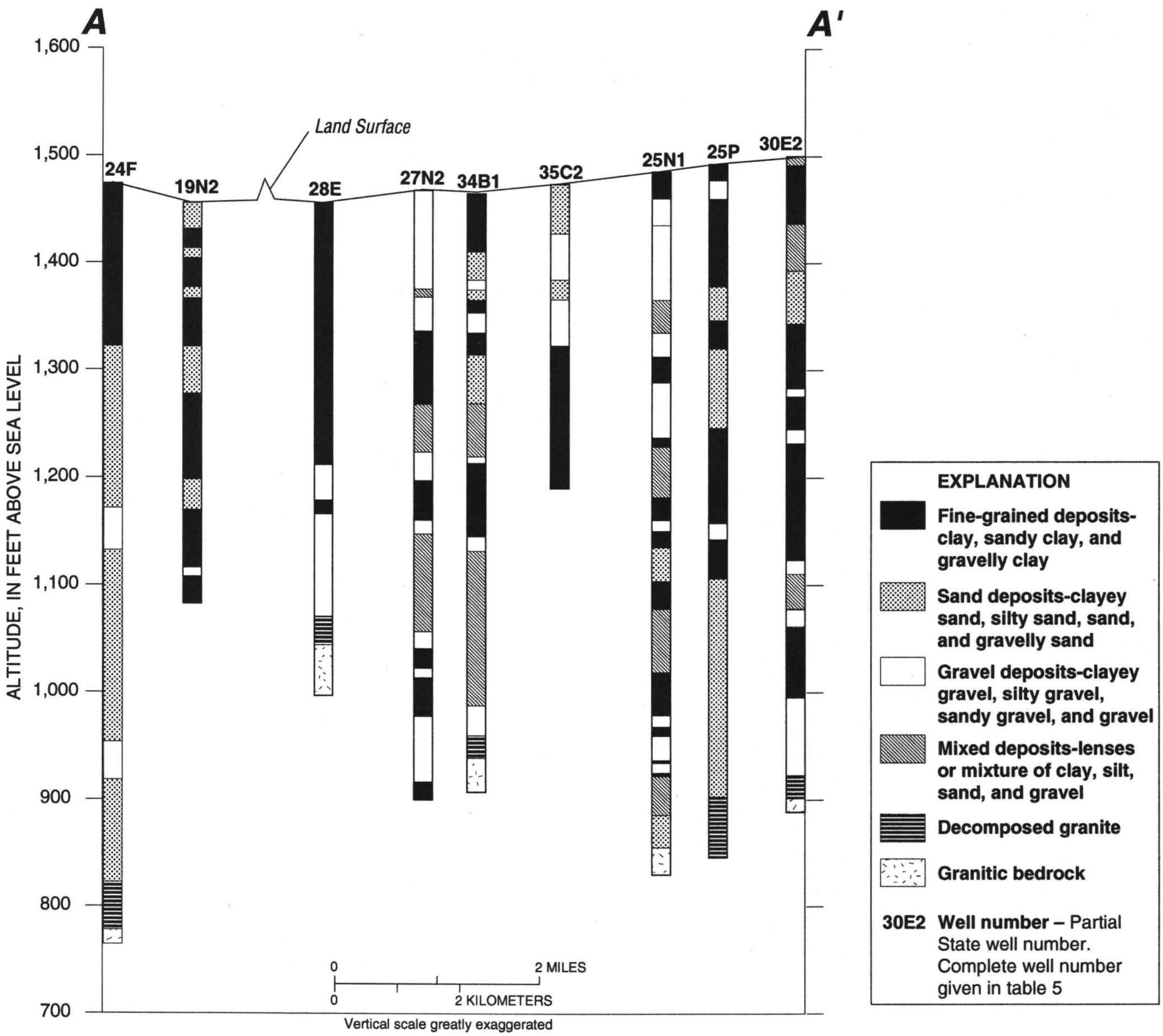


Figure 9. Generalized subsurface lithology along section *A–A'* through the Winchester subbasin, California. Line of section is shown in figure 2.

of the divide, ground water moves toward the western end of the subbasin (fig. 12) and through subsurface gaps in the basin-bounding bedrock toward the South Perris and the Menifee subbasins. The subsurface gap (not indicated by the generalized zero-thickness contour line in figure 7) connecting with the Menifee subbasin probably is shallow; some of the flow toward the Menifee subbasin may occur as fracture flow in the bedrock, in addition to flow in the alluvium.

Ground water moves from areas of recharge (higher potential) to areas of discharge (lower potential). Probable sources of alluvial-aquifer recharge, in part inferred from examination of the potentiometric-surface maps discussed previously (figs. 10–12), are infiltration of runoff from occasional flows in Salt Creek; infiltration of water from the upland bedrock areas that constitute the borders of the subbasin; limited areal infiltration of rainfall, during wet years, and applied irrigation; and percolation of water during the winter months from two reclaimed-water storage/infiltration ponds in the western part of the subbasin. In addition, an unknown quantity of subsurface recharge, laterally and from below, is contributed from the fractured crystalline rocks that bound the alluvial aquifers. The position of the ground-water divide east of Winchester suggests that a significant part of the recharge is contributed from the segment of Salt Creek in the vicinity of the divide and possibly from the Lakeview Mountains.

The direction of ground-water movement between the Winchester and the Hemet subbasins, and the position of the ground-water divide in the central part of the Winchester subbasin, have changed with time. The location and amount of pumpage from the aquifer apparently has been an important factor in these changes. Contoured historical water-level altitudes indicate that the ground-water divide has varied from a position at the town of Winchester, or within 1 mi to the east in 1935, and 1993 (figs. 12 and 13*A*,), to a position 1 to 2 mi west of the town of Winchester in 1952, 1970 and 1974 (fig. 13*B, C, D*). Prior to about 1974, however, instead of eastward flow from the divide into Hemet subbasin as indicated by the 1991–93 water-level data, ground water moved both eastward from the divide and westward from the Hemet subbasin toward a local depression of the water table caused by pumping in the eastern part of the Winchester subbasin (centered primarily in sections 25 and 26). The data for 1935–74 (fig. 13) indicate that the depression was greatest (more than 80 ft deep) in 1970 (fig. 13*C*). By 1974 (fig. 13*D*) the ground-water-level depression in the eastern Winchester subbasin had lessened, reversing the direction of ground-water flow between the Hemet and the Winchester subbasins. A major factor in the reversal most likely was a decrease in pumpage in the eastern part of the Winchester subbasin.

For the period 1991–93, comparison of the potentiometric-surface maps (figs. 10–12) and examination of hydrographs (fig. 14) show a general rise in water levels in the Winchester subbasin of 7 to 20 ft at the east end and about 5 ft in the western part. Most of the water-level rise took place during 1992–93, a period of above-average rainfall following several years of drought. For the period 1993–94, water levels declined about 5 ft at the east end of the subbasin, and the changes in the western to central part of the subbasin ranged from a rise of 2 ft to a decline of about 30 ft (fig. 14). Water-level altitudes may be influenced in part by pumping from nearby wells and, in a localized area in the western part of the subbasin, by the cyclic filling and draining of the reclaimed-water storage ponds (shown in figure 15) located near the intersection of Simpson Avenue and Leon Road. Measured depth to water in 1994–95 (fig. 15) ranged from 6 to 72 ft, and generally was less than 11 ft for most of the central part of the subbasin.

Long-term changes in water levels also are revealed by the data. Comparison of water levels for spring 1970 (fig. 13*C*), the date of the lowest known water levels in the eastern part of the subbasin, with the water levels for spring 1993 (fig. 12), the highest water levels for the data available during the study, indicates a net rise in water level of as much as 150 ft for the east end of the subbasin for the period 1970–93. For this same period, water levels rose about 3 to 20 ft in the western and central parts of the Winchester subbasin. The rise in water level probably is the result of a combination of decreased pumpage and increased recharge.

The four multiple-well monitoring sites in the subbasin allow the collection of hydraulic-head data at different depths and thus enable investigation of vertical gradients within the ground-water system. The data for three of these sites, presented in table 2, show a downward gradient at two sites in the eastern and central parts of the subbasin. The differences observed, 4 ft over a depth range of about 550 ft at site

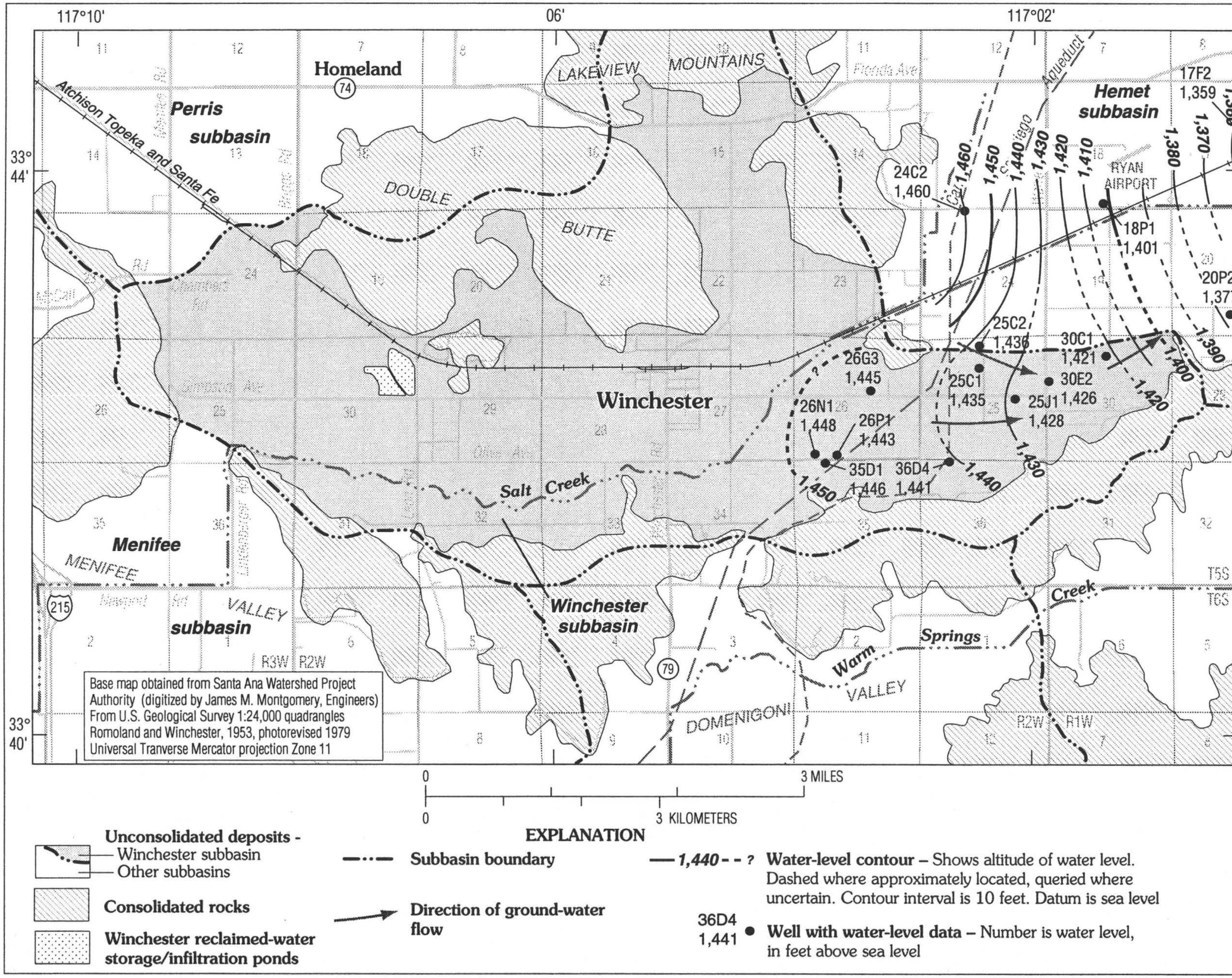


Figure 10. Water-level altitudes in the Winchester–Hemet subbasins border area, California, April–May 1991.

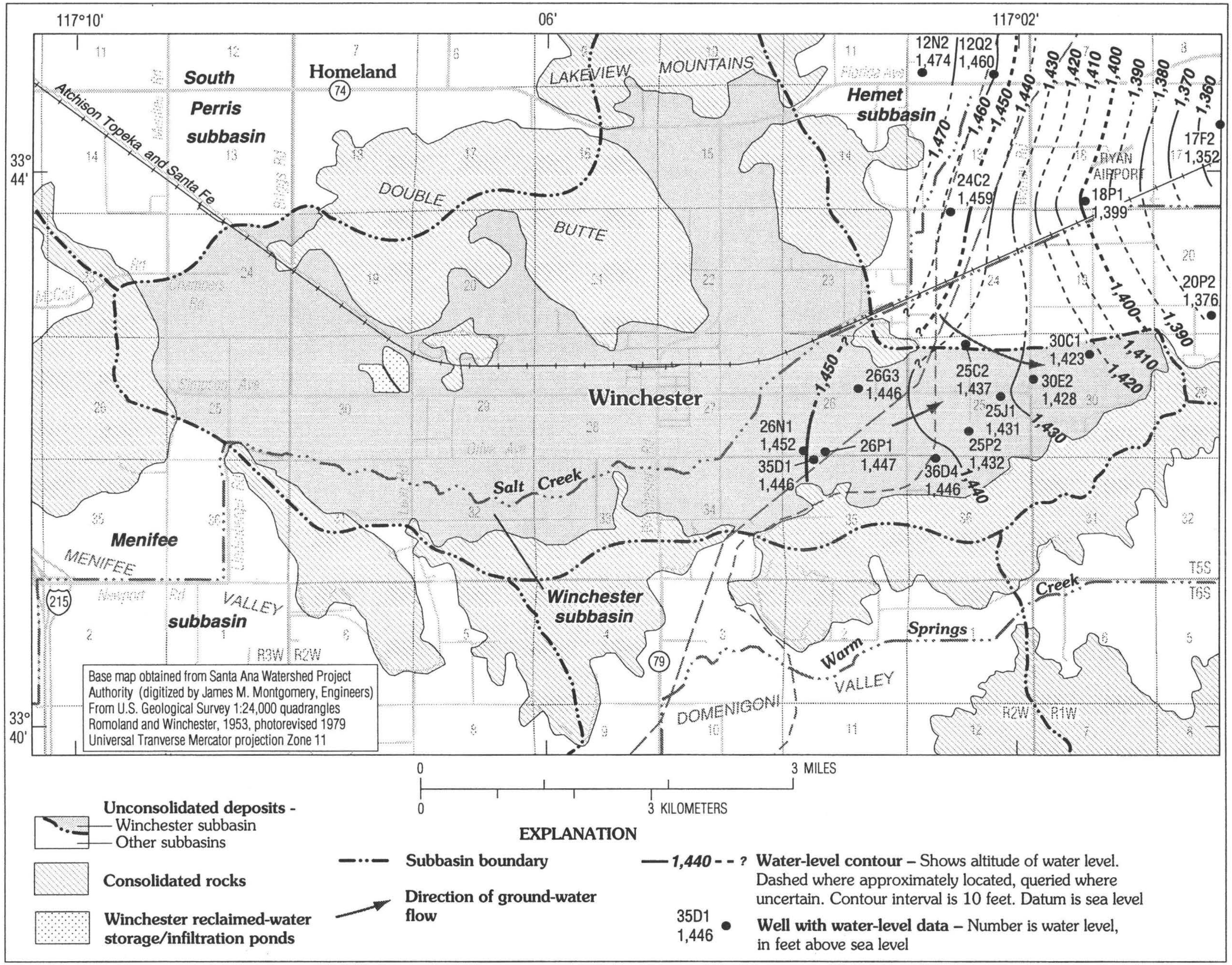


Figure 11. Water-level altitudes in the Winchester–Hemet subbasins border area, California, July 1992.

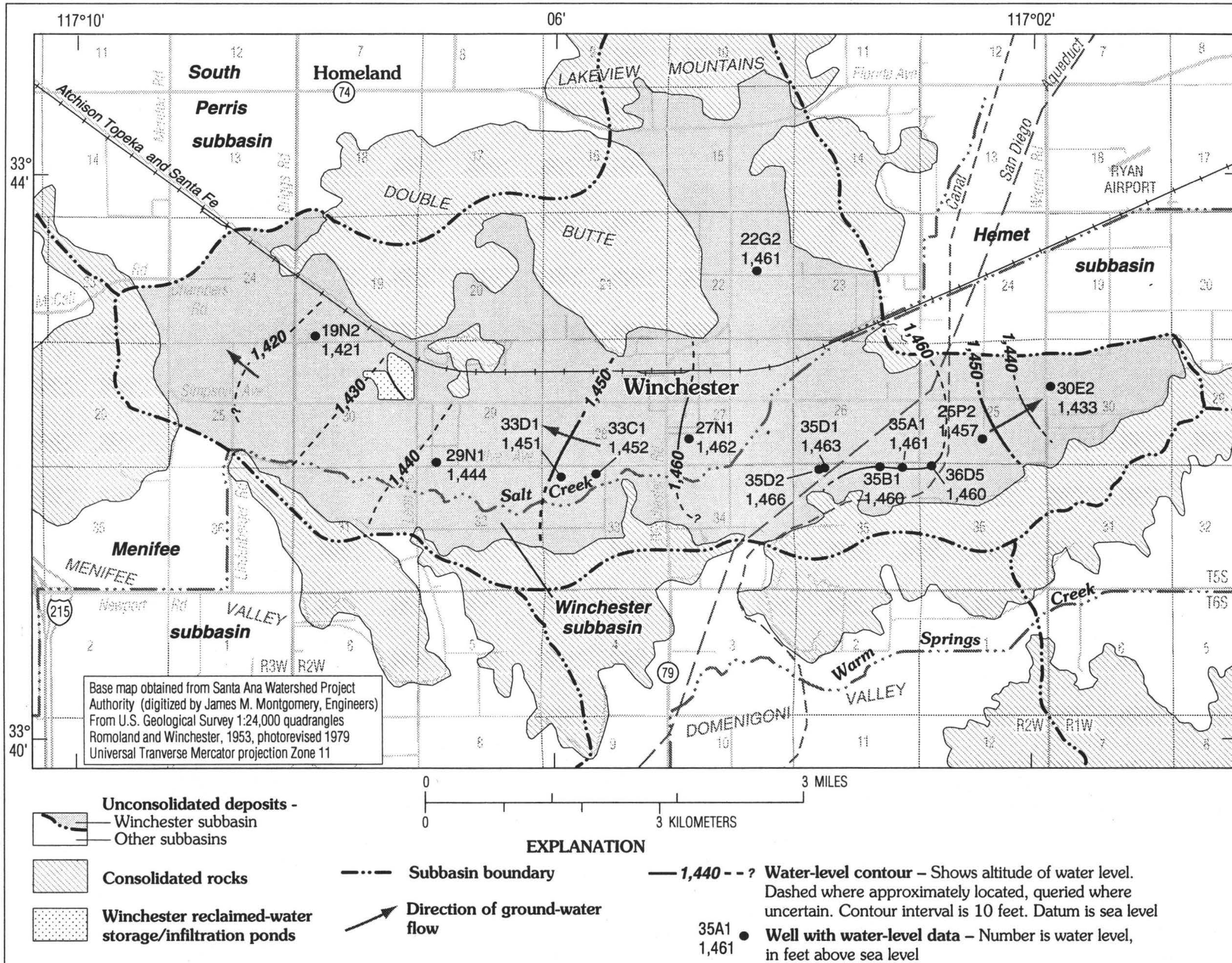


Figure 12. Water-level altitudes in the Winchester subbasin, California, May 1993.

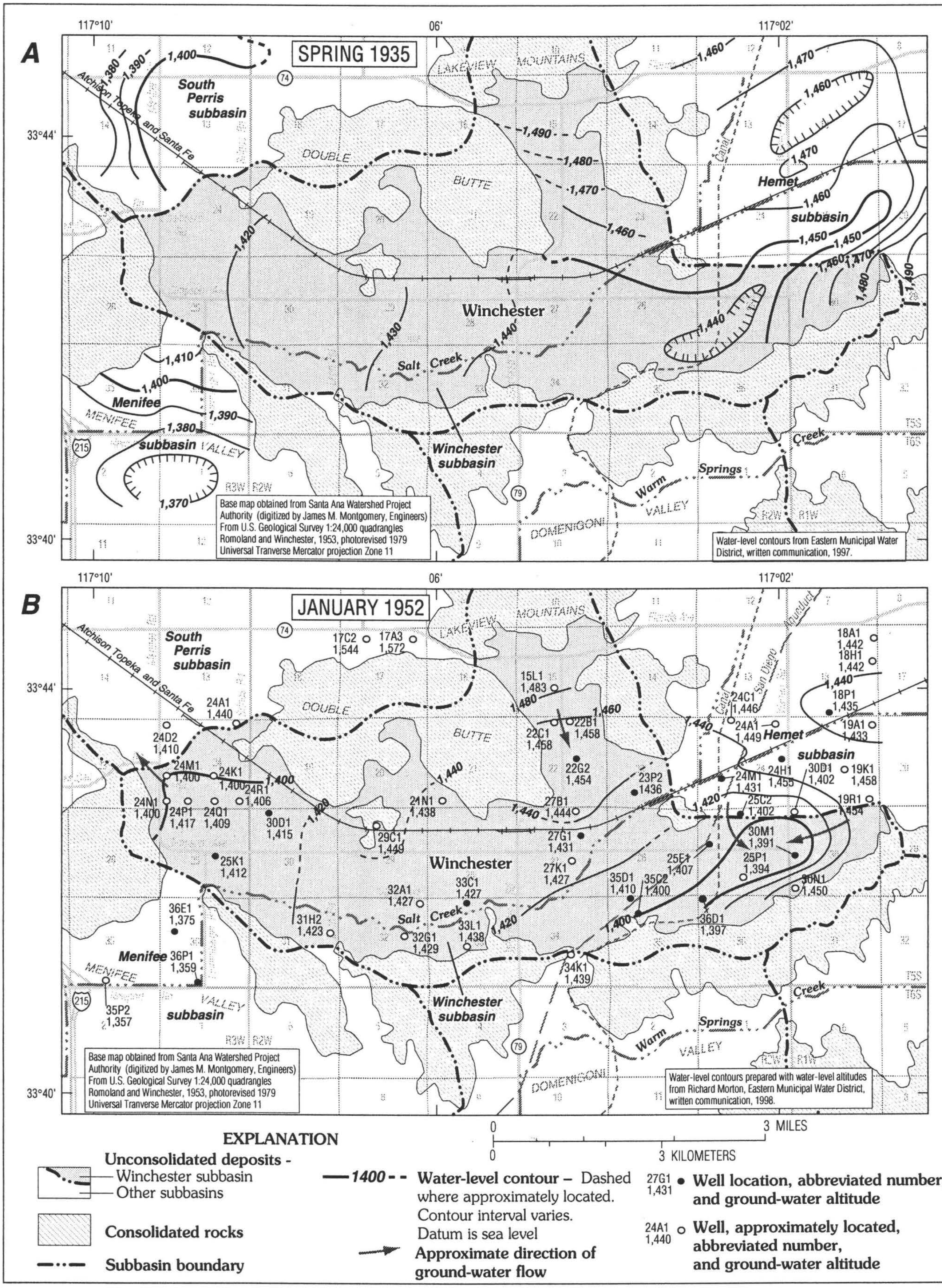


Figure 13. Historical water-level altitudes in the Winchester subbasin, California, 1935–74. *A,* spring 1935. *B,* January 1952. *C,* spring 1970. *D,* spring 1974.

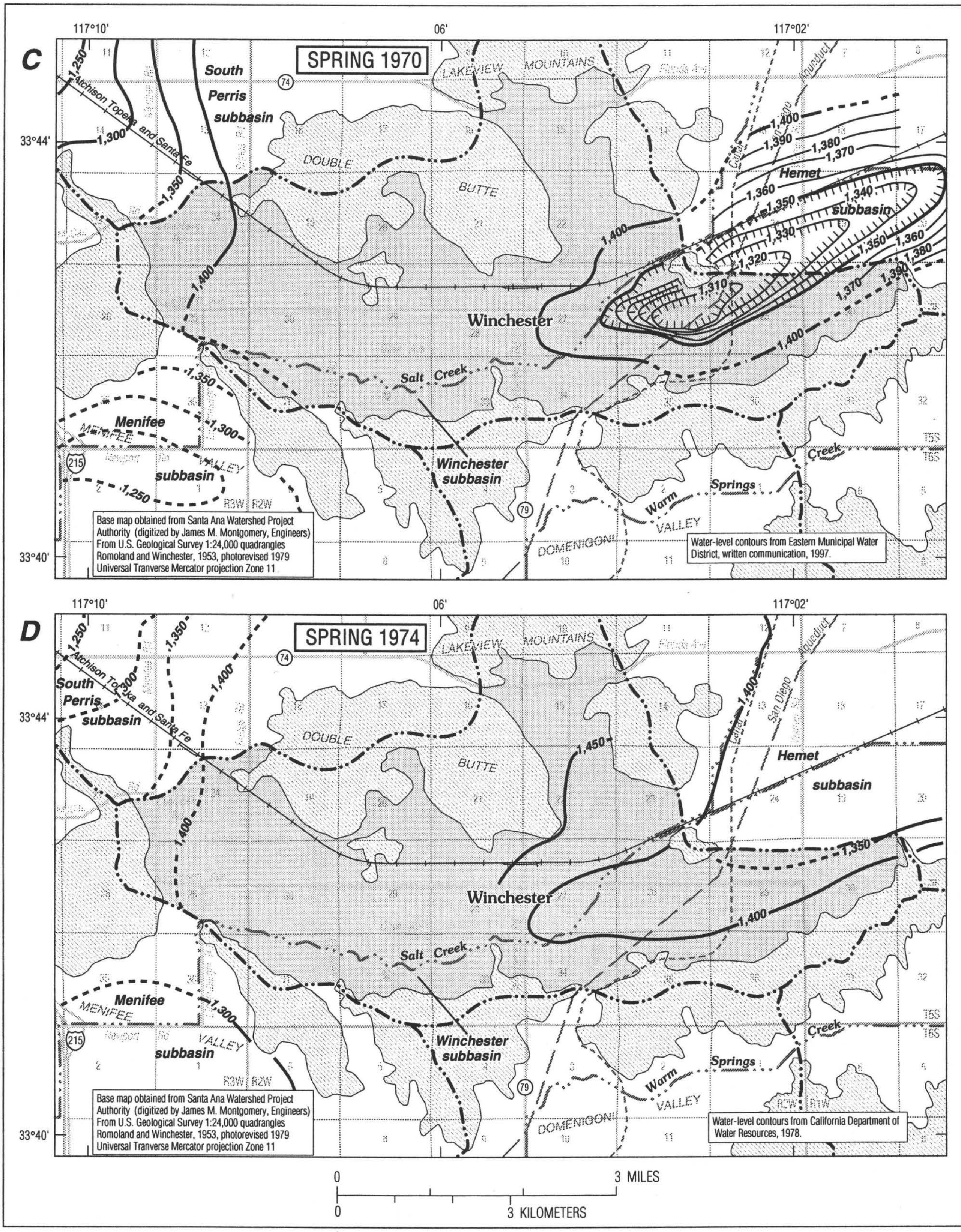


Figure 13.—Continued. (See figure 13*A*, *B* for explanation of symbols.)

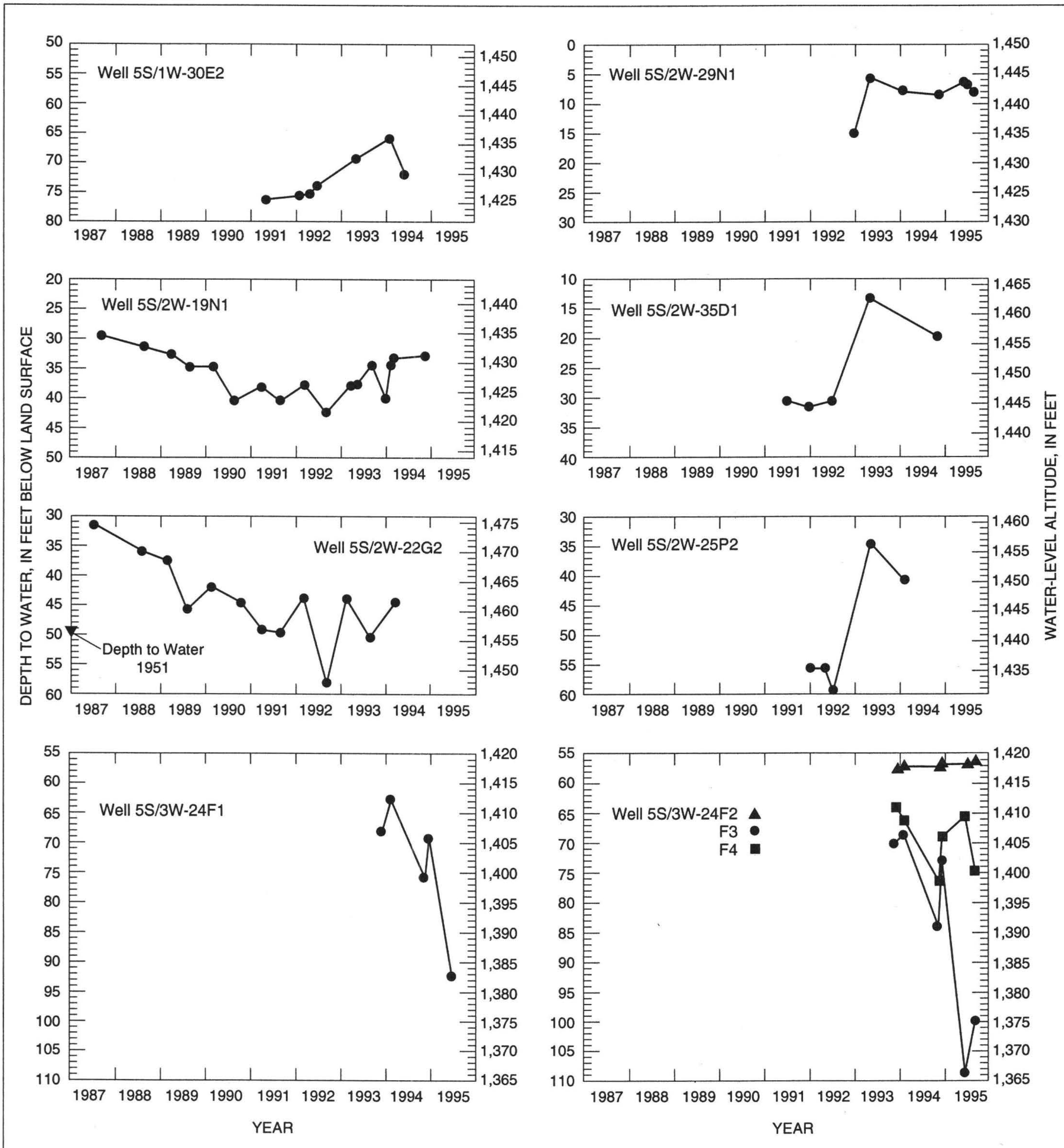


Figure 14. Hydrographs for selected wells in the Winchester subbasin, California.

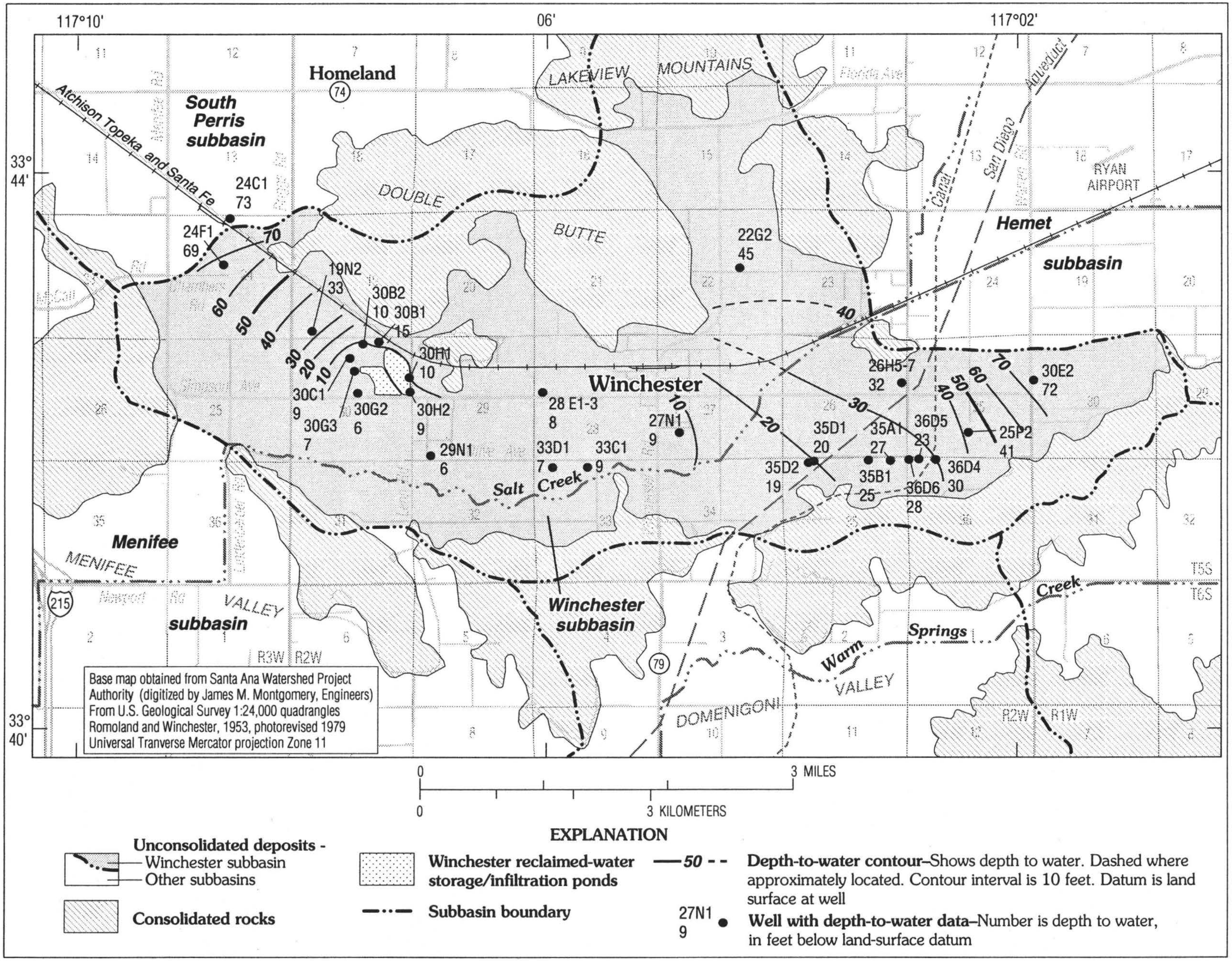


Figure 15. Depth to water for selected wells in the Winchester subbasin, California, 1994–95.

Table 2. Depth to water for different perforated intervals at selected sites in the Winchestger subbasin, California

[Perforated interval and depth to water in feet below land surface]

Well number	Perforated interval	Depth to water	Date
5S/2W-25P7	72–82	35.97	3/9/95
5S/2W-25P6	148–158	36.41	3/9/95
5S/2W-25P5	231–236	39.37	3/9/95
5S/2W-25P4	450–460	40.60	3/9/95
5S/2W-25P3	630–640	40.45	3/9/95
5S/2W-28E3	228–233	7.83	11/17/94
5S/2W-28E2	306–311	8.45	11/17/94
5S/2W-28E1	395–400	9.45	11/17/94
5S/3W-24F4	150–155	57.06	12/15/94
5S/3W-24F3	399–404	72.76	12/15/94
5S/3W-24F2	686–691	69.25	12/15/94

5S/2W-25P and 1.6 ft over a depth range of 170 ft at site 5S/2W-28E, are consistent with these sites being in areas of recharge. Water-level-altitude data at the third multiple-well monitoring site, 5S/3W-24F, can be interpreted several ways. There are both upward and downward gradients, suggesting that there may be an isolated intermediate-depth zone that is affected by pumping from another well in the vicinity. As a second possibility, perhaps in combination with pumping effects, the difference in water level of about 16 ft (between the shallow- and intermediate-depth wells, fig. 3) within the same alluvial aquifer over a depth range of about 250 ft also might indicate the presence of a significant confining zone. In addition, hydrographs from the two wells (fig. 14, wells 5S/3W -24F4 and F3) indicate a lack of hydraulic connection between the shallow and intermediate zones. During 1994–95, water levels in the shallow well (24F4) rose about 2 ft, while water levels in the intermediate-depth well (24F3) declined by about 35 ft. Although the borehole logs for this multiple-well monitoring site (fig. 3) do not indicate a thick, well-defined confining layer, a significant amount of fine-grained material is present in dispersed form or in thin layers in the vertical interval between the two well screens. The results of the aquifer test at this site, discussed in the "Hydrologic Properties" section, also support the concept of confined or semi-confined conditions. A less-likely explanation is that the upper piezometer was not adequately developed at installation, and that the perforations may be clogged. The increase in water-level altitude between the intermediate-depth and deep wells, about 4 ft over a depth range of about 300 ft, indicates an upward gradient—as would be expected at the discharge end of the ground-water subbasin.

Ground-Water Quality

The Winchester subbasin water-quality network (fig. 2) reported here consisted of the four USGS-installed multiple-well monitoring sites (5S/3W-24F, 5S/2W-28E, 5S/2W-25P, and 5S/2W-26H); 24 wells in alluvium in the Winchester subbasin; 4 wells in the alluvium in the South Perris subbasin; 6 wells in the alluvium in the Menifee subbasin; and 4 wells in the alluvium in the Hemet subbasin. Water-quality data collected as part of this investigation and historical data obtained from EMWD files are given in table 3 (at back of report). Water-quality samples were collected using techniques adapted from those described by Brown and others (1970). Specific conductance and pH were measured in the field using probes calibrated with appropriate standards. Alkalinity also was determined in the field by titration with dilute sulfuric acid. All other analyses were done by the USGS National Water Quality Laboratory and the USGS San Diego Projects Office laboratory using techniques described by Fishman and Friedman (1989).

Areal and Vertical Variability in Water Quality

Ground-water chemistry in the Winchester subbasin and adjacent subbasins varies areally and vertically. In general, sodium, calcium, chloride, and sulfate are dominant ions in the Winchester subbasin. Water quality is generally poor: dissolved-solids concentration exceeds 2,000 mg/L throughout much of the subbasin. Near the ground-water divide in the vicinity of the town of Winchester, water quality (well 5S/2W-27N1) is poor; dissolved-solids concentration is greater than 4,000 mg/L (fig.16) and pH is about 6.0 (table 3). On the basis of milliequivalent concentrations, the water type of this sample is classified as a sodium-calcium and chloride-sulfate water type (figs. 17–18). That is, sodium and calcium are the predominant cations [order of listing indicates that sodium is more predominant] and chloride and sulfate are the predominant anions. Eastward along the

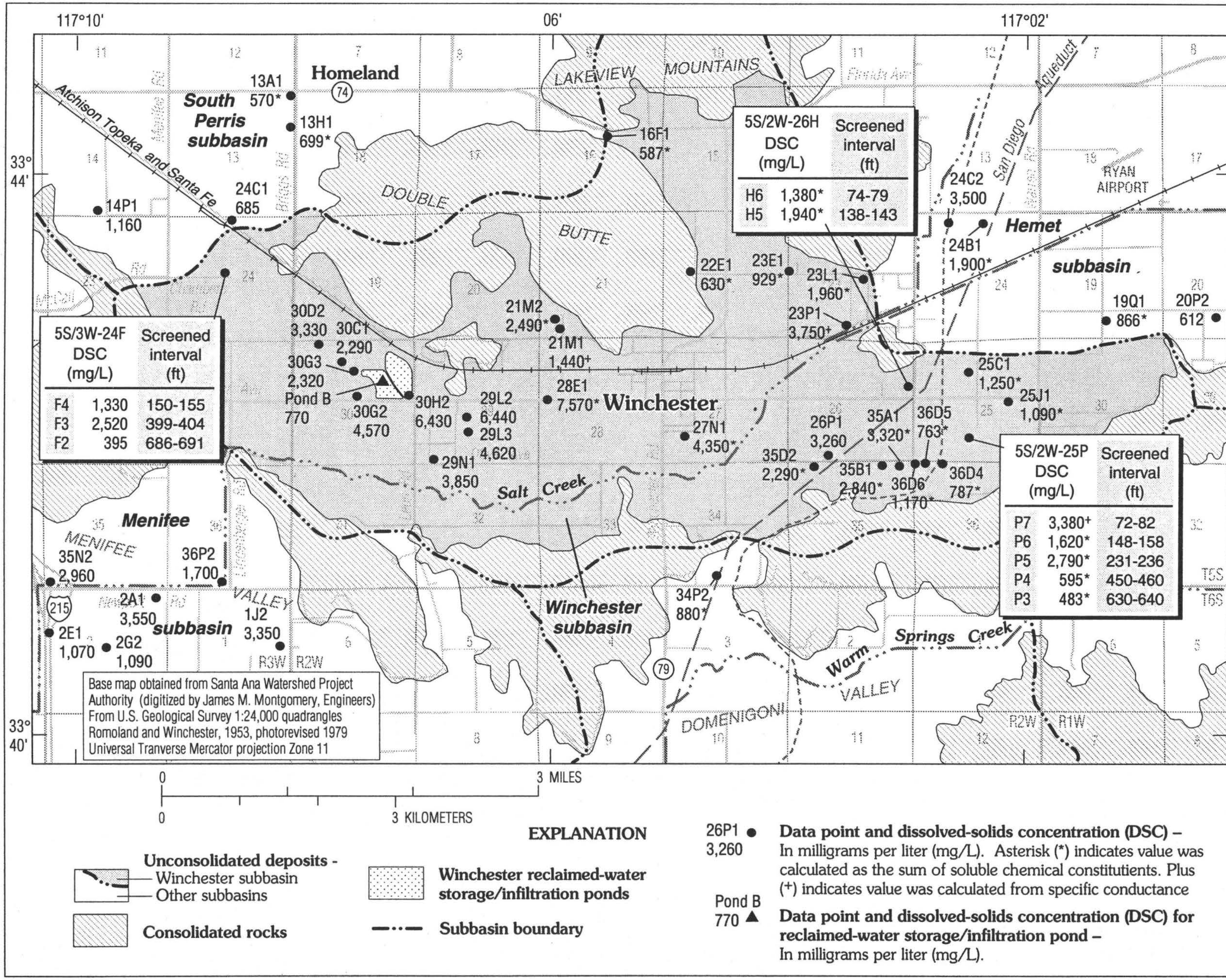


Figure 16. Distribution of dissolved-solids concentration in the Winchester subbasin and surrounding area, California, 1992–95.

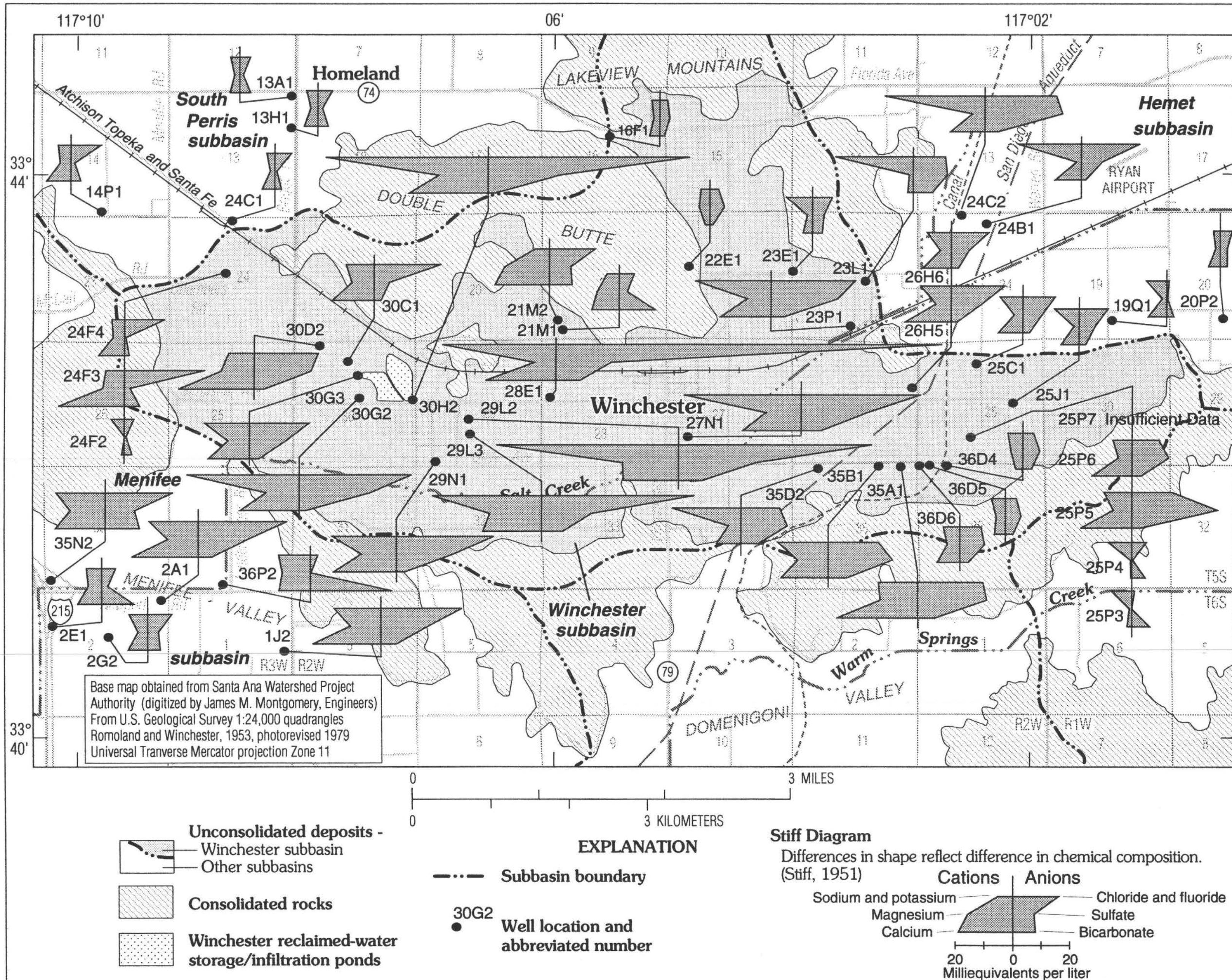


Figure 17. Stiff diagrams for selected wells in the Winchester subbasin and surrounding area, California, 1992–95.

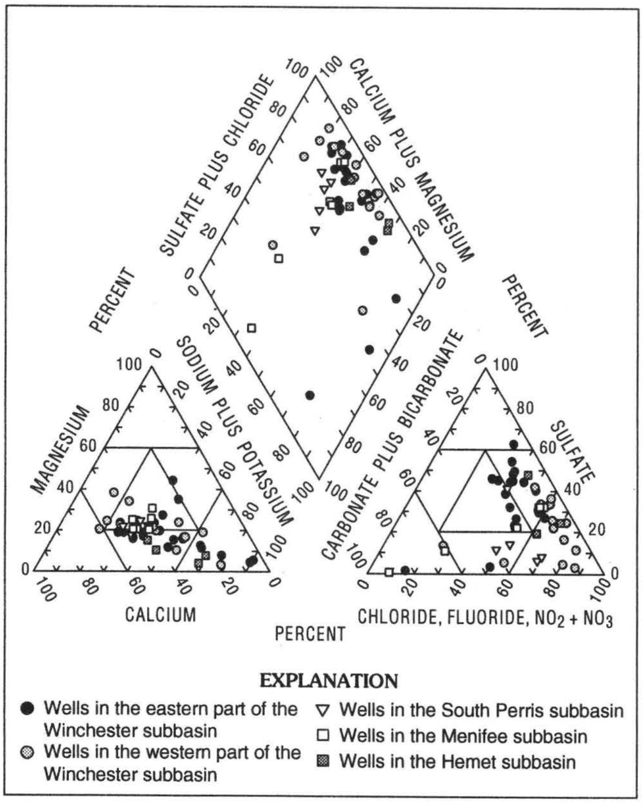


Figure 18. Trilinear diagram for selected wells in the Winchester subbasin and surrounding area, California, 1992–95.

subbasin axis (toward the Hemet subbasin), the dissolved-solids concentration decreases and the pH increases (generally greater than 7.0) (fig.16, table 3).

East of the ground-water divide, the water type varies from north to south. Water samples collected from the alluvium between Double Butte and the bedrock outcrops extending southward from the Lakeview Mountains are dominated by sodium and chloride-sulfate ions (wells 5S/2W-23E1, -23L1). To the south, sodium-calcium and chloride-sulfate ions dominate (wells 5S/2W-23P1, -26H5, -26H6, -25C1, and -25J1) (fig. 17). In the southeastern part of the Winchester subbasin (5S/2W-35 and -36), the water type is calcium-sodium and sulfate-chloride. Dissolved-solids concentration in the subbasin, from north to south to east, increases from 587 mg/L just south of the Lakeview Mountains (5S/2W-16F1) to greater than 3,300 mg/L (5S/2W-35A1), then generally decreases to 760 to 1,250 mg/L near the Winchester–Hemet subbasin boundary (5S/2W-36D5 and -25C1) (fig.16). However, higher dissolved-solids concentrations were observed at the shallow wells at multiple-well monitoring site 5S/2W-25P. The high concentrations of calcium, sulfate, and dissolved solids most likely result from the interaction of water with the aquifer matrix, evaporative processes, and agricultural practices.

Vertical differences in water quality were observed at multiple-well monitoring site 5S/2W-25P. The dissolved-solids concentration was relatively low (483 and 595 mg/L) in samples from the deeper wells (5S/2W-25P3 and -25P4) and high (1,620–3,380 mg/L) in samples from the shallower wells (5S/2W-25P5, -25P6, and -25P7) (fig.16). The water type changes from sodium and bicarbonate in the deeper wells to calcium-sodium and sulfate-chloride in the shallower wells (figs. 17–18). These results indicate that evaporative processes and agricultural practices may be a source of dissolved solids, calcium, and sulfate. The deeper wells (-25P3 and -25P4) are similar in water type to well 5S/1W-19Q1 in the Hemet subbasin. This similarity suggests that the water may have originated in the Hemet subbasin and flowed into the Winchester subbasin; alternatively, the chemistry may reflect of the influence of good-quality water flowing from the fractured bedrock basement to the alluvium in the eastern part of the Winchester subbasin. In addition, these data suggest that the potential problem of poor-quality water moving from the Winchester subbasin into the Hemet subbasin may not exist at all depths; fair- to good-quality water may be present below a depth of about 450 ft. Given the vertical differences in water quality, it should be noted that some of the areal differences in water quality among wells in the eastern part of the Winchester subbasin may in part be a reflection of dissimilar screened depths in the sampled wells.

Inspection of historical water-quality data at well 5S/2W-25C1 (table 3) shows that water quality has changed at this site between 1965 and the 1990's. The increases in dissolved-solids, calcium, and chloride concentrations with time probably are indicative of evaporative processes, the effects of agricultural practices, and (or) changes in ground-water flow direction.

Because the direction of ground-water flow (figs. 10–12) indicates that the potential exists for poor-quality ground water (dissolved-solids concentration greater than 1,000 mg/L) to flow from the Winchester subbasin into the Hemet subbasin, water samples also were collected from the alluvium in the part of the Hemet subbasin adjacent to the Winchester subbasin.

Dissolved-solids concentrations in the southwest part of the Hemet subbasin ranged from about 900 mg/L at well 5S/1W-19Q1 about one-quarter mile north of the Winchester–Hemet subbasin boundary to about 3,500 mg/L at 5S/2W-24C2 near the bedrock outcrops southeast of the Lakeview Mountains (fig. 16). Water from well 5S/2W-24B1 had an intermediate dissolved-solids concentration of about 1,900 mg/L. The water type changes from sodium and sulfate-chloride near the bedrock outcrops (well 5S/2W-24C2) to a sodium-calcium and bicarbonate water type at well 5S/1W-19Q1. The pH of the water from all three wells was similar (range 7.6 to 7.9, table 3). A trilinear diagram (Piper, 1944) of the water-quality data (fig. 18) suggests that the ground water in the Winchester subbasin is geochemically different from the water in the Hemet subbasin.

Although poor-quality ground water may flow from the Winchester subbasin into the Hemet subbasin, there is evidence that a source of poor-quality ground water also exists in the Hemet subbasin. High dissolved-solids concentration in the vicinity of well 5S/2W-24C2 is most likely a result of dissolution of constituents from the aquifer matrix, evaporative processes, and agricultural practices that occur in that vicinity rather than a result of flow from the Winchester subbasin.

The high dissolved-solids concentration (greater than 7,500 mg/L) in the ground water in the alluvium west of the ground-water divide in the vicinity of the town of Winchester (well 5S/2W-28E1) (fig. 16) may be a result of dissolution of ions from the aquifer matrix. The lower dissolved-solids concentration, 3,850 mg/L, near Salt Creek (well 5S/2W-29N1) suggests that in this area the periodic flows in Salt Creek may be a source of recharge. The lower dissolved-solids concentration observed in samples from wells west of the Winchester Ponds (5S/2W-30C1, -30G3) may be a result of mixing of ground water with the low-dissolved-solids water infiltrating from the ponds (fig. 16).

High dissolved-solids concentration in the west-central part of the Winchester subbasin may be a result of a large deposit of salts located within the alluvium. Although no direct evidence of such a deposit exists, the chloride and bromide concentrations suggest that a salt deposit in the vicinity of well 5S/2W-28E1 is a likely possibility. Chloride and bromide are relatively nonreactive and soluble in most ground-water environments. Evaporative processes that result in increased chloride concentration also will result in increased bromide concentration. Conversely, processes that decrease chloride concentrations also decrease bromide concentrations—thus producing a regression line having a slope of zero. Chloride and bromide concentrations are highest at well 5S/2W-28E1, 4,800 and 9.4 mg/L, respectively (table 3). A plot of chloride-to-bromide ratios as a function of chloride shows that the ratios are similar (zero slope on regression line) (fig. 19). Chloride and bromide concentrations decrease in the direction of ground-water flow (figs. 10–12, 17, and table 3), indicating that ground-water recharge in the western part of the Winchester subbasin is low in chloride and bromide and therefore has the effect of diluting chloride and bromide in the ground water. The source of this recharge may be periodic flows in Salt Creek or runoff from Double Butte; farther west the Winchester Pond is a source of recharge. The chloride-to-bromide ratio from one well in the western part of the Winchester subbasin does not plot close to the regression line (fig. 19): Well 5S/2W-24F2 is a deep well in which the water quality is significantly different from that in the rest of the Winchester subbasin, indicating that the ground water may come from a different source.

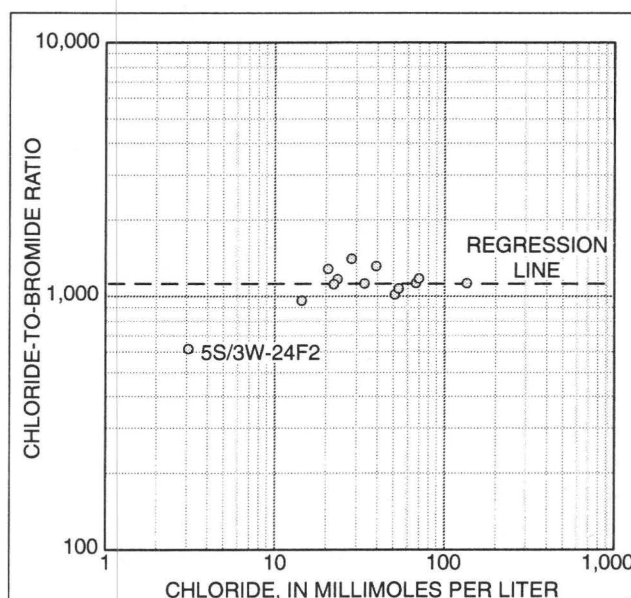


Figure 19. Chloride to bromide ratio as a function of chloride in water from wells in the western part of the Winchester subbasin, California, 1992–95.

Dissolved-solids concentration ranges from 1,440 to 2,490 mg/L in water samples collected from near the Double Butte landfill (wells 5S/2W-21M1, -21M2) (fig. 16). The dissolved-solids concentration is much higher than that in samples from wells on the east side of Double Butte (5S/2W-16F1, -22E1, -23E1). This difference may be a result of leaching from the landfill and differences in aquifer matrices.

Water samples collected in the western part of the Winchester subbasin are dominated by two water types that appear to be a result of vertical variability rather than areal variability. Water from shallower wells (well depth 200 ft or less: 5S/2W-29L2, -29L3, -29N1, -30H2, and -30G2, -30G3) is classified as a sodium-calcium and chloride-sulfate water type. Water from deeper wells (well depth greater than 300 ft: 5S/2W-30C1, -30D2, 5S/2W-24F3) is classified as a calcium-sodium and chloride-sulfate water type (fig. 17). Vertical variability is also observed at multiple-well monitoring site 5S/2W-24F. Although 5S/2W -24F3 and -24F4 have similar water types (calcium-sodium and chloride), the concentration of many constituents is higher in -24F3 (the intermediate depth well) than in -24F4 (the shallower well). Well 5S/2W -24F2 has good-quality (dissolved-solids concentration about 400 mg/L) sodium and chloride-bicarbonate water (figs. 16–17). This (-24F2) water sample was collected from near the alluvium-bedrock contact and may reflect the influence of the contribution of good-quality water from the fractured bedrock to the alluvium.

Inspection of historical water-quality data for well 5S/2W-19N1 (table 3) shows that water quality changed from the early 1950's to the late 1970's. Dissolved-solids, sodium, and sulfate concentrations show significant increasing trends during this time period. These results are indicative of evaporative processes and the effects of agricultural practices.

Because ground water flows from the Winchester subbasin into the South Perris subbasin (Burton and others, 1996, fig. 17), water samples also were collected from nearby wells in the South Perris subbasin. Water samples collected from alluvium in the southeastern part of the South Perris subbasin (wells 5S/3W-13A1, - 13H1, -14P1 and -24C1) are of relatively good quality: dissolved-solids concentrations ranged from about 600 mg/L near Briggs Road and the Winchester–South Perris subbasin boundary to about 1,200 mg/L farther to the west in the South Perris subbasin (fig. 16), and pH ranged from 6.1 to 7.5 (table 3). The water in this part of the South Perris subbasin is classified as calcium-sodium and chloride-bicarbonate (fig. 17). A trilinear diagram of water from the South Perris subbasin (fig. 18) shows that chemistry of the South Perris subbasin ground water is different from that of ground water from the western part of the Winchester subbasin. Because of a lack of multiple-well sites completed at different depths in the alluvium of the South Perris subbasin, it is not possible to assess the vertical distribution of water quality.

Ground water also flows from the Winchester subbasin into the Menifee subbasin (Burton and others, 1996). Water samples collected from alluvium in the Menifee subbasin have higher dissolved-solids concentrations (ranging from 1,070 to 3,550 mg/L) (fig. 16) than does water in the South Perris subbasin. The major cations, in order of milliequivalent abundance, are calcium and sodium (fig. 17), and pH ranges from 5.9 to 6.9 (table 3). In water samples from wells 5S/3W-35N2, 6S/3W-1J2, -2A1, and -2G2, the dominant anion is chloride, and the water type is similar to that of many water samples collected from the western part of the Winchester subbasin (fig. 18). Bicarbonate is the dominant anion in water samples from 5S/3W-36P2 and 6S/3W-2E1. This difference in water quality appears to be a result of vertical variability. Inspection of water-quality data from samples collected at different depths by EMWD (wells 5S/3W-35N2, -36P2, 6S/3W-2A1, -2E1, -2G2) indicates that bicarbonate concentrations in samples from depths greater than 560 ft are higher than concentrations in samples from shallower depths (Burton and others, 1996, table 2).

These data indicate that water samples from the eastern part of the Winchester subbasin are geochemically distinct from samples from the western part of the subbasin. Although chloride is abundant in samples from throughout the Winchester subbasin, samples from the eastern part have a higher percentage of sulfate and samples from the western part have a higher percentage of bicarbonate (fig.18). Water near the bedrock outcrops appears to contribute significant quantities of sodium and sulfate. Samples from the

Hemet and the South Perris subbasins also are geochemically distinct from samples from the Winchester subbasin, whereas the Menifee subbasin samples show some geochemical similarities to those from the Winchester subbasin.

Historical data for wells 5S/2W-19N1 and -25C1 (table 3) indicate an increasing trend in nitrate concentration. Nitrate concentration exceeded the U.S. Environmental Protection Agency Maximum Contaminant Level (MCL) (10 mg/L as nitrogen) (U.S. Environmental Protection Agency, 1994) for several areas within the Winchester subbasin (fig. 20, table 3). The MCL for nitrate was equaled or exceeded in water from shallow depths in sections 5S/2W-23, -26, -30, -35 and 5S/3W-24. Dairies, fish farms, other agricultural practices, and septic systems are possible sources of nitrate. Two of these sections are located in areas where reclaimed water is used for irrigation (fig. 20), which may be an additional source of nitrate. The wells with high nitrate concentrations in the eastern part of the Winchester subbasin may indicate a basinwide nitrate problem in shallow ground water possibly owing to agricultural practices and septic systems. The apparent variation in nitrate concentration within the Winchester subbasin may be in part an artifact of the sampling of wells that are perforated in different zones. Data for multiple-well monitoring sites 5S/2W-25P, -26H, and 5S/3W-24F indicate higher nitrate concentrations in the shallower zones than in deeper zones (fig. 20). Nitrate concentration in the wells near the Double Butte landfill was very high and may be a result of leaching from the landfill.

Boron concentrations are greater than 1 mg/L in the central part of the Winchester subbasin, and show an increasing trend eastward in the Winchester subbasin and into the Hemet subbasin (table 3). Boron does not have an MCL at this time but is listed for regulation by the U.S. Environmental Protection Agency (1994). Other trace metals, including arsenic, are all well below their MCL's.

Variability in Isotopic Composition

Oxygen-18 and deuterium are naturally occurring stable isotopes of oxygen and hydrogen, respectively. Delta oxygen-18 and delta deuterium abundances are expressed as ratios (per mil) relative to the standard known as Vienna Standard Mean Ocean Water (Gonfiantini, 1978). Because most of the world's precipitation originates as evaporation of seawater, the oxygen-18 and deuterium composition of precipitation throughout the world is linearly correlated and distributed along a line known as the meteoric water line (Craig, 1961). These isotopes provide a record of the source of the water and have been used as a tracer of the movement of water (Izbicki and Martin, 1997).

Stable isotopes of oxygen-18 and deuterium were determined from many of the water samples collected in the Winchester, South Perris, and Menifee subbasins. The distribution of these isotopes is shown in figure 21. Water from most wells plots to the right of the meteoric water line (fig. 22), indicating that most of the water has undergone evaporative processes (the water is "heavier"). Isotopes in water from wells in the eastern part of the Winchester subbasin near the Hemet subbasin boundary are generally lighter than those in samples from other areas. Williams and Rodoni (1997) showed that isotopes in water from the Hemet subbasin also are similarly light; this is an indication that water in samples from the eastern part of the Winchester subbasin may have originated in the Hemet subbasin. Other similarities in water chemistry discussed previously also support the possibility that the Hemet subbasin has been a historical source of inter-subbasin ground-water flow. Dating of the ground water would be needed to determine if the source of the ground water in the samples is ground water that flowed from the Hemet subbasin into the Winchester subbasin before the reversal of ground-water flow in the early 1970's (fig. 13).

Isotopes in samples from the western part of the Winchester subbasin also plotted to the right of the meteoric water line—an indication that ground water has undergone evaporative processes. However, the high chloride and sulfate values suggest that other processes, such as agricultural practices and geological processes, also have affected water quality. Isotopes in water from wells in the western part of the Winchester subbasin are generally heavier than water from wells in the eastern part of the subbasin (fig. 22), indicating that a source of recharge is runoff from the Lakeview Mountains.

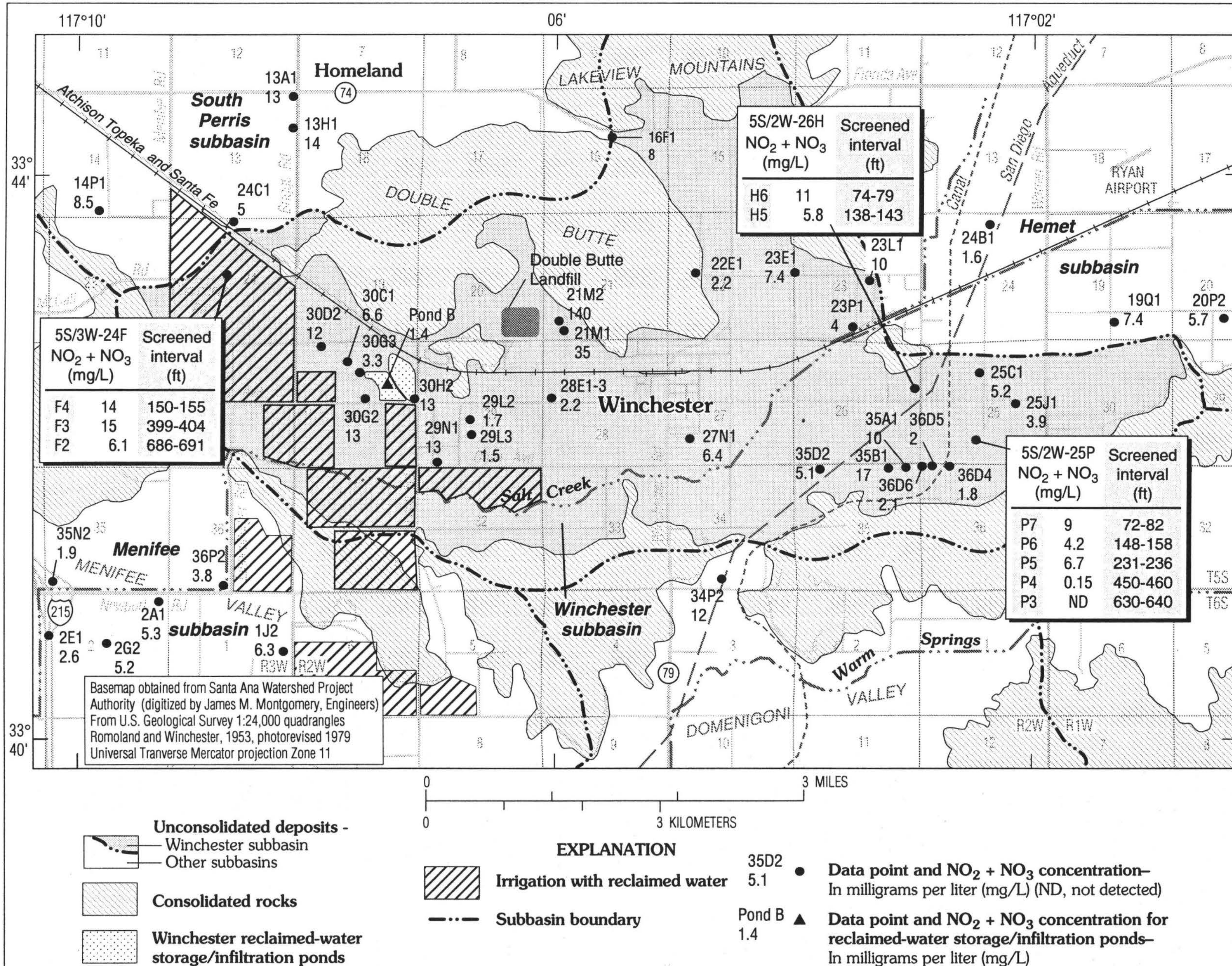


Figure 20. Nitrite (NO_2) plus nitrate (NO_3) concentration in the Winchester subbasin and surrounding area, California, 1993–95.

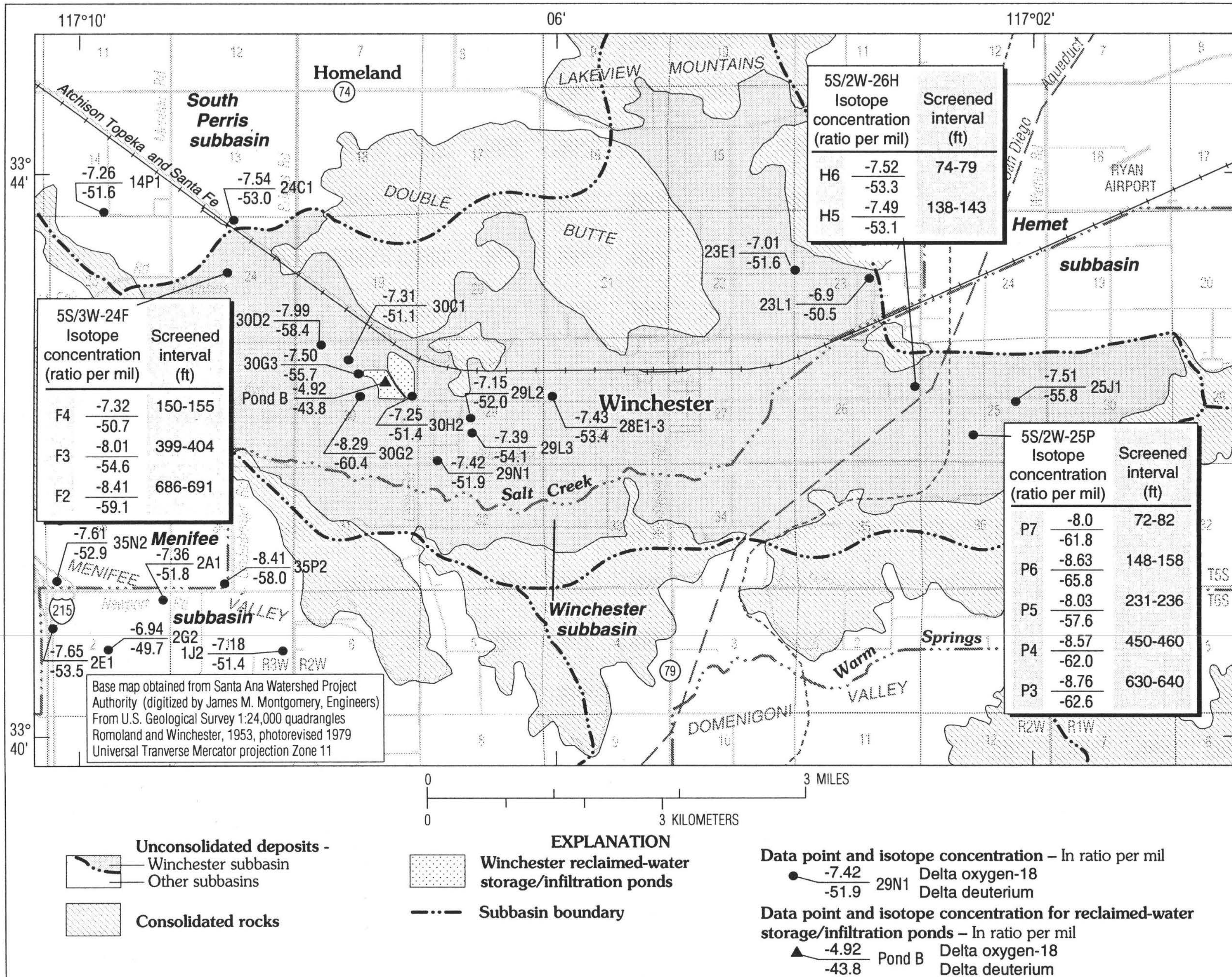


Figure 21. Delta oxygen-18 and delta deuterium isotope concentrations in the Winchester subbasin and surrounding area, California, 1993–95.

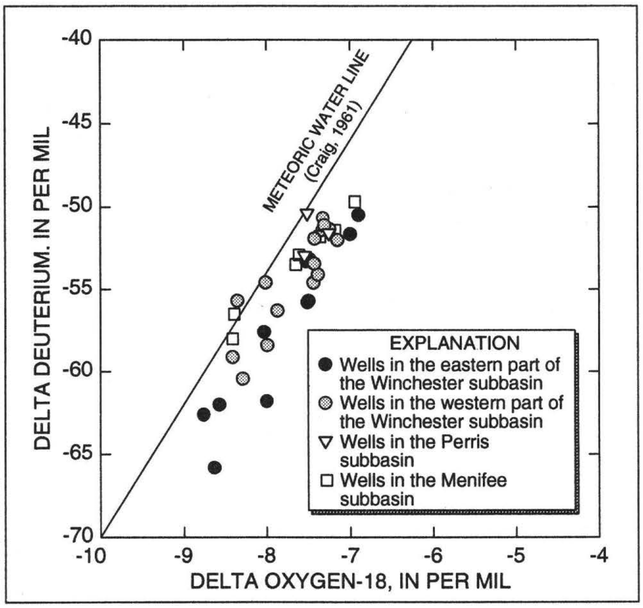


Figure 22. Delta deuterium as a function of delta oxygen-18 for selected wells in the Winchester subbasin and surrounding area, California, 1993–95.

HYDROLOGIC PROPERTIES

Prior to this study, few data existed regarding hydrologic properties of the alluvial aquifer system in the Winchester subbasin. As discussed previously, the aquifer is believed to consist of lenticular deposits of clay, silt, sand, and gravel. Specific-capacity data (included in table 1), which give a rough indication of aquifer transmissivities, are available from driller's logs for a few sites. Full characterization of the horizontal and vertical hydraulic properties of the subbasin aquifer would require a large number of aquifer tests of widespread areal and vertical distribution and was beyond the scope of this study. However, two aquifer tests were done: one at the eastern end of the subbasin near the border with the Hemet subbasin (utilizing well 5S/2W-25J1 and multiple-well cluster 5S/2W-25P3–7, hereafter referred to as site 5S/2W-25J), and one at the western end of the subbasin near the border with the South Perris subbasin (utilizing well 5S/3W-24F1 and multiple-well cluster 5S/3W-24F2–4, hereafter referred to as site 5S/3W-24F). The analysis of these two tests provides an estimate of hydraulic properties for the tested zones in the vicinity of the test sites.

Inspection of the potentiometric-surface data, lithologic logs, and geophysical logs at the two sites suggests that even though the aquifer deposits are lenticular and may not be laterally extensive, the main water-producing zones are probably confined or at least semiconfined. Data that support this conclusion include the rapid water-level-change response to pumping in the same zone, the distinct differences in water quality observed in the different producing zones, the differences in potentiometric heads between the producing zones, the presence of fine-grained deposits between the producing zones, and a small reverse response in an unpumped zone during the aquifer tests. These data are discussed later in this section of the report in which the individual test sites are described. The selection of pumping rates for the pumped well and of screen depths for the observation piezometers was made on the basis of this assumption of confined to semiconfined conditions.

The leaky-aquifer model of Moench (1985) was applied to the data from the two aquifer tests using the proprietary AQTESOLV software created by Glenn Duffield and James Rumbaugh and published by Geraghty and Miller, Inc. (Duffield and Rumbaugh, 1989). This model includes several assumptions: (1) semiconfining zones (aquitards) are present above and below the main pumping zone; (2) the main pumping zone and the semiconfined zones are homogeneous, isotropic, of constant thickness, and have infinite radial extent; (3) prior to the onset of pumping, the potentiometric surfaces in the pumping and semiconfining zones are horizontal; (4) flow in the semiconfining zones is vertical, and flow in the pumping zone is horizontal [$K_{\text{pumping zone}} > (100)(K_{\text{confining zone}})$]; (5) the pumping well fully penetrates the pumping zone; (6) pumping discharge is constant; (7) well-bore storage is finite; (8) surrounding the borehole is a zone in which the hydraulic conductivity has been altered relative to the hydraulic conductivity of the pumped zone; and (9) Darcy's law applies, with all its assumptions.

Parameters estimated by the model include the transmissivity (T), the aquifer storage coefficient or storativity (S), and the dimensionless well-bore storage coefficient (α):

$$\alpha = (r_w^2 / r_c^2) S, \qquad (1)$$

where: r_w is the well-screen radius;

r_c is the well-casing radius in the interval where the water level is measured; and

S is the storativity (specific storage times aquifer thickness).

Table 4. Monitoring-well information for aqujifer tests at sites 5S/2W-25J and 5S/3W-24F, Winchester subbasin, California

[Monitoring wells are 2 inches in diameter. mg/L, milligrams per liter; asterisk (*) indicates dissolved-solids concentration calculated from specific conductance. Site 5S/2W-25J: Distance of monitoring wells from the pumped well = 2,100 feet. Site 5S/3W-24F: Distance of monitoring wells from the pumped well = 113 feet]

Monitoring well number	Perforated intgerval (feet below land surface)	Static water level (feet below land surface) 1/30/95	Dissolved solids (mg/L) 11/2/94–11/4/94	Response during pumping of test well
		Site 5S/2W-25J		
25P7	72–82	37.60	3,110*	No clear response
25P6	148–158	38.54	1,570*	No clear response
25P5	231–236	40.64	2,070*	Drawdown = 0.57 feet
25P4	450–460	40.29	620*	Drawdown = 0.31 feet
25P3	630–640	40.96	730*	No clear response
		Site 5S/3W-24F		
		1/18/95	**[1]7/21/95 and [2]8/3/95**	
24F4	150–155	56.52	[1]1,330	Drawdown = –0.10 feet
24F3	399–404	68.31	[2]2,520	Drawdown = 10.09 feet
24F2	686–691	65.03	[1]395	Drawdown = 2.63 feet

In addition, the model provides an estimate of ß, the dimensionless leakage factor for the aquitards, as described by Hantush (1960):

$$ß = 0.5\, n\, r\, [(K'S_s')^* / T^*S^*]^{1/2}, \qquad (2)$$

where: n is the number of aquifers measured during the test;

r is the radial distance from center of pumped well;

$(K'S_s')^*$ is the product of vertical hydraulic conductivity and aggregate storativity for all the aquitards in the pumped system;

T^* is the aggregate transmissivity for all the aquifers in the pumped system; and

S^* is the aggregate storativity for all the aquifers in the pumped system.

The hydraulic conductivity (K) for the pumped zone can be calculated from the transmissivity (T) if the thickness (b) of the pumped zone is known:

$$K = T/b.$$

Site 5S/2W-25J

Site 5S/2W-25J is about 0.2 mi west of Warren Road and 60 ft south of Simpson Avenue and is in the bedrock constriction near the border with the Hemet subbasin (fig. 2). The pumped well (5S/2W-25J1) is an unused irrigation well that has an inside diameter of 14 in. and is approximately 520 ft deep (the depth was difficult to sound accurately). The location of the perforated intervals is unknown. However, a series of dye-injection tests done during the pumping phase of the aquifer test indicated that water was entering the well at depths between 273 and 423 ft below land surface (altitude 1,225 to 1,075 ft). Test-hole 5S/2W-25P, 2,100 ft southwest of the pumped well, was used as an observation well. Test hole 5S/2W-25P contains a nest of five piezometers, which were monitored during the test. Information about test-hole 5S/2W-25P is given in table 4 and figure 5.

Well 5S/2W-25J1 was pumped for 2,730 minutes at an average discharge rate of 50.1 gal/min during January 30–February 1, 1995. Discharge did not vary significantly during the test (fig. 23). Drawdown in the pumped well was approximately 11.6 ft (fig. 24). Irregularities in the time-drawdown curve can be correlated with minor fluctuations (about 1 gal/min) in discharge. Because the plot of the recovery data (fig. 25) is smoother than that of the drawdown data, the recovery data were used in the analysis of the test.

Transmissivity (*T*) is the principal parameter that can be determined from analysis of data from the pumped well. (The measured and simulated recovery curves are shown in figure 26.) The aquifer and well parameters estimated by the AQTESOLV curve-matching program are as follows:

$T = 880$ ft ^{2}/d;
$S = 0.00006$
$\alpha = 0.00008$; and
$\beta = 0.0023$.

Although the match between measured and simulated recovery is good, as seen by the residuals shown in figure 27, the solution is somewhat non-unique, especially with regard to storage coefficient (*S*); α (the well-bore storage factor); and ß (the parameter determined by contributions from aquitard storage). However, the values used in the solution are reasonable and congruent with the general physical characteristics of the aquifer system. The value for transmissivity (*T*) also should be considered to be an estimate.

The same model was used to analyze drawdown in observation well 5S/2W-25P5, a monitoring well located 2,100 ft southwest of the pumped well and perforated from 231 to 236 ft below land surface (altitude from 1,259 to 1,254 ft). Of the nested piezometers at this site, 25P5 had the greatest response (drawdown of 0.57 ft, table 4) even though its perforations are more shallow than the zone of production identified in the pumped well. Possible explanations for the large response are a hydraulic connection provided by a dipping permeable layer or by transmittal of the pumping effects (vertical leakage

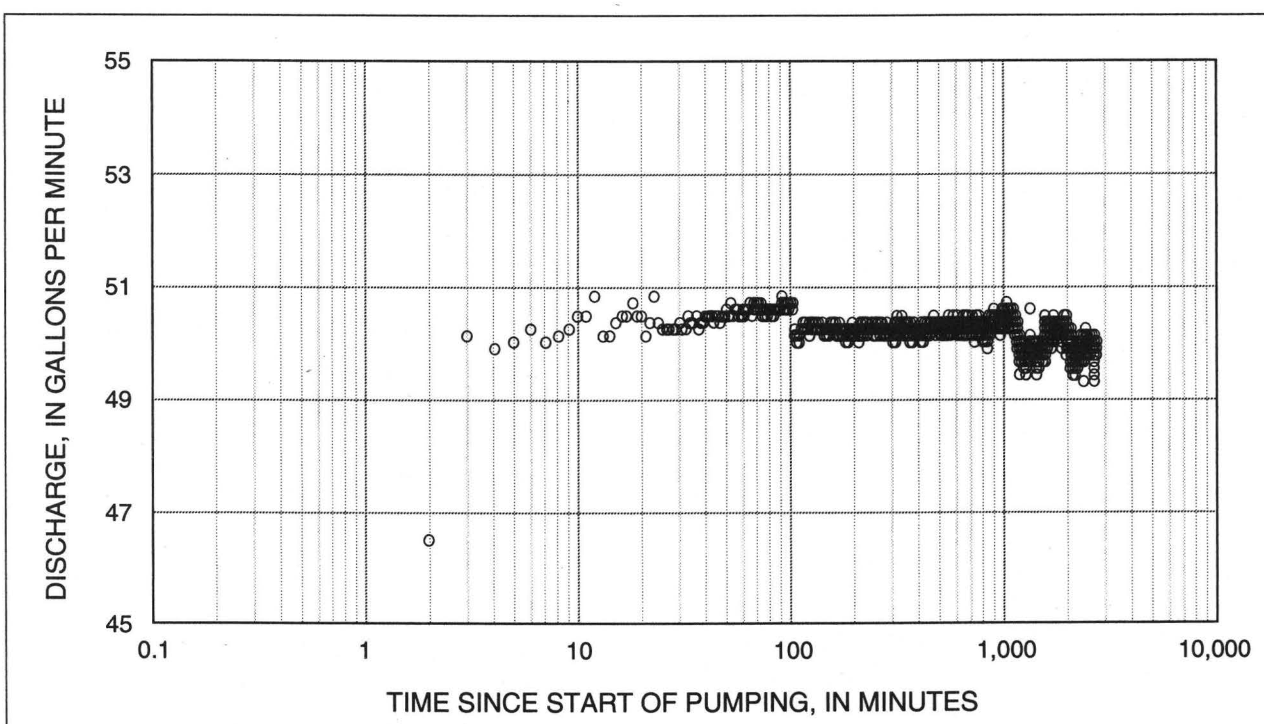


Figure 23. Discharge for pumped well 5S/2W-25J1 during aquifer test, Winchester subbasin, California.

through a thin confining zone) to an adjacent permeable layer. The possibility of vertical leakage may be supported by water-quality data: a sample taken from the pumped well 1 hour before the end of pumping had a dissolved-solids concentration of 1,430 mg/L, which may be the result of mixing of water from the zones tapped by piezometers 25P5 (2,070 mg/L) and 25P4 (620 mg/L) (table 4).

Measured and simulated drawdowns for observation well 25P5 are shown in figure 28. The aquifer and well parameters estimated by the model are:

$T = 950$ ft^2/d;
$S = 0.00007$;
$\alpha = 0.00009$; and
$\beta = 0.60$.

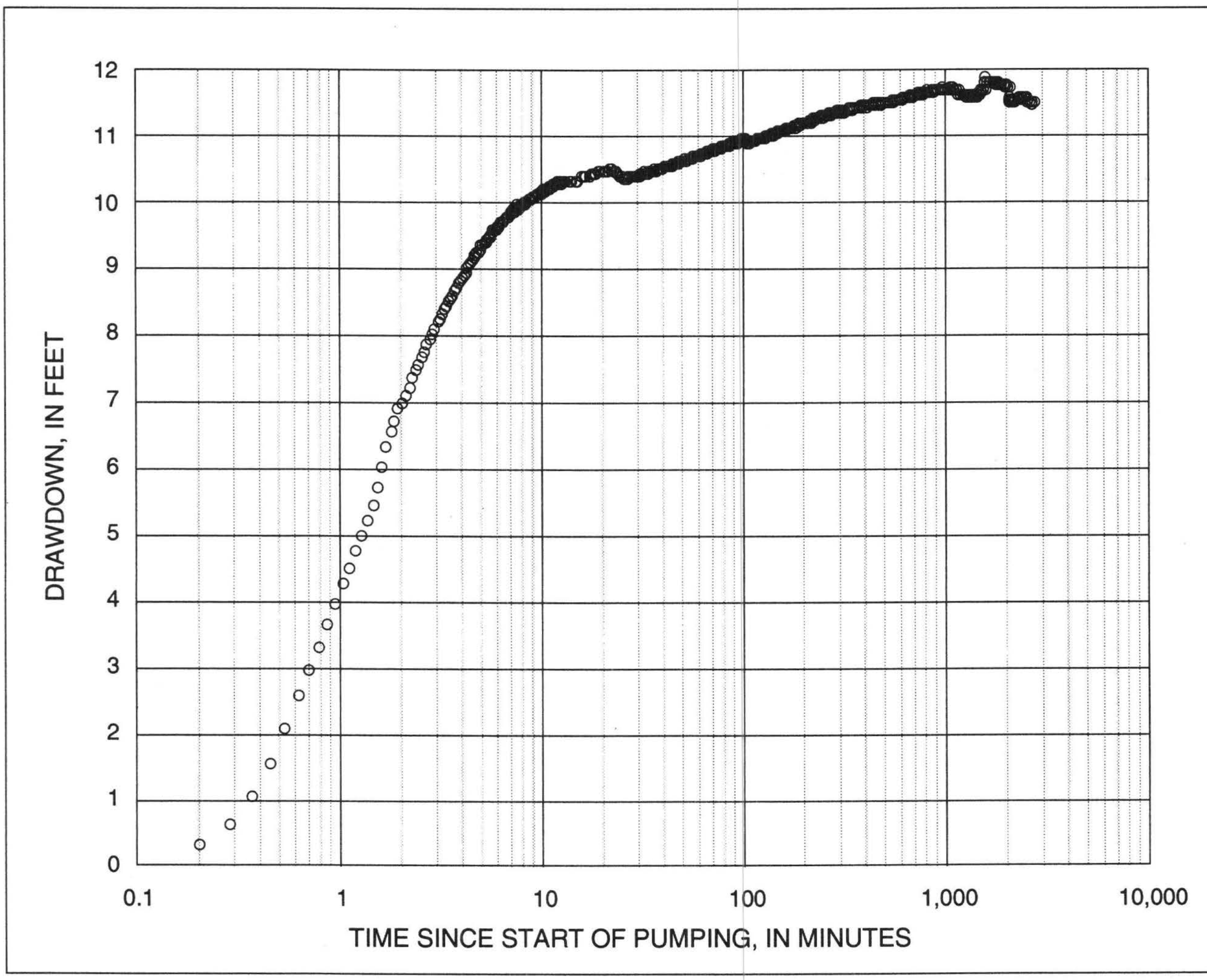


Figure 24. Drawdown in pumped well 5S/2W-25J1 during aquifer test, Winchester subbasin, California.

Once again, the solutions are non-unique for values of T ranging from 860 to 3,600 ft^2/d because at small values of ß, all the type curves have a similar shape. However, the solution shown here, which is consistent with the parameters estimated using the pumped-well data alone, is as good as any other. On the basis of the value of T determined above ($T = 950\ ft^2/d$) and the estimated thickness of the producing zone determined during the dye test described earlier (150 ft), the hydraulic conductivity is determined to be $K = 6.3$ ft/d for the producing zone.

Site 5S/3W-24F

Site 5S/3W-24F is about 0.45 mi east of Menifee Road and 132 ft north of Chambers Road and is in the

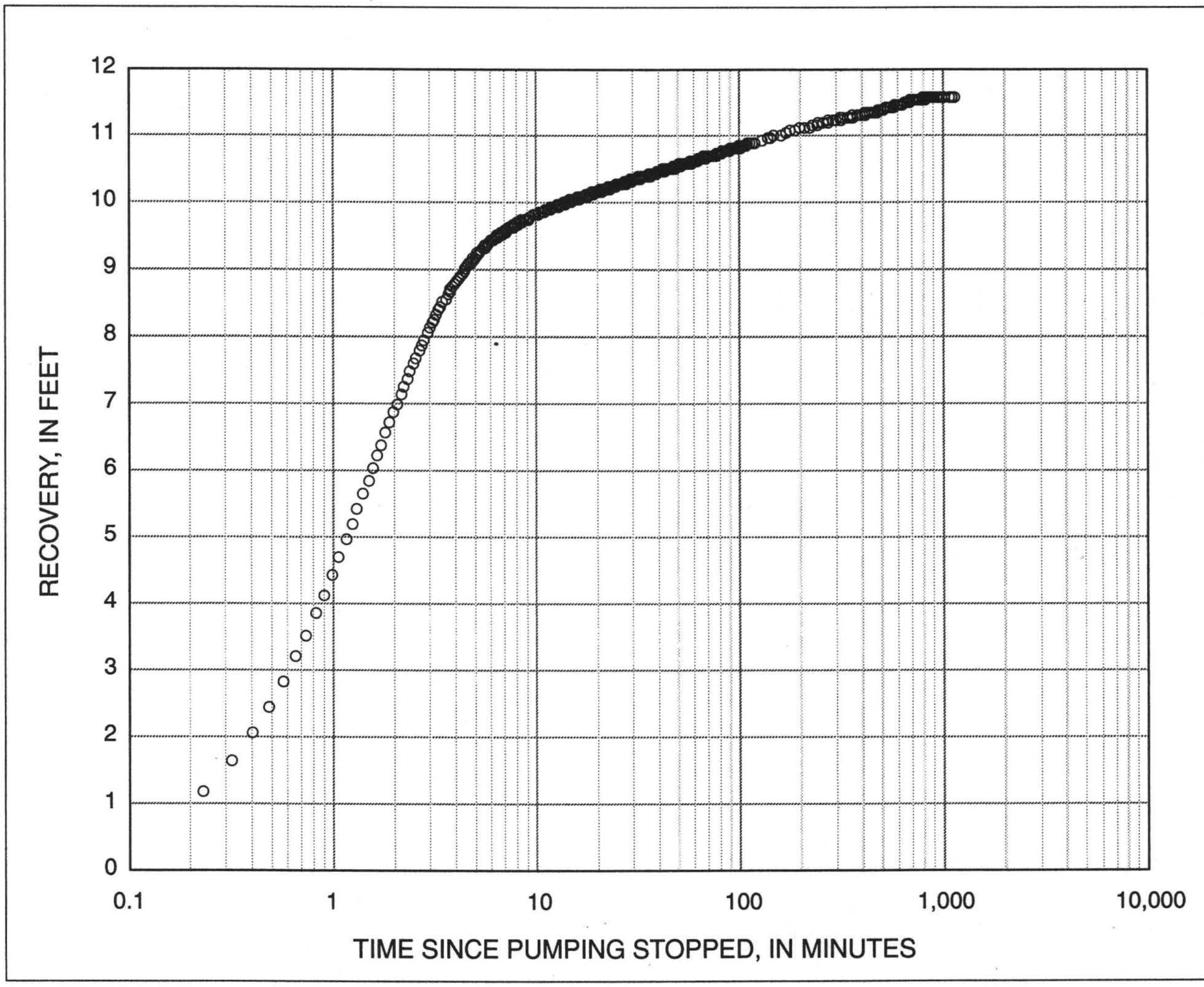


Figure 25. Recovery in pumped well 5S/2W-25J1 during aquifer test, Winchester subbasin, California.

alluvium-filled bedrock constriction at the border with the South Perris subbasin (fig. 2). The well pumped for the test (5S/3W-24F1) is 680 ft deep and has an inside diameter of 5.5 in. (r_c in eq. 1). The well is screened at depths of 310–349 ft, 388–427 ft, 524–544 ft, 563–583 ft, 622–641 ft, and 661–680 ft (altitudes 1,165–1,126 ft, 1,087–1,048 ft, 951–931 ft, 912–892 ft, 853–834 ft, and 814–795 ft). Dye-injection tests, conducted concurrently with the aquifer test, indicate that approximately 60 percent of the pumped water enters the well at a depth interval of 388–427 ft, and about half of that amount enters in the 388–403-foot depth (altitude 1,087–1,072 ft) interval. About 24 percent of the pumped water enters the well below a depth of 524 ft, and about 15 percent enters in the 310–349-foot depth interval. Three wells, 24F2, 24F3, and 24F4 (the 24F multiple-well monitoring site), used as observation wells during the test, were constructed 113 ft south of the pumped well. Information about the wells is summarized in table 4, and borehole logs and lithology for the site are shown in figure 3.

Well 5S/3W-24F1 was pumped for 1,450 minutes at an average discharge rate of 25.2 gal/min, with a variation of about ± 1 gal/min (fig. 29).

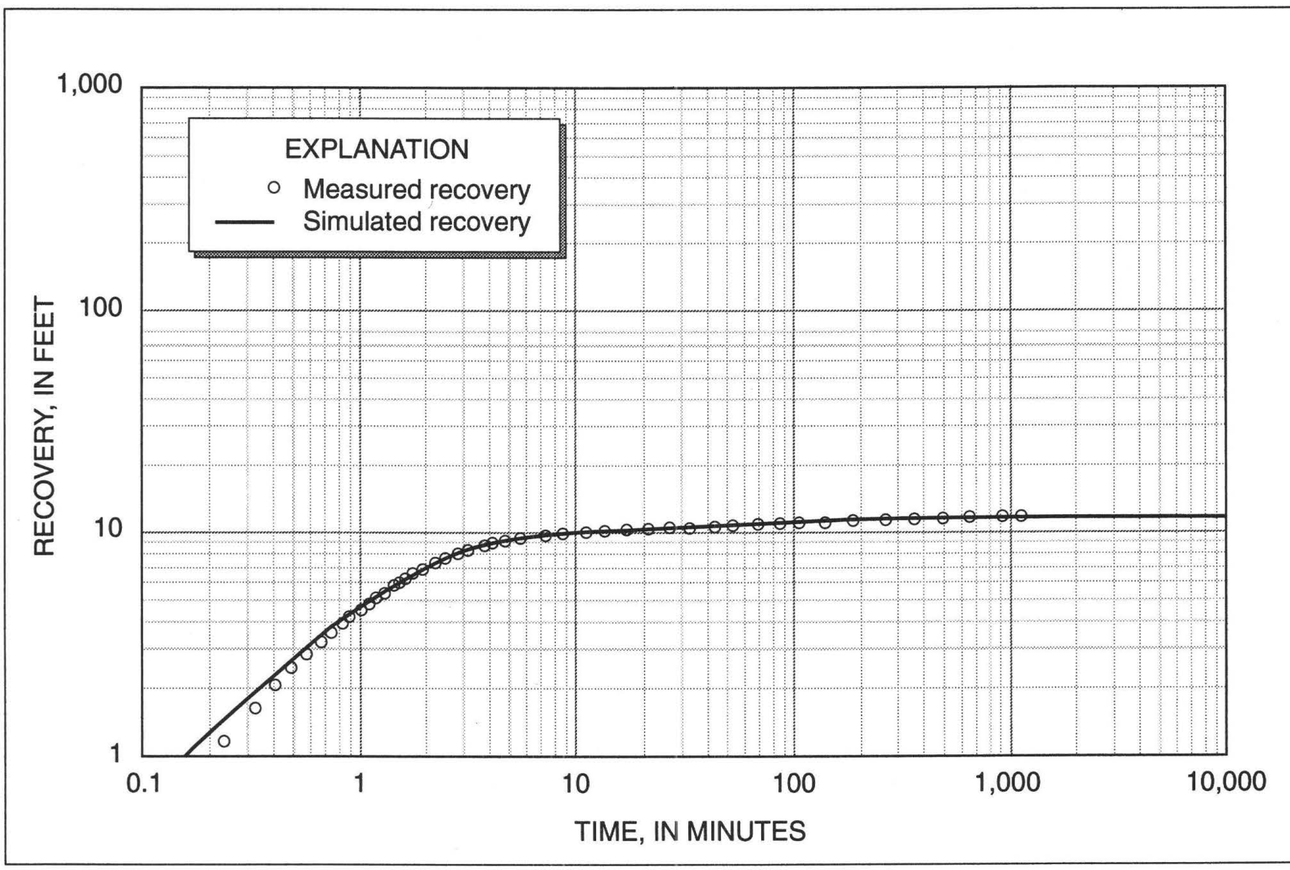


Figure 26. Measured and simulated recovery for pumped well 5S/2W-25J1 during aquifer test, Winchester subbasin, California

Drawdown data for the pumped well (fig. 30) and for observation well 24F3 (fig. 31) were used in the analysis of the test.

Analysis of drawdown data from the pumped well using the leaky-aquifer model of Moench (1985) produced an estimate of 44 ft^2/d for overall transmissivity for the producing zones. The measured and simulated drawdown curves are shown in figure 32. If we assume that water is produced over the entire interval from the top of the shallowest screen to the bottom of the deepest screen (370 ft), then the overall hydraulic conductivity is estimated to be $K = 0.12$ ft/d. The remaining parameters are non-unique, probably because response in the pumped well is influenced by the effects of partial penetration. Partial penetration may cause failure to meet the assumption of horizontal flow; the resulting greater flow velocities near the well may lead to an additional loss of hydraulic head.

The effects of partial penetration are less important when analyzing data from the observation well 5S/3W-24F3 because this well is screened opposite the zone of principal production and because the other two piezometers had minimal responses (the system responds as if it were strongly layered, in contrast to the apparent uniformity indicated by the logs shown in figure 3). Drawdown data from observation well 24F3 also were analyzed using the Moench model. The match of the measured and simulated drawdown curves shown in figure 33 generates the following parameter values:

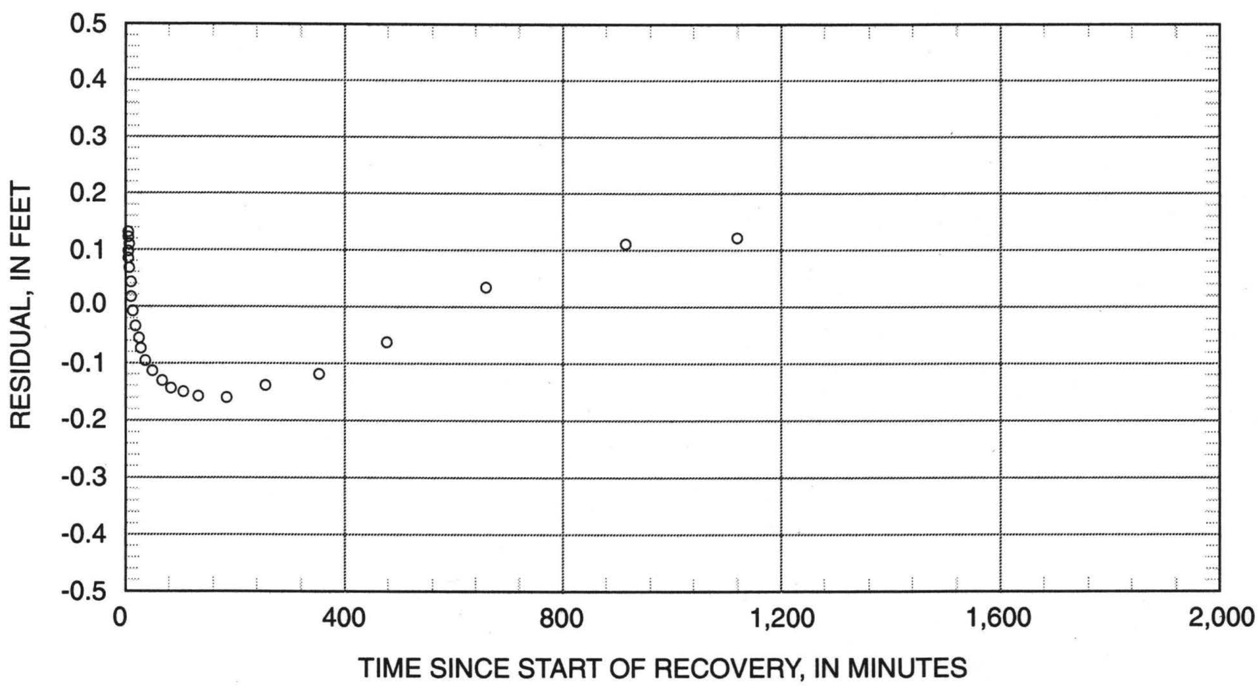


Figure 27. Residuals as a function of time since start of recovery, well 5S/2W-25J1, Winchester subbasin, California (residual equals measured minus simulated).

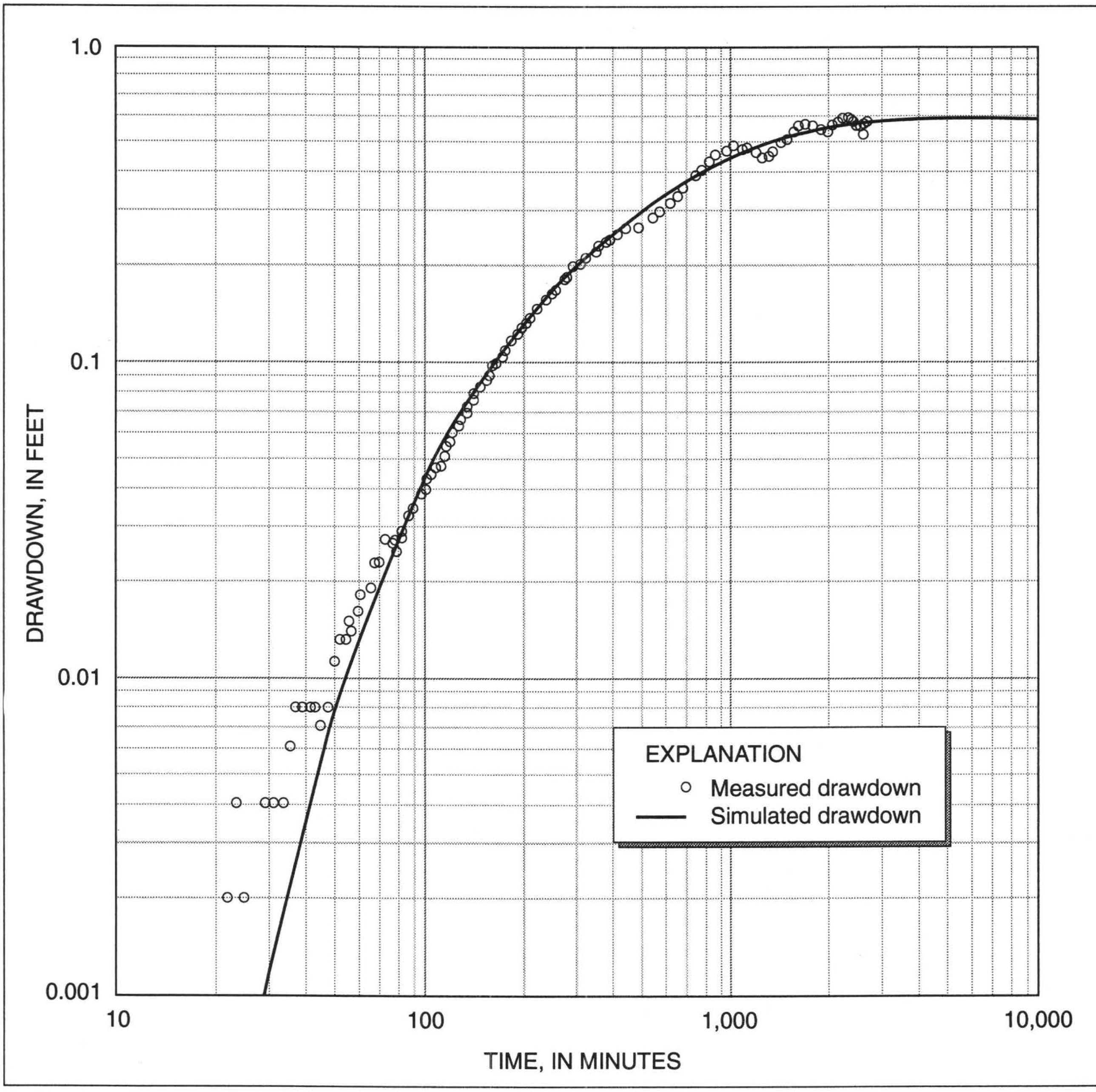


Figure 28. Measured and simulated drawdown for observation well 5S/2W-25P5, Winchester subbasin, California.

$T = 72\ ft^2/d$;
$S = 0.00016$;
$\alpha = 0.00021$; and
$\beta = 0.39$.

Results of a dye-injection well-bore-flow test indicated that about 60 percent of the water pumped from well 24F1 enters the well in the 388–427-foot depth interval, a zone that includes the perforated interval of observation well 24F3 (399–404 ft). Inspection of the lithologic and geophysical logs indicates that the probable bottom of the overlying aquitard is the bottom of the clay that ends at a depth of about 340 ft, and that the top of the underlying aquitard is the top of the clayey sand that starts at about 420 ft. If one assumes that 60 percent of the production from this well is from this 80-foot zone, the tested interval is calculated to yield a corrected transmissivity of $T_c = 43\ ft^2/d$ (60 percent of the transmissivity [$72\ ft^2/d$] calculated from data from well 24F3 using the Moench model). The corrected transmissivity is in general agreement with the value estimated from the pumped-well (24F1) data ($T = 44\ ft^2/d$). The estimated hydraulic conductivity using this value for this producing zone is $K = 0.53$ ft/d.

Summary of Aquifer Characteristics at the Two Test Sites

Several similarities exist between aquifer characteristics at site 5S/2W-25J, located at the eastern end of the Winchester subbasin, and aquifer characteristics at site 5S/3W-24F, located at the western end. The lithology at both sites consists of interbedded sand, silty sand, gravelly sand, clayey sand, and sandy silt, with a higher percentage of fine-grained material above a depth of about 175 ft. Given the general absence of well-defined interbedded clay layers, the lithologic descriptions might lead one to expect a permeable sand and gravel aquifer confined by fine-grained material near the surface and underlain by bedrock at a depth of 600 to 700 ft. However, whereas the transmissivity of about 950 ft^2/d estimated for site 5S/2W-25J is within the range of values typical of alluvial aquifers in the region, the value of about 43 ft^2/d estimated for site 5S/3W-24F is lower than would be expected on the basis of the lithologic descriptions. A possible explanation for this phenomenon is the alteration of feldspar in weathered highly arkosic alluvium derived from nearby granitic sources to a clayey matrix that clogs the primary porosity and results in poor permeability. The dispersed clayey material, or thin layers of clayey material, can be difficult to detect in drill cuttings and in interpretation of geophysical logs (F.S. Riley, U.S. Geological Survey, written commun., 1995). In layers in which the alluvium has been reworked after deposition, and the decaying feldspar has undergone winnowing, the permeability may be higher.

Evidence of another departure from the concept of a vertically homogeneous alluvial aquifer is the varying hydraulic head (water level) and varying water quality with depth. At both sites, vertical heterogeneity, and the presence of multiple aquifer zones, is indicated by higher values of dissolved-solids concentration for water sampled from zones shallower than a depth of about 400 to 450 ft (table 4). The lower values from the deeper zones probably reflect contribution from the fracture-flow system of the granitic bedrock below the alluvium. It should be noted that even this aspect is not uniform throughout the subbasin, as is seen in the high dissolved-solids concentration (almost 8,000 mg/L) (fig. 16) for the deepest zone sampled at site 28E1 in the north-central part of the subbasin.

As noted previously, the aquifer tests provide information about transmissivities in the vicinity of the test sites. Extrapolation of this information to other parts of the subbasin would be difficult owing to the scarcity of well-defined lithologic or textural information, and the apparent lack of well-defined areally extensive fine- and coarse-grained layers traceable from one part of the subbasin to another. However, specific-capacity data are available from drillers' logs of selected wells, and these data can be used to estimate transmissivity and hydraulic conductivity. Specific capacity is the yield of a well per unit of drawdown (in this report, expressed as (gal/min)/ft). Specific capacities for the Winchester subbasin and surrounding areas range from 0.4 to 42 (gal/min)/ft (fig. 34). Within the subbasin boundaries, the range is from 0.4 to 7.7 (gal/min)/ft. Values in the eastern part of the subbasin generally are greater than those in the western part; data are lacking for the central part of the subbasin west of the town of Winchester.

A relation between specific capacity and transmissivity was observed by Thomasson and others (1960, p. 222) for alluvial deposits in the Sacramento Valley of California, wherein the specific capacity in units of gallons per minute per foot multiplied by 230 approximated transmissivity in units of feet squared per day. This relation also was applied to the upper unit of Tertiary alluvial deposits (thickness of about 1,000 ft) in the Surprise Spring basin in San Bernardino County, California, by Londquist and Martin (1991), and is assumed in this report to be applicable to the alluvial deposits of the Winchester subbasin in estimating transmissivity.

Transmissivities, as estimated using Thomasson's method, range from 92 to 1,770 ft^2/d within the subbasin and from 115 to 9,660 ft^2/d for

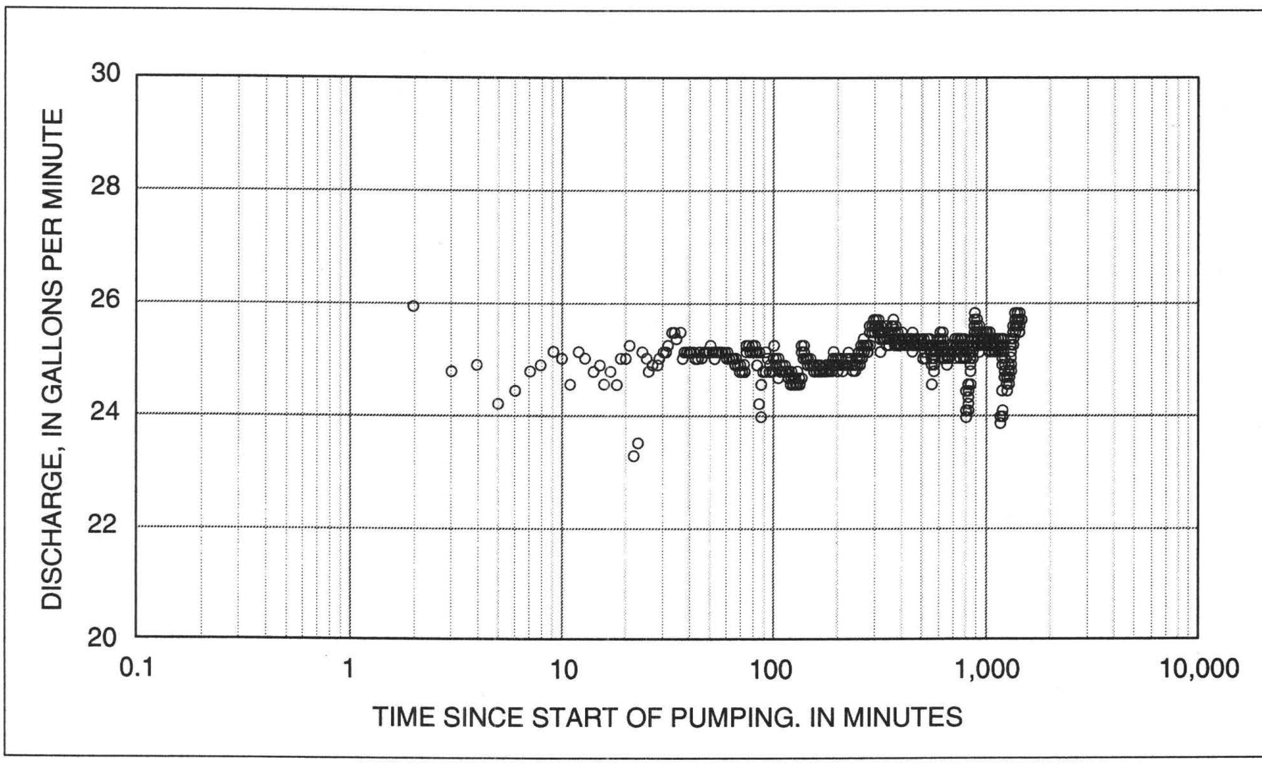


Figure 29. Discharge for pumped well 5S/3W-24F1 during aquifer test, Winchester subbasin, California.

wells adjacent to the Winchester subbasin (table 5, column B). Transmissivity divided by the total saturated thickness of the aquifer gave estimates of hydraulic conductivity that ranged from 0.3 to 3.2 ft/d for the subbasin. Values of transmissivity and hydraulic conductivity estimated on the basis of total saturated thickness are too low if the entire thickness of the aquifer is not supplying water to the well. To compensate for this and to obtain the high end of the range (values that may overestimate the actual values), one may assume that the values of transmissivity calculated from specific-capacity data apply only to the

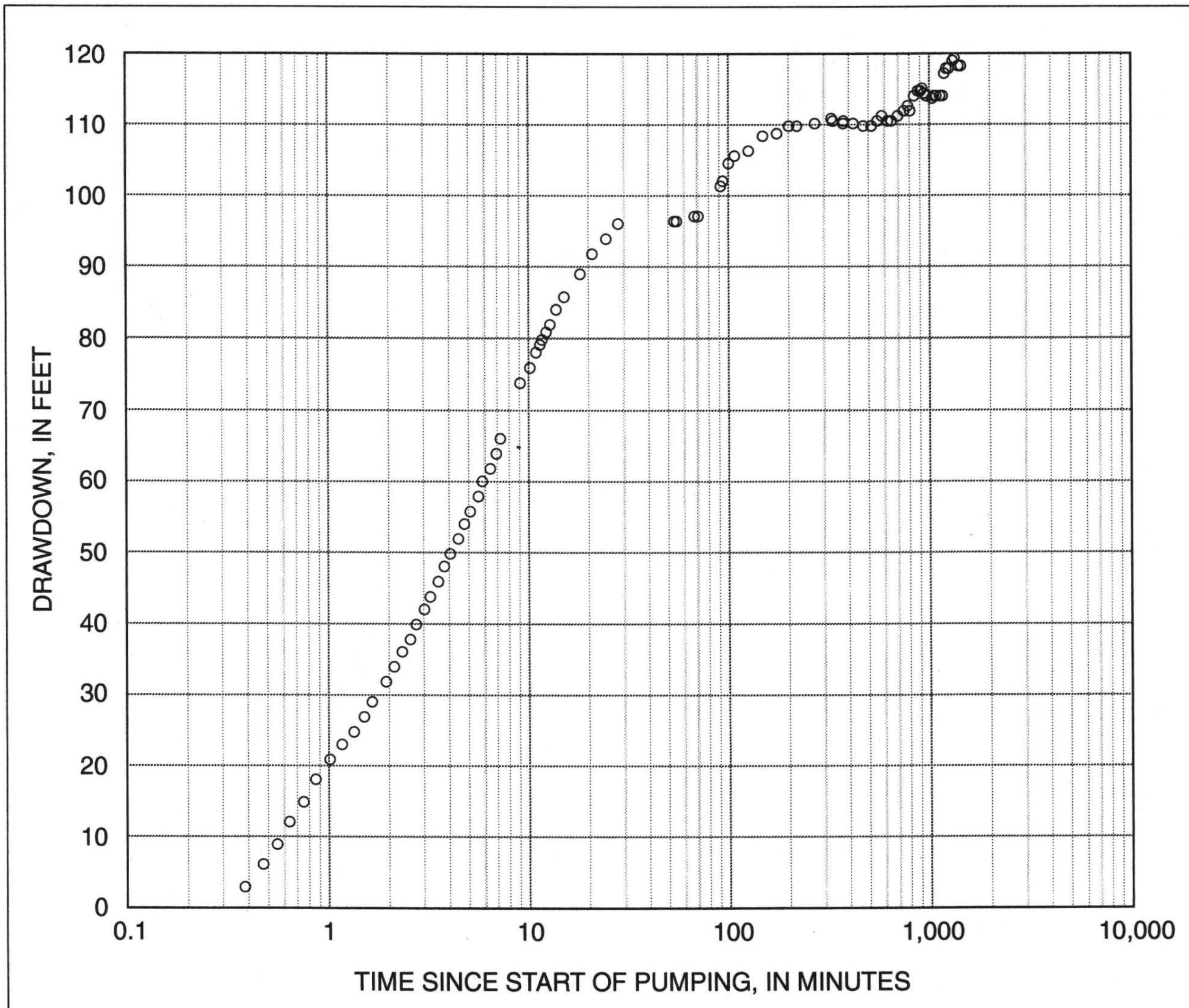


Figure 30. Drawdown in pumped well 5S/3W-24F1 during aquifer test, Winchester subbasin, California.

thickness of aquifer opposite the screened interval of the well (Heath, 1983, p. 61). The corrected values are obtained by dividing the calculated transmissivity by the length of the screened interval to determine hydraulic conductivity, and then multiplying hydraulic conductivity by the entire saturated thickness of the aquifer (table 5) (Londquist and Martin, 1991). The low- and high-range calculations for each well were averaged to obtain a mid-range estimated transmissivity (table 5, column H; fig. 34). The averaged estimated transmissivities ranged from 154 to 7,490 ft^2/d for the Winchester subbasin.

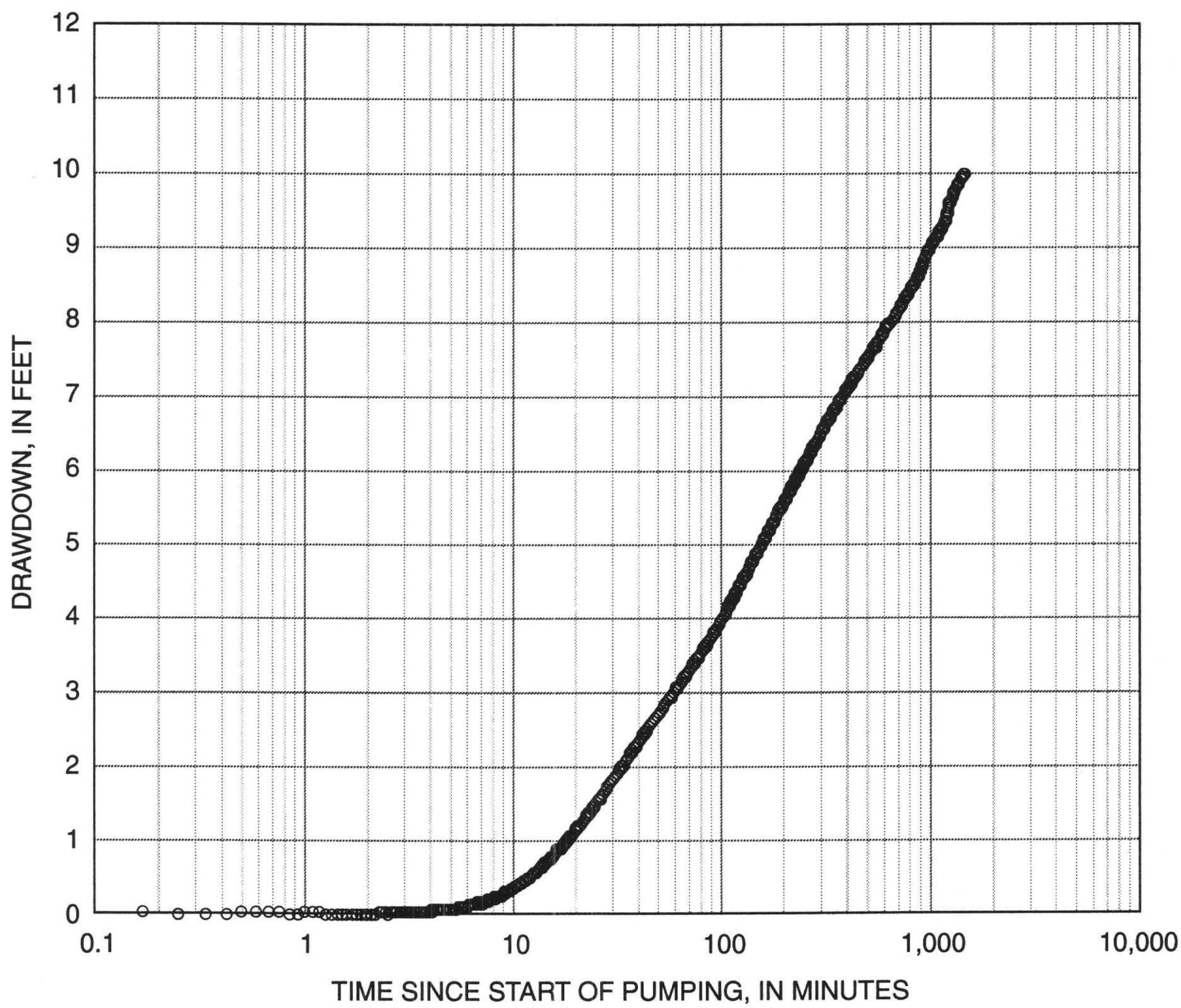


Figure 31. Drawdown in observation well 5S/3W-24F3 during aquifer test, Winchester subbasin, California.

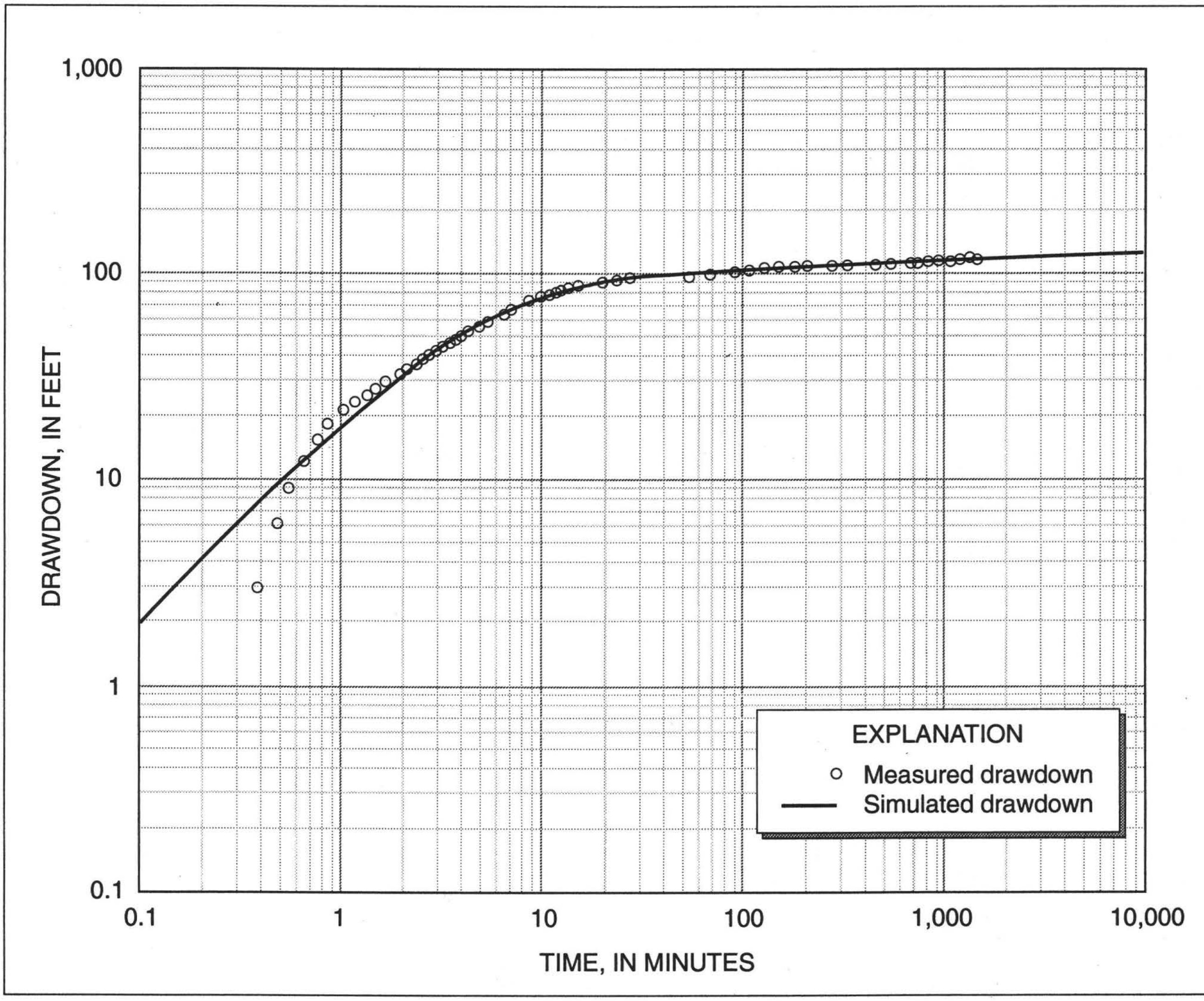


Figure 32. Measured and simulated drawdown for pumped well 5S/3W-24F1, Winchester subbasin, California.

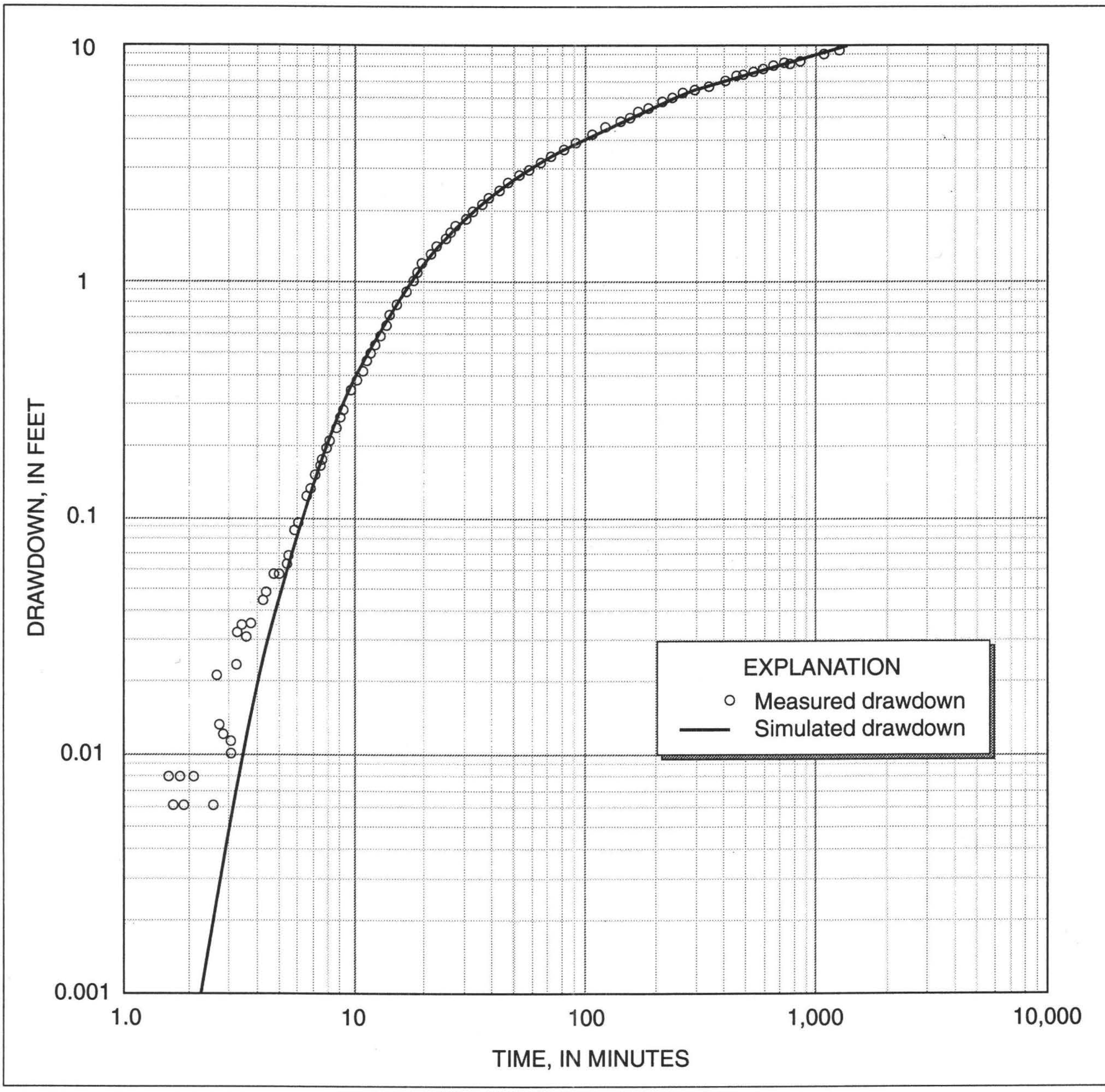


Figure 33. Measured and simulated drawdown for observation well 5S/3W-24F3, Winchester subbasin, California.

Table 5. Estimated transmissivity and hydraulic-conductivity values for the Winchester subbasin and surrounding area

[(gal/min)/ft, gallon per minute per foot; ft²/d, foot squared per day; ft, foot; ft/d, foot per day]

Well number	Specific capacity (gal/min)/ft (A)	Transmissivity (ft²/d) (B=Ax230)	Saturated thickness of aquifer (1994-5) (ft) (C)	Hydraulic conductivity based on total saturated thickness (ft/d) (D=B+C)	Length of perforated interval (ft) (E)	Hydraulic conductivity based on length of perforated interval (ft/d) (F=B+E)	Transmissivity (ft²/d) (G=CxF)	Transmissivity (average) (ft²/d) (H=(B+G)/2)
5S/1W-30C1	17.0	3,910	170	23	60	65.2	11,100	7,490
5S/2W-13D1	42	9,660	35	276	35	276	9,660	9,660
5S/2W-19N1	0.5	115	470	0.2	216	0.5	250	183
5S/2W-19N2	1.1	253	470	0.5	194	1.3	613	433
5S/2W-25J1	4.3	989	500	2.0	75	13.2	6,590	3,790
5S/2W-25N1	7.7	1,770	550	3.2	330	5.4	2,950	2,360
5S/2W-26G1	0.4	92	270	0.3	115	0.8	216	154
5S/2W-27G1	3	690	370	1.9	60	11.5	4,260	2,470
5S/2W-30C1	1.2	276	440	0.6	180	1.5	675	475
5S/2W-35C2	1.9	437	280	1.6	280	1.6	437	437
5S/2W-36D1	3.2	736	370	2.0	203	3.6	1,340	1,040
5S/3W-13A1	2.1	483	325	1.5	200	2.4	785	634
5S/3W-13N1	0.5	115	550	0.2	170	0.7	372	244
5S/3W-24F1	0.5	115	620	0.2	156	0.7	457	286
5S/3W-36N2	18.2	4,190	600	7.0	380	11.0	6,610	5,400
5S/3W-36P2	1.2	276	600	0.5	120	2.3	1,380	828
5S/3W-36Q1	15.8	3,630	600	6.1	508	7.2	4,290	3,960

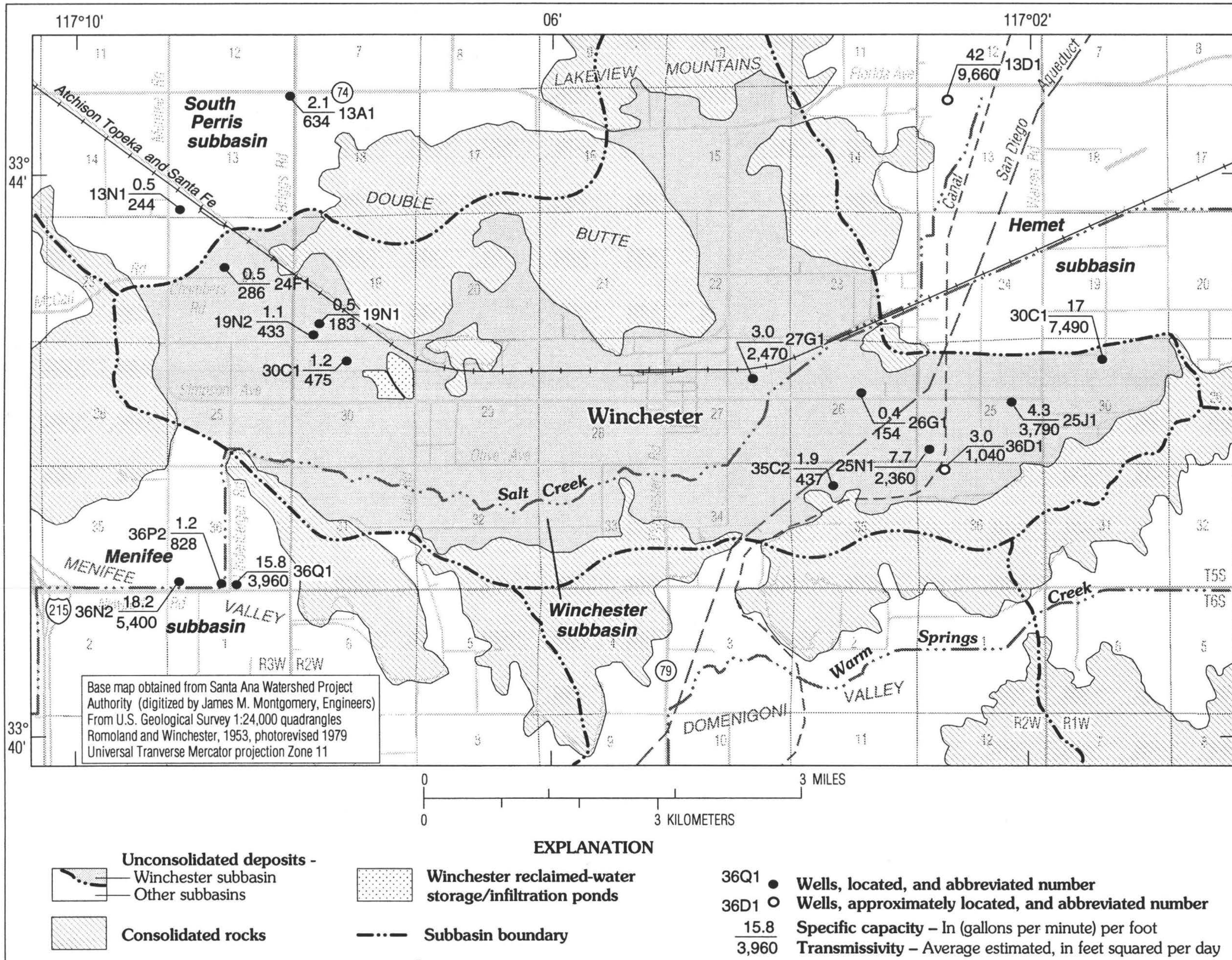


Figure 34. Specific capacity, and estimated transmissivity based on specific capacity, for selected wells in the Winchester subbasin and surrounding area, California.

QUANTITY OF GROUND WATER

The quantity of extractable ground water available in the alluvial-aquifer system in the Winchester subbasin can be estimated using water levels, estimated specific yield, and thickness of alluvial basin fill. The map showing the thickness of basin fill (fig. 7), was used in conjunction with 1994–95 water-level data to calculate the volume of saturated alluvial fill in the Winchester subbasin (table 6). The calculated volume, 1.13×10^{11} ft^3, then was multiplied by the estimated specific yield to obtain an estimated volume of extractable ground water in the subbasin. Specific yield is the volume of water that an aquifer releases by gravity drainage from storage per unit surface area of aquifer per unit decline in the water table. The specific yield used to estimate quantity of water extractable from the calculated volume of saturated alluvium, 0.092, is a weighted average of values determined from drillers' logs (Mukae, 1973) in conjunction with laboratory-derived specific-yield values (Johnson, 1967) for various alluvial textures in California; this value was used in an earlier study of the Winchester subbasin (California Department of Water Resources, 1979, p. 8). The resulting estimated volume of water is 230,000 acre-ft (1.00×10^{10} ft^3). This value of extractable volume is greater than the value of 80,000 acre-ft estimated in the earlier study because the volume of saturated alluvium used to calculate the extractable volume of water in the present report was made on the basis of a greater thickness of alluvium (Biehler and Lee, 1994) than previously was thought to exist (California Department of Water Resources, 1978).

The estimated volume of extractable ground water probably should be considered to be a maximum, for several reasons. First, it is not likely that water levels could be pumped all the way down to bedrock throughout the subbasin as would be required to actually extract all of the water. Second, the specific-yield

Table 6. Estimated volumes of alluvium and extractable ground water in the Winchester subbasin, California

Total volume of alluvium [1]	
(cubic feet)	1.13×10^{11}
Total volume of alluvium below a depth of 5 feet	
(cubic feet)	1.13×10^{11}
(acre-feet)	2,600,000
Current (1994–95) volume of unsaturated alluvium	
(acre-feet)	102,000
Current (1994–95) volume of saturated alluvium	
(acre-feet)	2,500,000
Potential storage capacity (for maximum water levels 5 feet below land surface)	
(acre-feet)	239,000
using specific-yield value of 0.092	
Current (1994–95) volume of extractable ground water in storage	
(acre-feet)	
Using specific yield = 0.092	230,000
Percent of capacity	96

[1] Calculated using depth-to-bedrock map of Biehler and Lee (1994).

value used probably does not take into account reduction of specific yield with depth owing to compaction and induration. Third, poor sorting of grain sizes, which reduces permeability, may not be apparent from drillers' logs. Fourth, aquifer tests made as a part of this study indicated permeabilities that are somewhat lower than would be expected from description of the alluvial textures penetrated by the test wells.

Comparison of the estimated current volume of extractable ground water in storage with an estimate of the potential storage capacity of the subbasin (assumes maximum water levels of 5 ft below land surface) (table 6) indicates about 9,000 acre-ft of unused storage capacity. The present shallow depth to water for much of the subbasin area (fig. 15) is the principal reason for the small volume of unused storage capacity.

The quantity of ground water moving from the Winchester subbasin into the Hemet subbasin is estimated to be from 29 to 423 acre-ft/yr. This range of values was calculated using an estimate of hydraulic conductivity determined from the aquifer test at site 5S/2W-25J, the hydraulic gradients, and the cross-sectional area of the aquifer (table 7). All were applied to Darcy's law:

Flow = (hydraulic conductivity) × (hydraulic gradient) × (cross-sectional area).

A range of hydraulic conductivity, from 1.9 to 6.3 ft/d, was estimated by dividing the transmissivity determined from the aquifer test at site 5S/2W-25J by a minimum and a maximum thickness: The minimum thickness of 150 ft is the estimated cumulative thickness of probable productive zones contributing water to the test well, and the maximum thickness of 455 ft is the total saturated thickness penetrated by the well. The calculation of ground-water flow from the Winchester subbasin to the Hemet subbasin is complicated by the fact that ground-water flow in the vicinity of the subbasin boundary moves generally from west to east, subparrallel to the boundary (figs. 10 and 11). Specifically, the ground-water contours for 1991–92 indicate east-southeast flow from the Hemet subbasin into the Winchester subbasin for the western half of the boundary, and east-northeast flow from the Winchester subbasin into the Hemet subbasin for the eastern half of the boundary. A range of gradients was determined using water levels measured in wells 5S/1W-30C1 and 5S/1W-20P2 for April–May 1991 and July 1992, and in wells 5S/2W-36D4 and 5S/1W-20P2 for April–June 1991 and July 1992. The range of gradients was from 0.0057 to 0.0089.

Saturated cross-sectional area was determined from the maps showing thickness of alluvial fill (depth to bedrock) (fig. 7) and water levels (fig. 10), along the

Table 7. Range of values used in calculating flow between the Winchester and the Hemet subbasins, California

[Equation: Flow = (hydraulic conductivity) × (hydraulic gradient) × (cross-sectional area)]

Hydraulic conductivity (*K*=*T*/*b*)		Hydraulic gradient (I) between wells 5S/1W-30C1 and 5S/1W-20P2		Cross-sectional area (*A*)
Transmissivity (*T*)	**Thickness (*b*)**	**Gradient**	**Date**	
878–950 feet squared per day	[1]150–455			
		[2]0.0083	April–May 1991	
		[3].0057	May–June 1991	
K = 1.9 to 6.3 feet per day (determined at site 5S/2W-25J)		[2].0089	July 1992	315,000 to 900,000 squared feet
		[3].0058	July 1992	

[1]150 feet = estimated cumulative thickness of probable productive zones contributing water to the test well; 455 feet = total saturated thickness penetrated by the test well.
[2]Hydraulic gradient between wells 5S/1W-30C1 and 5S/1W-20P2.
[3]Hydraulic gradient between wells 5S/2W-36D4 and 5S/1W-20P2.

boundary chosen by the California Department of Water Resources at the bedrock constriction between the two subbasins. For a low end of the range, a cross-sectional area of 315,000 ft^2 was calculated for the part of the cross section east of the 1,430-foot contour line, where there is the most certainty of water moving from the Winchester subbasin to the Hemet subbasin. For the high end of the range, an area of 900,000 ft^2 was calculated for the eastern half of the cross section to include the most western point that water-level contour lines indicate possible flow from the Winchester subbasin to the Hemet subbasin.

The range of values of flow (Q) was calculated using the ranges of hydraulic conductivity (K), hydraulic gradient (I), and cross-sectional area (A):

$$Q = (K)\,(I)\,(A);$$

Low end of range: Q = (1.9 ft/d) (0.0057) (315,000 ft^2) = 3,400 ft^3/d;

High end of range: Q = (6.3 ft/d) (0.0089) (900,000 ft^2) = 50,500 ft^3/d;

Q = 3,400 to 50,500 ft^3/d;

Q = 29 to 423 acre-ft/yr.

The estimates of flow do not take into account several factors: (1) possible fining of material toward the sides of the subbasin or changes in texture between the location of the cross section and the aquifer-test site (the assumption was made that the material for the entire cross section has the same hydraulic conductivity as was determined at site 5S/2W-25J [near the center of the paleocanyon]); (2) possible smaller value of hydraulic conductivity with depth than determined from the test, owing to compaction and consolidation of the aquifer matrix; and (3) possible fluctuation (greater than has been taken into account) in the portion of the cross-section through which flow is in the direction of the Hemet subbasin.

SUMMARY AND CONCLUSIONS

The 20-mi^2 Winchester structural subbasin is an alluvium-filled paleocanyon that is as much as 900 ft deep (and thus is deeper than previously thought). The alluvial aquifer is composed of detrital material that generally ranges in size from clay to fine gravel; the fine and coarse materials are mixed in some places and interbedded in others. Data from logs indicate that the fine- and coarse-grained materials are not areally extensive in the form of stratigraphic layers, but instead are heterogeneous and lenticular. The apparent lenticularity of fine- and coarse-grained materials, along with evidence of differing water quality with depth at the multiple-well monitoring sites, supports a conceptualization of the aquifer as partly or locally confined, although probably without a traceable, widespread confining layer.

A ground-water divide exists east of the town of Winchester. On the west side of the divide, ground water moves toward the western end of the subbasin into the South Perris and the Menifee subbasins. On the east side of the divide, ground water moves toward and into the Hemet subbasin. The components of flow direction in the Winchester–Hemet border area are complex: along the border, some water moves from the southwest corner of the Hemet subbasin into the Winchester subbasin, and then eastward subparallel to the border before moving back into the Hemet subbasin. The direction of ground-water movement between the Winchester and the Hemet subbasins, and the position of the ground-water divide in the central part of the Winchester subbasin, have changed with time. Data for 1935–93 indicate that prior to about 1974, ground water moved both eastward from the divide and westward from the Hemet subbasin toward a local depression of the water table caused by pumping in the eastern part of the Winchester subbasin (centered primarily in sections 25 and 26).

Long-term change in water levels has varied for different parts of the subbasin. Comparison of water-levels for spring 1970, the date of the lowest known water levels in the eastern part of the subbasin, with the water levels for spring 1993, the highest water levels for the data available during the study, indicates a net rise in water level of as much as 150 ft in the east end of the Winchester subbasin for the period 1970–93. For this same period, water levels rose about 3 to 20 ft in the western and central parts of the subbasin.

Ground-water chemistry in the Winchester subbasin and adjacent subbasins varies areally and vertically. In general, sodium, calcium, chloride, and sulfate are dominant ions in the Winchester subbasin. Water quality is generally poor: dissolved-solids concentration exceeded 2,000 mg/L throughout most of the subbasin and was highest west of the town of Winchester. Eastward along the subbasin axis (toward the Hemet subbasin), the dissolved-solids concentration decreases and the pH increases (generally greater than 7.0).

Samples from two multiple-well monitoring sites at the west and east ends of the subbasin indicated that the best quality water (dissolved-solids concentrations of 395 and 483 mg/L) was from the deepest wells (perforated near the alluvium–bedrock contact); dissolved-solids concentrations in intermediate and shallow samples at these sites ranged from 1,330 to 3,380 mg/L. Samples from the deeper wells in the eastern part of the Winchester subbasin are similar in water type to a sample from well 5S/1W-19Q1 in the western part of the Hemet subbasin. This similarity suggests that the water may have originated in the Hemet subbasin and flowed into the Winchester subbasin; alternatively, the chemistry may reflect the influence of good-quality water flowing from the fractured bedrock basement to the alluvium in the eastern part of the Winchester subbasin. In addition, the potential problem of poor-quality water moving from the Winchester subbasin into the Hemet subbasin may not exist at all depths; fair- to good-quality water may be present below a depth of about 450 ft.

Although poor-quality ground water may flow from the Winchester subbasin into the Hemet subbasin, there is evidence that a source of poor-quality ground water also exists in the Hemet subbasin. Dissolved-solids concentrations in the southwest part of the Hemet subbasin ranged from about 900 mg/L at well 5S/1W-19Q1 about one-quarter mile north of the Winchester–Hemet subbasin boundary to about 3,500 mg/L at 5S/2W-24C2 near the bedrock outcrops south of the Lakeview Mountains. High dissolved-solids concentration in the vicinity of well 5S/2W-24C2 most likely is a result of dissolution of constituents from the aquifer matrix, evaporative processes, and agricultural practices that occur in that vicinity rather than a result of flow from the Winchester subbasin.

The MCL for nitrate was exceeded in water from shallow depths in parts of the subbasin. Most of these high-nitrate samples were from wells located in areas where reclaimed water is used for irrigation, and thus irrigation return may be an additional source of nitrate. Boron concentrations are greater than 1 mg/L in the central part of the Winchester subbasin, and show an increasing trend eastward within the Winchester subbasin and into the Hemet subbasin. Boron does not have an MCL at this time but is listed for regulation by the U.S. Environmental Protection Agency.

Aquifer-test results for the eastern part of the subbasin near the boundary with the Hemet subbasin indicate that the transmissivity is about 950 ft^2/d. Aquifer-test results for the western part of the subbasin near the boundary with the South Perris subbasin indicate that the transmissivity in this part of the subbasin is about 72 ft^2/d. The quantity of extractable ground water available in the alluvial-aquifer system in the Winchester subbasin was estimated to be 230,000 acre-ft using measured water levels, estimated specific yield, and thickness of alluvial basin fill. In 1993, there was about 9,000 acre-ft of unused ground-water storage capacity in the alluvium. On the basis of observed hydraulic gradients and the aquifer properties determined during the aquifer tests, from 29 to 423 acre-ft/yr of water is moving from the Winchester subbasin into the Hemet subbasin.

Given the areal and vertical complexities of the geohydrology of the Winchester subbasin, an improved understanding of the hydraulic properties of the alluvial-aquifer system could be obtained through the installation of a number of pairs of test wells and observation wells distributed areally throughout the subbasin (and perforated at selected depths) for the purpose of doing additional aquifer tests. Cores collected during drilling might help to better define the presence of confining layers. Analysis of water samples obtained from these wells also would serve to define the water-quality characteristics of the subbasin in greater detail. Alternatively, aquifer tests and water-quality data-collection efforts could be concentrated in an area of special interest, such as the border area of the Winchester and the Hemet subbasins, to build on the new hydrologic data and interpretations presented in this report and to investigate the effects of new reservoirs and ponds in the area.

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Table 3. Water-quality data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California

[Wells not shown in figure 1 were not located in the field or have been destroyed; ft, foot; ft blw LSD, feet below land-surface datum; µS/cm, microsiemens per centimeter at 25°C; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; per mil, parts per thousands; RCFC&WCD, Riverside County Flood Control and Water Conservation District; EMWD, Eastern Municipal Water District; BABCOCK, E.S. Babcock and Sons, Inc.; SEC, Smith-Emery Company; USGS, U.S. Geological Survey; <, less than; asterisk (*) indicates data from USGS laboratory located in San Diego Projects Office]

State well number	Date	Water level (ft blw LSD)	Well depth (ft)	Altitude of LSD (ft)	Specific conductance (µS/cm)	pH (standard units)	Water temperature (°C)	Hardness (mg/L as CaO_3)
5S/1W-18P1	4/21/81	--	--	--	2,500	7.4	21.5	480
5S/1W-19Q1	7/22/93	--	--	1,510	1,470	7.8	21.0	410
5S/1W-20P2	5/10/91	--	--	1,528	975	7.7	23.0	290
5S/1W-30D2	2/21/92	--	--	--	1,700	--	--	--
	6/16/77	--			1,650	7.5	--	400
5S/1W-30E2	1/21/92	--	582	1,502	2,200	--	--	--
	6/16/77	--			1,400	--	23.5	310
5S/1W-30L1	/13/1963	--	277	--	1,430	7.5	22.0	640
	8/25/59	--			1,660	6.3	--	670
5S/1W-30M1	9/14/60	--	452	--	1,240	8.0	22.0	360
	3/25/60	--			1,320	7.9	21.0	350
	9/1/59	--			1,230	7.0	23.0	380
	9/16/59	--			1,180	7.0	22.0	420
	10/15/58	--			1,220	7.8	23.5	390
	5/13/58	--			1,520	8.2	19.5	410
	9/18/58	--			1,520	8.2	20.0	460
	7/9/57	--			1,640	7.4	20.0	450
5S/2W-14R1	4/21/81	--	--	--	455	7.3	21.5	180
	11/18/80	--			520	6.7	--	200
5S/2W-16F1	11/18/93	--	100	1,640	840	6.9	21.0	270
	12/9/91	--			750	7.0	--	360
	11/1/82	--			675	7.3	--	200
5S/2W-19N1	5/23/79	--	358	--	989	7.8	17.0	270
	5/9/78	--			1,070	8.1	22.0	280
	10/28/78	--			1,050	8.1	22.0	300
	5/19/77	--			1,120	8.1	23.0	300
	9/20/76	--			949	7.3	22.0	240
	5/7/76	--			794	7.3	19.0	200
	9/30/75	--			888	8.2	21.5	230
	4/23/75	--			802	8.6	22.0	200
	9/20/74	--			883	8.5	27.0	220
	5/3/74	--			805	7.0	22.0	180
	9/27/73	--			700	8.0	22.0	190
	4/27/73	--			653	8.0	24.5	180
	5/11/72	--			637	8.2	23.0	150
	11/4/71	--			649	8.0	24.5	150
	5/7/71	--			750	8.0	21.0	200
	11/18/70	--			851	7.7	24.5	240
	4/28/70	--			872	8.1	21.0	230
	1/8/70	--			755	7.9	22.0	180
	10/23/69	--			990	7.6	26.5	250
	4/24/69	--			1,020	7.3	26.5	250
	10/15/68	--			1,040	7.7	26.5	260
	4/23/68	--			735	7.5	25.5	190
	5/11/67	--			743	7.1	20.0	200
	3/30/65	--			675	6.9	24.5	160
	3/13/64	--			710	7.3	22.0	210
	9/29/67	--			848	7.9	23.5	220
	9/15/66	--			789	7.5	25.5	210
	3/23/66	--			740	7.4	28.0	180
	9/27/65	--			755	7.0	24.5	200
	5/6/64	--			692	7.3	22.0	160

Table 3. Water-quality data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

State well number	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Alkalinity (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)
5S/1W-18P1	140	28	360	9.0	--	300	520	0.6
5S/1W-19Q1	130	20	160	6.3	130	130*	280*	< 2.0*
5S/1W-20P2	82	20	78	--	120	120	150	0.3
5S/1W-30D2	120	20	200	8.0	--	--	--	--
	120	21	190	7.0	--	170	350	0.3
5S/1W-30E2	220	51	170	9.0	--	--	--	--
	93	18	170	8.0	--	140	280	0.4
5S/1W-30L1	150	61	84	16	--	0	77	0.5
	160	63	72	9.0	--	160	85	0.4
5S/1W-30M1	120	14	100	10	--	150	180	0.1
	100	22	140	10	--	200	200	0.1
	82	44	97	6.0	--	190	180	0.3
	110	35	105	--	--	200	180	0.2
	110	27	100	--	--	180	170	--
	110	32	160	--	--	200	250	--
	120	39	150	--	--	240	270	0.2
	120	36	180	--	--	260	270	0.2
5S/2W-14R1	52	13	26	3.0	--	34	43	0.2
	56	14	25	2.0	110	28	53	--
5S/2W-16F1	69	24	56	10	89	180*	101*	--
	66	23	53	11	73	190	82	0.7
	56	16	50	10	--	81	73	0.5
5S/2W-19N1	75	22	110	2.0	120	160	130	0.4
	74	23	110	2.0	130	150	140	0.3
	80	24	120	3.0	120	180	130	0.6
	72	29	130	7.0	140	190	130	0.4
	67	17	99	2.7	120	120	120	0.4
	57	14	79	3.1	110	61	120	0.3
	67	15	83	3.1	120	76	120	0.3
	56	16	79	2.7	110	66	120	0.5
	85	1.1	88	8.6	130	72	130	0.2
	51	12	76	2.0	110	56	110	0.4
	46	14	77	2.0	99	51	110	0.2
	36	22	55	3.1	87	38	100	0.9
	39	12	58	2.7	87	40	96	0.3
	42	11	61	2.7	86	39	100	0.2
	54	15	73	3.0	110	61	120	0.1
	61	21	76	6.0	130	70	130	0.2
	65	16	81	3.1	130	78	120	0.3
	50	14	81	5.0	100	61	110	0.3
	69	19	98	2.0	150	89	120	0.3
	60	23	100	2.0	160	130	61	--
	71	20	99	2.0	140	84	140	0.1
	49	15	70	2.0	110	45	110	0.3
	58	13	69	3.0	100	38	110	0.0
	45	11	63	3.0	94	37	100	0.2
	58	15	67	5.0	90	40	150	0.3
	61	17	81	3.0	120	47	120	0.2
	59	16	70	3.0	110	42	120	0.3
	53	13	67	3.0	98	39	120	3.0
	57	13	69	3.0	110	36	110	0.3
	50	10	60	4.0	--	60	110	0.2

Table 3. Water-quality data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

State well number	Bromide, dissolved (mg/L)	Silica, dissolved (mg/L as SiO_2)	Dissolved solids (mg/L)	Nitrite, dissolved (mg/L as N)	Nitrite + nitrate, dissolved (mg/L as N)	Ammonia, dissolved (mg/L as N)	Phosphorus, ortho (mg/L as P)	Arsenic, dissolved (µg/L)
5S/1W-18P1	--	--	1,650	--	2.4	--	--	--
5S/1W-19Q1	< 0.2*	29	--	< 0.01	7.4	0.03	< 0.01	< 1
5S/1W-20P2	0.4	46	610	< 0.01	5.7	< 0.01	0.02	--
5S/1W-30D2		--	1,190	--	2.7	--	--	--
	--	--	1,040	--	7.3	--	--	--
5S/1W-30E2	--	--	1,600	--	8.1	--	--	--
	--	--	890	--	4.9	--	--	--
5S/1W-30L1	--	60	820	--	0.1	--	--	--
	--	67	1,180	--	0.0	--	--	--
5S/1W-30M1	--	--	780	--	2.0	--	--	--
	--	--	835	--	1.8	--	--	--
	--	55	834	--	2.5	--	--	--
	--	--	738	--	1.6	--	--	--
	--	--	770	--	0.7	--	--	--
	--	--	978	--	1.6	--	--	--
	--	--	977	--	1.6	--	--	--
	--	--	1,060	--	2.7	--	--	--
5S/2W-14R1	--	--	330	--	5.7	--	--	--
	--	--	300	--	--	--	--	--
5S/2W-16F1	--	60	--	< 0.01	8.0	0.02	0.30	< 1
	--	--	520	--	3.1	--	--	< 10
	--	--	415	--	4.4	--	--	--
5S/2W-19N1	--	--	722	--	15	--	--	--
	--	--	729	--	14	--	--	--
	--	--	847	--	17	--	--	--
	--	--	799	--	16	--	--	--
	--	--	623	--	12	--	--	--
	--	--	522	--	9.5	--	--	--
	--	--	603	--	13	--	--	--
	--	--	383	--	12	--	--	--
	--	--	589	--	9.0	--	--	--
	--	--	495	--	8.6	--	--	--
	--	--	519	--	7.9	--	--	--
	--	--	492	--	7.0	--	--	--
	--	--	398	--	5.6	--	--	--
	--	--	441	--	6.8	--	--	--
	--	--	515	--	5.9	--	--	--
	--	--	504	--	7.2	--	--	--
	--	--	544	--	6.8	--	--	--
	--	--	446	--	8.1	--	--	--
	--	--	595	--	9.3	--	--	--
	--	--	614	--	0	--	--	--
	--	--	602	--	17	--	--	--
	--	--	480	--	10	--	--	--
	--	--	464	--	12	--	--	--
	--	--	458	--	5.7	--	--	--
	--	--	459	--	4.1	--	--	--
	--	--	615	--	16	--	--	--
	--	--	466	--	14	--	--	--
	--	--	484	--	9.5	--	--	--
	--	--	530	--	11	--	--	--
	--	--	419	--	5.7	--	--	--

Table 3. Water-quality data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

State well number	Barium, dissolved (µg/L)	Beryllium, dissolved (µg/L)	Boron, dissolved (µg/L)	Cadmium, dissolved (µg/L)	Chromium, dissolved (µg/L)	Cobalt, dissolved (µg/L)	Copper, dissolved (µg/L)	Iron, dissolved (µg/L)	Lead, dissolved (µg/L)
5S/1W-18P1	--	--	5,000	--	--	--	--	--	--
5S/1W-19Q1	46	0.8	1,200	< 1	5	4	< 10	13	10
5S/1W-20P2	59	< 0.5	80	< 1	< 5	< 3	< 10	19	< 10
5S/1W-30D2	--	--	1,700	--	--	--	--	--	--
	--	--	1,600	--	--	--	--	--	--
5S/1W-30E2	--	--	500	--	--	--	--	--	--
	--	--	2,000	--	--	--	--	--	--
5S/1W-30L1	--	--	60	--	--	--	--	--	--
	--	--	0	--	--	--	--	--	--
5S/1W-30M1	--	--	400	--	--	--	--	--	--
	--	--	400	--	--	--	--	--	--
	--	--	200	--	--	--	--	--	--
	--	--	500	--	--	--	--	--	--
	--	--	300	--	--	--	--	--	--
	--	--	310	--	--	--	--	--	--
	--	--	100	--	--	--	--	--	--
	--	--	350	--	--	--	--	--	--
5S/2W-14R1	--	--	100	--	--	--	--	--	--
	--	--	--	--	--	--	50	20	--
5S/2W-16F1	24	< 0.5	40	< 1	< 5	< 3	< 10	11	< 10
	< 100	--	--	< 1	< 10	--	10	110	< 5
	--	--	--	--	--	--	--	--	--
5S/2W-19N1	--	--	60	--	--	--	--	--	--
	--	--	90	--	--	--	--	--	--
	--	--	40	--	--	--	--	--	--
	--	--	40	--	--	--	--	--	--
	--	--	0	--	--	--	--	--	--
	--	--	50	--	--	--	--	--	--
	--	--	240	--	--	--	--	--	--
	--	--	150	--	--	--	--	--	--
	--	--	180	--	--	--	--	--	--
	--	--	40	--	--	--	--	--	--
	--	--	0	--	--	--	--	--	--
	--	--	0	--	--	--	--	--	--
	--	--	60	--	--	--	--	--	--
	--	--	20	--	--	--	--	--	--
	--	--	30	--	--	--	--	--	--
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	--	--	30	--	--	--	--	--	--
	--	--	90	--	--	--	--	--	--
	--	--	300	--	--	--	--	--	--
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	--	--	30	--	--	--	--	--	--
	--	--	20	--	--	--	--	--	--
	--	--	20	--	--	--	--	--	--
	--	--	100	--	--	--	--	--	--

Table 3. Water-quality data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

State well number	Lithium, dissolved (µg/L)	Manganese, dissolved (µg/L)	Molybdenum, dissolved (µg/L)	Nickel, dissolved (µg/L)	Selenium, dissolved (µg/L)	Silver, dissolved (µg/L)	Strontium, dissolved (µg/L)	Vanadium, dissolved (µg/L)	Zinc, dissolved (µg/L)
5S/1W-18P1	--	--	--	--	--	--	--	--	--
5S/1W-19Q1	20	2	20	< 10	4	2	780	16	14
5S/1W-20P2	10	18	20	< 10	3	< 1	470	11	29
5S/1W-30D2	--	--	--	--	5	--	--	--	--
	--	--	--	--	--	--	--	--	--
5S/1W-30E2	--	--	--	--	10	--	--	--	--
	--	--	--	--	--	--	--	--	--
5S/1W-30L1	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--
5S/1W-30M1	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--
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	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--
5S/2W-14R1	--	--	--	--	--	--	--	--	--
	--	< 10	--	--	--	--	--	--	540
5S/2W-16F1	30	1	< 10	< 10	14	< 1	210	< 6	580
	--	< 10	--	--	13	< 10	--	--	130
	--	--	--	--	--	--	--	--	--
5S/2W-19N1	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--
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Table 3. Water-quality data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

State well number	Dueterium (ratio per mil)	Oxygen-18 (ratio per mil)	Source of data
5S/1W-18P1	--	--	EMWD
5S/1W-19Q1	--	--	USGS
5S/1W-20P2			
5S/1W-30D2	--	--	BABCOCK
	--	--	EMWD
5S/1W-30E2	--	--	BABCOCK
	--	--	USGS
5S/1W-30L1	--	--	RCFC&WCD
	--	--	RCFC&WCD
5S/1W-30M1	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
5S/2W-14R1	--	--	EMWD
	--	--	BABCOCK
5S/2W-16F1	--	--	USGS
	--	--	BABCOCK
	--	--	EMWD
5S/2W-19N1	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
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	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD

Table 3. Water-quality data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

State well number	Date	Water level (ft blw LSD)	Well depth (ft)	Altitude of LSD (ft)	Specific conductance (µS/cm)	pH (standard units)	Water temperature (°C)	Hardness (mg/L as CaO_3)
	9/27/63	--			698	7.0	23.5	160
	5/28/63	--			611	7.0	21.0	170
	3/14/63	--			660	6.7	--	160
	9/25/62	--			668	7.0	22.0	170
	10/5/61	--			658	7.9	--	140
	4/13/61	--			671	8.1	21.0	190
	9/14/60	--			657	8.2	23.5	180
	3/25/60	--			796	6.9	22.0	210
	9/16/59	--			635	7.0	22.0	160
	4/23/59	--			786	8.3	21.0	210
	10/14/58	--			738	7.7	29.0	180
	5/8/58	--			721	7.2	23.5	190
	9/18/57	--			781	8.0	22.0	230
	5/8/57	--			724	7.0	20.5	180
	9/18/56	--			1,060	--	22.0	320
	5/10/56	--			807	--	19.0	200
	8/10/55	--			997	7.1	22.0	290
	12/16/54	--			867	7.2	--	--
	12/18/53	--			888	7.2	--	--
5S/2W-21M1	6/9/93	--	260	1,480	2,150	6.8	24.0	860
5S/2W-21M2	1/21/94	--	260	1,490	3,690	6.5	22.0	1,700
	6/9/93	26.21			3,980	6.3	23.0	1,700
5S/2W-22E1	7/22/93	--	200	1,640	950	6.6	21.0	270
5S/2W-23E1	6/23/94	--	140	1,500	1,530	7.8	21.0	260
	1/20/94	--			1,550	7.8	22.0	270
	6/24/93	--			1,580	7.4	22.5	260
5S/2W-23J1	1/26/72	--	--	--	8,700	7.7	--	1,500
5S/2W-23K1	6/16/83	--	--	--	7,000	7.7	--	--
5S/2W-23L1	6/21/94	--	120	1,500	3,080	8.0	22.0	170
	1/20/94	--			3,020	8.1	21.5	150
	6/8/93	--			3,110	8.0	22.0	160
5S/2W-23P1	6/8/93	--	140	1,490	5,490	7.4	22.0	1,300
	7/12/89	--	160	--	9,200	--	--	1,800
5S/2W-23P2	7/12/89	--	130	--	6,200	7.9	--	1,500
5S/2W-23Q1	6/9/86	--	--	--	4,650	7.6	--	980
5S/2W-23R1	7/2/73	--	--	--	2,885	7.7	--	--
5S/2W-23R2	10/28/86	--	--	--	1,650	--	--	--
5S/2W-24B1	7/22/93	--	200	1,495	3,290	7.9	22.0	530
5S/2W-24C2	2/26/92	41.17	160	1,500	5,220	7.6	21.5	820
	4/30/91	--			5,270	7.7	21.5	960
5S/2W-25C1	6/23/94	--	235	1,495	2,060	7.5	21.5	580
	3/20/92	57.84			1,930	7.6	19.5	550
	5/10/91	59.61			2,030	7.6	20.0	590
	6/16/77	--			1,820	7.5	--	500
	5/16/68	--			1,620	8.1	--	410
	5/4/65	--			1,480	7.9	21.0	330
5S/2W-25E1	8/9/83	--	116	--	1,800	7.7	--	540
	3/13/63	--			2,660	7.9	--	760
	9/3/59	--			1,770	6.8	--	530
5S/2W-25J1	6/14/94	--	525	1,498	1,840	7.7	23.0	430
	6/24/93	--			1,790	7.3	23.5	430
	11/25/91	--			1,810	--	--	--
5S/2W-25P3	11/3/94	44.52	640	1,490	1,090	7.5	18.5	190
	6/13/94	--			900	7.4	23.5	110
5S/2W-25P4	11/3/94	45.10	460	1,490	930	7.5	21.0	42
	6/14/94	--			950	7.3	22.5	45
5S/2W-25P5	11/4/94	43.64	236	1,490	3,040	7.1	21.0	1,200

Table 3. Water-quality data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

State well number	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Alkalinity (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)
	48	10	58	2.0	--	28	120	0.2
	57	7.0	60	4.0	--	28	110	0.2
	50	10	70	2.3	--	40	110	0.2
	57	7.0	62	3.0	--	36	120	0.1
	50	4.0	55	6.0	--	35	89	0.3
	61	9.0	60	6.0	--	50	99	0.0
	54	12	64	4.0	--	60	99	0.1
	61	13	70	6.0	--	40	110	0
	47	10	58	--	--	30	100	0
	62	13	69	--	--	50	130	--
	52	13	64	--	--	30	110	0
	55	13	60	--	--	40	120	--
	60	19	72	--	--	55	150	0.2
	54	12	63	--	--	40	120	0.2
	86	26	95	--	--	78	220	--
	56	14	68	--	--	56	120	0.1
	82	20	84	3.5	--	65	200	0.1
	73	16	72	3.2	--	56	140	0.0
	77	15	76	4.0	--	53	150	0.3
5S/2W-21M1	190	93	120	--	640	140*	190*	--
5S/2W-21M2	370	180	140	18	360	350*	540*	< 2.5*
	380	190	140	--	400	360*	570*	--
5S/2W-22E1	32	46	64	13	54	250*	110*	--
5S/2W-23E1	66	22	210	2.1	170	190*	240*	< 0.2*
	70	22	210	2.3	170	200*	260*	--
	67	23	230	--	180	210*	240*	--
5S/2W-23J1	280	200	1,300	10	--	660	2,020	0.9
5S/2W-23K1	--	--	--	--	--	--	--	--
5S/2W-23L1	38	17	630	2.7	340	580*	400*	< 2.5*
	35	15	580	2.6	310	570*	400*	< 2.5*
	36	16	590	--	300	600*	390*	< 2.0*
5S/2W-23P1	350	100	630	--	240	1,100*	1,050*	< 2.0*
	--	--	--	--	--	--	--	--
5S/2W-23P2	--	--	--	--	--	--	--	--
5S/2W-23Q1	280	79	600	8.5	--	970	790	0.5
5S/2W-23R1	--	--	340	9.0	--	--	560	0.2
5S/2W-23R2	--	--	--	--	--	--	--	0.4
5S/2W-24B1	180	18	500	8.7	88	360*	740*	0.6*
5S/2W-24C2	240	52	830	--	230	1,300	880	0.7
	280	63	860	--	240	1,700	1,000	0.6
5S/2W-25C1	170	37	180	5.9	120	320*	400*	< 1.3*
	160	36	160	--	120	260	360	0.1
	170	39	190	--	120	270	430	0.2
	160	22	170	10	88	310	310	--
	120	25	160	5.8	87	240	300	0.3
	100	42	170	7.0	--	270	300	0.1
5S/2W-25E1	160	36	170	6.0	--	340	280	0.3
	250	35	260	8.2	--	370	570	0.5
	150	39	150	6.0	--	170	410	0.4
5S/2W-25J1	130	25	200	7.0	110	260*	350*	0.3*
	130	25	200	--	120	240*	330*	< 2.0*
	--	--	--	--	--	--	--	--
5S/2W-25P3	51	14	160	6.2	310	--	--	--
	30	9.0	160	5.6	320	6.0*	43*	< 0.2*
5S/2W-25P4	8.8	4.7	170	3.9	120	--	--	--
	7.4	6.3	190	3.4	240	18*	180*	< 0.2*
5S/2W-25P5	350	77	210	10	150	--	--	--

Table 3. Water-quality data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

State well number	Bromide, dissolved (mg/L)	Silica, dissolved (mg/L as SiO_2)	Dissolved solids (mg/L)	Nitrite, dissolved (mg/L as N)	Nitrite + nitrate, dissolved (mg/L as N)	Ammonia, dissolved (mg/L as N)	Phosphorus, ortho (mg/L as P)	Arsenic, dissolved (µg/L)
	--	--	389	--	2.7	--	--	--
	--	--	428	--	7.2	--	--	--
	--	55	490	--	5.9	--	--	--
	--	--	420	--	3.4	--	--	--
	--	--	394	--	3.6	--	--	--
	--	--	402	--	4.7	--	--	--
	--	--	394	--	4.5	--	--	--
	--	--	482	--	8.1	--	--	--
	--	--	379	--	2.0	--	--	--
	--	--	476	--	2.7	--	--	--
	--	--	445	--	4.5	--	--	--
	--	--	434	--	4.1	--	--	--
	--	--	473	--	2.0	--	--	--
	--	--	436	--	2.0	--	--	--
	--	--	--	--	2.0	--	--	--
	--	--	--	--	2.5	--	--	--
	--	--	759	--	4.8	--	--	--
	--	--	574	--	6.6	--	--	--
	--	--	596	--	4.2	--	--	--
5S/2W-21M1	--	58	--	--	35*	--	--	--
5S/2W-21M2	< 2.5*	59	--	0.40	140	0.08	0.11	7
	--	59	--	--	140*	--	--	--
5S/2W-22E1	--	68	--	< 0.01	2.2	0.03	< 0.01	< 1
5S/2W-23E1	--	53	--	< 0.01	7.4	< 0.01	0.03	1
	--	50	--	0.04	7.5	0.02	0.03	2
	--	54	--	--	--	--	--	--
5S/2W-23J1	--	--	6,880	--	2.3	0	--	--
5S/2W-23K1	--	--	3,950	--	8.8	--	--	--
5S/2W-23L1	--	45	--	< 0.01	10	< 0.01	0.15	10
	< 2.5*	42	--	0.04	10	0.02	0.15	10
	< 2.0*	44	--	--	--	--	--	--
5S/2W-23P1	< 2.0*	44	--	--	4.0*	--	--	--
	--	--	--	--	1.6	--	--	--
5S/2W-23P2	--	--	--	--	5.1	--	--	--
5S/2W-23Q1	--	--	3,200	--	0.3	0	--	--
5S/2W-23R1	--	--	2,020	--	0.2	0	--	--
5S/2W-23R2	--	--	--	--	5.8	--	--	--
5S/2W-24B1	< 0.2*	23	--	< 0.01	1.6	0.02	< 0.01	< 1
5S/2W-24C2	1.9	30	3,500	< 0.01	2.1	0.02	< 0.01	--
	0.2	32	3,860	< 0.01	2.1	< 0.01	0.02	--
5S/2W-25C1	--	42	--	< 0.01	5.2	< 0.01	0.01	< 1
	1.0	42	1,240	< 0.01	5.5	< 0.01	< 0.01	--
	1.2	48	1,300	< 0.01	5.1	0.02	< 0.01	--
	--	38	1,230	--	5.4	0	0.1	--
	--	--	1,050	--	3.4	--	--	--
	--	--	980	--	2.7	--	--	--
5S/2W-25E1	--	--	1,210	--	4.3	--	--	--
	--	34	1,840	--	2.3	--	--	--
	--	37	1,150	--	1.8	--	--	--
5S/2W-25J1	--	31	--	< 0.01	3.9	0.02	0.01	< 1
	--	35	--	--	3.0*	--	--	--
	--	--	1,130	--	4.3	--	--	--
5S/2W-25P3	--	31	--	< 0.01	17	0.62	0.06	6
	< 0.2*	30	--	< 0.01	< 0.05	0.04	0.96	2
5S/2W-25P4	--	15	--	< 0.01	0.06	< 0.02	< 0.01	22
	< 0.2*	37	--	0.04	0.15	0.05	1.0	11
5S/2W-25P5	--	37	--	< 0.01	20	0.02	3.7	2

Table 3. Water-quality data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

State well number	Barium, dissolved (µg/L)	Beryllium, dissolved (µg/L)	Boron, dissolved (µg/L)	Cadmium, dissolved (µg/L)	Chromium, dissolved (µg/L)	Cobalt, dissolved (µg/L)	Copper, dissolved (µg/L)	Iron, dissolved (µg/L)	Lead, dissolved (µg/L)
	--	--	100	--	--	--	--	--	--
	--	--	100	--	--	--	--	--	--
	--	--	60	--	--	--	--	--	--
	--	--	100	--	--	--	--	--	--
	--	--	200	--	--	--	--	--	--
	--	--	200	--	--	--	--	--	--
	--	--	100	--	--	--	--	--	--
	--	--	100	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--
	--	--	90	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--
	--	--	200	--	--	--	--	--	--
	--	--	180	--	--	--	--	--	--
	--	--	0	--	--	--	--	--	--
	--	--	150	--	--	--	--	--	--
	--	--	160	--	--	--	--	--	--
5S/2W-21M1	150	3.8	--	3	< 15	< 9	< 30	13	< 30
5S/2W-21M2	170	< 1.5	230	< 3	< 15	< 9	< 30	24	< 30
	190	3.4	--	< 3	< 15	< 9	< 30	18	< 30
5S/2W-22E1	13	< 0.5	100	< 1	< 5	< 3	< 10	26	< 10
5S/2W-23E1	21	< 0.5	1,400	3	< 5	< 3	< 10	< 3	30
	20	< 0.5	1,400	< 1	< 5	< 3	< 10	4	< 10
	20	0.6	--	< 1	< 5	< 3	< 10	< 3	< 10
5S/2W-23J1	--	--	7,400	--	--	--	--	--	--
5S/2W-23K1	--	--	4,700	--	--	--	--	--	--
5S/2W-23L1	23	< 1.5	7,600	10	< 15	< 9	< 30	< 9	30
	20	< 1.5	7,000	4	< 15	< 9	< 30	< 9	< 30
	22	3.1	--	< 3	< 15	< 9	< 30	42	< 30
5S/2W-23P1	37	3.5	--	< 3	17	< 9	< 30	52	50
	--	--	5,700	--	--	--	--	--	--
5S/2W-23P2	--	--	4,600	--	--	--	--	--	--
5S/2W-23Q1	--	--	3,400	--	--	--	--	--	--
5S/2W-23R1	--	--	1,100	--	--	--	--	--	--
5S/2W-23R2	--	--	600	--	--	--	--	--	--
5S/2W-24B1	69	< 1.5	6,800	< 3	200	< 9	< 30	310	< 30
5S/2W-24C2	9	< 1.5	8,400	< 3	< 15	< 9	< 30	37	< 30
	24	< 0.5	8,000	< 1	< 5	< 3	< 10	12	< 10
5S/2W-25C1	35	< 1.5	1,000	< 3	21	< 9	< 30	20	< 30
	35	0.6	790	< 1	< 5	< 3	< 10	13	< 10
	37	< 0.5	170	< 1	< 5	< 3	< 10	38	< 10
	--	--	800	--	--	--	--	70	--
	--	--	1,500	--	--	--	--	--	--
	--	--	950	--	--	--	--	--	--
5S/2W-25E1	--	--	900	--	--	--	--	--	--
	--	--	1,950	--	--	--	--	--	--
	--	--	240	--	--	--	--	--	--
5S/2W-25J1	49	< 0.5	2,200	< 1	< 5	< 3	< 10	5	< 10
	46	< 0.5	--	< 1	< 5	< 3	< 10	< 3	< 10
	--	--	2,100	--	--	--	--	--	--
5S/2W-25P3	66	0.8	580	< 1	< 5	< 3	< 10	< 3	< 10
	51	< 0.5	650	1	< 5	< 3	< 10	45	< 10
5S/2W-25P4	15	1.4	1,500	< 1	< 5	< 3	< 10	19	< 10
	28	2.2	1,600	< 1	< 5	12	< 10	2,300	< 10
5S/2W-25P5	77	2.4	510	< 3	< 15	< 9	< 30	< 9	< 30

Table 3. Water-quality data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

State well number	Lithium, dissolved (µg/L)	Manganese, dissolved (µg/L)	Molybdenum, dissolved (µg/L)	Nickel, dissolved (µg/L)	Selenium, dissolved (µg/L)	Silver, dissolved (µg/L)	Strontium, dissolved (µg/L)	Vanadium, dissolved (µg/L)	Zinc, dissolved (µg/L)
	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--
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	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--
5S/2W-21M1	110	< 3	< 30	< 30	--	< 3	850	24	250
5S/2W-21M2	170	220	< 30	< 30	< 1	< 3	1,400	19	230
	160	320	40	< 30	--	< 3	1,700	< 18	540
5S/2W-22E1	200	30	10	40	16	< 1	180	< 6	9,800
5S/2W-23E1	< 4	< 1	< 10	< 10	--	3	360	38	9
	< 4	< 1	< 10	< 10	5	< 1	350	36	18
	< 4	< 1	< 10	< 10	--	< 1	380	38	14
5S/2W-23J1	--	--	--	--	--	--	--	--	--
5S/2W-23K1	--	--	--	--	--	--	--	--	--
5S/2W-23L1	< 12	< 3	180	< 30	--	8	450	49	25
	< 12	< 3	120	< 30	10	< 3	420	43	17
	< 12	< 3	140	< 30	--	< 3	460	44	34
5S/2W-23P1	< 12	< 3	40	< 30	--	5	4,200	22	< 9
	--	--	--	--	--	--	--	--	--
5S/2W-23P2	--	--	--	--	--	--	--	--	--
5S/2W-23Q1	--	--	--	--	--	--	--	--	--
5S/2W-23R1	--	--	--	--	--	--	--	--	--
5S/2W-23R2	--	--	--	--	--	--	--	--	--
5S/2W-24B1	30	23	< 30	40	56	< 3	1,300	19	100
5S/2W-24C2	50	< 3	< 30	< 30	14	< 3	1,400	21	36
	30	8	20	< 10	8	< 1	1,600	14	75
5S/2W-25C1	30	< 3	< 30	< 30	--	3	1,300	18	61
	30	6	< 10	< 10	8	< 1	1,200	7	150
	30	3	< 10	< 10	8	< 1	1,300	10	140
	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--
5S/2W-25E1	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--
5S/2W-25J1	20	< 1	< 10	< 10	--	< 1	930	14	9
	20	< 1	< 10	< 10	--	< 1	890	13	21
	--	--	--	--	< 5	--	--	--	--
5S/2W-25P3	30	99	120	< 10	--	< 1	450	< 6	< 3
	30	120	10	< 10	--	1	360	< 6	7
5S/2W-25P4	20	90	< 10	< 10	--	< 1	180	45	< 3
	20	270	< 10	< 10	--	< 1	150	24	14
5S/2W-25P5	30	9	< 30	< 30	--	< 3	2,100	< 18	24

Table 3. Water-quality data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

State well number	Dueterium (ratio per mil)	Oxygen-18 (ratio per mil)	Source of data
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
5S/2W-21M1	--	--	USGS
5S/2W-21M2	--	--	USGS
	--	--	USGS
5S/2W-22E1	--	--	USGS
5S/2W-23E1	-51.6	-7.00	USGS
	--	--	USGS
	--	--	USGS
5S/2W-23J1	--	--	EMWD
5S/2W-23K1	--	--	EMWD
5S/2W-23L1	-50.5	-6.90	USGS
	--	--	USGS
	--	--	USGS
5S/2W-23P1	--	--	USGS
	--	--	EMWD
5S/2W-23P2	--	--	EMWD
5S/2W-23Q1	--	--	EMWD
5S/2W-23R1	--	--	EMWD
5S/2W-23R2	--	--	EMWD
5S/2W-24B1	--	--	USGS
5S/2W-24C2	--	--	USGS
	--	--	USGS
5S/2W-25C1	--	--	USGS
	--	--	USGS
	--	--	USGS
	--	--	BABCOCK
	--	--	RCFC&WCD
	--	--	RCFC&WCD
5S/2W-25E1	--	--	EMWD
	--	--	RCFC&WCD
	--	--	RCFC&WCD
5S/2W-25J1	-55.8	-7.51	USGS
	--	--	USGS
	--	--	BABCOCK
5S/2W-25P3	--	--	USGS
	-62.6	-8.76	USGS
5S/2W-25P4	--	--	USGS
	-62.0	-8.57	USGS
5S/2W-25P5	--	--	USGS

Table 3. Water-quality data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

State well number	Date	Water level (ft blw LSD)	Well depth (ft)	Altitude of LSD (ft)	Specific conductance (µS/cm)	pH (standard units)	Water temperature (°C)	Hardness (mg/L as CaO_3)
	6/14/94	--			3,170	7.3	22.0	1,200
5S/2W-25P6	11/3/94	39.85	158	1,490	2,320	7.1	19.0	940
	6/14/94	--			2,360	7.1	21.5	940
5S/2W-25P7	11/2/94	--	82	1,490	4,560	7.2	18.0	2,200
	6/14/94	--			5,000	7.2	23.0	2,600
5S/2W-26B1	7/6/87	--	--	--	4,100	--	--	1,200
5S/2W-26G1	6/26/63	--	245	1,485	5,920	7.7	--	2,700
5S/2W-26G2	6/18/57	--	--	--	3,700	--	--	1,400
5S/2W-26H2	11/7/63	--	120	1,488	3,650	8.0	26.0	1,200
5S/2W-26H3	11/3/64	--	--	--	2,570	7.3	--	840
5S/2W-26H5	6/17/94	--	143	1,485	3,160	7.4	22.5	1,100
5S/2W-26H6	6/17/94	--	79	1,485	2,310	7.4	21.5	690
5S/2W-26L1	5/29/63	--	--	--	10,896	7.6	--	4,600
	3/14/63	--			11,230	7.3	--	4,300
5S/2W-26N1	2/24/67	--	--	--	2,380	--	--	--
5S/2W-26P1	2/21/92	33.12	300	1,477	4,820	7.1	20.5	1,700
	6/21/91	34.13			4,740	7.0	21.0	1,800
5S/2W-27N1	1/20/94	--	58	1,491	6,630	6.1	21.0	1,600
	6/8/93	--			6,780	6.0	21.5	1,500
	1/15/88	--			8,100	--	--	--
5S/2W-28E1	7/13/94	--	400	1,459	14,800	6.5	22.5	1,600
5S/2W-29L2	8/11/95	--	85	1,458	9,550	6.6	21.0	2,000
	6/9/95	14.35			9,450	6.5	21.0	2,000
5S/2W-29L3	8/14/95	9.85	196	1,455	7,270	6.2	21.5	1,900
	6/26/95	11.00			7,110	6.1	21.5	2,000
5S/2W-29N1	7/12/95	6.83	114	1,450	5,320	6.1	22.5	1,700
	6/24/94	9.88			5,200	6.0	22.0	1,700
	1/20/94	8.48			5,050	6.0	21.5	1,700
	6/7/93	6.40			6,070	6.2	20.0	1,700
5S/2W-30C1	7/28/95	12.00	356	1,452	3,370	7.1	23.0	1,100
5S/2W-30D2	8/18/95	--	355	1,455	4,200	6.2	--	1,600
	7/19/95	--			4,440	6.3	22.5	1,900
	6/17/94	--			4,450	6.2	22.5	1,600
	1/20/94	--			4,400	6.3	22.5	1,600
	6/25/93	--			4,330	6.0	22.5	1,500
	11/25/91	--			4,210	7.9	--	1,230
5S/2W-30G2	7/7/95	6.95	70	1,447	6,550	6.6	21.5	1,600
5S/2W-30G3	8/2/95	10.30	71	1,449	3,660	6.7	20.5	1,100
5S/2W-30H2	7/6/95	10.90	70	1,460	9,430	6.3	22.0	2,200
5S/2W-30J1	4/6/75	--	--	--	7,800	6.8	--	1,400
5S/2W-33E1	2/26/81	--	--	--	1,900	7.1	--	500
5S/2W-34P1	5/12/53	--	10	1,472	1,080	7.2	--	360
5S/2W-34P2	7/21/93	--	200	1,478	1,450	7.2	21.0	390
5S/2W-35A1	1/20/94	--	260	1,480	4,600	6.5	20.0	2,100
	7/26/93	--			3,970	6.4	20.0	1,800
	7/21/93	25.70			4,030	6.4	21.0	1,800
	11/18/91	--			3,700	--	--	1,400
5S/2W-35B1	7/21/93	13.44	168	1,480	4,050	6.9	19.0	1,400
	8/20/69	--			1,260	6.5	--	430
5S/2W-35D2	7/22/93	--	32	1,476	3,560	7.3	20.0	640
5S/2W-36D4	7/22/93	--	235	1,487	1,200	7.5	20.5	340
5S/2W-36D5	7/26/93	--	32	1,485	1,160	7.1	20.5	360
5S/2W-36D6	7/26/93	--	282	1,485	1,750	6.7	20.5	630
5S/3W-13A1	8/29/95	--	431	1,522	910	7.6	--	270
	11/18/93	--			890	7.6	22.0	270
	5/11/81	--			625	7.9	23.5	190
	9/17/77	--			600	7.6	23.5	180

Table 3. Water-quality data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

State well number	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Alkalinity (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)
	360	80	220	10	160	1,400*	500*	< 2.5*
5S/2W-25P6	280	57	140	7.9	170	--	--	--
	280	59	150	8.5	170	620*	340*	< 2.5*
5S/2W-25P7	660	140	270	9.7	230	--	--	--
	760	170	310	10	--	1,800*	720*	< 2.5*
5S/2W-26B1	330	90	460	14	--	780	--	--
5S/2W-26G1	710	220	340	11	--	900	1,780	0.2
5S/2W-26G2	330	150	250	--	--	610	860	--
5S/2W-26H2	410	48	320	10	--	560	880	0.1
5S/2W-26H3	240	57	210	7.0	--	300	630	0.5
5S/2W-26H5	320	65	240	9.4	110	520*	660*	< 2.5*
5S/2W-26H6	200	47	190	7.6	120	300*	460*	< 2.5*
5S/2W-26L1	1,200	380	800	3.0	--	2,000	3,140	0.3
	1,100	390	1,200	18	--	2,300	3,040	0.9
5S/2W-26N1	120	38	360	--	--	--	730	--
5S/2W-26P1	510	100	400	--	320	810	1,100	0.2
	540	110	420	--	330	820	1,100	0.2
5S/2W-27N1	410	150	940	9.1	350	1,100*	1,490*	--
	370	140	950	--	340	1,100*	1,460*	--
	--	170	--	--	--	1,100	--	--
5S/2W-28E1	490	92	890	31	430	930	4,800	< 0.1
5S/2W-29L2	390	240	1,500	5.6	410	1,300	2,400	0.2
	380	250	1,500	--	380	1,300	2,300	0.2
5S/2W-29L3	410	220	870	9.3	370	840	1,900	0.2
	430	220	870	9.0	360	830	1,800	0.3
5S/2W-29N1	440	150	510	9.7	150	950	1,200	0.1
	440	150	480	9.9	160	930*	1,160*	< 2.5*
	430	140	440	9.6	160	920*	1,160*	--
	380	180	1,300	--	210	1,500*	1,110*	--
5S/2W-30C1	290	94	220	5.8	120	260	830	0.3
5S/2W-30D2	420	130	300	8.0	180	300	1,400	0.2
	530	140	200	7.7	170	950	790	0.1
	410	130	290	8.6	170	280*	1,190*	--
	430	120	280	7.4	160	290*	1,210*	--
	410	120	290	--	170	280*	1,130*	--
	390	61	270	8.0	160	280	1,100	--
5S/2W-30G2	410	140	900	6.5	120	1,200	1,400	0.2
5S/2W-30G3	290	91	360	4.5	160	600	730	0.3
5S/2W-30H2	550	210	1,300	7.9	120	1,200	2,500	0.2
5S/2W-30J1	330	140	820	8.0	--	710	1,630	0.3
5S/2W-33E1	120	47	200	2.5	--	150	440	0.5
5S/2W-34P1	89	33	81	--	120	47	230	< 2.0
5S/2W-34P2	100	33	130	10	160	220*	190*	0.3
5S/2W-35A1	570	160	310	10	310	1,200*	810*	
	490	140	280	10	340	1,000*	630*	--
	490	140	270	10	340	960*	670*	--
	400	110	260	14	--	--	--	--
5S/2W-35B1	330	130	400	7.8	330	1,100*	630*	< 2.0*
	120	52	100	8.0	--	170	160	--
5S/2W-35D2	170	52	550	6.6	310	780	480	0.4
5S/2W-36D4	51	52	120	3.5	150	280	130	0.2
5S/2W-36D5	76	40	110	4.6	130	200*	130*	--
5S/2W-36D6	160	55	130	6.6	150	410*	260*	--
5S/3W-13A1	72	22	70	5.0	180	50	100	0.5
	70	23	72	5.3	180	55*	130*	--
	48	16	62	4.5	--	26	79	0.7
	47	16	59	4.5	--	27	73	0.6

Table 3. Water-quality data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

State well number	Bromide, dissolved (mg/L)	Silica, dissolved (mg/L as SiO_2)	Dissolved solids (mg/L)	Nitrite, dissolved (mg/L as N)	Nitrite + nitrate, dissolved (mg/L as N)	Ammonia, dissolved (mg/L as N)	Phosphorus, ortho (mg/L as P)	Arsenic, dissolved (µg/L)
	--	36	--	< 0.01	6.7	0.06	0.32	2
5S/2W-25P6	--	42	--	< 0.01	10	0.80	0.03	1
	< 2.5*	40	--	< 0.01	4.2	0.05	0.54	3
5S/2W-25P7	--	45	--	< 0.01	0.09	0.02	< 0.01	4
	< 2.5*	46	--	0.02	9	0.12	0.24	2
5S/2W-26B1	--	--	3,000	--	4.8	--	--	--
5S/2W-26G1	--	--	4,130	--	0.5	--	--	--
5S/2W-26G2	--	41	2,380	--	--	--	--	--
5S/2W-26H2	--	32	2,920	--	1.4	--	--	--
5S/2W-26H3	--	12	1,650	--	1.1	--	--	--
5S/2W-26H5	< 2.5*	37	--	0.02	5.8	0.04	0.29	< 1
5S/2W-26H6	< 2.5*	45	--	< 0.01	11	0.02	0.60	2
5S/2W-26L1	--	--	7,640	--	0.7	--	--	--
	--	--	10,300	--	4.1	--	--	--
5S/2W-26N1	--	--	--	--	--	--	--	--
5S/2W-26P1	2.3	35	3,260	< 0.01	3.3	0.03	< 0.01	--
	2.5	38	3,550	< 0.01	3.2	0.04	< 0.01	--
5S/2W-27N1	--	--	--	0.03	6.4	0.06	0.02	< 1
	--	--	--	--	--	--	--	--
	--	--	6,440	--	3.4	--	--	--
5S/2W-28E1	9.4	57	--	< 0.01	2.2	0.26	0.22	3
5S/2W-29L2	4.5	64	6,440	< 0.01	1.8	0.06	0.04	< 1
	0.5	64	--	< 0.01	1.7	0.09	0.04	< 1
5S/2W-29L3	3.6	56	4,620	0.05	1.3	0.12	< 0.01	< 1
	3.6	57	--	0.04	1.5	0.11	< 0.01	< 1
5S/2W-29N1	2.6	60	3,850	< 0.01	16	0.12	0.06	1
	--	58	--	< 0.01	13	0.03	0.04	1
	--	54	--	0.03	12	0.06	0.04	1
	--	--	--	--	--	--	--	--
5S/2W-30C1	1.6	48	2,290	< 0.01	6.6	0.03	0.06	3
5S/2W-30D2	--	--	3,000	< 0.40	14	< 0.40	--	--
	1.6	63	3,330	< 0.01	13	0.08	0.07	1
	1.4*	59	--	< 0.01	12	0.06	0.07	1
	< 2.0*	63	--	0.03	12	0.06	0.06	1
	< 2.0*	66	--	--	--	--	--	--
	--	69	3,280	--	12	--	--	--
5S/2W-30G2	2.7	60	4,570	< 0.01	13	0.08	0.09	1
5S/2W-30G3	1.3	56	2,320	< 0.01	3.3	0.02	0.13	3
5S/2W-30H2	4.6	60	6,430	< 0.01	13	0.11	0.48	3
5S/2W-30J1	--	--	4,220	--	6.1	< 1	--	--
5S/2W-33E1	--	--	1,240	--	9.6	--	--	--
5S/2W-34P1	--	35	1,080	--	--	--	--	--
5S/2W-34P2	< 0.2*	31	1,120	< 0.01	12	0.03	0.10	< 1
5S/2W-35A1	< 2.0*	51	--	0.02	15	0.07	0.02	1
	< 2.0*	55	--	< 0.01	10	0.06	0.01	< 1
	< 2.0*	55	--	--	--	--	--	< 1
	--	51	2,630	--	6.8	--	--	--
5S/2W-35B1	--	53	--	--	17*	--	--	4
	--	--	850	--	2.0	--	--	--
5S/2W-35D2	0.8	41	--	< 0.01	2.0	0.03	0.04	3
5S/2W-36D4	0.3	51	--	< 0.01	1.8	0.02	0.09	7
5S/2W-36D5	< 0.2*	52	--	< 0.01	2.0	0.02	0.04	4
5S/2W-36D6	< 0.2*	52	--	< 0.01	2.1	0.02	0.03	1
5S/3W-13A1	--	--	550	< 0.40	11	< 0.4	--	--
	--	46	--	< 0.01	13	0.04	0.02	4
	--	--	395	--	7.5	--	--	--
	--	--	400	--	5.6	--	--	--

Table 3. Water-quality data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

State well number	Barium, dissolved (µg/L)	Beryllium, dissolved (µg/L)	Boron, dissolved (µg/L)	Cadmium, dissolved (µg/L)	Chromium, dissolved (µg/L)	Cobalt, dissolved (µg/L)	Copper, dissolved (µg/L)	Iron, dissolved (µg/L)	Lead, dissolved (µg/L)
	84	< 1.5	490	< 3	< 15	< 9	< 30	< 9	< 30
5S/2W-25P6	56	2.6	130	< 3	< 15	< 9	< 30	< 9	< 30
	86	< 1.5	140	< 3	< 15	< 9	< 30	< 9	< 30
5S/2W-25P7	77	2.4	70	< 3	< 15	< 9	< 30	< 9	< 30
	96	< 1.5	80	< 3	< 15	< 9	< 30	< 9	< 30
5S/2W-26B1	--	--	1,700	--	--	--	--	--	--
5S/2W-26G1	--	--	900	--	--	--	--	--	--
5S/2W-26G2	--	--	600	--	--	--	--	--	--
5S/2W-26H2	--	--	880	--	--	--	--	--	--
5S/2W-26H3	--	--	600	--	--	--	--	--	--
5S/2W-26H5	75	< 1.5	990	< 3	< 15	< 9	< 30	< 9	< 30
5S/2W-26H6	61	< 1.5	870	< 3	< 15	< 9	< 30	< 9	< 30
5S/2W-26L1	--	--	1,800	--	--	--	--	--	--
	--	--	1,800	--	--	--	--	--	--
5S/2W-26N1	--	--	< 80	--	--	--	--	--	--
5S/2W-26P1	38	< 1.5	2,100	4	< 15	< 9	< 30	44	< 30
	49	< 1.5	2,200	< 3	< 15	< 9	< 30	26	< 30
5S/2W-27N1	--	--	2,500	< 1	1	< 1	4	460	< 1
	< 100	< 10	--	< 1	3	2	5	70	< 1
	--	--	--	--	--	--	--	--	--
5S/2W-28E1	400	< 10	100	< 1	4	3	< 1	100	< 1
5S/2W-29L2	< 100	< 10	1,300	< 1	2	< 1	< 1	10	< 2
	< 100	< 10	1,200	< 1	< 1	< 1	1	30	2
5S/2W-29L3	< 100	< 10	1,100	< 1	2	6	< 1	--	< 2
	100	< 10	--	< 1	1	6	< 1	--	< 1
5S/2W-29N1	20	< 1.5	1,300	< 3	< 15	< 9	< 30	< 9	< 30
	23	< 1.5	1,400	< 3	< 15	< 9	< 30	< 9	< 30
	23	< 1.5	1,300	< 3	< 15	< 9	< 30	< 9	< 30
	< 100	< 10	--	< 1	8	< 1	1	< 10	< 1
5S/2W-30C1	180	< 1.0	90	< 2	< 10	< 6	< 20	87	30
5S/2W-30D2	--	--	100	--	--	--	< 1	520	--
	36	< 1.5	250	< 3	< 15	< 9	< 30	10	70
	79	< 1.5	130	< 3	< 15	< 9	< 30	12	< 30
	74	< 1.5	130	< 3	< 15	< 9	< 30	12	< 30
	79	< 1.5	--	< 3	< 15	< 9	< 30	9	< 30
	--	--	100	--	--	--	10	150	--
5S/2W-30G2	26	< 2.0	230	< 4	< 20	< 12	< 40	< 12	< 40
5S/2W-30G3	25	< 1.0	90	< 2	< 10	< 6	< 20	< 6	< 20
5S/2W-30H2	33	< 5.0	170	20	< 50	< 30	< 100	< 30	< 100
5S/2W-30J1	--	--	700	--	--	--	--	--	--
5S/2W-33E1	--	--	300	--	--	--	--	--	--
5S/2W-34P1	46	< 0.5	--	< 1	< 5	< 3	< 10	< 3	< 10
5S/2W-34P2	49	< 0.5	2,200	< 1	< 5	< 3	< 10	5	< 10
5S/2W-35A1	48	< 1.5	390	< 3	< 15	< 9	< 30	67	< 30
	51	< 1.5	500	< 3	< 15	< 9	< 30	52	< 30
	50	< 1.5	460	< 3	15	< 9	< 30	71	< 30
	--	--	500	--	--	--	--	--	--
5S/2W-35B1	46	< 1.5	920	< 3	< 15	< 9	< 30	16	40
	--	--	100	--	--	--	--	--	--
5S/2W-35D2	23	< 1.5	1,400	< 3	< 15	< 9	< 30	13	< 30
5S/2W-36D4	27	< 0.5	120	< 1	< 5	< 3	< 10	44	< 10
5S/2W-36D5	23	< 0.5	190	< 1	< 5	< 3	< 10	7	< 10
5S/2W-36D6	36	< 0.5	230	< 1	< 5	< 3	< 10	87	< 10
5S/3W-13A1	--	--	< 100	--	--	--	< 1	< 1	--
	260	< 0.5	70	< 1	< 5	< 3	< 10	< 3	< 10
	--	--	300	--	--	--	--	--	--
	--	--	200	--	--	--	--	--	--

Table 3. Water-quality data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

State well number	Lithium, dissolved (µg/L)	Manganese, dissolved (µg/L)	Molybdenum, dissolved (µg/L)	Nickel, dissolved (µg/L)	Selenium, dissolved (µg/L)	Silver, dissolved (µg/L)	Strontium, dissolved (µg/L)	Vanadium, dissolved (µg/L)	Zinc, dissolved (µg/L)
	30	60	< 30	< 30	--	< 3	2,200	< 18	10
5S/2W-25P6	< 12	< 3	< 30	< 30	--	< 3	1,600	< 18	18
	20	130	< 30	< 30	--	4	1,700	18	18
5S/2W-25P7	< 12	3	< 30	< 30	--	< 3	4,300	< 18	10
	20	45	< 30	< 30	--	< 3	5,200	< 18	< 9
5S/2W-26B1	--	--	--	--	--	--	--	--	--
5S/2W-26G1	--	--	--	--	--	--	--	--	--
5S/2W-26G2	--	--	--	--	--	--	--	--	--
5S/2W-26H2	--	--	--	--	--	--	--	--	--
5S/2W-26H3	--	--	--	--	--	--	--	--	--
5S/2W-26H5	30	55	< 30	< 30	--	< 3	2,200	< 18	< 9
5S/2W-26H6	30	10	< 30	< 30	--	4	1,600	20	17
5S/2W-26L1	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--
5S/2W-26N1	--	--	--	--	--	--	--	--	--
5S/2W-26P1	70	< 3	< 30	< 30	9	< 3	3,700	< 18	250
	60	< 3	< 30	< 30	11	< 3	3,800	< 18	150
5S/2W-27N1	30	80	1	4	6	< 1	--	37	90
	30	100	1	4	--	< 1	1,700	--	110
	--	--	--	--	--	--	--	--	--
5S/2W-28E1	190	790	6	5	--	< 1	4,100	120	180
5S/2W-29L2	30	10	9	1	--	< 1	2,700	64	< 10
	40	20	< 2	3	--	< 1	2,900	55	< 10
5S/2W-29L3	60	--	15	6	--	< 1	2,800	40	10
	60	--	7	7	--	< 1	2,900	36	20
5S/2W-29N1	70	1,200	< 30	< 30	--	< 3	2,900	< 18	10
	40	1,100	< 30	< 30	--	< 3	2,800	< 18	< 9
	40	1,100	< 30	< 30	7	< 3	2,600	21	12
	40	230	14	2	--	< 1	3,300	--	30
5S/2W-30C1	20	8	30	< 20	--	< 2	1,400	< 12	< 6
5S/2W-30D2	--	390	--	--	--	--	--	--	< 10
	40	5	< 30	< 30	--	< 3	3,400	< 18	< 9
	30	210	< 30	< 30	--	< 3	2,400	< 18	< 9
	20	150	< 30	< 30	6	< 3	2,100	< 18	29
	30	94	30	< 30	--	< 3	2,200	< 18	11
	--	< 10	--	--	< 5	--	--	--	< 10
5S/2W-30G2	40	4	< 40	< 40	--	< 4	2,200	< 24	13
5S/2W-30G3	< 8	< 2	< 20	< 20	--	< 2	1,400	< 12	11
5S/2W-30H2	50	14	< 100	< 100	--	< 10	3,100	< 60	< 30
5S/2W-30J1	--	--	--	--	--	--	--	--	--
5S/2W-33E1	--	--	--	--	--	--	--	--	--
5S/2W-34P1	20	< 1	< 10	< 10	--	< 1	930	14	9
5S/2W-34P2	30		< 10	< 10	--	1	360	< 6	7
5S/2W-35A1	30	5	< 30	< 30	20	< 3	3,100	< 18	13
	40	< 3	< 30	< 30	18	< 3	3,000	< 18	< 9
	40	< 3	< 30	< 30	18	< 3	3,000	< 18	15
	--	--	--	--	12	--	--	--	--
5S/2W-35B1	20	9	< 30	< 30	16	< 3	2,500	41	23
	--	--	--	--	--	--	--	--	--
5S/2W-35D2	20	10	40	< 30	8	< 3	1,200	< 18	< 9
5S/2W-36D4	10	10	< 10	< 10	3	< 1	200	13	8
5S/2W-36D5	20	< 1	< 10	< 10	3	< 1	400	16	< 3
5S/2W-36D6	30	27	< 10	< 10	7	< 1	890	10	8
5S/3W-13A1	--	< 1	--	--	--	--	--	--	< 0.1
	9	7	< 10	< 10	2	< 1	370	30	4
	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--

Table 3. Water-quality data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

State well number	Dueterium (ratio per mil)	Oxygen-18 (ratio per mil)	Source of data
	-57.6	-8.03	USGS
5S/2W-25P6	--	--	USGS
	-65.8	-8.63	USGS
5S/2W-25P7	--	--	USGS
	-61.8	-8.00	USGS
5S/2W-26B1	--	--	EMWD
5S/2W-26G1	--	--	RCFC&WCD
5S/2W-26G2	--	--	RCFC&WCD
5S/2W-26H2	--	--	RCFC&WCD
5S/2W-26H3	--	--	RCFC&WCD
5S/2W-26H5	-53.1	-7.49	USGS
5S/2W-26H6	-53.3	-7.52	USGS
5S/2W-26L1	--	--	RCFC&WCD
	--	--	RCFC&WCD
5S/2W-26N1	--	--	SEC
5S/2W-26P1	--	--	USGS
	--	--	USGS
5S/2W-27N1	--	--	USGS
	--	--	USGS
	--	--	EMWD
5S/2W-28E1	-53.4	-7.43	USGS
5S/2W-29L2	-52.0	-7.15	USGS
	--	--	USGS
5S/2W-29L3	-54.1	-7.39	USGS
	--	--	USGS
5S/2W-29N1	-51.9	-7.42	USGS
	-54.6	-7.44	USGS
	--	--	USGS
	--	--	USGS
5S/2W-30C1	-51.1	-7.31	USGS
5S/2W-30D2	--	--	BABCOCK
	-58.4	-7.99	USGS
	--	--	USGS
	--	--	USGS
	--	--	USGS
	--	--	BABCOCK
5S/2W-30G2	-60.4	-8.29	USGS
5S/2W-30G3	-55.7	-7.50	USGS
5S/2W-30H2	-51.4	-7.25	USGS
5S/2W-30J1	--	--	EMWD
5S/2W-33E1	--	--	EMWD
5S/2W-34P1	--	--	USGS
5S/2W-34P2	--	--	USGS
5S/2W-35A1	--	--	USGS
	--	--	USGS
	--	--	USGS
	--	--	BABCOCK
5S/2W-35B1	--	--	USGS
	--	--	BABCOCK
5S/2W-35D2	--	--	USGS
5S/2W-36D4	--	--	USGS
5S/2W-36D5	--	--	USGS
5S/2W-36D6	--	--	USGS
5S/3W-13A1	--	--	BABCOCK
	--	--	USGS
	--	--	RCFC&WCD
	--	--	RCFC&WCD

Table 3. Water-quality data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

State well number	Date	Water level (ft blw LSD)	Well depth (ft)	Altitude of LSD (ft)	Specific conductance (µS/cm)	pH (standard units)	Water temperature (°C)	Hardness (mg/L as CaO_3)
5S/3W-13H1	1/25/94	--	460	1,518	1,110	7.5	22.0	330
	11/18/93	--	460	1,518	1,160	7.4	21.5	370
5S/3W-14P1	8/10/95	--	250	1,447	1,750	6.1	22.5	610
5S/3W-24C1	8/28/95	--	505	1,480	950	7.1	--	290
	8/4/95	--			960	6.8	25.0	310
	6/24/94	--			830	7.1	24.0	250
	1/25/94	--			910	7.4	21.0	270
	11/18/93	--			920	7.4	21.0	290
5S/3W-24F2	7/21/95	76.36	691	1,475	690	8.0	24.5	70
	6/15/94	72.08			700	7.7	23.5	71
5S/3W-24F3	8/3/95	106.95	403	1,475	3,780	6.3	24.0	1,600
	6/15/94	101.29			3,790	6.4	23.5	1,400
5S/3W-24F4	7/21/95	56.75	155	1,475	1,970	6.8	35.0	650
	6/15/94	57.25			1,880	6.8	22.0	610
5S/3W-35N2	8/1/95	--	588	1,425	4,310	5.9	25.5	1,500
5S/3W-36P2	8/1/95	--	680	1,430	2,610	6.3	26.0	1,000
	7/13/94	104.71			2,580	6.2	24.0	980
6S/3W-1J2	8/15/95	--	300	1430	4,670	6.5	21.5	1,700
6S/3W-2A1	7/26/95	--	577	1425	4,910	6.3	23.5	1,700
6S/3W-2E1	7/27/95	--	651	1425	1,730	6.1	29.0	660
6S/3W-2G2	7/26/95	--	622	1428	1,750	6.9	23.0	530
Winchester Pond	6/29/95	--	--	1460	1,260	9.7	26.0	210

Table 3. Water-quality data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

State well number	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Alkalinity (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)
5S/3W-13H1	87	27	78	5.9	160	83*	180*	--
	96	31	87	6.0	180	80*	180*	--
5S/3W-14P1	170	45	100	4.1	180	68	380	0.2
5S/3W-24C1	81	22	61	5.0	120	41	180	0.2
	89	20	63	4.5	110	28	200	0.2
	72	16	56	4.0	100	27*	160*	< 0.2*
	74	21	64	4.6	140	43*	160*	--
	76	23	68	4.4	160	50*	170*	--
5S/3W-24F2	24	2.4	110	3.6	120	17	110	0.4
	24	2.7	110	3.9	120	19*	110*	< 0.2*
5S/3W-24F3	470	95	150	10	260	86	1,000	< 0.1
	430	86	170	12	230	97*	1,010*	< 2.5*
5S/3W-24F4	180	48	98	6.4	88	28	510	0.1
	170	45	99	7.1	84	30*	--	< 0.2*
5S/3W-35N2	350	150	390	13	610	500	850	0.2
5S/3W-36P2	220	120	250	10	1,400	13	95	0.3
	210	110	220	10	1,400	12	100	0.3
6S/3W-1J2	480	130	370	11	280	790	1,000	0.3
6S/3W-2A1	470	130	390	11	240	840	1,100	0.3
6S/3W-2E1	170	58	120	8.2	570	100	170	0.3
6S/3W-2G2	140	43	150	5.5	220	180	300	0.4
Winchester Pond	53	18	200	14	--	170	180	0.5

Table 3. Water-quality data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

State well number	Bromide, dissolved (mg/L)	Silica, dissolved (mg/L as SiO_2)	Dissolved solids (mg/L)	Nitrite, dissolved (mg/L as N)	Nitrite + nitrate, dissolved (mg/L as N)	Ammonia, dissolved (mg/L as N)	Phosphorus, ortho (mg/L as P)	Arsenic, dissolved (µg/L)
5S/3W-13H1	--	43	--	0.03	14	0.02	0.02	5
	--	48	--	< 0.01	13	0.02	0.02	4
5S/3W-14P1	0.9	62	1,160	< 0.01	8.5	< 0.02	0.05	1
5S/3W-24C1	--	--	750	< 0.40	6.3	< 0.40	--	--
	0.5	54	685	< 0.01	4.9	< 0.02	0.04	2
	--	49	--	< 0.01	5.0	0.02	0.05	2
	--	40	--	0.10	6.6	0.06	0.03	2
	--	43	--	< 0.01	6.6	0.03	0.03	2
5S/3W-24F2	0.4	30	395	< 0.01	5.7	< 0.02	0.16	1
	--	27	--	0.02	6.1	0.02	0.80	2
5S/3W-24F3	1.6	69	2,520	< 0.01	13	0.09	0.87	1
	--	53	--	< 0.01	15	0.06	1.0	6
5S/3W-24F4	1.2	49	1,330	< 0.01	14	0.02	1.0	1
	0.9*	45	--	< 0.01	14	0.03	1.0	4
5S/3W-35N2	1.7	73	2,960	< 0.01	1.9	0.08	0.08	3
5S/3W-36P2	0.1	89	1,700	0.02	3.4	0.05	0.10	2
	0.4	76	--	< 0.01	3.8	0.02	0.14	2
6S/3W-1J2	2.0	52	3,350	< 0.01	6.3	0.10	0.05	1
6S/3W-2A1	1.9	57	3,550	< 0.01	5.3	0.12	0.06	< 1
6S/3W-2E1	0.5	65	1,070	< 0.01	2.6	0.03	0.06	2
6S/3W-2G2	0.7	56	1,090	< 0.01	5.2	0.03	0.06	1
Winchester Pond	0.3	14	772	0.06	1.4	< 0.02	0.56	6

Table 3. Water-quality data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

State well number	Barium, dissolved (µg/L)	Beryllium, dissolved (µg/L)	Boron, dissolved (µg/L)	Cadmium, dissolved (µg/L)	Chromium, dissolved (µg/L)	Cobalt, dissolved (µg/L)	Copper, dissolved (µg/L)	Iron, dissolved (µg/L)	Lead, dissolved (µg/L)
5S/3W-13H1	190	< 0.5	60	< 1	< 5	< 3	< 10	15	< 10
	200	< 0.5	60	< 1	< 5	< 3	< 10	5	< 10
5S/3W-14P1	210	< 0.5	150	1	< 5	< 3	< 10	9	30
5S/3W-24C1	--	--	< 100	--	--	--	< 1	< 1	--
	200	< 0.5	30	< 1	< 5	< 3	< 10	13	20
	170	< 0.5	40	< 1	< 5	< 3	< 10	8	10
	190	< 0.5	50	2	< 5	< 3	< 10	15	< 10
	200	< 0.5	40	< 1	< 5	< 3	< 10	22	< 10
5S/3W-24F2	36	< 0.5	70	< 1	< 5	< 3	< 10	9	< 10
	23	< 0.5	90	< 1	< 5	< 3	< 10	62	< 10
5S/3W-24F3	510	< 1.0	80	< 2	< 10	< 6	< 20	< 6	< 20
	470	< 1.5	80	< 3	< 15	< 9	< 30	< 9	< 30
5S/3W-24F4	570	< 0.5	40	< 1	< 5	< 3	< 10	< 3	< 10
	410	< 0.5	50	< 1	< 5	< 3	< 10	17	< 10
5S/3W-35N2	200	< 1.5	610	< 3	< 15	< 9	< 30	130	70
5S/3W-36P2	630	< 1.0	330	< 2	< 10	8	< 20	180	40
	590	< 0.5	360	< 1	< 5	7	< 10	4	< 10
6S/3W-1J2	70	< 1.5	290	< 3	< 15	< 9	< 30	< 9	< 30
6S/3W-2A1	44	< 2.0	410	< 4	< 20	< 12	< 40	45	< 40
6S/3W-2E1	180	< 0.5	160	< 1	< 5	< 3	< 10	62	< 10
6S/3W-2G2	74	< 0.5	80	< 1	< 5	< 3	< 10	37	< 10
Winchester Pond	23	< 0.5	590	3	< 5	5	< 10	< 3	10

Table 3. Water-quality data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

State well number	Lithium, dissolved (µg/L)	Manganese, dissolved (µg/L)	Molybdenum, dissolved (µg/L)	Nickel, dissolved (µg/L)	Selenium, dissolved (µg/L)	Silver, dissolved (µg/L)	Strontium, dissolved (µg/L)	Vanadium, dissolved (µg/L)	Zinc, dissolved (µg/L)
5S/3W-13H1	20	2	< 10	< 10	2	< 1	430	26	< 3
	20	6	< 10	< 10	2	< 1	480	24	7
5S/3W-14P1	20	1	20	< 10	--	< 1	960	20	10
5S/3W-24C1	--	< 1	--	--	--	--	--	--	< 0.1
	20	2	< 10	< 10	--	< 1	410	16	11
	10	1	< 10	< 10	--	2	320	19	9
	5	27	< 10	< 10	2	< 1	370	20	9
	5	9	< 10	< 10	2	< 1	390	20	< 3
5S/3W-24F2	6	52	30	10	--	< 1	200	< 6	< 3
	7	83	20	< 10	--	< 1	240	10	13
5S/3W-24F3	40	14	< 20	< 20	--	< 2	2,000	16	13
	40	280	< 30	< 30	--	< 3	2,200	20	< 9
5S/3W-24F4	8	< 1	20	< 10	--	< 1	1,100	16	< 3
	10	53	< 10	< 10	--	< 1	1,200	22	8
5S/3W-35N2	140	530	40	50	--	< 3	1,600	< 18	3,600
5S/3W-36P2	200	1,200	< 20	< 20	--	< 2	1,100	28	3,900
	190	1,100	< 10	< 10	--	2	1,000	19	24
6S/3W-1J2	40	< 3	40	< 30	--	4	2,300	< 18	38
6S/3W-2A1	50	4	< 40	110	--	< 4	2,300	< 24	< 12
6S/3W-2E1	80	520	10	30	--	< 1	1,000	10	6
6S/3W-2G2	20	19	20	< 10	--	< 1	740	11	15
Winchester Pond	20	1	20	< 10	--	< 1	470	21	< 3

Table 3. Water-quality data for selected wells in the Winchester, Hemet, South Perris, and Menifee subbasins, California—Continued

State well number	Dueterium (ratio per mil)	Oxygen-18 (ratio per mil)	Source of data
5S/3W-13H1	--	--	USGS
	--	--	USGS
5S/3W-14P1	-51.6	-7.26	USGS
5S/3W-24C1	--	--	BABCOCK
	-53.0	-7.54	USGS
	-50.5	-7.51	USGS
	--	--	USGS
	--	--	USGS
5S/3W-24F2	-59.1	-8.41	USGS
	-55.7	-8.35	USGS
5S/3W-24F3	-54.6	-8.01	USGS
	-56.3	-7.87	USGS
5S/3W-24F4	-50.7	-7.32	USGS
	-51.4	-7.33	USGS
5S/3W-35N2	-52.9	-7.61	USGS
5S/3W-36P2	-58.0	-8.41	USGS
	-56.6	-8.39	USGS
6S/3W-1J2	-51.4	-7.18	USGS
6S/3W-2A1	-51.8	-7.36	USGS
6S/3W-2E1	-53.5	-7.65	USGS
6S/3W-2G2	-49.7	-6.94	USGS
Winchester Pond	-43.8	-4.92	USGS

APPENDIX

Appendix 1. Lithologic log for multiple-well monitoring site 5S/3W-24F

[Borehole for wells 5S/3W-24F2, -24F3, -24F4: Drilled by U.S. Geological Survey using mud-rotary method, September 30, 1993. Descriptions from microscopic examination of small samples of sieved drill cuttings; color codes (in parentheses) from Munsell, 1994. Altitude of land surface approximately 1,475 feet. Total depth 729 feet; screened intervals, 686–691, 399–404, 150–155 feet, respectively]

Sample depth (feet below land surface)	Description
5	**Sandy, gravelly silt;** sand is fine to coarse, poorly sorted, sub-angular; gravel is very fine to fine (2–5 mm), angular, poorly sorted; dark yellowish brown (10YR 4/2m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, tourmaline, biotite, feldspar.
10–13	**Sandy, gravelly silt;** sand is fine to coarse, poorly sorted, sub-angular to sub-rounded; gravel is very fine to medium (2–5 mm), poorly sorted, angular; dark yellowish brown (10YR 4/2m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, biotite, tourmaline, mica feldspar.
25	**Sandy, gravelly, sandy clay;** sand is very fine to coarse, poorly sorted, subangular; gravel is very fine to fine (2–4 mm), poorly sorted, subrounded; moderate yellowish brown (10YR 5/3m, 10YR 4/4d); major minerals in decreasing order of abundance: quartz, tourmaline, mica, feldspar.
30–34	**Sandy clay;** sand is fine to medium, moderately sorted, subangular to subrounded; moderate yellowish brown (10YR 5/4d).
43–46	**Slightly silty, gravelly sand;** sand is medium to very coarse, poorly sorted, angular; gravel is fine to medium (2–6 mm), poorly sorted, angular; moderate yellowish brown (10YR 5/2m, 10YR 6/4d); major minerals in decreasing order of abundance: quartz, feldspar, biotite, multi-mineral clasts, tourmaline.
55	**Slightly gravelly, silty, clayey sand;** sand is fine to very coarse, poorly sorted, subrounded; gravel is very fine to medium (2–6 mm), poorly sorted, subrounded; dark yellowish brown (10YR 5/2m, 10YR 6/4d); major minerals in decreasing order of abundance: quartz, biotite, feldspar.
70–73	**Sandy clayey silt;** sand is very fine to coarse, moderately sorted; moderate yellowish brown (10YR 5/3m, 10YR 4/2d); major minerals in decreasing order of abundance: quartz, mica, biotite.
75–80	**Silty, sandy clay;** sand is very fine to fine, moderately sorted; moderate yellowish brown (10YR 5/4m, 10YR 5/2d); major minerals in decreasing order of abundance: quartz, mica, biotite, tourmaline.
85–90	**Silty, sandy clay;** sand is very fine to fine, moderately sorted; moderate yellowish brown (10YR 5/4d).
95–100	**Sandy clay;** sand is fine to medium, moderately sorted, subangular to subrounded; moderate yellowish brown (10YR 5/4m).
110–115	**Sandy, clayey silt;** sand is fine to medium, moderately sorted, moderate yellowish brown (10YR 5/4m 10YR 6/4d).
130	**Sandy, clayey silt;** sand is fine to medium, moderately sorted, moderate yellowish brown (10YR 5/4m 10YR 6/4d).
150	**Slightly silty sand;** sand is fine to medium, moderately sorted, angular; moderate yellowish brown (10YR 5/3m, 10YR 5/6d); major minerals in decreasing order of abundance: quartz, biotite, mica.
170	**Slightly silty sand;** sand is fine to medium, moderately sorted, angular; moderate yellowish brown (10YR 5/3m, 10YR 5/6d); major minerals in decreasing order of abundance: quartz, biotite, mica.
185	**Slightly silty, gravelly sand;** sand is very fine to coarse, poorly sorted, subangular; moderate yellow brown (10YR 6/2m, 10YR 7/2d).
205	**Slightly silty, gravelly sand;** sand is medium to very coarse, poorly sorted, angular; gravel is very fine to medium (2-5 mm), poorly sorted, angular; pale yellowish brown (10YR 6/2m, 10YR 7/2d); major minerals in decreasing order of abundance: quartz, feldspar, biotite, gravel is mainly multi-mineral clasts.
225–230	**Silty, clayey sand;** sand is very fine to very coarse, poorly sorted, angular; moderate brown (10YR 5/3m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, feldspar, biotite, mica.
245–250	**Silty, gravelly sand;** sand is very fine to very coarse, poorly sorted, angular; gravel is fine to medium (2–6 mm), moderately sorted, angular to subrounded; pale yellowish brown (10YR 6/4m, 10YR 7/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica.
270	**Silty, gravelly sand;** sand is very fine to very coarse, poorly sorted, angular; gravel is very fine to medium (2–6 mm), moderately sorted, angular to subrounded; pale yellowish brown (10YR 6/4m, 10YR 7/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica, metamorphic rock clasts.
288–290	**Silty, gravelly sand;** sand is very fine to very coarse, poorly sorted, angular; gravel is very fine to fine (2–4 mm), poorly sorted, subrounded; pale yellowish brown (10YR 6/4m, 10YR 7/2d); major minerals in decreasing order of abundance: quartz, feldspar, mica biotite.
310–312	**Slightly silty, gravelly sand;** sand is fine to very coarse, poorly sorted, angular; gravel is very fine to fine (2–5 mm), poorly sorted, subangular to subrounded; pale yellowish brown (10YR 6/4m, 10YR 7/3d); major minerals in decreasing order of abundance: quartz, feldspar, mica, biotite.

Appendix 1. Lithologic log for multiple-well monitoring site 5S/3W-24F—Continued

Sample depth (feet below land surface)	Description
332–336	**Silty sand;** sand is very fine to medium, moderately sorted, subangular; moderate yellowish brown (10YR 5/4m, 10YR 6/4); major minerals in decreasing order of abundance: quartz, mica.
355	**Gravelly sand;** sand is fine to very fine, poorly sorted, angular to subangular; gravel is very fine to fine, poorly sorted, angular; pale yellowish brown (10YR 6/3m, 10YR 7/2d); major minerals in decreasing order of abundance: quartz, feldspar, biotite.
375	**Gravelly sand;** sand is fine to very fine, poorly sorted, angular to subangular; gravel is very fine to fine, poorly sorted, angular; pale yellowish brown (10YR 6/3m, 10YR 7/2d); major minerals in decreasing order of abundance: quartz, feldspar, biotite.
390–395	**Slightly gravelly sand;** sand is fine to very coarse, poorly sorted, angular to subangular; gravel is fine, moderately sorted, subangular; moderate yellowish brown (10YR 4/3m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica.
410–415	**Slightly silty sand;** sand is fine to very coarse, poorly sorted, angular; pale yellowish brown (10YR 6/2m, 10YR 6/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica.
430	**Slightly gravelly sand;** sand is fine to very coarse, poorly sorted, angular; gravel is very fine to fine (2–4 mm), poorly sorted, subrounded; pale yellowish brown (10YR 6/2m, 10YR 7/2d); major minerals in decreasing order of abundance: quartz, mica, biotite.
450	**Slightly gravelly sand;** sand is fine to very coarse, poorly sorted, angular; gravel is very fine to fine (2–4 mm), poorly sorted, subrounded; pale yellowish brown (10YR 6/3m, 10YR 7/3d); major minerals in decreasing order of abundance: quartz, mica, biotite.
470	**Slightly gravelly sand;** sand is fine to very coarse, poorly sorted, angular; gravel is very fine to fine (2–4 mm), poorly sorted, subrounded; pale yellowish brown (10YR 6/3m, 10YR 7/3d); major minerals in decreasing order of abundance: quartz, mica, biotite.
490	**Slightly silty, gravelly sand;** sand is fine to very coarse, poorly sorted, angular to subangular; gravel is very fine to medium (2–5 mm), poorly sorted, subrounded to rounded; (10YR 5/4m, 10YR 6/3d); major minerals in decreasing order of abundance: quartz, feldspar, mica, biotite.
510	**Slightly silty, gravelly sand;** sand is fine to very coarse, poorly sorted, angular to subangular; gravel is very fine to medium (2–5 mm), poorly sorted, subrounded to rounded; (10YR 5/4m, 10YR 6/3d); major minerals in decreasing order of abundance: quartz, feldspar, mica, biotite.
530	**Slightly silty, gravelly sand;** sand is fine to very coarse, poorly sorted, angular to subangular; gravel is very fine to medium (2–5 mm), poorly sorted, subrounded to rounded; (10YR 5/4m, 10YR 6/3d); major minerals in decreasing order of abundance: quartz, feldspar, mica, biotite.
550	**Slightly gravelly sand;** and is fine to very coarse, poorly sorted, subangular; grayish orange (10YR 7/4m, 10YR 7/3d); major minerals in decreasing order of abundance: quartz, feldspar, mica.
570	**Silty sand;** sand is fine to very coarse, poorly sorted, subangular to subrounded; moderate yellowish brown (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica, biotite.
590	**Sand;** medium to very coarse, moderately sorted, subangular to subrounded; pale yellowish brown (10YR 6/3m, 10YR 7/3d); major minerals in decreasing order of abundance: quartz, feldspar, mica, biotite.
615	**Slightly silty, slightly gravelly sand;** sand is fine to coarse, poorly sorted, subangular; gravel is very fine to medium (2–5 mm), poorly sorted, subangular; (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica, biotite.
630	**Slightly silty, slightly gravelly sand;** sand is fine to coarse, poorly sorted, subangular; gravel is very fine to medium (2–5 mm), poorly sorted, subangular; (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica, biotite.
645–650	**Slightly silty, slightly gravelly sand;** sand is fine to coarse, poorly sorted, subangular; gravel is very fine to medium (2–5 mm), poorly sorted, subangular; (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica, biotite.
670–675	**Sand;** fine to coarse, moderately sorted, subangular; moderate yellowish brown (10YR 5/4m, 10YR 6/4d); major minerals in decreasing order of abundance: quartz, feldspar, biotite. (Probably decomposed granite.)
690–695	**Sand;** fine to coarse, moderately sorted, subangular; moderate yellowish brown (10YR 5/4m, 10YR 5/3d); major minerals in decreasing order of abundance: quartz, feldspar, biotite. (Probably decomposed granite.)
705–725	**Bedrock material, weathered (?) granite;** gravel is very fine to medium (2–5 mm), poorly sorted, angular; moderate yellowish brown (10YR 5/4m, 10YR 5/3d); gravel is mainly multi-mineral chips.

Appendix 2. Lithologic log for multiple-well monitoring site 5S/2W-28E

[Borehole for wells 5S/2W-28E1, -28E2, -28E3: Drilled by U.S. Geological Survey using mud-rotary method, October 11, 1993. Descriptions from microscopic examination of small samples of sieved drill cuttings; color codes (in parentheses) from Munsell, 1994. Altitude of land surface approximately 1,459 feet. Total depth 457 feet; screened intervals, 395–400, 306–311, 228–233 feet, respectively]

Sample depth (feet below land surface)	Description
15–20	**Silty, clayey sand;** sand is fine to very coarse, poorly sorted, subrounded to rounded; moderate brown (5YR 4/4m, 5YR 5/6d); major minerals in decreasing order of abundance: quartz, feldspar, organic matter.
45–55	**Slightly gravelly, clayey sand;** sand is fine to medium, moderately sorted, subrounded; gravel is very fine to fine (2–3 mm), poorly sorted; moderate brown (5YR 4/4m, 5YR 5/4d); major minerals in decreasing order of abundance: quartz, mica, tourmaline.
60–65	**Silty, clayey sand;** sand is fine to medium, moderately sorted, subangular; moderate yellowish brown (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, mica, tourmaline.
75–80	**Slightly silty sand;** sand is fine to medium, moderately sorted, subangular; moderate yellowish brown (10YR 5/4m, 10YR 6/4d); major minerals in decreasing order of abundance: quartz, mica, tourmaline.
85–90	**Slightly silty, clayey sand;** sand is very fine to fine, moderately sorted, subangular to subrounded; moderate yellowish brown (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, mica.
90–100	**Slightly silty, clayey sand;** sand is very fine to fine, moderately sorted, subangular to subrounded; moderate yellowish brown (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, mica, tourmaline.
105–115	**Slightly silty sand;** sand is medium to coarse, poorly sorted, subangular to subrounded; moderate yellowish brown (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, mica, tourmaline.
120–130	**Clayey sand;** sand is fine to medium, moderately sorted, subangular to subrounded; moderate brown (5YR 4/4m, 5YR 5/4d); major minerals in decreasing order of abundance: quartz, mica.
130–140	**Sandy clay;** sand is very fine to fine, moderately sorted, subangular, poorly sorted; moderate brown (5YR 4/4m, 5YR 5/4d); major minerals in decreasing order of abundance: quartz, mica.
145–155	**Sandy clay;** sand is very fine to fine, moderately sorted, subangular, poorly sorted; moderate brown (5YR 4/4m, 5YR 5/4d); major minerals in decreasing order of abundance: quartz, mica.
160–165	**Clayey sand;** sand is very fine to medium, moderately sorted, subangular; moderate brown (5YR 4/4m, 5YR 5/4d); major minerals in decreasing order of abundance: quartz, mica.
185–190	**Clayey, silty sand;** sand is very fine to fine, moderately sorted, subangular; moderate brown (5YR 4/4m, 5YR 5/4d); major minerals in decreasing order of abundance: quartz, mica.
205–220	**Silty sand;** sand is very fine to medium, moderately sorted, subangular; moderate brown (5YR 4/4m, 5YR 5/4d); major minerals in decreasing order of abundance: quartz, mica.
230–240	**Slightly gravelly, silty sand;** sand is very fine to very coarse, poorly sorted, subangular to subrounded; gravel is very fine to fine (2-4 mm), poorly sorted, subrounded; moderate yellowish brown (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica.
245–255	**Slightly gravelly, slightly silty sand;** sand is fine to very coarse, poorly sorted, subrounded; gravel is very fine to fine (2-4 mm), poorly sorted, subrounded; moderate yellowish brown (10YR 5/4m, 10YR 6/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica.
265–275	**Gravelly sand;** sand is very fine to fine, poorly sorted, subangular; gravel is very fine to medium (2-6 mm), poorly sorted, subangular; pale yellowish brown (10YR 5/4m, 10YR 6/5d); major minerals in decreasing order of abundance: quartz, feldspar, mica, biotite.
280–285	**Slightly silty, gravelly sand;** sand is fine to very coarse, poorly sorted, angular to subangular; gravel is fine to medium (2-6 mm), poorly sorted, angular to subangular; moderate yellowish brown (10YR 5/4m, 10YR 6/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica.
300–320	**Slightly gravelly sand;** sand is fine to very coarse, poorly sorted, angular to subangular; gravel is fine to medium (2–6 mm), poorly sorted, subangular to subrounded; moderate yellowish brown (10YR 5/4m, 10YR 6/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica, multi-mineral clasts.
320–340	**Slightly gravelly sand;** sand is fine to very coarse, poorly sorted, angular to subangular; gravel is fine to medium (2–6 mm), poorly sorted, subangular to subrounded; moderate yellowish brown (10YR 5/4m, 10YR 6/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica.

Appendix 2. Lithologic log for multiple-well monitoring site 5S/2W-28E—Continued

Sample depth (feet below land surface)	Description
345–350	**Slightly gravelly sand;** sand is fine to very coarse, poorly sorted, angular to subangular; gravel is fine to medium (2–6 mm), poorly sorted, subangular to subrounded; moderate yellowish brown (10YR 5/4m, 10YR 6/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica.
365–370	**Slightly gravelly sand;** sand is fine to very coarse, poorly sorted, angular to subangular; gravel is fine to medium (2–6 mm), poorly sorted, subangular to subrounded; moderate yellowish brown (10YR 5/4m, 10YR 6/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica.
380–385	**Slightly gravelly sand;** sand is fine to very coarse, poorly sorted, angular to subangular; gravel is fine to medium (2–6 mm), poorly sorted, subangular to subrounded; moderate yellowish brown (10YR 5/4m, 10YR 6/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica.
385–390	**Gravelly sand;** sand is fine to very coarse, poorly sorted, angular; gravel is very fine to fine (2–4 mm), poorly sorted, angular; moderate yellowish brown (10YR 5/4m, 10YR 6/4d); major minerals in decreasing order of abundance: multi-mineral clasts, quartz, feldspar, mica, biotite.
390–395	**Slightly gravelly sand;** sand is fine to very coarse, poorly sorted, angular; gravel is very fine to fine (2–4 mm), poorly sorted, angular; moderate yellowish brown (10YR 5/4m, 10YR 6/4d); major minerals in decreasing order of abundance: multi-mineral clasts, quartz, feldspar, mica, biotite.
400–410	**Decomposed granite;** sand is fine to very coarse, poorly sorted, angular; gravel is very fine to fine (2–4 mm), poorly sorted, angular; moderate yellowish brown (10YR 5/4m, 10YR 6/4d); major minerals in decreasing order of abundance: multi-mineral clasts, quartz, feldspar, mica, biotite.
415–455	**Bedrock material, granite;** gravel is very fine to fine (2–4 mm), poorly sorted, angular; moderate yellowish brown (10YR 5/4m, 10YR 6/4d); major minerals in decreasing order of abundance: multi-mineral clasts, quartz, feldspar, mica, biotite.

Appendix 3. Lithologic log for multiple-well monitoring site 5S/2W-25P

[Borehole for wells 5S/2W-25P3, -25P4, -25P5, -25P6, -25P7: Drilled by U.S. Geological Survey using mud-rotary method, May 18, 1994. Descriptions from microscopic examination of small samples of sieved drill cuttings; color codes (in parentheses) from Munsell, 1994. Total depth 658 ft. Altitude of land surface approximately 1,490 feet.; screened intervals, 630–640, 450–460, 231–236, 148–158, and 72–82 feet, respectively]

Sample depth (feet below land surface)	Description
0–10	**Sandy silt**; sand is fine to very coarse, poorly sorted, angular to subrounded, moderate yellowish brown (10YR 5/4m, 10YR 6/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica.
20–25	**Gravelly sand;** sand is fine to very coarse, poorly sorted, subangular to subrounded; gravel is very fine to medium (2–8 mm); pale yellowish brown (10YR 5/4m, 10YR 6/4d); major minerals in decreasing order of abundance: multi-mineral clasts, quartz, feldspar, biotite, mica.
35	**Clayey, silty sand;** sand is very fine to fine, moderately sorted, angular; dark yellowish brown (10YR 4/4m, 10YR 4/2d); major minerals in decreasing order of abundance: quartz, mica.
45–50	**Slightly gravelly, silty sand;** sand is fine to medium, poorly sorted, subangular; gravel is fine to medium (2–6 mm), poorly sorted, angular to subangular; moderate brown (5YR 4/4m, 5YR 4/2d); major minerals in decreasing order of abundance: quartz, mica, gravel is mainly multi-mineral clasts.
65	**Slightly gravelly, silty sand;** sand is fine to medium, poorly sorted, subangular; gravel is fine to medium (2–6 mm), poorly sorted, angular to subangular; moderate brown (5YR 4/4m, 5YR 4/2d); major minerals in decreasing order of abundance: quartz, mica, gravel is mainly multi-mineral clasts.
75	**Slightly gravelly, clayey sand;** sand is very fine to very coarse, poorly sorted, angular to subangular; gravel is very fine to fine (2–4 mm), poorly sorted, subrounded; dark yellowish brown (10YR 5/4m, 10YR 6/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica.
85–90	**Slightly gravelly, clayey sand;** sand is very fine to very coarse, poorly sorted, angular to subangular; gravel is very fine to fine (2–4 mm), poorly sorted, subrounded; dark yellowish brown (10YR 5/4m, 10YR 6/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica.
95–100	**Silty sand;** sand is very fine to medium, moderately sorted, angular to subangular; moderate yellowish brown (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, feldspar.
105	**Silty sand;** sand is very fine to fine, moderately sorted, subrounded; moderate yellowish brown (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, mica.
115	**Silty sand;** sand is very fine to fine, moderately sorted, subrounded; moderate yellowish brown (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, mica.
125	**Silty sand;** sand is very fine to very coarse, poorly sorted, subrounded, moderate yellowish brown (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, mica.
135–140	**Silty sand;** sand is very fine to very coarse, poorly sorted, angular to subangular; gravel is very fine to fine (2–3 mm), poorly sorted, subrounded; moderate yellowish brown (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica, biotite.
145	**Sand;** sand is very fine to coarse, moderately sorted, subangular; moderate yellowish brown (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, mica.
155	**Slightly gravelly sand;** sand is very fine to coarse, moderately sorted, subangular; gravel is very fine to fine (2–3 mm), poorly sorted, subrounded; moderate yellowish brown (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, mica.
170–175	**Clayey sand;** sand is very fine to medium, moderately sorted, subangular; moderate yellowish brown (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, mica.
185–190	**Slightly gravelly sand;** sand is very fine to very coarse, poorly sorted, subangular; gravel is very fine to medium (2–6 mm), poorly sorted, subrounded; moderate yellowish brown (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, mica, feldspar.
205	**Slightly gravelly sand;** sand is very fine to very coarse, moderately sorted, subrounded, gravel is very fine to fine (2–3 mm), poorly sorted, subrounded; moderate yellowish brown (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, mica, feldspar.
230	**Slightly gravelly sand;** sand is very fine to very coarse, moderately sorted, subrounded, gravel is very fine to fine (2–3 mm), poorly sorted, subrounded; moderate yellowish brown (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, mica, feldspar.
245	**Slightly gravelly sand;** sand is very fine to very coarse, moderately sorted, subrounded, gravel is very fine to fine (2–3 mm), poorly sorted, subrounded; moderate yellowish brown (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, mica, feldspar.
265	**Silty sand;** sand is very fine to fine, moderately sorted; moderate yellowish brown (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, mica, feldspar.

Appendix 3. Lithologic log for multiple-well monitoring site 5S/2W-25P—Continued

Sample depth (feet below land surface)	Description
288–290	**Silty sand;** sand is very fine to fine, moderately sorted; moderate yellowish brown (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, mica, feldspar.
305–310	**Silty sand;** sand is very fine to fine, moderately sorted; moderate yellowish brown (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, mica, feldspar.
325	**Silty sand;** sand is very fine to fine, moderately sorted; moderate yellowish brown (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, mica, feldspar.
345–350	**Silty sand;** sand is very fine to fine, moderately sorted; moderate yellowish brown (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, mica, feldspar.
365	**Slightly silty sand;** sand is very fine to medium, moderately sorted; moderate yellowish brown (10YR 4/4m, 10YR 5/4d); major minerals in decreasing order of abundance: quartz, mica, feldspar.
395	**Gravelly sand;** sand is very fine to very coarse, poorly sorted, subrounded; gravel is very fine to fine, poorly sorted, subrounded; moderate yellowish brown (10YR 5/4m, 10YR 6/4d); major minerals in decreasing order of abundance: quartz, mica, feldspar.
415	**Gravelly sand;** sand is very fine to very coarse, poorly sorted, subrounded; gravel is very fine to fine, poorly sorted, subrounded; moderate yellowish brown (10YR 5/4m, 10YR 6/4d); major minerals in decreasing order of abundance: quartz, mica, feldspar.
425–430	**Gravelly sand;** sand is very fine to very coarse, poorly sorted, subrounded; gravel is very fine to fine, poorly sorted, subrounded; moderate yellowish brown (10YR 5/4m, 10YR 6/4d); major minerals in decreasing order of abundance: quartz, mica, feldspar.
450–455	**Slightly sandy silt;** sand is very fine to medium, moderately sorted; angular, moderate olive brown (5Y 5/4d); major minerals in decreasing order of abundance: mica, quartz.
470	**Slightly gravelly sand;** sand is very fine to medium, moderately sorted; angular; gravel is very fine to fine (2–3 mm), poorly sorted; moderate olive brown (5Y 4/4m, (5Y 6/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica.
485	**Slightly gravelly sand;** sand is very fine to medium, moderately sorted, angular; gravel is very fine to fine (2–3 mm), poorly sorted; moderate olive brown (5Y 4/4m, (5Y 6/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica.
505–512	**Slightly gravelly sand;** sand is very fine to medium, moderately sorted, angular; gravel is very fine to fine (2–3 mm), poorly sorted; moderate olive brown (5Y 4/4m, 5Y 6/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica.
525	**Slightly gravelly sand;** sand is very fine to medium, moderately sorted, angular; gravel is very fine to fine (2–3 mm), poorly sorted; moderate olive brown (5Y 4/4m, 5Y 6/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica.
545–550	**Slightly gravelly sand;** sand is very fine to medium, moderately sorted, angular; gravel is very fine to fine (2–3 mm), poorly sorted; moderate olive brown (5Y 4/4m, 5Y 6/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica.
570–575	**Slightly gravelly sand;** sand is very fine to medium, moderately sorted, angular; gravel is very fine to fine (2–3 mm), poorly sorted; moderate olive brown (5Y 4/4m, 5Y 6/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica.
590–595	**Slightly gravelly sand;** sand is very fine to medium, moderately sorted, angular; gravel is very fine to fine (2–3 mm), poorly sorted; moderate olive brown (5Y 4/4m, 5Y 6/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica.
610–615	**Slightly gravelly sand;** sand is very fine to medium, moderately sorted, angular; gravel is very fine to fine (2–3 mm), poorly sorted; moderate olive brown (5Y 4/4m, 5Y 6/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica.
630	**Slightly gravelly sand;** sand is very fine to medium, moderately sorted, angular; gravel is very fine to fine (2–3 mm), poorly sorted; moderate olive brown (5Y 4/4m, 5Y 6/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica.
645	**Slightly gravelly sand;** sand is very fine to medium, moderately sorted, angular; gravel is very fine to fine (2–3 mm), poorly sorted; moderate olive brown (5Y 4/4m, 5Y 6/4d); major minerals in decreasing order of abundance: quartz, feldspar, mica.

Appendix 4. Lithologic log for multiple-well monitoring site 5S/2W-26H

[Borehole for wells 5S/2W-26H5, -26H6, -26H7: Drilled by U.S. Geological Survey using mud-rotary method, September 23, 1993. Descriptions from microscopic examination of small samples of sieved drill cuttings; color codes (in parentheses) from Munsell, 1994. Altitude of land surface approximately 1,485 feet. Total depth 170 feet; screened intervals, 143–138, 79–74, and 45–40 feet, respectively]

Sample depth (feet below land surface)	Description
0–20	**Slightly gravelly sand;** sand is very fine to fine, poorly sorted, subangular to subrounded; gravel is very fine to fine (2–3 mm), poorly sorted, subrounded; pale yellowish brown (10YR 5/4m, 10YR 7/3d); quartz, tourmaline, mica.
20–40	**Slightly gravelly, silty sand;** sand is fine to very coarse, poorly sorted, subangular; gravel is fine, moderately sorted, subangular to subrounded; dark yellowish brown (10YR 4/4m, 10YR 7/3d); quartz, tourmaline, mica.
40–60	**Slightly gravelly, silty sand;** sand is fine to very coarse, poorly sorted, subangular; gravel is fine, moderately sorted, subangular to subrounded; dark yellowish brown (10YR 4/4m, 10YR 6/4d); quartz, tourmaline, mica.
60–80	**Gravelly sand;** sand is medium to very coarse, poorly sorted, subangular; gravel is very fine to fine (2–4 mm), subangular; moderate yellowish brown (10YR 5/4m, 10YR 7/3d); quartz, feldspar, mica, biotite, metamorphic clasts.
80–100	**Decomposed intrusive rock;** fine to medium gravel-sized fragments (2–5 mm), angular; dusky brown (5YR 2/2m, 5YR 3/2d).
100–120	**Decomposed intrusive rock;** medium gravel-sized fragments (3–8 mm), angular, dusky brown (5YR 2/2m, 5YR 3/2d).
120–150	**Intrusive rock;** medium gravel-sized fragments (3–8 mm), angular, dark greenish gray (5YR 4/1m, 5GY 6/1d).
150–159	**Slightly decomposed intrusive rock;** fine to medium gravel-sized fragments (2–5 mm), angular; dusky brown (5YR 2/2m, 5YR 3/2d).

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