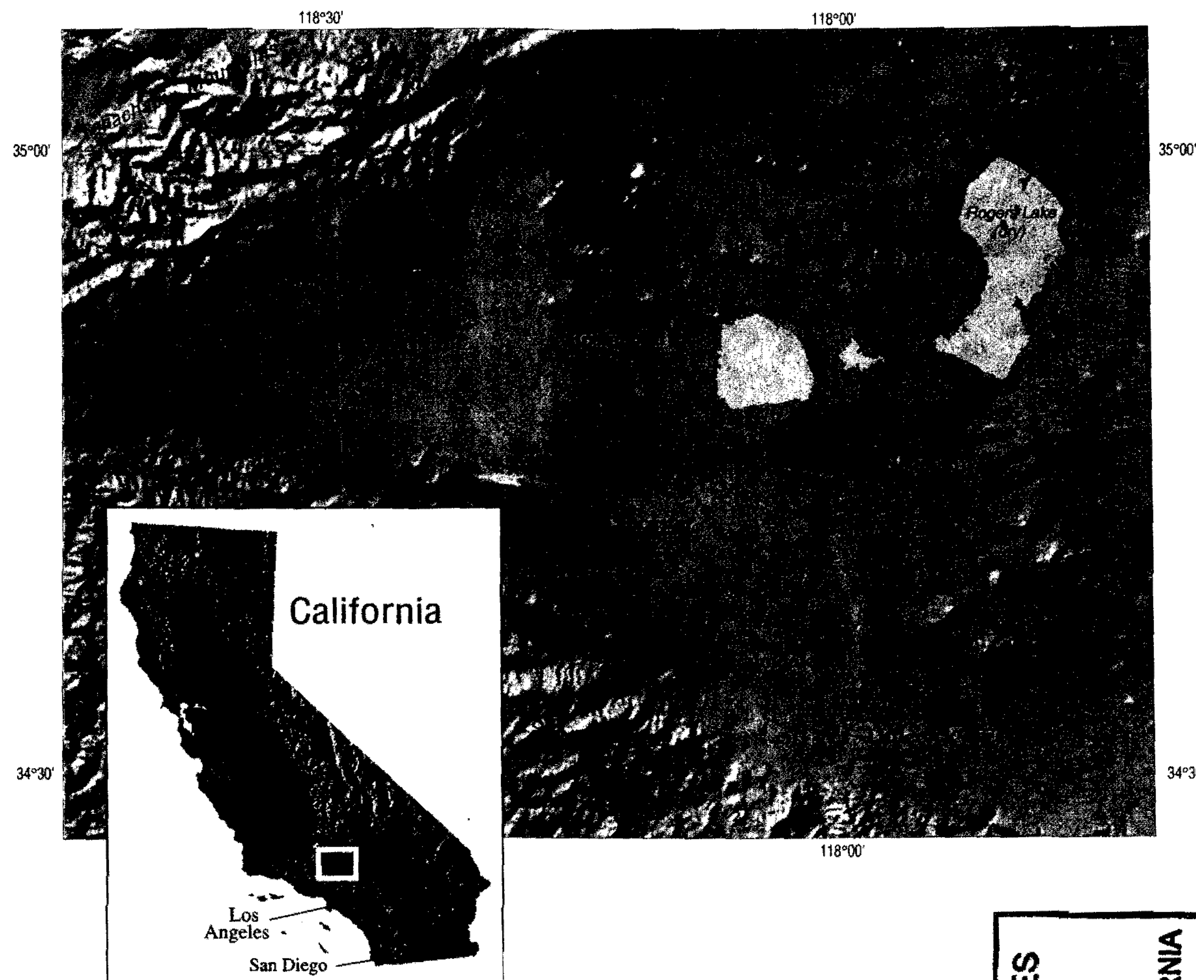
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Regional Water Table (1996) and Water-Table Changes in the Antelope Valley Ground-Water Basin, California

By Carl S. Carlson, David A. Leighton, Steven P. Phillips, and Loren F. Metzger

Prepared in cooperation with the ANTELOPE VALLEY WATER GROUP



USGS
science for a changing world

Water-Resources Investigations Report 98-4022

Introduction

Antelope Valley is located in the western part of the Mojave Desert in southern California, about 50 mi northeast of Los Angeles (fig. 1). Ground water historically has been the primary source of water in this region because of the scarcity of surface water. Water use in the valley has increased significantly since development began in the late 1800's. Ground-water pumping for agricultural uses peaked in the 1950's, possibly exceeding 400,000 acre-feet per year (acre-ft/yr) in 1953 (Snyder, 1955). Increased pumping costs from greater pumping lifts (greater depth to water because of declining ground-water levels) and increased electric power costs (Templin and others, 1995) resulted in a decrease in agricultural pumping in the early 1970's. By the early 1980's, ground-water pumping for urban use, which grew rapidly with urban development in the 1970's and 1980's, exceeded agricultural use. Since the late 1940's, ground-water pumping has exceeded estimated average annual recharge, 40,700 acre-ft/yr (Durbin, 1978), resulting in hundreds of feet of drawdown and more than 6 ft of land subsidence in some areas (Ikehara and Phillips, 1994). Since 1972, supplemental surface water has been imported from the California Water Project to help meet the demand for water in the Antelope Valley. To plan for future development in the Antelope Valley, an understanding of present ground-water conditions, and recent changes, is needed.

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Description of Antelope Valley

Antelope Valley is a triangular-shaped, topographically closed basin covering about 2,200 mi^2 (fig. 1). It is bounded on the northwest by the Tehachapi Mountains, on the north by the Fremont Valley, on the east by the Mojave River Ground-Water Basin, and on the south by the San Gabriel Mountains. The land-surface slopes from topographic highs along the surrounding mountains and low hills toward central topographic lows in the vicinity of the playa surfaces of Rosamond, Buckhorn, and Rogers Lakes (dry).

The climate of Antelope Valley is semi-arid to arid, characterized by low precipitation (less than 10 in. annually during the period 1928-91 in the interior) (Templin and others, 1995), low humidity, and temperatures that range from below 32° F in the winter to above 100° F in the summer (Londquist and others, 1993). Current land use, which has changed substantially from the historical predominance of agriculture, includes urban, military, industrial, and agricultural categories. Although the Antelope Valley is largely undeveloped, because of its proximity to Los Angeles, several communities expanded rapidly in the 1980's, increasing urban water use. Lancaster and Palmdale are the largest population centers in Antelope Valley, having had a combined population of about 33,000 in 1960 (Templin and others, 1995) compared with a combined population of 156,000 in 1990 (U.S. Department of Commerce, Bureau of the Census, 1990). Agricultural land use in 1996 is about 20 percent of the maximum levels in the 1950's and 1960's (D.L. Galloway, U.S. Geological Survey, written commun., 1996).

Geohydrology

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The Antelope Valley drainage basin has been divided into 12 ground-water subbasins (fig. 1) by faults and consolidated rock and, in some instances, by arbitrary boundaries (Weir and others, 1965; Bloyd, 1967). As defined, the drainage basin consists of the Lancaster, Buttes, Pearland, Neenach, West Antelope, Finger Buttes, North Muroc, Oak Creek, Chaffe, Gloster, Willow Springs, and Peerless subbasins (fig. 1).

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1996 Water Table

Water-level data from 188 wells were used to define the 1996 water-table surface and the direction of ground-water movement in the Antelope Valley ground-water basin. In areas where water-level data were sparse for 1996, the contours were defined on the basis of previous water-table maps (Londquist and others, 1993) and selected water levels for 1995 (seven wells, table 1). No contours were drawn for the Finger Buttes and West Antelope subbasins for 1996, because data were sparse (fig. 2). Water-level data were collected by the USGS from 172 wells in April 1996 as part of an annual monitoring program in cooperation with the Antelope Valley-East Kern Water Agency, and seven wells in July 1995 in the Palmdale area. Additional water-level data (April 1996) from nine wells were supplied by the Palmdale Water District (table 1). Water-level and well-construction data for each well shown on figure 2 are shown in table 1.

The water table is defined as the surface on which the fluid pressure in the pores of a porous medium is exactly atmospheric. The location of the surface is revealed by the level at which water stands in a shallow well open along its length and penetrating the surficial deposits just deep enough to encounter standing water in the bottom (Freeze and Cherry, 1979). The data collected as part of the project were used to draw water-table contours in figure 2 and are assumed to represent static conditions. It is important to note that there are factors that may violate this assumption. Water levels in the deeper wells probably do not accurately reflect conditions at the water table. Recent pumping of measured wells or pumping of nearby active wells will affect static conditions. For example, water-level data from production wells in the Palmdale Water District may not represent static conditions (D.D. LaMoreaux, Palmdale Water District, written commun., 1997). These data were collected in April to reflect the conditions before the summer pumping season. Local areas of perched water might exist (Johnson, 1911; Thompson, 1929; and Londquist and others, 1993) and water-level data from wells completed within a perched water body do not represent the regional water table.

Ground-Water Movement

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Ground water flows from areas of higher to areas of lower water table altitude and perpendicular to contours of equal water level (see red arrows, fig. 2). In general, ground water moves east from the Finger Buttes, West Antelope, and Neenach subbasins toward the Lancaster subbasin and northwest from the Buttes and Pearland subbasins toward

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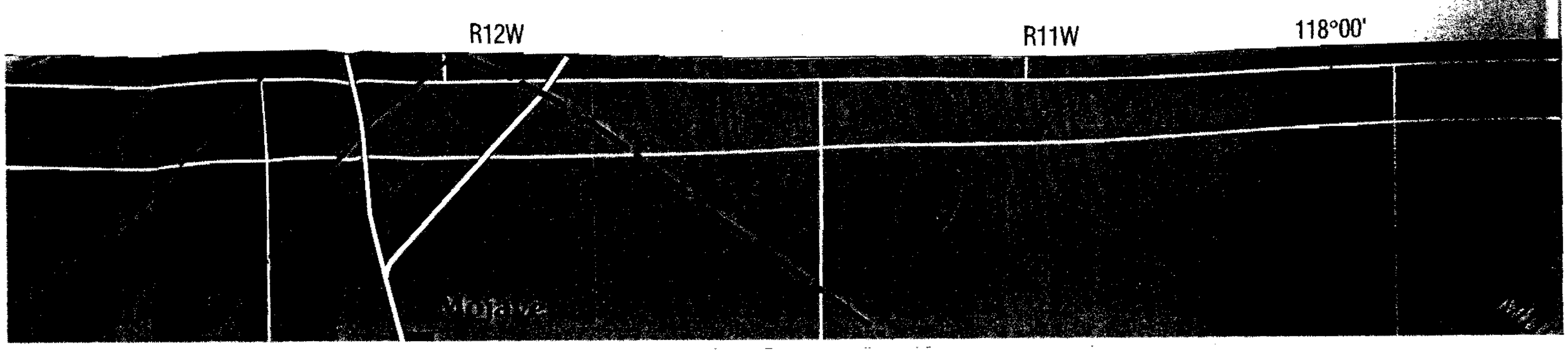

Ikehara and Phillips, 1994, fig. 3).

Water-Level Changes

Historical water-level data were compared with data collected during this study to determine water-table change in the Antelope Valley (fig. 4). Historical water-level changes are represented in hydrographs showing water levels from 1950 to 1996 at selected wells. Regional water-level changes were determined by comparing 1996 ground-water levels with ground-water levels from April and May 1983 (fig. 4, table 1).

Hydrographs that show the water-level data for 20 wells were selected, on the basis of length of historical data, to show long-term water-level trends in the Antelope Valley (fig. 4). In general, the hydrographs show declining water levels from the 1950's through the 1960's, when agricultural ground-water use in the valley peaked. With the exception of declining water levels near urban areas (7N/12W-19R1 and 7N/12W-22K1) and rising water levels near former agricultural areas, most of the water levels have remained relatively unchanged, although some have risen by as much as 50 ft from the 1970's to 1996 as a result of decreased agricultural pumping. The largest water-level rises are shown in the hydrographs for well 7N/14W-13A1 in the southwestern part of the Lancaster subbasin and well 7N/10W-19D1 in the eastern part of the subbasin (fig. 4).

A water-level change map was developed by comparing ground-water levels from April 1983 with ground-water levels from April 1996 (fig. 4), a period representing increased urban development and associated water use. The year 1983 was selected on the basis of the relatively large number of water-level measurements in common with the 1996 water-level measurements. Water-level changes in these wells were contoured, and shaded to show the areal distribution of water-level change in the Antelope Valley. The water-table change map shows four primary areas

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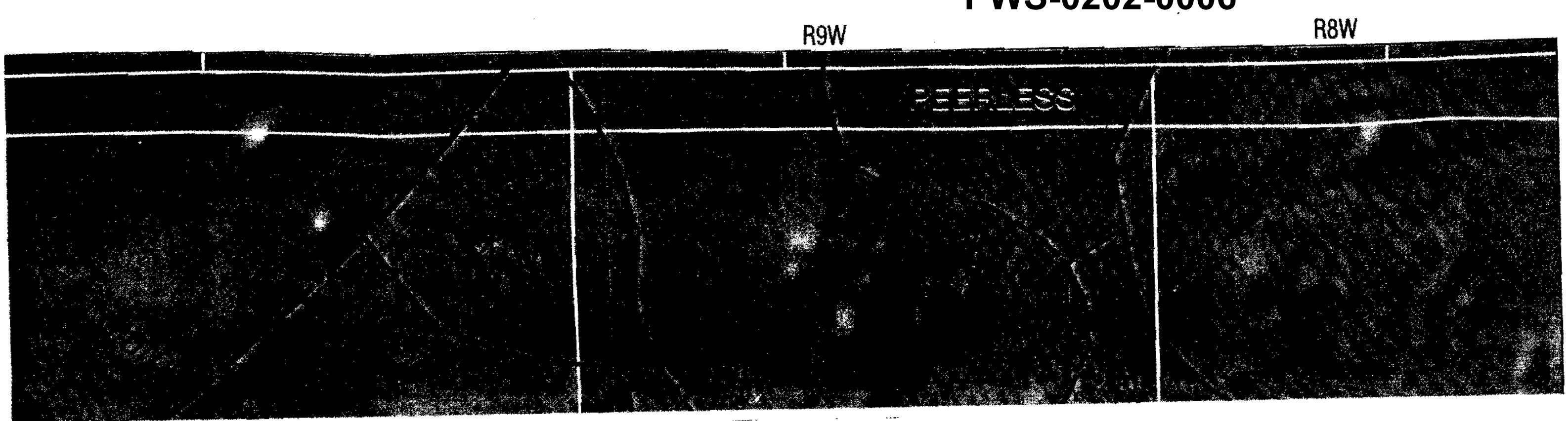

where water levels have declined: the vicinity of Lancaster, 10- to 21-ft decline; the vicinity of Palmdale, 33- to 107-ft decline; northwest of Littlerock, 15- to 31-ft decline, and east of Rogers Lake, greater than 10-ft decline. The area of water-level decline shown east of Rogers Lake (dry) in the Lancaster subbasin is larger than would be justified by one data point (9N/9W-27H2) and was based on historical water levels that do not correspond to the period 1983-1996 (not shown). On the basis of a single well measurement (10N/9W-24A2), an area of a greater than 10-ft water-level decline is shown in the North Muroc subbasin. Notably, 1983 water-level data are not available near the southern end of Rogers Lake (dry) in the primary ground water production zone for Edwards Air Force Base. The available records show a water-level decline of about 2 ft/yr on the basis of April water levels in this area (9N/10W-36P2) since 1992.

There are two primary areas where water levels have risen: east of Lancaster between Redman and Littlerock, 10- to 46-ft rise; northwest of Lancaster, 11- to 42-ft rise. None of the areas with rising water levels are near major urban centers, and probably all of these areas previously were irrigated more heavily. Even though water levels have risen in these areas (fig. 4), they are still regional water-table lows, as shown on the water-table map (fig. 2).

Summary

The 1996 water-table map indicates that ground-water movement is toward regional water table lows southwest of Rosamond and south and east of Lancaster. Ground-water movement also occurs toward water table lows both north and south of Rogers Lake (dry). Generally, areas of increased urbanization show water-level declines for the period 1983-1996: the vicinity of Lancaster, 10- to 21-ft decline; the vicinity of Palmdale, 33- to 107-ft decline; and northwest of Littlerock, 15- to 31-ft decline. Limited data indicate areas of greater than 10-ft water-level declines east of Rogers Lake (dry). Water-level data for 1983 are not available near the southern end of Rogers Lake (dry) in the primary ground-water production zone for Edwards Air Force Base. Available records indicate a water-level decline of about 2 ft/yr since 1992 on the basis of April water levels in this area. Areas of decreased agricultural production show water-level rises for the period 1983-1996: east of Lancaster between Redman and Littlerock, 10- to 46-ft rise; and northwest of Lancaster, 11- to 42-ft rise. Even though water levels have risen in these areas (fig. 4), the areas are still regional water-table lows, as shown on the water-table map (fig. 2). Ground-water movement, pumping lifts, and subsidence rates are affected by these changing conditions. Water-table conditions could be defined better by including additional wells in the monitoring network, particularly in areas of sparse data and rapidly changing water levels.

Antelope Valley
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