Regional Water Table (2002) and Water-Level Changes in the Mojave River and Morongo Ground-Water Basins, Southwestern Mojave Desert, California

By Gregory A. Smith, Christina L. Stamos, and Steven K. Predmore

In cooperation with the
MOJAVE WATER AGENCY

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CONVERSION FACTORS

Multiply	By	To obtain
feet (ft)	0.3048	meter
inch (in.)	2.54	centimeter
inch per year (in./yr)	25.4	millimeter per year
mile (mi)	1.609	kilometers
square miles (mi^2)	12.590	square kilometers

DATUM

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

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

ABBREVIATIONS

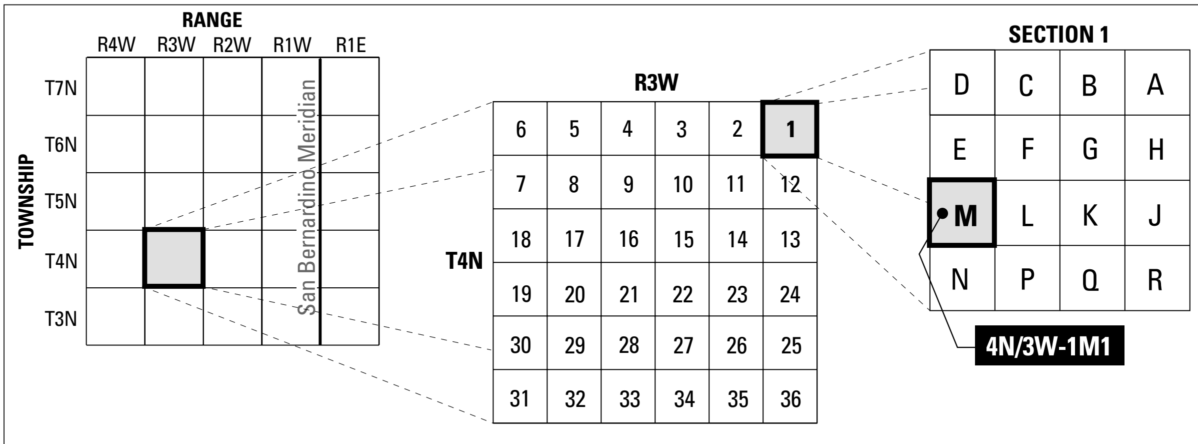
ft	feet
in./yr	inch per year
mi	mile
mi^2	square miles
SWP	California State Water Project

Organizations

MWA	Mojave Water Agency
USGS	U.S. Geological Survey

Well-Numbering System

Wells are identified and numbered according to their location in the rectangular 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 sequentially numbered in the order 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). All wells in the study area are referenced to the San Bernardino base line and meridian (S) Well numbers consist of 15 characters and follow the format 004N003W01M001S. In this report, well numbers are abbreviated and written 4N/3W-1M1. Wells in the same township and range are referred to only by their section designation, 1M1. The following diagram shows how the number for well 4N/3W-1M1 is derived.



Well-numbering diagram (Note: maps in this report use abbreviated well numbers such as **"1M1"**)

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Abstract

The Mojave River and Morongo ground-water basins are in the southwestern part of the Mojave Desert in southern California. Ground water from these basins supplies a major part of the water requirements for the region. The continuous population growth in this area has resulted in ever-increasing demands on local ground-water resources. The collection and interpretation of ground-water data helps local water districts, military bases, and private citizens gain a better understanding of the ground-water flow systems, and consequently, water availability.

During 2002, the U.S. Geological Survey and other agencies made approximately 2,500 water-level measurements in the Mojave River and Morongo ground-water basins. These data document recent conditions and, when compared with previous data, changes in ground-water levels. A water-level contour map was drawn using data from about 600 wells, providing coverage for most of the basins. Twenty-eight hydrographs show long-term (up to 70 years) water-level conditions throughout the basins, and 9 short-term (1997 to 2002) hydrographs show the effects of recharge and discharge along the Mojave River. In addition, a water-level-change map was compiled to compare 2000 and 2002 water levels throughout the basins.

In the Mojave River ground-water basin, about 66 percent of the wells had water-level declines of 0.5 ft or more since 2000 and about 27 percent of the wells had water-level declines greater than 5 ft. The only area that had water-level increases greater than 5 ft that were not attributed to fluctuations in nearby pumpage was in the Harper Lake (dry) area where there has been a significant reduction in pumpage during the last decade. In the Morongo ground-water basin, about 36 percent of the wells had water-level declines of 0.5 ft or more and about 10 percent of the wells had water-level declines greater than 5 ft. Water-level increases greater than 5 ft were measured only in the Warren subbasin, where artificial-recharge operations have caused water levels to rise almost 60 ft since 2000.

Introduction

The Mojave River and Morongo ground-water basins are in the southwestern part of the Mojave Desert in southern California, approximately 80 and 40 mi northeast, respectively, of Los Angeles (fig. 1, pl. 1). Surface water in these basins is minimal and is normally limited to ephemeral flow during winter and spring storms and discharge from perennial springs in some areas of the Morongo ground-water basin. The major source of surface water is the Mojave River; however, it is unpredictable and not a dependable source for water supply because most of the river's 100-mi channel is usually dry. The lack of significant surface-water resources has resulted in the use of ground water as the primary source for private, agricultural, and municipal supply. Because of increasing urbanization, demands on local water supplies have created overdraft conditions in some areas of the desert basins. Periodic monitoring of ground-water levels aids in the management of the Mojave River and Morongo ground-water basins.

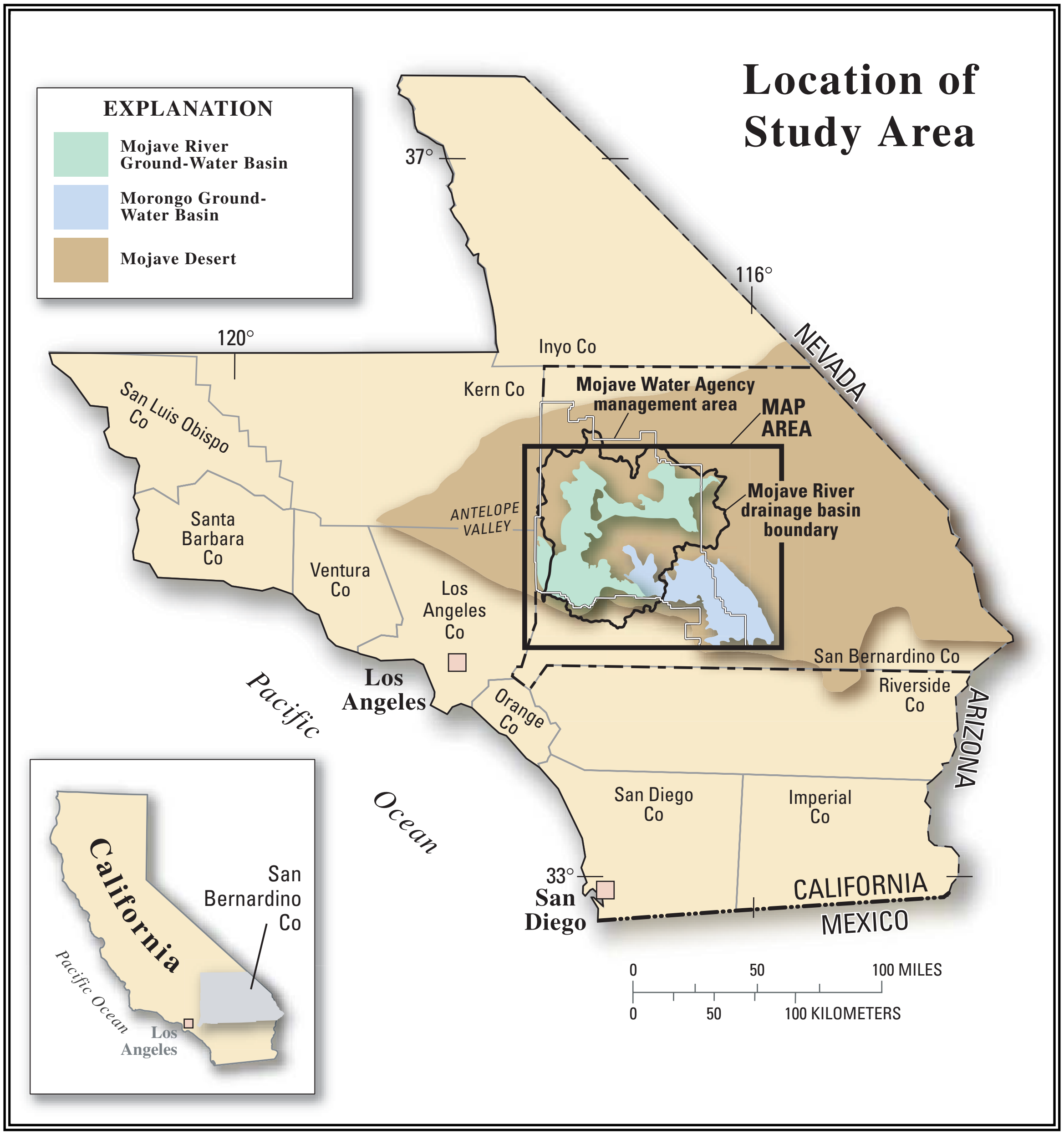

Figure 1. Location of the Mojave River and Morongo ground-water basins in the southwestern Mojave Desert, California.

The U.S. Geological Survey (USGS), in cooperation with the Mojave Water Agency (MWA), measured water levels and constructed a water-table map describing the ground-water conditions in the spring of 2002 in a continuing effort to monitor ground-water conditions in the Mojave River and Morongo ground-water basins. Water-level data were collected from approximately 600 wells during the spring of 2002 to construct the map, which shows the altitude of the water table and general direction of ground-water movement. Historical water-level data were used in conjunction with data collected from this study to construct water-level hydrographs to show both long-term (1930–2002) and short-term (1997–2002) water-level changes in the Mojave River and Morongo ground-water basins. Water-level changes between spring 2000 and spring 2002 were determined by comparing water levels measured in the same well during both periods. Data presented in this report are referenced to the North American Vertical Datum of 1988 (NAVD 88). This report is a continuation of a series of previously published USGS reports and maps (Stamos and Predmore, 1995; Trayler and Koczot, 1995; Mendez and Christensen, 1997, Smith and Pimentel, 2000; and Smith, 2002).

Description of Study Area

The Mojave River and Morongo ground-water basins together encompass about 2,400 mi^2. The climate of these basins is typical of the Mojave Desert region of southern California. Most areas of the basin floor receive 4 to 6 in./yr of precipitation, although annual precipitation can be greater than 40 in. in the southern and eastern San Bernardino and the San Gabriel Mountains (Lines, 1996). Recharge to the ground-water system from direct infiltration of precipitation is minimal.

The Mojave River ground-water basin (fig. 1) is approximately 1,400 mi^2 and extends from the San Bernardino and the San Gabriel Mountains in the south to north of Harper and Coyote Lakes (dry) (pl. 1). The ground-water basin is bordered on the west by Antelope Valley and shares its southeastern boundary with the Morongo ground-water basin. For water-management purposes, the Mojave River ground-water basin has been divided into five subareas; Alto (including the Transition zone), Baja, Centro, Este, and Oeste (fig. 2).

The primary source of ground-water recharge in the Mojave River ground-water basin is intermittent streamflow in the Mojave River, which usually occurs during January through March, and from sporadic releases of imported water from the California State Water Project (SWP) at the Rock Springs, Hodge, and Lenwood outlets (pl. 1). Since July 1994, the basin has received SWP water at the Rock Springs Outlet (near well 4N/3W-31L9) southeast of Hesperia (Mojave Water Agency, 1996); SWP water also has been released at the Lenwood Outlet (near well 9N/3W-1R7) and at the Hodge Outlet (near well 9N/3W-22J4) (pl. 1) since 1988.

The Morongo ground-water basin is about 1,000 mi^2 and is surrounded by the Ord and Granite Mountains to the north, the Bullion Mountains to the east, the San Bernardino Mountains to the southwest, and (not shown on pl. 1) the Pinto and Little San Bernardino Mountains to the south. The Morongo ground-water basin is separated into 17 subbasins; Copper Mountain, Deadman, Emerson, Fry, Giant Rock, Johnson, Joshua Tree, Lucerne, Mainside, Means, Mesquite, Pipes, Reche, Surprise Spring, Twentynine Palms, Upper Johnson, and Warren (fig. 2). The Morongo ground-water basin is recharged by infiltration from flow in ephemeral stream channels and, since 1995, from SWP water at the High Desert recharge ponds (near well 1N/5E-36M5) in the Warren subbasin (pl. 1).

Acknowledgements

This report could not have been completed without the assistance provided by the city of Adelanto, the Apple Valley Ranchos Water Company, the Baldy Mesa Water District, the County of San Bernardino, the Hesperia Water District, the Bighorn-Desert View Water Agency, the Hi-Desert Water District, the Joshua Basin Water District, the Lockheed Martin Corporation, the Sheep Creek Water Company, the Southern California Water Company, the Twentynine Palms Water District, and the Victor Valley Water District. Appreciation is also expressed to the private well owners who provided access to their wells, staff members from the MWA for collecting and providing data, and to the many USGS personnel that contributed to this project.

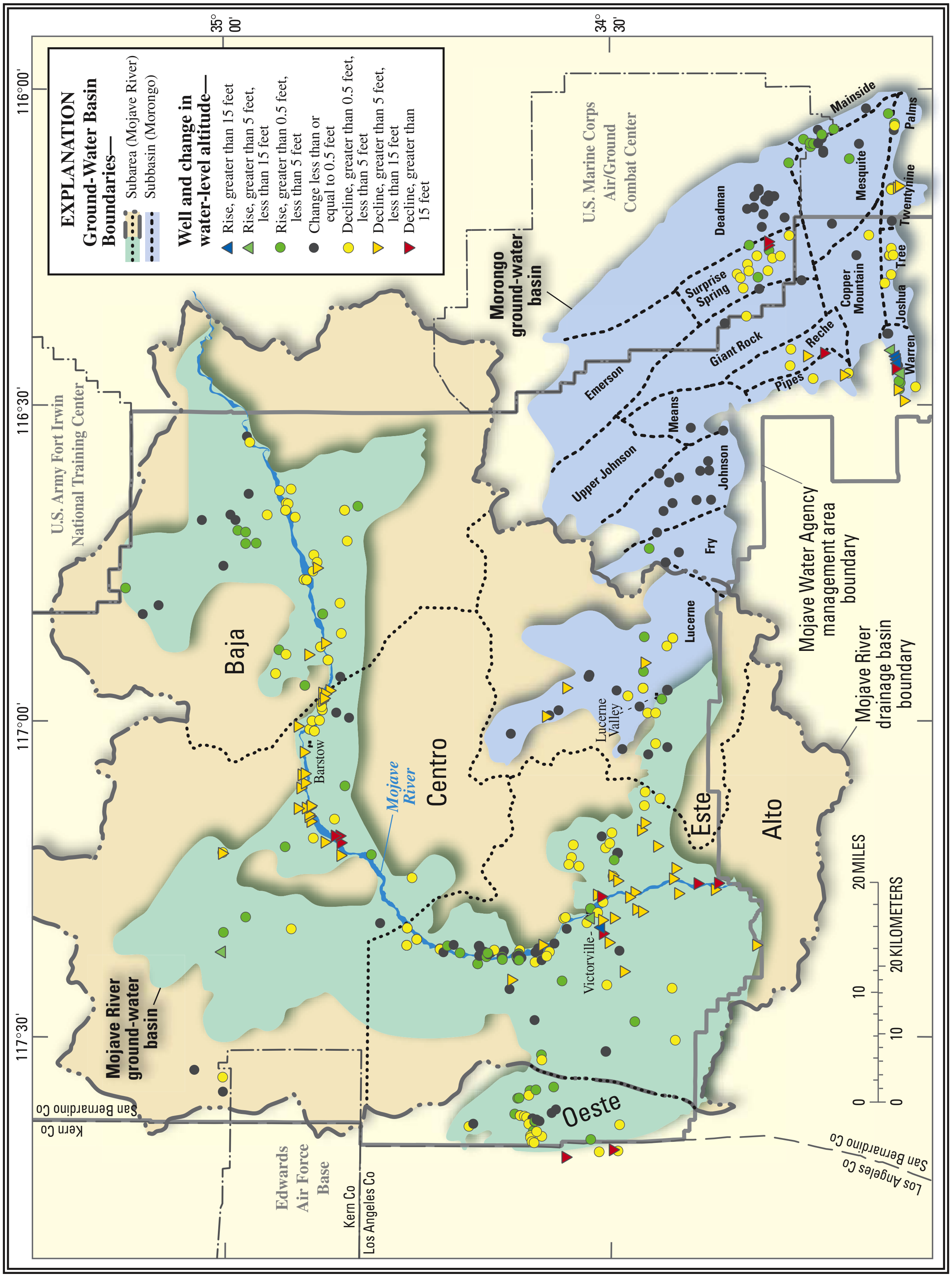

Figure 2. Water-level changes between spring 2000 and spring 2002 in the Mojave River and Morongo ground-water basins in the southwestern Mojave Desert, California.

Geohydrology

The boundaries of the Mojave River and the Morongo ground-water basins are generally defined by the contact between water-bearing unconsolidated deposits and surrounding and underlying non-water-bearing consolidated igneous and metamorphic rocks. The ground-water system in the Mojave River Basin consists of two unconfined aquifers. The most productive aquifer is the floodplain aquifer, which is composed of permeable young river deposits of Holocene age and older river deposits of Pleistocene age. This aquifer is as much as 200 ft thick and yields most of the ground water pumped from the Mojave River Basin (Stamos and others, 2001). The most widespread aquifer in the area is the regional aquifer; it is composed of unconsolidated older alluvium and fan deposits of Pleistocene to Tertiary age. In some places, the regional aquifer also consists of partly consolidated to consolidated sedimentary deposits of Tertiary age. The regional aquifer is as much as 1,000 ft thick. Other geologic units, such as bedrock and lake deposits, commonly contain ground water, but they are not considered reliable sources of ground water in the study area.

The Mojave River and Morongo ground-water basins are separated by the Helendale Fault, which acts as a barrier to ground-water flow near Lucerne Valley (pl. 1). The regional aquifer in the Morongo ground-water basin consists of continental deposits of Quaternary and Tertiary age that extend to as much as 10,000 ft deep (Moyle, 1984). For a more comprehensive description of the geohydrology of the ground-water basins, the reader is referred to Stamos and others (2001), Smith and Pimentel (2000), and Mendez and Christensen (1997).

Perched ground water has been identified in four areas of the Mojave River and Morongo ground-water basins. Perched ground water is unconfined ground water separated from an underlying body of ground water by an unsaturated zone (Lohman, 1972). The approximate areas of perched ground water are near El Mirage Lake (dry)(fig. 3), Adelanto (Montgomery Watson, 1998), Lucerne Valley (Jill Densmore, U.S. Geological Survey, written commun., 1999) and Mesquite Lake (dry) (Mendez and Christensen, 1997) (pl. 1). Scant data were available for the Adelanto area; hence, the extent of the perched ground water is not clearly known and is based on the Montgomery Watson (1998) report.

Ground-Water Levels and Flow

Water-level data were collected in the spring of 2002 from 606 wells in the Mojave River and Morongo ground-water basins to determine the altitude of the water table and the direction of ground-water flow (pl. 1). To download a file containing the USGS site identification and California State well numbers for the wells used to construct the maps in this report, click here. This file can be used to retrieve water-level and water-quality data from the USGS National database by going to http://waterdata.usgs.gov/ca/nwis.

The water table is the surface on which the fluid pressure in the pores of a porous medium is exactly atmospheric (Freeze and Cherry, 1979). The water table is defined by the levels at which water stands in wells that just penetrate the water body (Lohman, 1972). The water-level measurements used for plate 1 are from wells with various perforated intervals in the saturated zone (ground-water body). Although these wells may perforate different zones, the measured water levels accurately represent the water-table altitude and can be used with sufficient confidence to indicate the general direction of ground-water flow; ground water flows from areas of higher hydraulic head to areas of lower hydraulic head (downgradient), and perpendicular to the water-level contours (pl. 1). Where 2002 water-level data were not available, contours were drawn on the basis of the 2000 water levels reported by Smith (2002).

As part of a ground-water observation network, the USGS, in cooperation with local water agencies, water districts, the military, and private landowners, has constructed many multiple-well monitoring sites. These sites consist of a cluster of two or more observation wells completed at different depths within a single borehole, each typically screened across a 20-foot interval. Data from the shallowest well of a multiple-well site were used for the regional water-table map. In areas of a perched water table, both the perched and regional water levels are shown on the water-level map (pl. 1 and fig. 3). The 2002 water levels were measured using a steel tape or a calibrated electric tape; when neither of these methods was possible, an airline was used. Water-level data collected by other agencies for this report were validated and deemed to adhere to USGS guidelines (noted as “reported” in the USGS National database). The water-level altitude was determined by subtracting the water-level measurement (depth to water, in feet below land surface) from the established land-surface referenced to the North American Vertical Datum 1988 (NAVD 88).

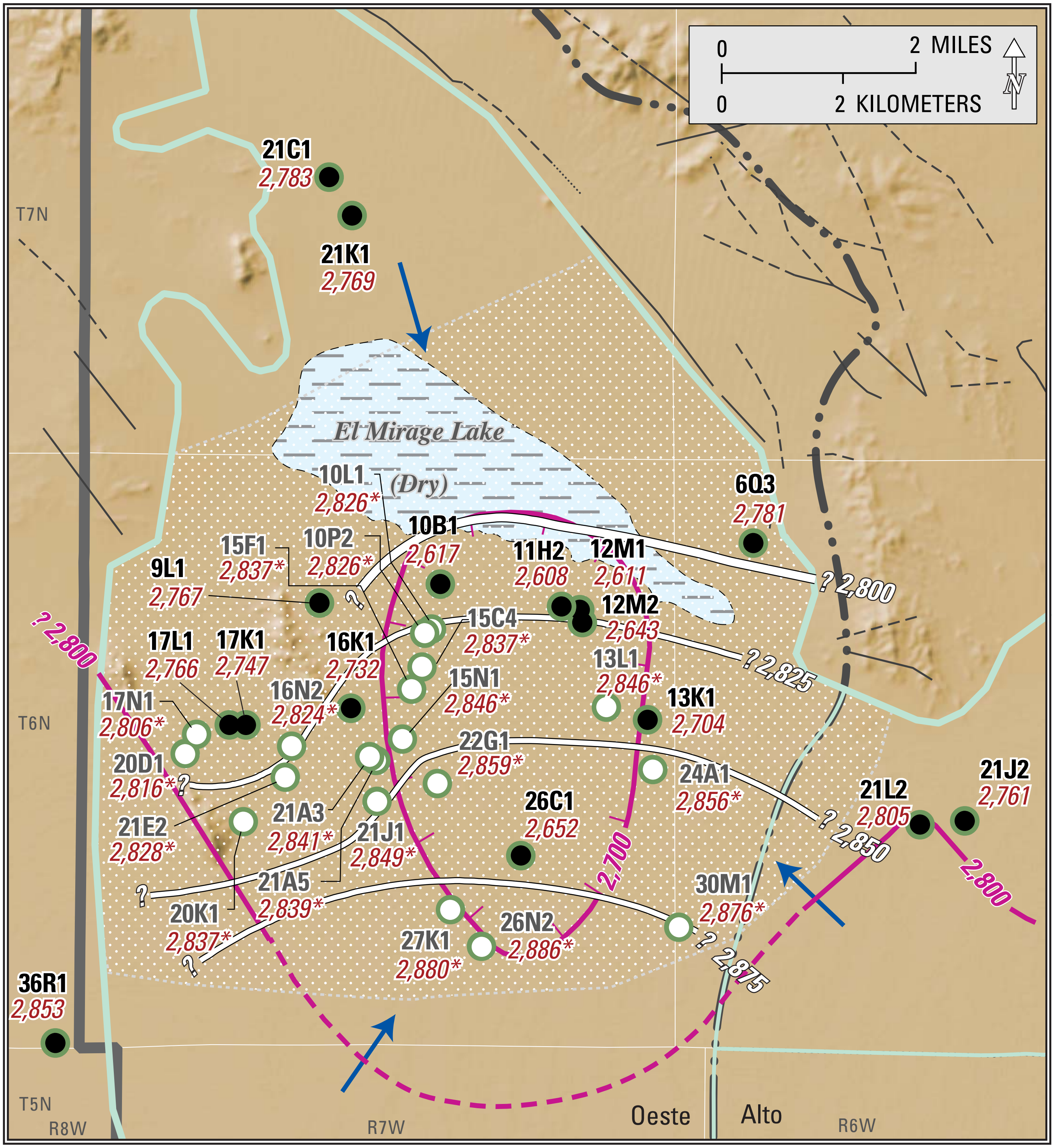

Figure 3. Enlarged view of the regional and perched water tables in the El Mirage Lake (dry) area of the Mojave River ground-water basin, southwestern Mojave Desert, California. (NAVD 88, North American Vertical Datum of 1988)

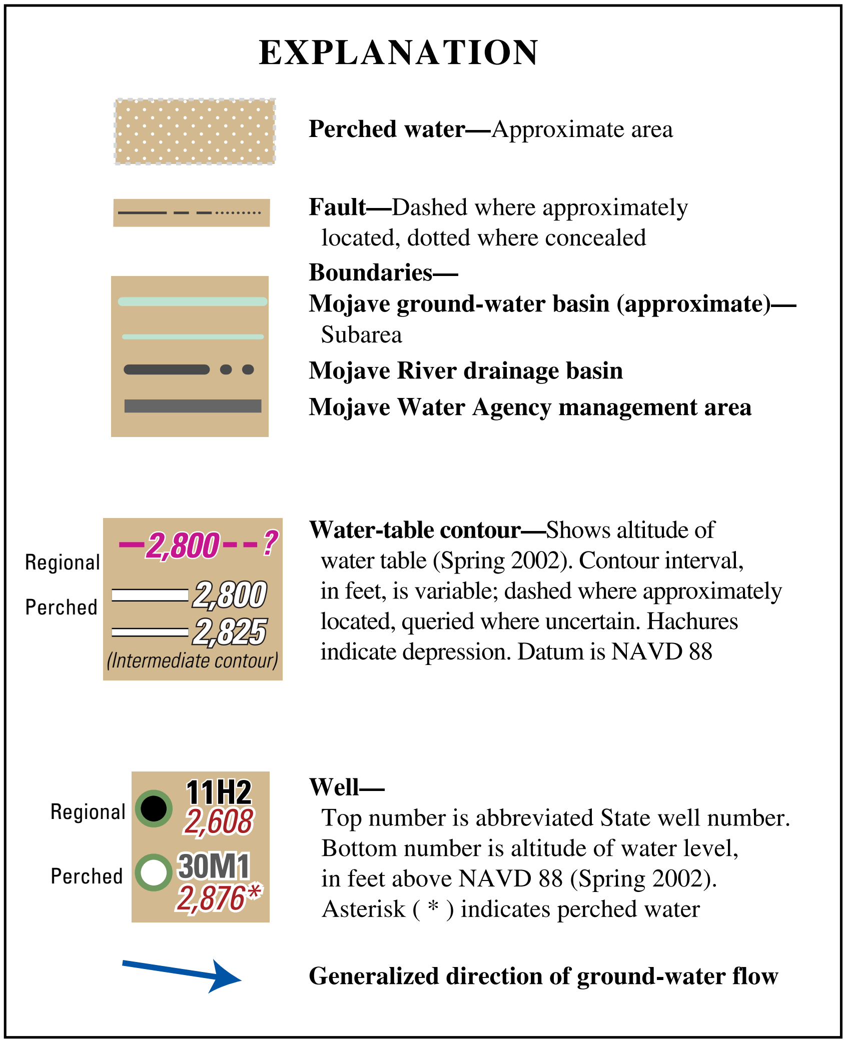

Figure 3—Continued.

Water-Level Changes

Historical water-level data were used in conjunction with data collected during this study to determine both long-term (1930–2002) and short-term (1997–2002) water-level changes in the Mojave River and Morongo ground-water basins. Long-term water-level changes are depicted by 28 water-level hydrographs (pl. 1). Some hydrographs combine data from more than one well to show water-level changes over a greater period of time in a particular area. The long-term hydrographs in the Mojave River ground-water basin show that water levels have declined between 50 and 75 ft in the Alto subarea (fig. 2, pl. 1) since the mid 1940s, about 100 ft in the Harper Lake region of the Centro subarea since the 1960s, and as much as 100 ft in the area northwest of Newberry Springs in the Baja subarea since the early 1940s. In the Morongo ground-water basin, the long-term hydrographs show little or no change in most of the subbasins, but there have been significant water-level declines in five of the subbasins due to pumpage. Water levels have declined about 40 ft in the Joshua Tree subbasin since the early 1960s, about 50 ft in the Reche subbasin since the early 1960s, about 100 ft in the Lucerne subbasin since the mid 1950s, about 150 ft in the Surprise Spring subbasin since the early 1950s, and over 300 ft in the Warren subbasin since the mid 1940s (fig.2, pl. 1).

Nine short-term hydrographs were constructed from data collected between 1997 and 2002 in the Mojave River ground-water basin (pl. 1) to record the effects of seasonal recharge and discharge along the river, and the effects of evapotranspiration of riparian vegetation, which is minimal during winter. These short-term hydrographs show that, since 1997, there has been some recharge to the floodplain aquifer from stormflows in the Mojave River in the Alto and Centro subareas, but that there has been minimal recharge from stormflows in the Baja subarea. In the Transition zone, the ground-water levels in the vicinity of well 7N/5W-23R3 (pl. 1) have been maintained by recharge from treated wastewater that is discharged about 4 mi upstream by the Victor Valley Wastewater Reclamation Authority.

A water-level change map (fig. 2) was prepared by comparing water levels from spring 2000 and spring 2002 in the same wells. Of the 474 wells for which water-level data had been collected for both years, about 24 percent had water levels in 2002 that were within 0.5 ft of the water levels in 2000, and about 56 percent had water-level declines of 0.5 ft or more. About 21 percent of the wells had declines greater than 5 ft. In the Mojave River ground-water basin, about 66 percent of the wells had water-level declines of 0.5 ft or more and 27 percent of the wells had declines greater than 5 ft. In the Morongo ground-water basin, 36 percent of the wells had water-level declines of 0.5 ft or more and 10 percent of the wells had declines greater than 5 ft.

The water-level change data also show that about 19 percent of the 474 wells had water-level increases. These increases occurred near Victorville, near Harper Lake (dry), and in Yucca Valley (Warren subbasin) (fig. 2, pl.1). Near Victorville, pumpage from the numerous municipal wells caused fluctuations in water levels and affected static water-level measurements in the wells in that area. In the Harper Lake (dry) area, there has been a significant reduction in pumpage during the last decade (Stamos and others, 2001), resulting in steadily increasing water levels since the early 1990s (pl.1, fig. 2). Well 11N/4W-30N1 is the only well in the Mojave River Basin that had a water-level increase greater than 5 ft that was not due to fluctuations in nearby pumpage. The only area in the Morongo ground-water basin that had water level increases greater than 5 ft was the Warren subbasin, where artificial-recharge operations in Yucca Valley (pl. 1, figs. 2, 4) have caused water levels to rise almost 160 ft.

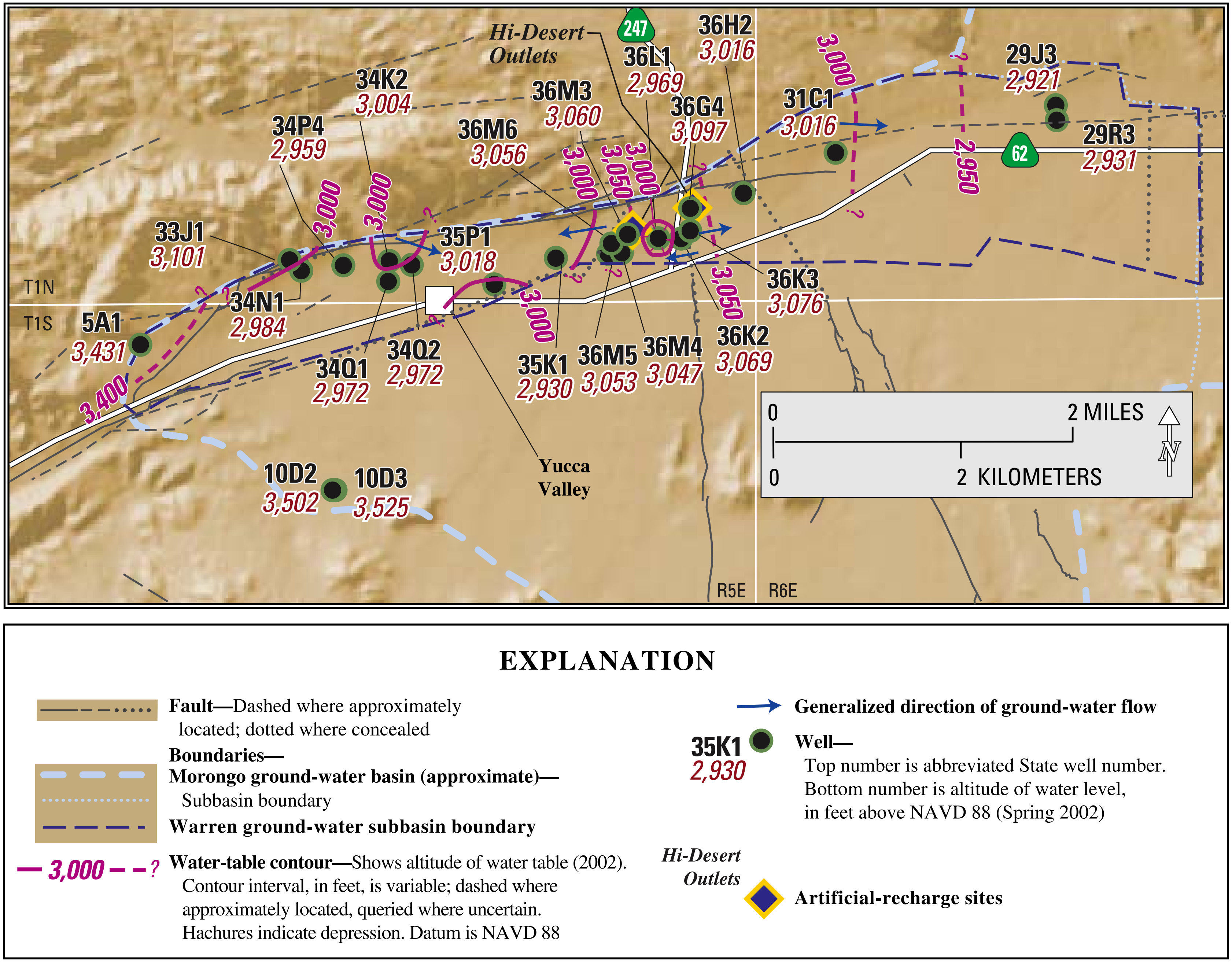

Figure 4. Enlarged view of the regional water table in the Yucca Valley area of the Morongo ground-water basin, southwestern Mojave Desert, California. (NAVD 88, North American Vertical Datum of 1988)

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