GEOHYDROLOGY OF THE ANTELOPE VALLEY AREA, CALIFORNIA, AND DESIGN FOR A GROUND-WATER-QUALITY MONITORING NETWORK

By Lowell F. W. Duell, Jr.

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 84-4081

Prepared in cooperation with the

CALIFORNIA STATE WATER RESOURCES CONTROL BOARD and the

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD--LAHONTAN REGION

Sacramento, California
1987

DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information write to:

District Chief
U.S. Geological Survey
Federal Building, Room W-2234
2800 Cottage Way
Sacramento, CA 95825

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[Plates are in pocket]

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CONVERSION FACTORS

For readers who prefer to use International System of Units (SI) rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply	By	To obtain
acres	0.4047	ha (hectares)
acre-ft (acre-feet)	.001233	hm^3 (cubic hectometers)
acre-ft/yr (acre-feet per year)	.001233	hm^3/a (cubic hectometers per annum)
ft (feet)	.3048	m (meters)
gal (gallons)	.003785	m^3 (cubic meters)
gal/min (gallons per minute)	.003785	m^3/m (cubic meters per minute)
(gal/min)/ft (gallons per minute per foot)	.01242	m^2/min (meters squared per minute)
inches	25.4	mm (millimeters)
Mgal/d (million gallons per day)	3785	m^3/d (cubic meters per day)
mi (miles)	1.609	km (kilometers)
mi^2 (square miles)	2.590	km^2 (square kilometers)
µmho/cm (micromhos per centimeter)	1	µS/cm (microsiemens per centimeter)

Degree Fahrenheit is converted to degree Celsius by using the formula:

$$(°F-32)/1.8 = \text{temp } °C$$

Abbreviations:
mg/L or MG/L milligrams per liter
µg/L or UG/L micrograms per liter
UMHOS micromhos per centimeter

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called mean sea level.

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ABSTRACT

A basinwide ideal network and an actual network were designed to identify ambient ground-water quality, trends in ground-water quality, and degree of threat from potential contamination sources in Antelope Valley, California. In general, throughout the valley ground-water quality has remained unchanged and no specific trends are apparent. The main source of ground water for the valley is generally suitable for domestic, irrigation, and most industrial uses. Water-quality data for selected constituents of some network wells and surface-water sites are presented.

The ideal network of 77 sites was selected on the basis of site-specific criteria, geohydrology, and current land use (agricultural, residential, and industrial). These sites were used as a guide in the design of the actual network consisting of 44 existing wells. Actual wells are currently being monitored and were selected whenever possible because of budgetary constraints. Of the remaining ideal sites, 20 have existing wells not part of a current water-quality network, and 13 are locations where no wells exist. The methodology used for the selection of sites, constituents monitored, and frequency of analysis will enable network users to make appropriate future changes to the monitoring network.

INTRODUCTION

The California State Water Resources Control Board and the California Regional Water Quality Control Boards are charged by the California Water Code under the Porter-Cologne Water Quality Control Act and by Federal regulations (including the Federal Water Pollution Control Act of 1972 [PL-92-500]) with protecting ground-water quality in California. To carry out this mandate, ground-water-quality monitoring networks are to be established in the more populated ground-water basins such as Antelope Valley.

This report represents the results of phase 3 of a four-phase study. In phase 1, the level of ongoing surveillance in Antelope Valley was determined. In phase 2, a comprehensive cataloging of operational ground-water-quality monitoring networks in the valley was compiled, along with a description of the data being collected and well-construction information. Phase 1 and 2 reports were not published, but are available for inspection at the California State Water Resources Control Board (State Board). The catalog of active ground-water-monitoring networks compiled under phase 2 was used in selecting the two networks presented in this report. Phase 4, after the suggested time period of 5 years, will consist of a detailed review of results and appropriate modifications to the monitoring network.

Currently (1983), numerous governmental and private agencies have specific regional monitoring programs consistent with their objectives. The State Board's statutory responsibilities include the exchange of data and other information relating to ground water and ground-water quality among State agencies. In the interest of uniformity and consistency, the U.S. Geological Survey, in cooperation with the California State Water Resources Control Board and the California Regional Water Quality Control Board--Lahontan Region (Regional Board) designed a single network from the many ground-water-quality monitoring networks already in operation.

The program began in October 1979. Twenty-one ground-water basins in California are of initial concern and are being studied in an order determined by the State Board. This report is one of seven in the first group of basins studied. The others in this first group are Coachella Valley, San Fernando Valley, Lower Mojave River valley, San Joaquin Valley, Salinas Valley, and Santa Rosa Valley basins.

Wells in the phase 2 report were classified on the basis of five key items of information: (1) casing perforation interval from opening record, (2) depth of well, (3) depth and diameter of casing, (4) type of seal used, and (5) well logs. Wells are divided into four classes based on which and how many of the five key information items are available on that particular well:

- Class 1 - all five of the key information items are available.
- Class 2 - the perforated interval record is available, but any one or all of the remaining key information items may be lacking.
- Class 3 - the perforated interval record is lacking, but one or more of the remaining key information items are available.
- Class 4 - all key information items are lacking.

Classes 3 and 4 are predominant in Antelope Valley.

Purpose and Scope

The purpose of this study was to design a water-quality-monitoring network based on a thorough knowledge of the geohydrology to enable the California State Water Resources Control Board (State Board) and the California Regional Water Quality Control Board--Lahontan Region (Regional Board), to determine ambient ground-water quality, trends in ground-water-quality change, and degree of threat of contamination from various land-use sources in Antelope Valley. This report was done by the U.S. Geological Survey under a cooperative program with the State and Regional Boards. Management objectives, land use, hydrologic conditions, and status of wells change from year to year, and the network designed as part of this study should be reevaluated and modified every 5 years. The format used in the development of the monitoring network and the detailed geohydrology and background information will be useful to the State Board for any modification to the networks presented in this report.

Previous reports published on Antelope Valley were reviewed. It was important to evaluate the water quality of the entire basin as a unit. Proposed network sites were selected on the basis of site-specific criteria, geohydrology, and current land use (agricultural, residential, and industrial). The proposed monitoring network is intended to provide an appraisal of ground-water quality and indicate what damage, if any, is occurring to the ground water of Antelope Valley.

The scope of the project was limited to an evaluation of existing data. Well-construction information was lacking for many of the available wells, and some of the historical data may not be reliable. Any additional network design work should include use of borehole geophysical techniques to determine well-construction information.

Approach

The network objectives used for selecting monitoring sites in each ground-water subdivision of Antelope Valley were as follows: First was the need to determine the effect of point and nonpoint sources of contamination. The basic approach in meeting this need was to select an upgradient and downgradient site to monitor suspected plumes of known or potential pollutants and to detect long-term trends. Second was the need for establishing base line water-quality conditions (control sites), particularly in areas where these conditions are virtually unknown. Third was the need for monitoring sites where there are known water-quality problems. The most likely potential contamination sources in Antelope Valley are agricultural land use, sewage disposal sites, mining, and golf courses. Golf courses may be irrigated by sewage effluents in addition to the high levels of nitrogen fertilizers that are applied frequently.

In this study, three networks were developed as follows: (1) An ideal site network, designed on the basis of the geohydrology, land use, and ground-water-quality conditions of the various ground-water subdivisions in Antelope Valley. Economic factors were not considered. The ideal network, made up of key monitoring locations, was used as a guide in selecting the sites for the other two networks. (2) An ideal well network, actually part of the site network except that wells presently exist but are not being monitored by any agency. (3) An actual well network, designed with the constraint of using wells already being monitored (phase 2), evaluating the cost factor of each ground-water monitoring objective, and also considering well classification (adequate log data, active for long-term use, proper location, sampling categories and sampling frequency). These networks represent the location, sampling frequency, and suite of categories that best meet the network objectives.

The reasons for the development of each of the three networks are defined as monitoring objectives. Establishing the priority of each well or site provides a tool to delete or trim the development of the actual network. Thus, with all the information provided for the ideal network, in the event that the monitoring objectives change, a new actual network can be developed.

Previous Investigations and Acknowledgments

The geologic description was based mainly on previous reports by Johnson (1911); Thompson (1929); Kunkel and Dutcher (1960); Dutcher and others (1962); Moyle (1965, 1969); Koehler (1966); Bloyd (1967); and Dibblee (1967).

Reports used extensively to compile descriptions of the ground-water subdivisions include those by Dutcher and Worts (1963); Weir, Crippen, and Dutcher (1964); Bloyd (1967); Lewis and Miller (1968); Durbin (1978); and Lamb (1980).

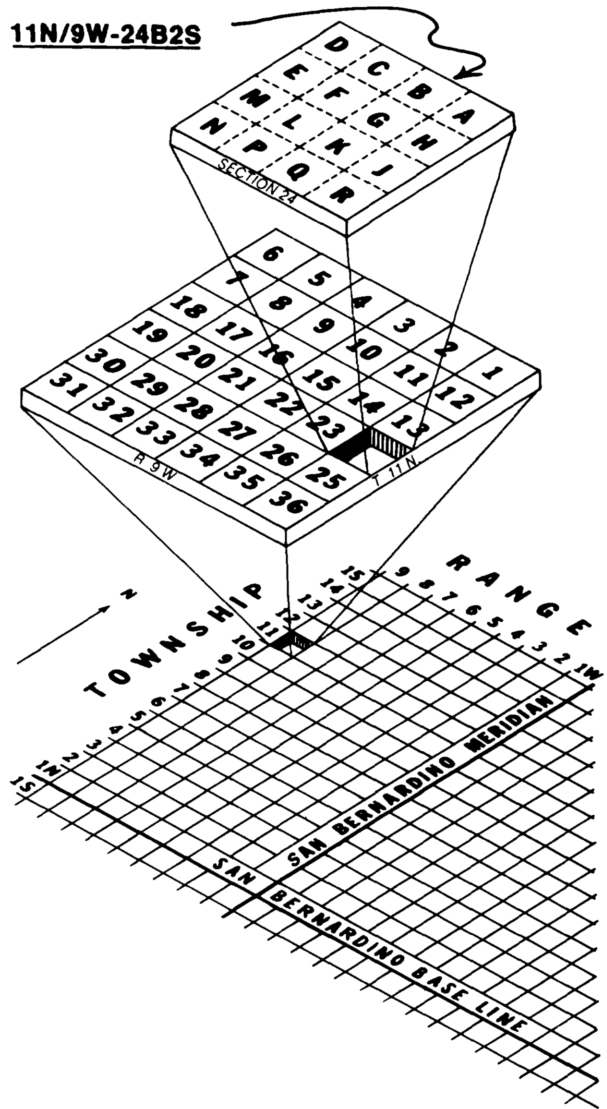
The water-quality overview included interpretation of historical records available through the U.S. Geological Survey WATSTORE (National Water Data Storage and Retrieval System) computer system, and reports by Dutcher and Worts (1963); Bloyd (1967); Lamb (1976); Chandler (1972); Hatai (1979); and the California Department of Water Resources (1980).

Two reports used in the selection of the recommended sampling categories and the frequency of monitoring were Hughes (1975), and VanDenburgh and others (1982).

Appreciation is expressed to the staff of the California Regional Water Quality Control Board--Lahontan Region, especially Robert S. Dodds and Michael B. Wochnick, for their assistance and input into developing the water-quality-monitoring network.

Well-Numbering System

Wells are numbered according to their location in the rectangular system for subdivision of public land. For example, in the well number 11N/9W-24B2S, that part of the number preceding the slash indicates the township (T. 11 N.); the number and letter following the slash indicate the range (R. 9 W.); the number following the hyphen indicates the section (sec. 24); the letter (B) following the section number indicates the 40-acre subdivision of the section; the final digit (2) is a serial number for wells in each 40-acre subdivision; and the final letter (S) indicates the San Bernardino or (M) Mount Diablo base line and meridian. The computer-tabulated well number (local identifier) in table 3 is a 14-character number in which unused spaces and the slash and hyphen are replaced with zeros. Thus, well 11N/9W-2P2S would be identified in table 3 as 011N009W24P02S. All the wells are either in the northwest quadrant of the San Bernardino base and meridian or in the southeast quadrant of the Mount Diablo base and meridian.



DESCRIPTION OF THE STUDY AREA

Location and General Features

Antelope Valley is in the southwestern part of the Mojave Desert region in southern California (fig. 1), in the northeastern and southeastern part of Los Angeles and Kern Counties. The basin is approximately 40 miles north of the center of Los Angeles.

The valley is roughly triangular in shape, lies between the San Andreas and Garlock faults (pl. 1), and is a part of the Mojave block, a structural depression that has been downfaulted. The area is bounded on the northwest by the forested Tehachapi Mountains, which rise to an altitude of 7,981 feet, and on the southwest by the forested San Gabriel Mountains, which rise to 9,399 feet. The east boundary is a series of sparsely vegetated granitic hills and buttes in the general area of the San Bernardino County line.

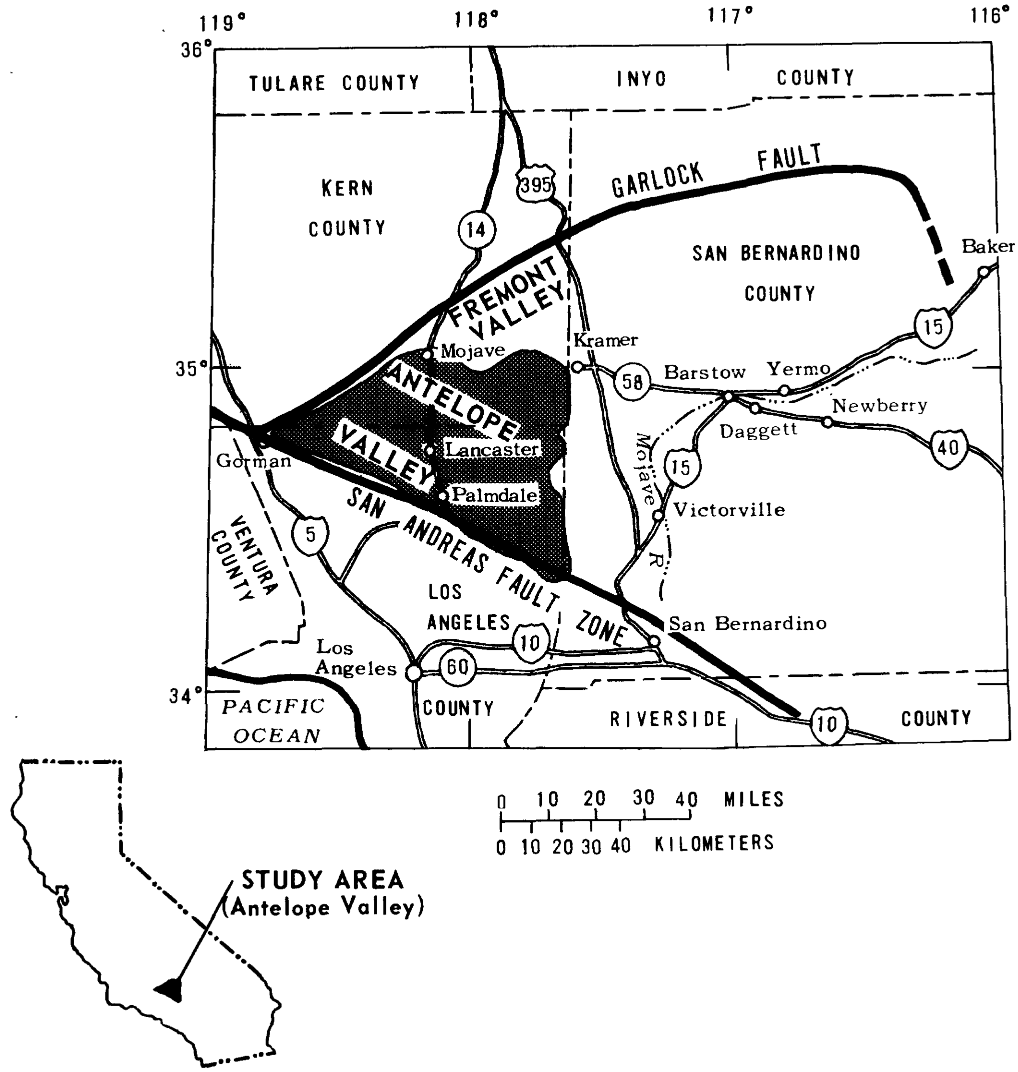


FIGURE 1.--Location of study area.

The study area covers about 1,600 square miles. The valley floor ranges from 2,300 to 3,500 feet above sea level. The area is characterized by interior drainage in which infrequent floodflows terminate at either Rosamond Lake or Rogers Lake (dry). Gently sloping alluvial plains and fans extend into the area, as much as 15 miles from the mountains and higher slopes. The basin has been arbitrarily divided into ground-water subdivisions by faults and other structural features.

The vegetation of the area consists of varieties of desert shrubs; the large species are confined to the mountains or upper slopes of the valley. The most noticeable tree-like form in the valley is the Joshua tree. Other native plants include saltbrush, mesquite trees, sagebrush, and creosote bush. Coniferous trees grow in the higher altitudes.

The population of Antelope Valley is approximately 130,000. The principal communities and approximate population figures in the area are: Lancaster, 55,000; Palmdale, 18,000; Mojave, 4,000; Boron, 2,000; Rosamond, 4,000; and Edwards Air Force Base, 6,000. Principal access to the area is by California State Highways 14, 15, 18, 58, 138, and 395, as well as several other paved and unpaved roads.

The major source of public drinking water for the Antelope Valley area is ground water. Another important source of drinking water (since 1972) is imported water via the California Water Project (CWP). Many private wells serve as domestic drinking water and irrigation supplies. By 1979 the Antelope Valley-East Kern Water Agency (AVEK) was receiving 70,000 acre-ft/yr from the CWP. This included 60,000 acre-ft/yr for irrigation (mostly in the area around Lancaster and to the west), and 10,000 acre-ft/yr for supplemental municipal drinking water.

Climate

The area is predominantly semiarid. Characteristic of the region, precipitation varies widely within its boundaries (fig. 2). Average annual precipitation on the valley floor is less than 10 inches, and in the mountain areas it is more than 12 inches (Rantz, 1969). Eighty percent of the mean annual precipitation falls in the winter months, including some snow in the higher altitudes. Summer precipitation is limited to local thunderstorms mostly at higher altitudes. The mean summer temperature is 78°F and mean daily summer temperatures range from 63° to 93°F. The mean winter temperature is 45°F and mean daily winter temperatures range from 34° to 57°F. The principal growing season is April through October.

GEOHYDROLOGY

The desert areas of California consist of mountain ranges and isolated hills surrounding broad valleys underlain by alluvial deposits. Commonly, faults border the areas and transect ground-water basins to form barriers to ground-water flow. Many of these faults are concealed, but are evident by disparities in the ground-water levels on opposite sides of the faults.

Faults in Antelope Valley (pl. 1) include the San Andreas fault, which strikes along the northern margin of the San Gabriel Mountains, and the Garlock fault, which trends southwest along the southeast side of the Tehachapi Mountains to its intersection with the San Andreas fault. Some of the faults have been named, such as the Cottonwood, Rosamond, Randsburg-Mojave, Neenach, and Muroc; others are unnamed. The geologic formations of Antelope Valley are divided into two main groups, the consolidated, virtually non-water-bearing rocks, and the water-bearing, mostly unconsolidated deposits.

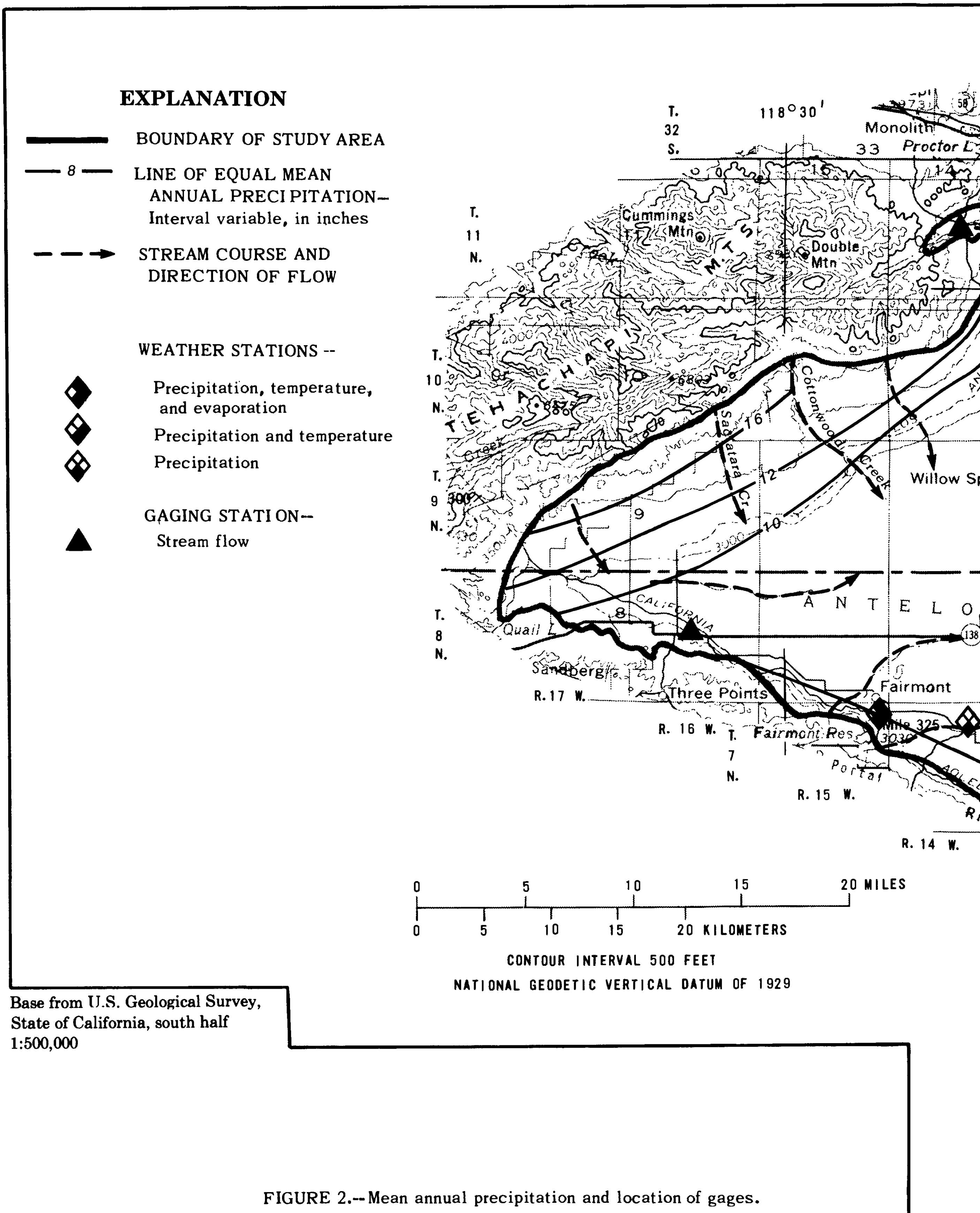
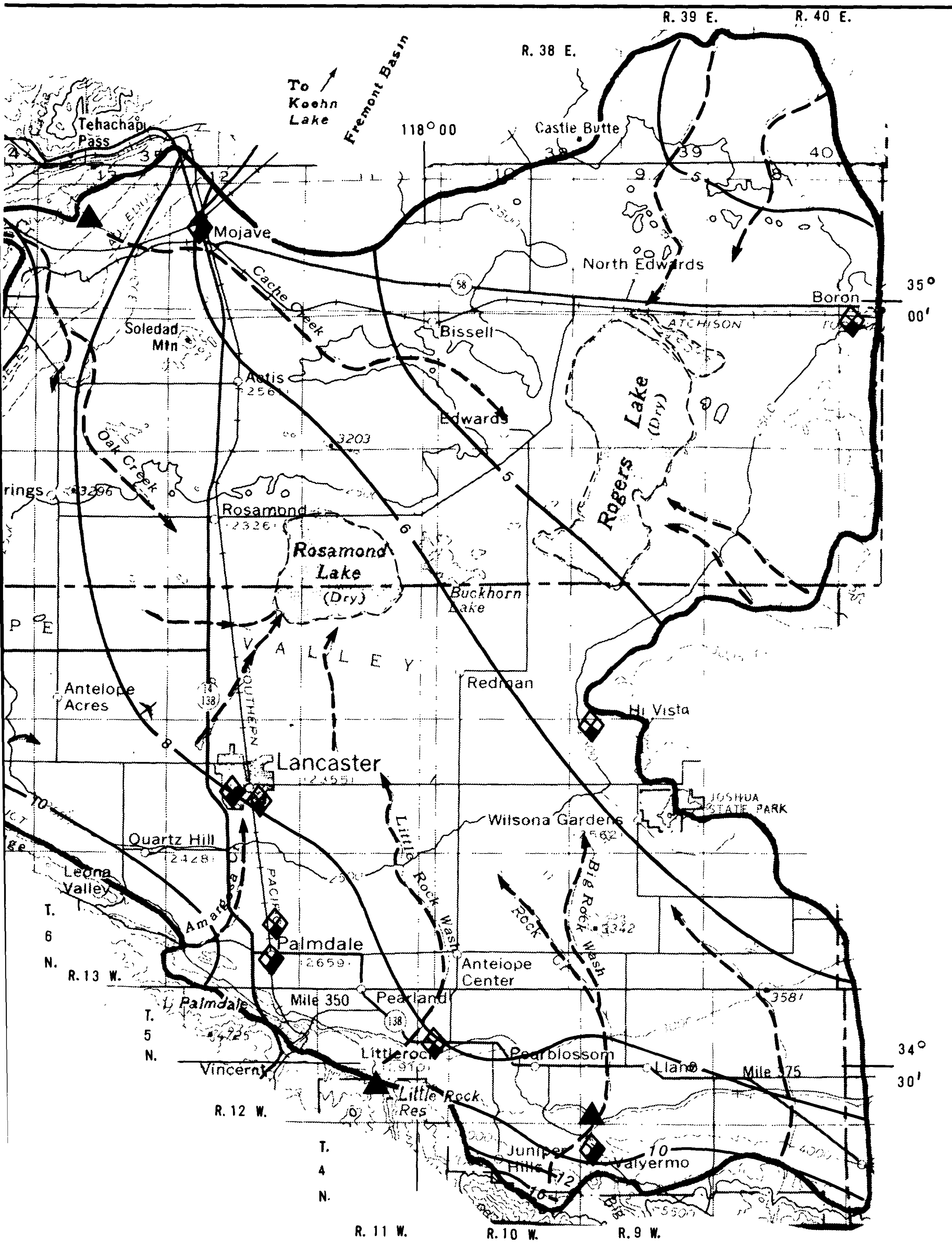


FIGURE 2.--Mean annual precipitation and location of gages.



Hydrology modified from Rantz (1969)

Consolidated Rocks and Their Water-Bearing Characteristics

Consolidated rocks surround Antelope Valley and form the sides and bottom of the ground-water basin (pl. 1). Most of the recharge to Antelope Valley is derived from surface-water runoff originating as precipitation over areas underlain by consolidated rocks. They consist of igneous intrusive and metamorphic rocks of pre-Tertiary age, and basalt, continental volcanic, and marine and continental sedimentary rocks of Tertiary age. The oldest formations are pre-Tertiary and form the basement complex. Generally, these rocks are impermeable except for joints and weathered zones that yield small quantities of water to springs. Basalt of probable Miocene to Pliocene age may yield small to moderate amounts of water locally. The volcanic rocks of Miocene age yield very little water because the material has low permeability (hydraulic conductivity) even where fractured. Consolidated sedimentary rocks of Tertiary age yield little water, if any.

Unconsolidated Deposits and Their Water-Bearing Characteristics

The unconsolidated deposits that underlie Antelope Valley (pl. 1) include younger and older alluvium, older fan deposits, windblown dune sand, and playa deposits. These deposits comprise the aquifers of the area. The older alluvium of Pliocene(?) and Pleistocene age is the principal aquifer and underlies most of the valley floor at depth. The older alluvium consists of compact gravel, sand, silt, and clay. These deposits are weathered, and locally the feldspar has been altered to clay. Near the hills these deposits consist predominantly of gravel, but beneath the valley area they are finer grained and better sorted. The older alluvium is porous and permeable and yields water freely, and is the most important water-bearing unit.

The younger alluvium of Holocene age remains unweathered near the hills and consists predominantly of poorly sorted gravel and sand. The hydraulic conductivity of the alluvium decreases with increasing age and, consequently, with increasing depth. Presumably, the thickness of the younger alluvium is not greater than 100 feet; it is permeable and yields water where saturated.

The older fan deposits of Pliocene(?) and Pleistocene age occur as isolated erosional remnants and consist of slightly consolidated fanglomerate, or unsorted boulder gravel, cobble-pebble gravel, and sand mainly from a granitic source. Where saturated, the deposits may yield small quantities of water to deep wells. Younger fan deposits of Holocene age (undifferentiated from the older fan deposits in pl. 1) are still being deposited in the area and consist of unconsolidated angular boulders, cobbles, and gravel, with small amounts of sand, silt, and clay. These are formed by intermittent streams that issue from nearby hills and mountains and transport the material only a short distance. These deposits mostly represent mudflow or slope-wash debris, have low permeability, and are mainly above the water table.

Playa or lacustrine deposits of Pliocene through Holocene age are composed of siltstone, clay, and marl. During pluvial periods, or times of relatively heavy precipitation, massive beds of blue clay formed in deep, perennial lakes. Individual clay beds are locally as much as 400 feet thick. These beds are interbedded with lenses of coarser material as much as 20 feet thick. The clay yields virtually no water to wells, but interbedded materials supply some water to wells.

In the area around the town of Lancaster and farther northeast (pl. 1, fig. 3) an older lacustrine deposit divides the unconsolidated deposits into an upper principal aquifer and a lower deep aquifer. The buried lacustrine deposits may have a somewhat lenticular shape. Near the south boundary of Antelope Valley, lacustrine deposits are buried beneath about 300 to 500 feet of alluvium, but near the north boundary they are exposed at the land surface.

A perched water body overlies additional clay lenses (remnants of old lake features including cut terraces, beaches, bars, and spits) that act as local ground-water barriers capable of retarding irrigation return or sewage infiltration. The approximate extent of this shallow perched water body (identified by R.M. Bloyd in 1967) is shown in plate 2. This additional aquifer is separate from the underlying principal aquifer and occurs generally within 80 feet of the ground surface. The water in this aquifer may contain high concentrations of bacteria, chloride, dissolved solids, nitrate, and pesticides.

Playa deposits of Holocene age are composed of silt, clay, sandy clay, and small amounts of soluble salts. They occur mostly along faults in structural depressions or sagponds. Characteristically, the deposits have low permeability and are above the water table. Dune sand of Holocene age is partly composed of actively drifting fine to medium sand. The dunes have not been stabilized by vegetation and still drift during windy periods. They are mostly above the water table, although in some places the dunes contain small quantities of perched ground water.

Values of specific capacity ranged from 10 to 125 (gal/min)/ft of drawdown where data are available (fig. 4). Values were developed from existing w without consideration of perforated intervals.

Recharge and Ground-Water Movement

The Antelope Valley drainage basin receives an average annual precipitation of about 1.5 million acre-ft; of this amount, only about 76,000 acre-ft, or about 5 percent, may ultimately percolate to ground-water reservoirs. The remainder is lost by natural processes (evapotranspiration), although about 10,000 acre-ft may be consumptively used by man before reaching the valley floor (Bloyd, 1967).

The major source of recharge to the ground-water basin is surface-water runoff from the surrounding mountains. Figure 2 shows the location of existing stream gages and weather stations within the study area. Average annual discharges for the period of record at U.S. Geological Survey surface-water sites are given in table 1. Another significant source of recharge is irrigation return from the imported water that is directly applied to agricultural land. Most of the runoff is derived from the San Gabriel Mountains and the Tehachapi Mountains, with flow onto the alluvial fans, across the valley alluvium, and, infrequently, into the playas. Perennial streams seldom extend beyond the foot of the mountains. Creeks in the San Gabriel Mountains include Little Rock, Big Rock, Armagosa, and several smaller ones. In the Tehachapi Mountains they include Oak, Cottonwood, and other small creeks. Minor additional recharge is from reclaimed water applied for irrigation in the Lancaster area.

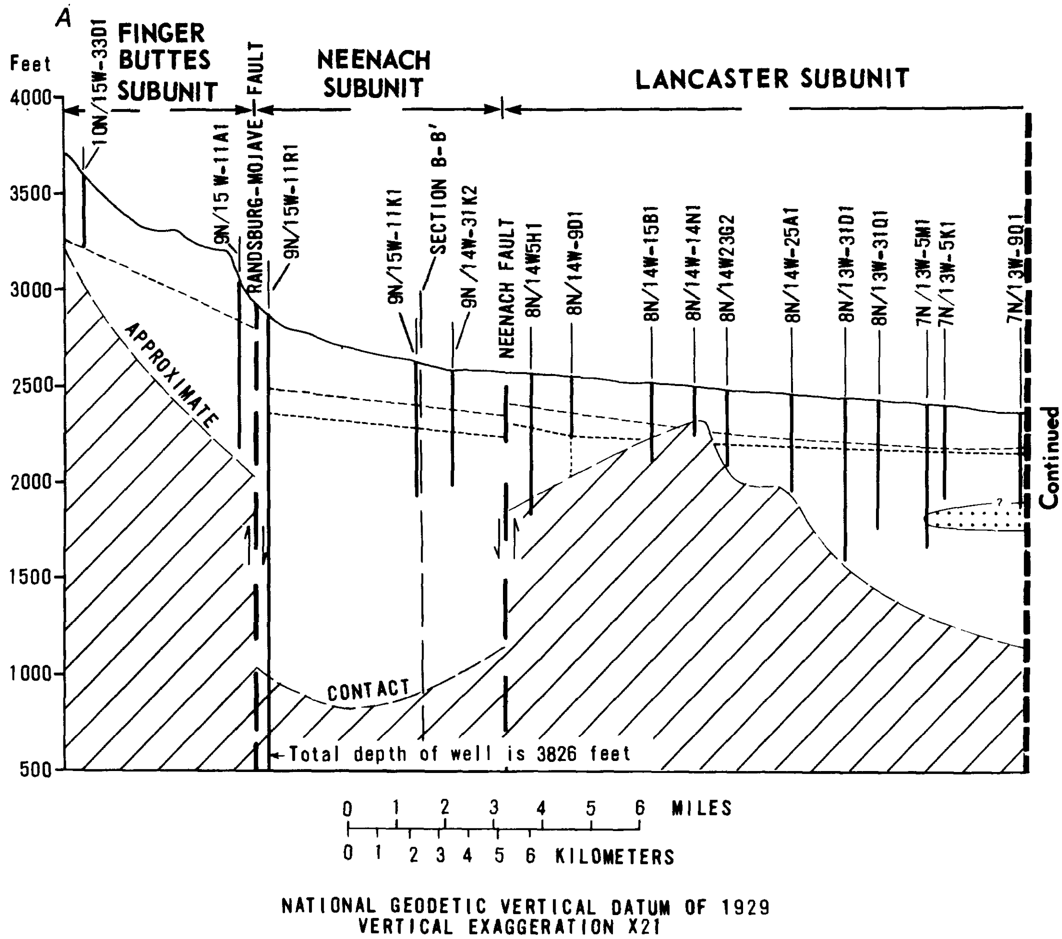
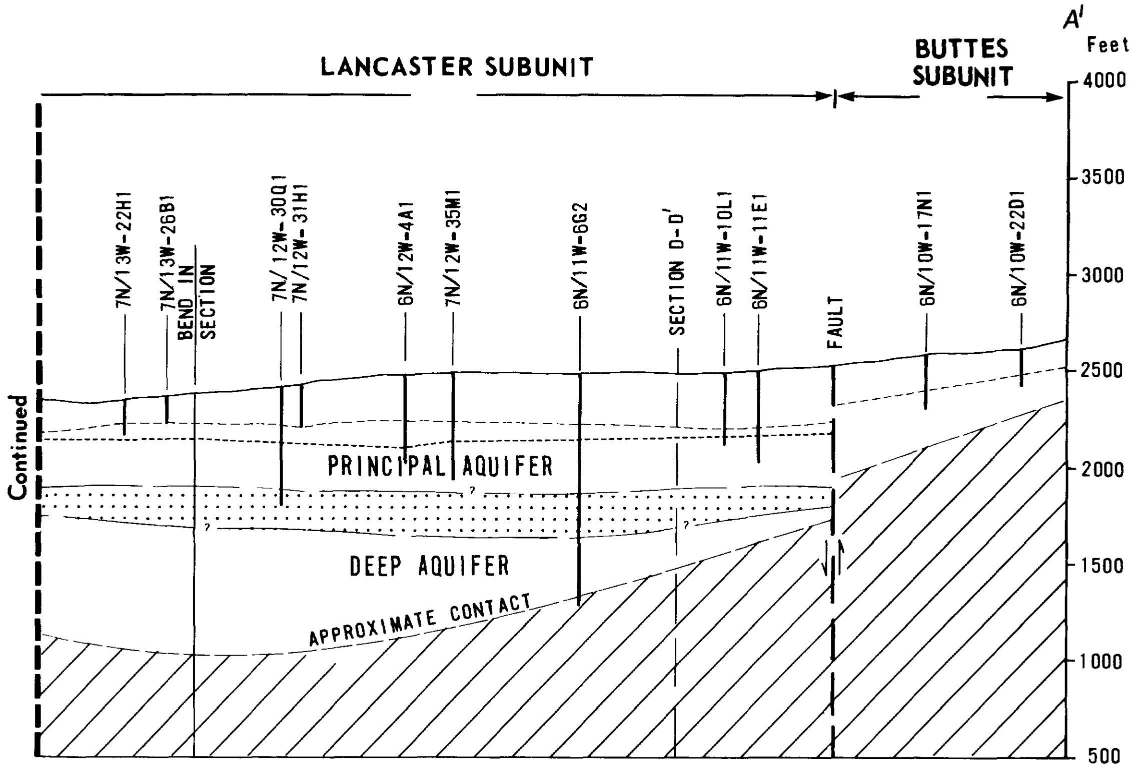


FIGURE 3.--Generalized geologic section A-A' showing water-level profiles. Location of line of section shown on Plate 1.

TABLE 1. - Average annual discharge for selected surface-water sites

Station name	Period of record, in years	Average annual discharge in acre-feet
Big Rock Creek near Valyermo, California	1924-81	12,680
Little Rock Creek near Littlerock, California	1930-37 1939-77 1978-79	11,660
Spencer Canyon Creek near Fairmont, California	1964-73	38
Cottonwood Creek near Rosamond, California	1965-72	10
Oak Creek near Mojave, California	1957-81	717
Cache Creek near Mojave, California	1965-72	87



Geology modified from Bloyd (1967) and Durbin (1978)
Lacustrine deposits shown diagrammatically

EXPLANATION

UNCONSOLIDATED DEPOSITS

LACUSTRINE DEPOSITS

CONSOLIDATED ROCKS

FAULT—Approximately located; arrows indicate direction of relative vertical movement

9N/15W-11K1 WELL--Dashed where perforated

WATER LEVEL, 1964

WATER LEVEL, 1982

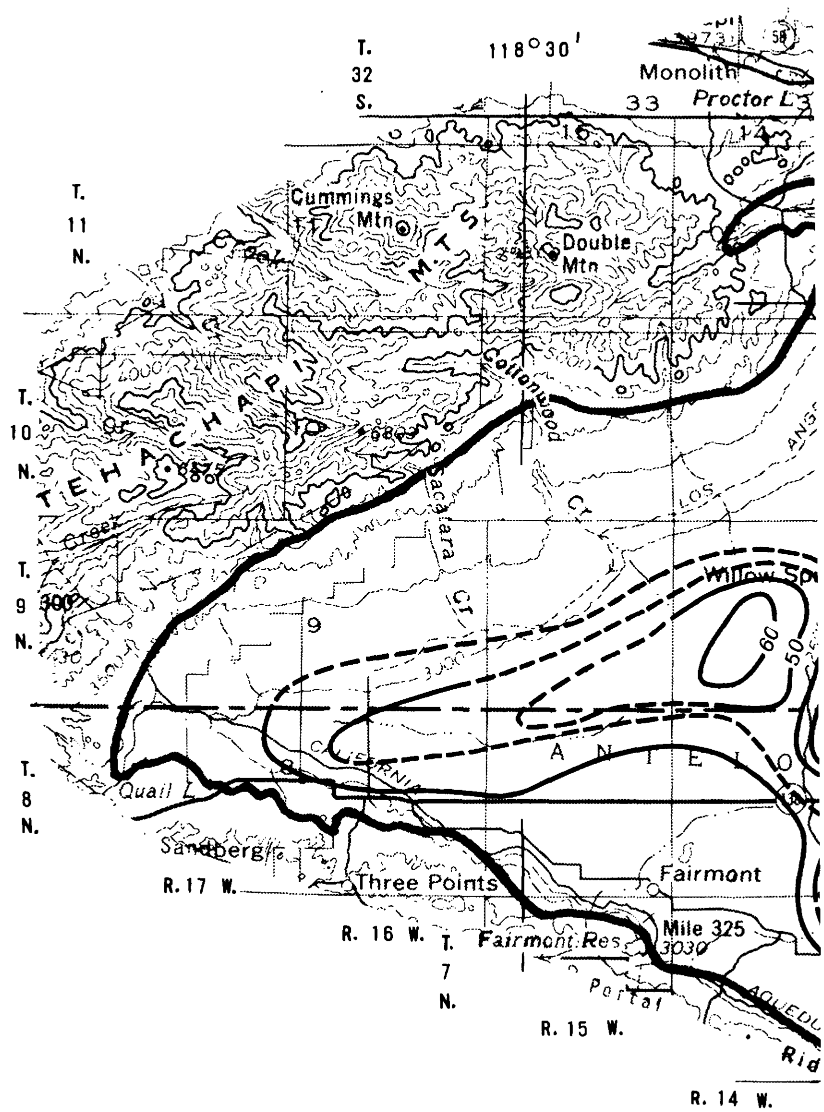
FIGURE 3.--Continued.

Recharge to the area southwest of the Muroc fault occurs by percolation of water from Cache and Oak Creeks and minor streams draining the Tehachapi Mountains, and in minor amounts by deep percolation of rain during infrequent periods of heavy precipitation. A considerable part of the ground-water recharge from Cache Creek moves generally eastward and discharges across the Muroc fault into the ground-water basin to the north. The remainder of the ground-water flow from Cache Creek moves eastward and southeastward. Recharge from the Oak Creek drainage system moves generally southeastward toward Soledad Mountain then southward along the west side of the mountain, and finally eastward along the south edge. Some of the water may move southward and southwestward to eventually discharge across the Rosamond fault (Kunkel and Dutcher, 1960).

EXPLANATION

BOUNDARY OF STUDY AREA

20 LINE OF EQUAL SPECIFIC CAPACITY--Dashed where estimated. Interval variable, in gallons per minute per foot of drawdown



0 5 10 15 20 MILES

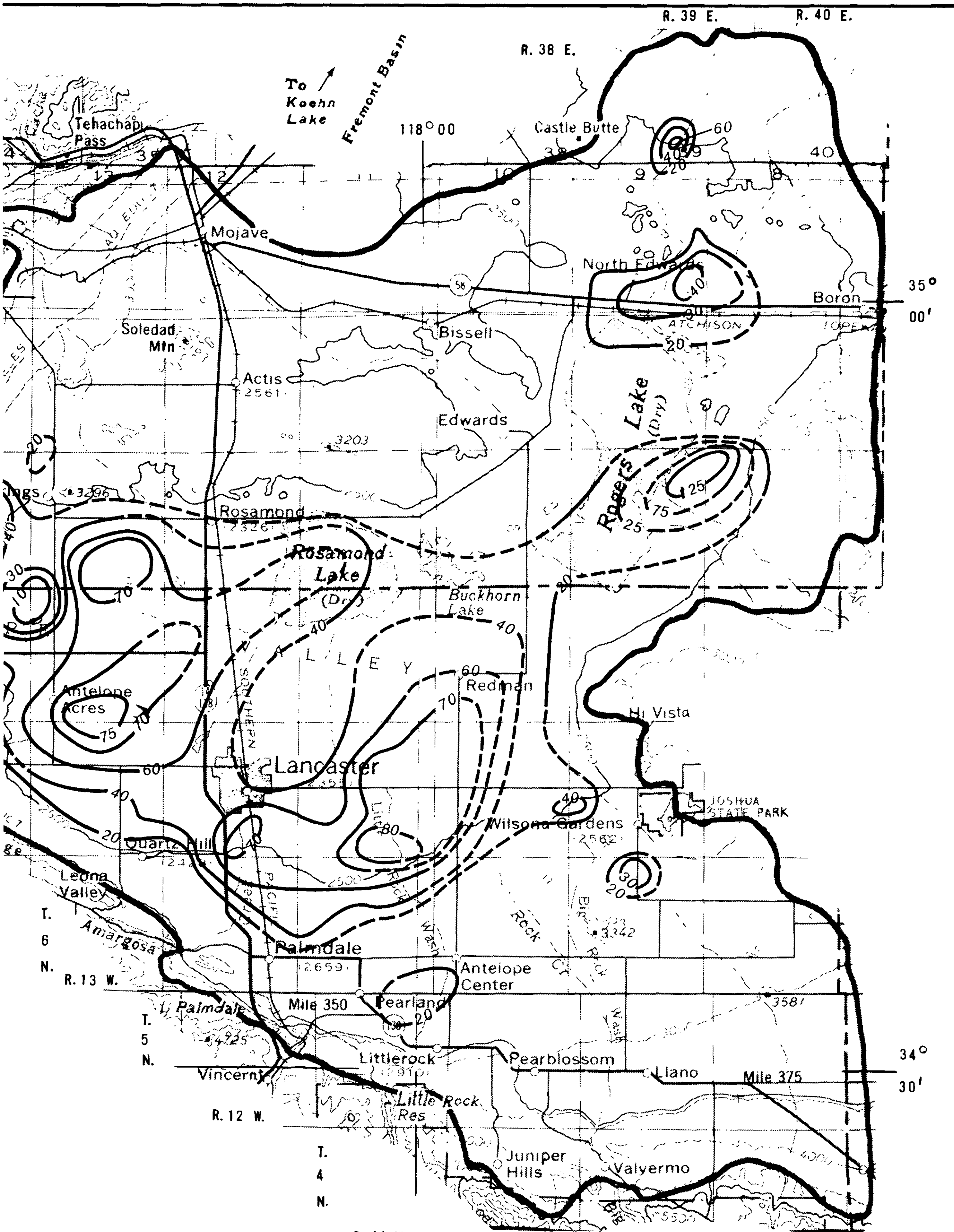
0 5 10 15 20 KILOMETERS

CONTOUR INTERVAL 500 FEET

NATIONAL GEODETIC VERTICAL DATUM OF 1929

Base from U. S. Geological Survey State of California, south half 1:500,000

FIGURE 4.--Specific capacity of wells.



Hydrology modified from Bloyd (1967)

The main source of recharge to the Lancaster subunit is streamflow from Big and Little Rock Creeks. Other sources of recharge are underflow from the Finger Buttes, West Antelope, and Neenach subunits. This underflow divides, with part recharging the principal aquifer and part recharging the deep aquifer. Ground water from Buttes and Pearland subunits flows entirely into the principal aquifer above the lacustrine clay deposits (Hatai, 1979). Also, recharge may enter the Lancaster subunit as underflow from two other areas, one is beneath a large alluvial fan southeast of Rogers Lake, and the other is Cottonwood Creek alluvial fan across the Willow Springs fault west of the Rosamond Hills. North of Rogers Lake, water flows into Fremont Valley (Dutcher and Worts, 1963).

Discharge

Before development of the ground-water resources in the Antelope Valley, evapotranspiration (largely occurring at or near Rosamond and Rogers Lakes), subsurface outflow (occurring northeast of Rogers Lake), and spring discharge were the main mechanisms of ground-water discharge (Johnson, 1911; Thompson, 1929; and Synder, 1955). However, at the present time, pumpage constitutes the main discharge, and subsurface outflow, evapotranspiration, and spring discharge are probably insignificant.

Ground-Water Subdivisions

Two types of ground-water subdivisions are described for Antelope Valley, on the basis of hydrologic properties such as subunits and hard-rock areas (Bloyd, 1967). The subunits contain extensive alluvial deposits that serve as useful aquifers. The hard-rock areas are characterized by exposed or shallowly buried consolidated bedrock that does not yield much water. Hard-rock areas commonly are less populated and relatively undeveloped probably due in part to the absence of available water. The subunit and hard-rock area boundaries (pl. 2) are defined by faults, bodies of consolidated rock, and ground-water divides, and in some areas, by arbitrary boundaries. The subunits are Finger Buttes, West Antelope, Neenach, Willow Springs, Gloster, Chaffee, Oak Creek, Pearland, Buttes, Lancaster, North Muroc, and Peerless. Hard-rock areas are Rosamond-Bissell, Randsburg-Castle Butte, Hi Vista, and Foothill (north and south). The subdivisions are listed in upgradient-to-downgradient order where possible, or generally from west to east or north to south.

Subunits

Finger Buttes.--The Finger Buttes subunit is bounded on the south by an unnamed fault in the West Antelope subunit, on the east by the Randsburg-Mojave fault, on the northeast by the Cottonwood fault, and on the west and northwest by the consolidated rock of the Tehachapi Mountains (pl. 2). A large part of the subunit is range or forest land (pl. 3). Ground water moves generally from the northwest to the southeast. Inflow is from the surrounding mountains and outflow is into the Neenach subunit. The water level in well 8N/17W-4D1 (fig. 5) declined 50 feet between 1948 and 1972, but between 1972 and 1982 the water level rose about 50 feet, approximately back to the 1948 level. Water use in the area is mainly agricultural. The use of agricultural water undoubtedly caused the water-level decline. The water-level recovery was because of a decrease in agricultural development, and a decrease in ground-water pumpage because of imported water from the California State Water Project for irrigation. The depth to water in this subunit varies widely, but commonly is more than 300 feet. Few data are available for specific capacity of wells in this subunit.

West Antelope.--The West Antelope subunit is bounded on the southwest by consolidated rock, the south and southeast by the Randsburg-Mojave fault, and on the north by the unnamed fault mentioned above, the location of which cannot be precisely determined from available data (Bloyd, 1967). In this subunit, ground water moves in a southeastward direction where outflow travels into the Neenach subunit (pl. 2). Water levels have declined 50 feet since 1964, as shown in section B-B' (fig. 6). Water use in this subunit is for agricultural purposes. The depth to water ranges from 250 to 300 feet (fig. 7). Specific capacity of wells ranges from 20 to 40 (gal/min)/ft of drawdown (fig. 4).

Neenach.--The Neenach subunit is bounded on the south by the Neenach fault, on the north by the Rosamond fault, and on the northwest by the Randsburg-Mojave fault (pl. 2). Ground water in this subunit moves generally eastward (pl. 2) into the principal and deep aquifers of the Lancaster subunit. Ground-water levels in the east have dropped 100 feet and in the west 50 feet between 1964 and 1982 (figs. 3 and 6). Agriculture accounts for the entire water use of the subunit. Depth to water ranges from 150 to 350 feet (fig. 7). Specific capacity of wells ranges from 20 to 60, but about 50 (gal/min)/ft of drawdown (fig. 4) is the most common value for the subunit.

Willow Springs.--The Willow Springs subunit borders the Oak Creek subunit along the Randsburg-Mojave fault. The south boundary of the Willow Springs subunit is the Rosamond fault and the consolidated rock of Tropico Hill and several adjacent hills. The northeast boundary of the subunit is the bedrock of the Rosamond Hills, the buttes 4 miles west of Soledad Mountain (pl. 2), and the ground-water divides which extend northwestward and southeastward from those buttes. Ground water flows southeast (pl. 2) as outflow through the alluvium in the gap between the Rosamond and Tropico Hills, crossing the Rosamond fault and entering the Lancaster subunit. Recharge to the area is from intermittent streams of the surrounding mountain areas. Water levels have declined as much as 50 feet in the subunit from 1964 to 1982 (fig. 6). Water use in the area is for agricultural and urban land use. Depth to water ranges from 100 to 300 feet (fig. 7). Specific capacity of wells is estimated at 20 (gal/min)/ft in the southeast area of the subunit (fig. 4).

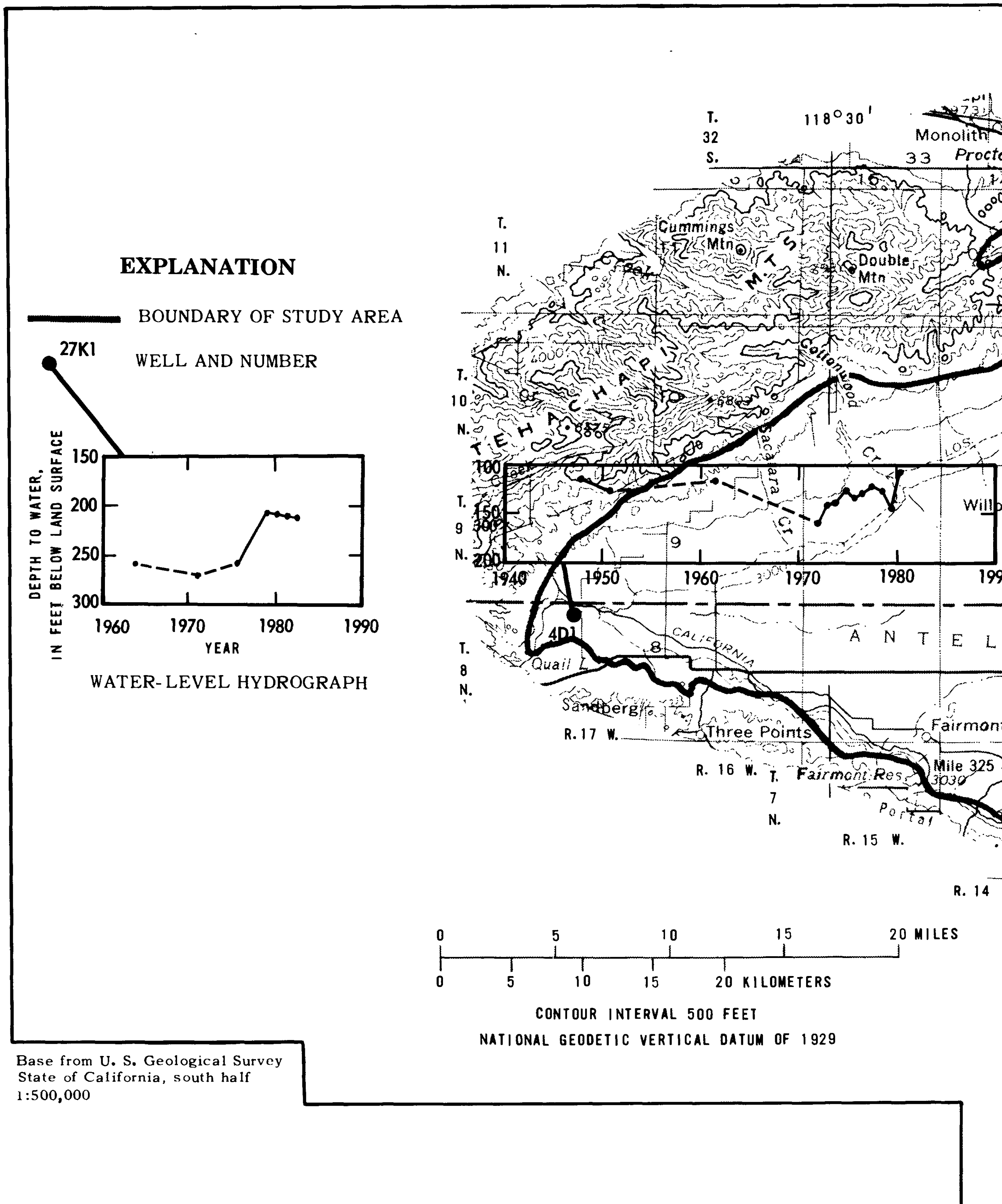
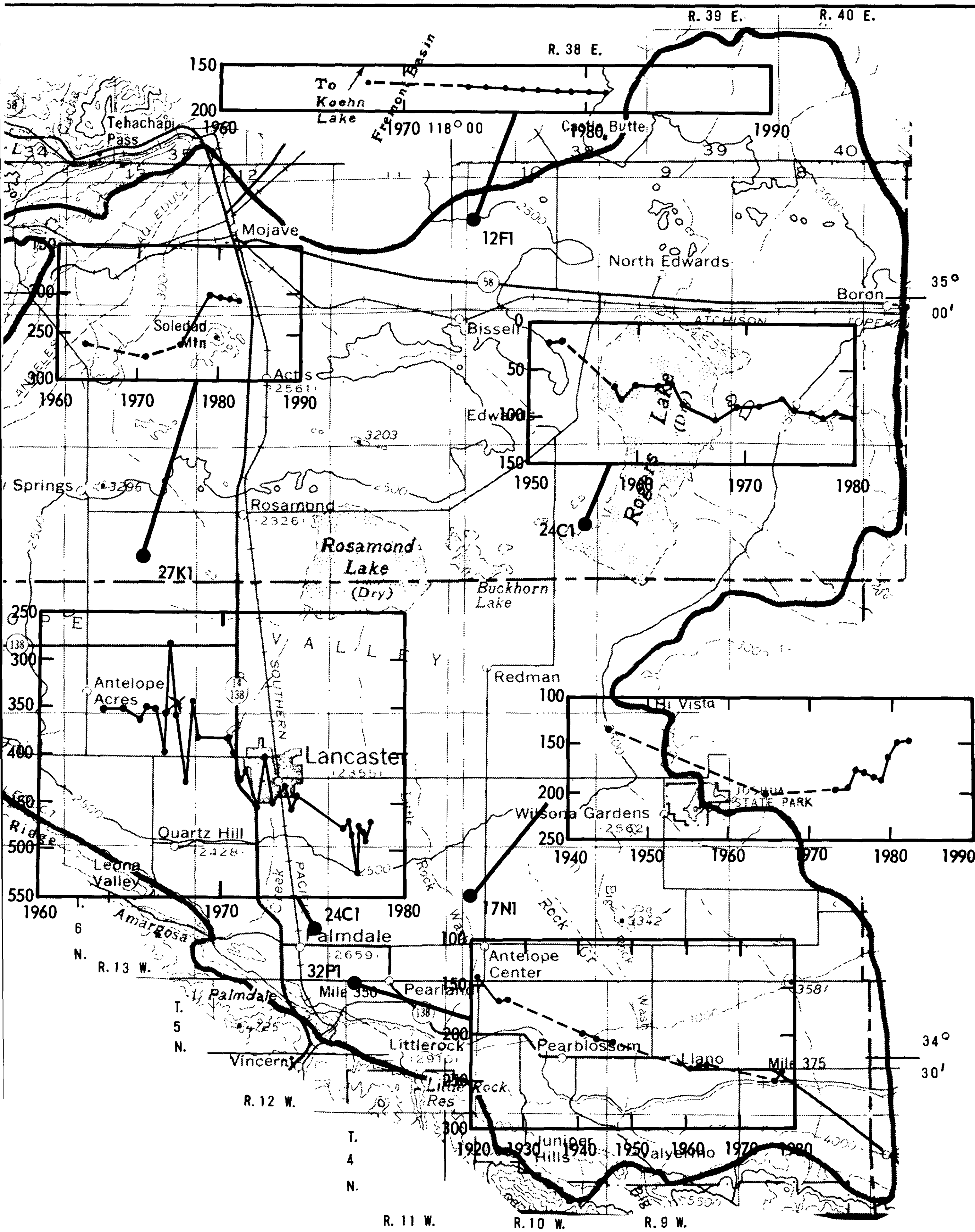
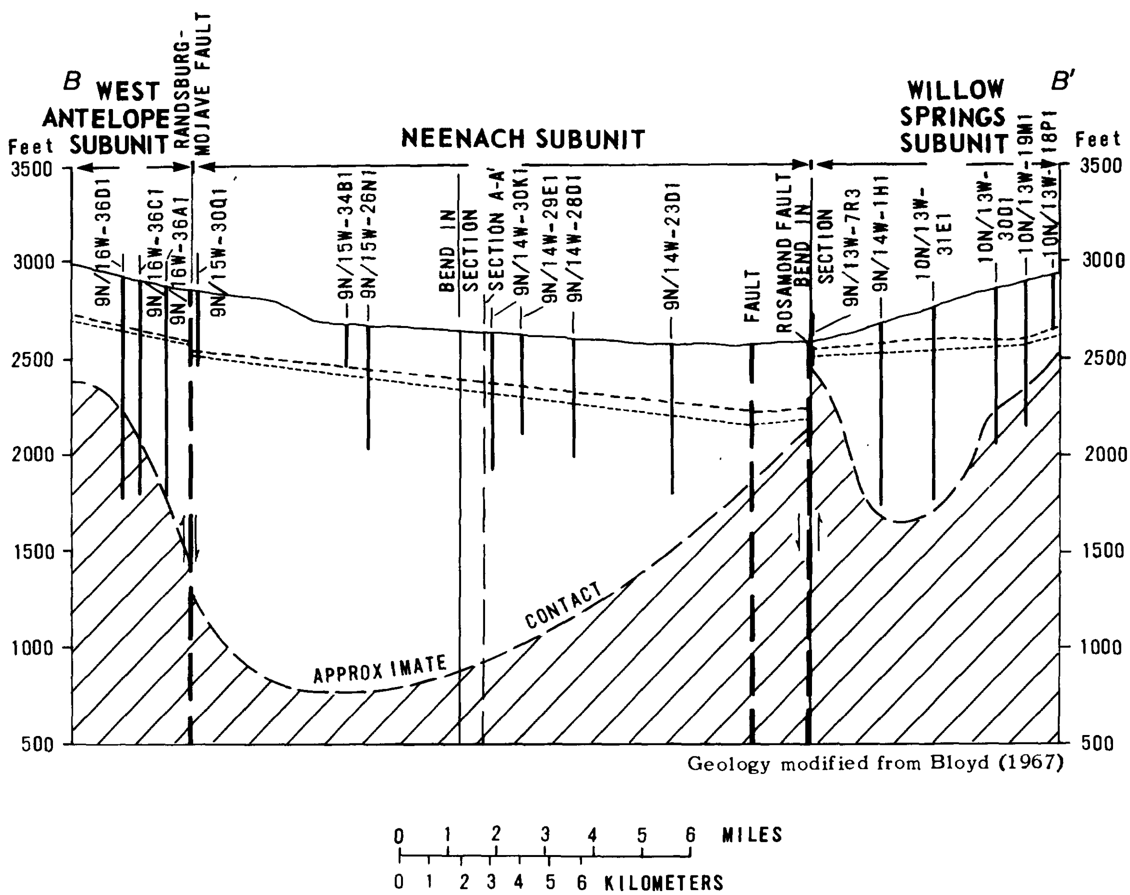


FIGURE 5.--Hydrographs of selected wells.


R. 38 E.
R. 39 E.
R. 40 E.
To Koehn Lake
Fremont Basin
Tehachapi Pass
Castle Butte
118° 00
Mojave
12F1
North Edwards
Boron
35° 00′
Soledad Mtn
Acton
Bissell
Edwards
Rogers Lake (Dry)
24C1
Springs
Rosamond
Rosamond Lake (Dry)
27K1
Buckhorn Lake
ANTELOPE VALLEY
Redman
Antelope Acres
Lancaster
Quartz Hill
Leona Valley
Amargosa
Palmdale
24C1
32P1
Mile 350
Pearland
Wilsona Gardens
17N1
Hi Vista
JOSHUA STATE PARK
Antelope Center
Pearblossom
Llano
Mile 375
Littlerock
Little Rock Res
Vincent
Juniper Hills
Valyermo
34° 30′
T. 6 N.
T. 5 N.
T. 4 N.
R. 13 W.
R. 12 W.
R. 11 W.
R. 10 W.
R. 9 W.
SOUTHERN PACIFIC
1920
1930
1940
1950
1960
1970
1980
1990



NATIONAL GEODETIC VERTICAL DATUM OF 1929
VERTICAL EXAGGERATION X21

EXPLANATION

UNCONSOLIDATED DEPOSITS

CONSOLIDATED ROCKS

FAULT—Approximately located; arrows indicate direction of relative vertical movement

9N/15W-11K1 WELL--Dashed where perforated

WATER LEVEL, 1964

WATER LEVEL, 1982

FIGURE 6. --Generalized geologic section B-B' showing water-level profiles. Location of line of section shown on Plate 1.

Gloster.--The north boundary of the Gloster subunit is the consolidated rock of Soledad Mountain and the general line of scattered hills trending westward through Elephant Butte to the Randsburg-Mojave fault. The east and south boundaries are the consolidated rock of the southern part of the Bissell Hills and the Rosamond Hills. The west boundary of the subunit is partly the Randsburg-Mojave fault and partly the consolidated rock of the butte 4 miles west of Soledad Mountain. Ground-water divides are present along the west and southwest boundaries. The movement of ground water in this subunit is mainly to the southeast and east as outflow to the Chaffee subunit (pl. 2). Water levels have declined 10 to 20 feet in the southern part of this subunit from 1964 to 1982. Water use is confined to urban and mining (quarry pits) activity. Data on depth to water in this subunit are sparse (fig. 7); levels for the southeast area of the subunit are 50 and 100 feet. No information on specific capacity of wells is available.

Chaffee.--The Chaffee subunit is bounded on the northeast by the Muroc fault. The east and south boundaries are the consolidated rock of the northern part of the Bissell Hills, and the general east-west line of scattered hills trending through Elephant Butte westward to the Randsburg-Mojave fault. The southern bedrock boundary is discontinuous, thus an arbitrary line (not a hydrological line) separates the Gloster subunit. The northwest boundary of the Chaffee subunit is the Randsburg-Mojave fault. Very little change has occurred to the ground-water levels since 1964 (fig. 8). Inflow to the subunit is from Cache Creek and adjacent fans to the west, and in lesser amounts from the Gloster subunit to the south. Ground water moves eastward in the western part and northward in the southern part of the subunit, generally toward the town of Mojave (pl. 2). Any outflow would be north across the Muroc fault to the Koehn Lake area (outside of Antelope Valley). Water use in the area is mainly for the town of Mojave. Depth to water ranges from 50 to 300 feet (fig. 7). Data on specific capacity of wells are not available for the subunit.

Oak Creek.--The Oak Creek subunit is bounded on the southwest by the Randsburg-Mojave fault and on the northwest by the consolidated rock of the Tehachapi Mountains. The northeast boundary separating the Koehn Lake area is arbitrarily defined (pl. 2). The southwest boundary of the Oak Creek subunit is the Cottonwood fault northeast of Cottonwood Creek. Available data generally show that water levels have remained the same since 1964. Part of the subunit cross section is shown in figure 8. Recharge to the subunit is from the Tehachapi Mountains. Ground-water movement is generally southeastward, but some outflow occurs northeastward to the Koehn Lake area (pl. 2). Water use in the area is nominal except for the mining activity in the central part of the subunit. Well data for specific capacity, depth to water, and water quality are not available.

EXPLANATION

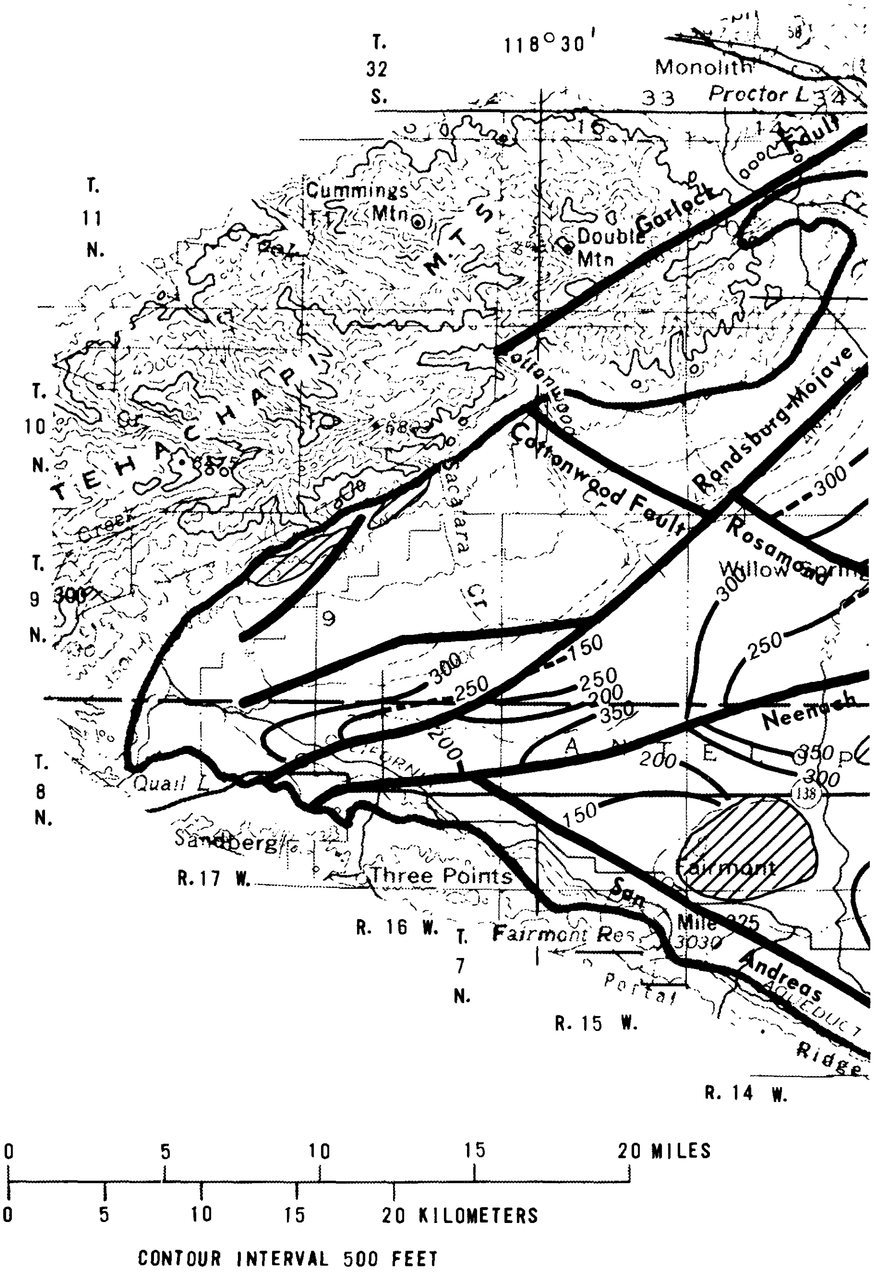
UNCONSOLIDATED DEPOSITS

CONSOLIDATED ROCKS

BOUNDARY OF STUDY AREA

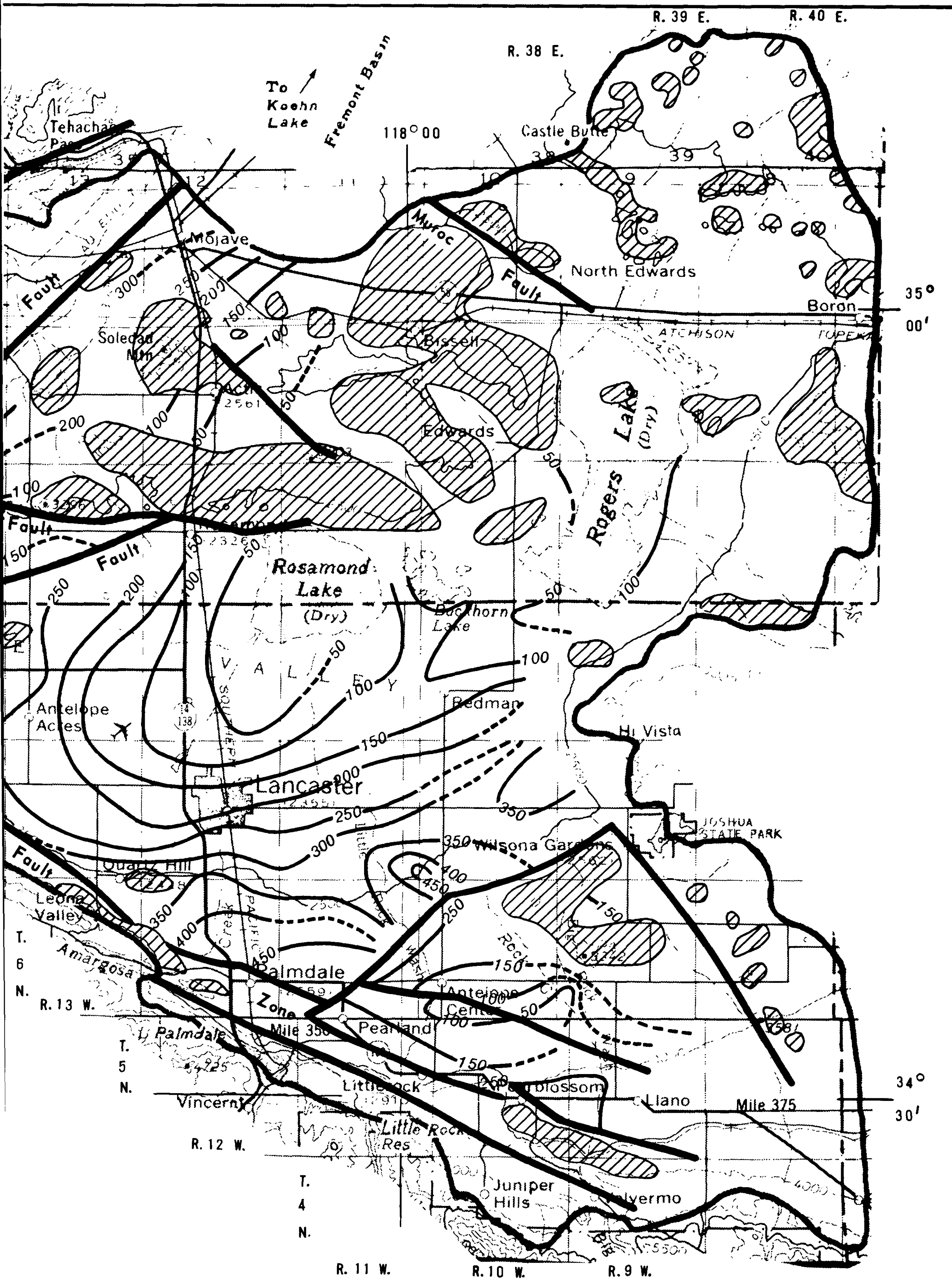
FAULT

300 — LINE OF EQUAL DEPTH TO WATER--Dashed where approximately located. Interval variable, in feet. Datum is land surface

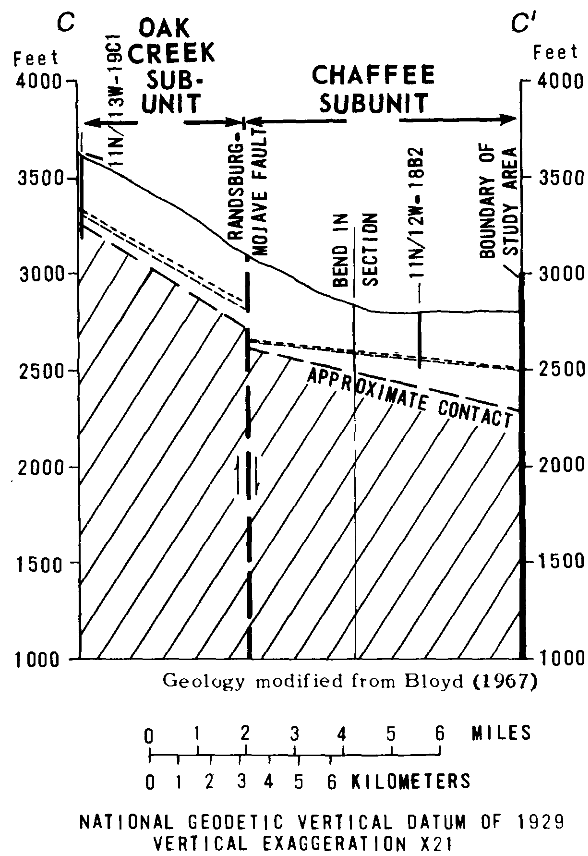


Base from U. S. Geological Survey State of California, south half 1:500,000

FIGURE 7.--Depth to water, spring 1978.



Hydrology modified from Blankenbaker (1978)



EXPLANATION

UNCONSOLIDATED DEPOSITS

CONSOLIDATED ROCKS

FAULT—Approximately located; arrows indicate direction of relative vertical movement

9N/10W-34H1

WELL--Dashed where perforated

WATER LEVEL, 1964

WATER LEVEL, 1982

FIGURE 8.--Generalized geologic section C-C' showing water-level profiles. Location of line of section shown on Plate 1.

Pearland.--The Pearland subunit is bounded on the north, west, and south by unnamed faults that are postulated from an analysis of water-level data. The consolidated rock of the San Gabriel Mountains forms the southeast boundary of the subunit. Substantial recharge occurs to the Pearland and the Buttes subunits from Little Rock and Big Rock Creeks. In the Pearland subunit, ground water generally moves from the southeast to the northwest (pl. 2), with outflow to the Lancaster subunit. Water levels have declined as much as 150 feet in the southeast, but have remained virtually unchanged in the northwest area of the subunit from 1964 to 1981. In the northwest part of the subunit from 1920 to 1978 the water level in well 6N/11W-32P1 (fig. 5) declined 100 feet. This decline is attributed to urban (Pearland, Pearblossom, and Littlerock) and irrigation water use. Depth to water ranges from 100 to 250 feet (fig. 7). The only information on specific capacity of wells is for the western part which is 20 (gal/min)/ft of drawdown (fig. 4).

Buttes.--The Buttes subunit is bounded on the northwest, the northeast, and the southwest by unnamed faults which are postulated from water-level data. The southeast boundary of the subunit is a ground-water divide between the Antelope Valley and the El Mirage valley drainage area to the east, but has not been well defined. In this subunit, ground water generally moves from the southeast to the northwest (pl. 2) and discharges as outflow into the Lancaster subunit. Available data indicate that from 1965 to 1982 water levels declined as much as 50 feet in the eastern part. The hydrograph of well 6N/11W-17N1 (fig. 5) shows a 70-foot decline from 1945 to 1964 followed by a 60-foot increase in 1981. Imported water (California Water Project) became available for irrigation to the subunit in 1972. Water use in this subunit includes urban (Antelope Center and smaller communities) and agricultural. Depth to water ranges from 50 to 250 feet (fig. 7). Information on specific capacity of wells is available only for the alluvium in the northeast corner of the subunit with values ranging from 20 to 30 (gal/min)/ft of drawdown (fig. 4).

Lancaster.--The Lancaster subunit is the largest in both water use and size, and the most economically significant in terms of population and agriculture. The northwest boundary is the Neenach fault, farther east the Rosamond fault. The consolidated rock of the Rosamond and Bissell Hills and the near-surface bedrock body beneath the northern part of Rogers Lake (dry) forms the north boundary. The east boundary of the subunit is the consolidated rock that forms the hills in the Hi Vista area. The southeast and south boundary is on an unnamed fault, mostly concealed and postulated from water-level disparity. The southwest boundary is the San Andreas Fault zone.

In the Lancaster subunit, ground water moves toward several new pumping depressions (pl. 2). Between 1964 and 1982 water levels declined 50 to 100 feet in the northwest, 75 feet in the northeast, and 25 to 50 feet in the central part (figs. 3 and 9). Hydrographs (fig. 5) show that in well 6N/12W-24C1 from 1963 to 1978 water levels declined 110 feet, in well 9N/13W-27K1 (north central) water levels rose 60 feet from 1964 to 1982 (probably owing to use of imported water), and in well 9N/10W-24C1 (northeast) water level declined 80 feet from 1952 to 1980. The declines are caused by agricultural, urban, and industrial water use. The depth to water (fig. 7) varies widely in this subunit, but in general is greatest in the south and west. Specific capacities of wells range from 10 to 125 (gal/min)/ft of drawdown, but more commonly they are about 70 (gal/min)/ft of drawdown (fig. 4). The area includes Antelope Acres, Quartz Hill, Rosamond, Lancaster, Palmdale, and other smaller communities. Sewage disposal sites and some golf courses are located within the subunit.

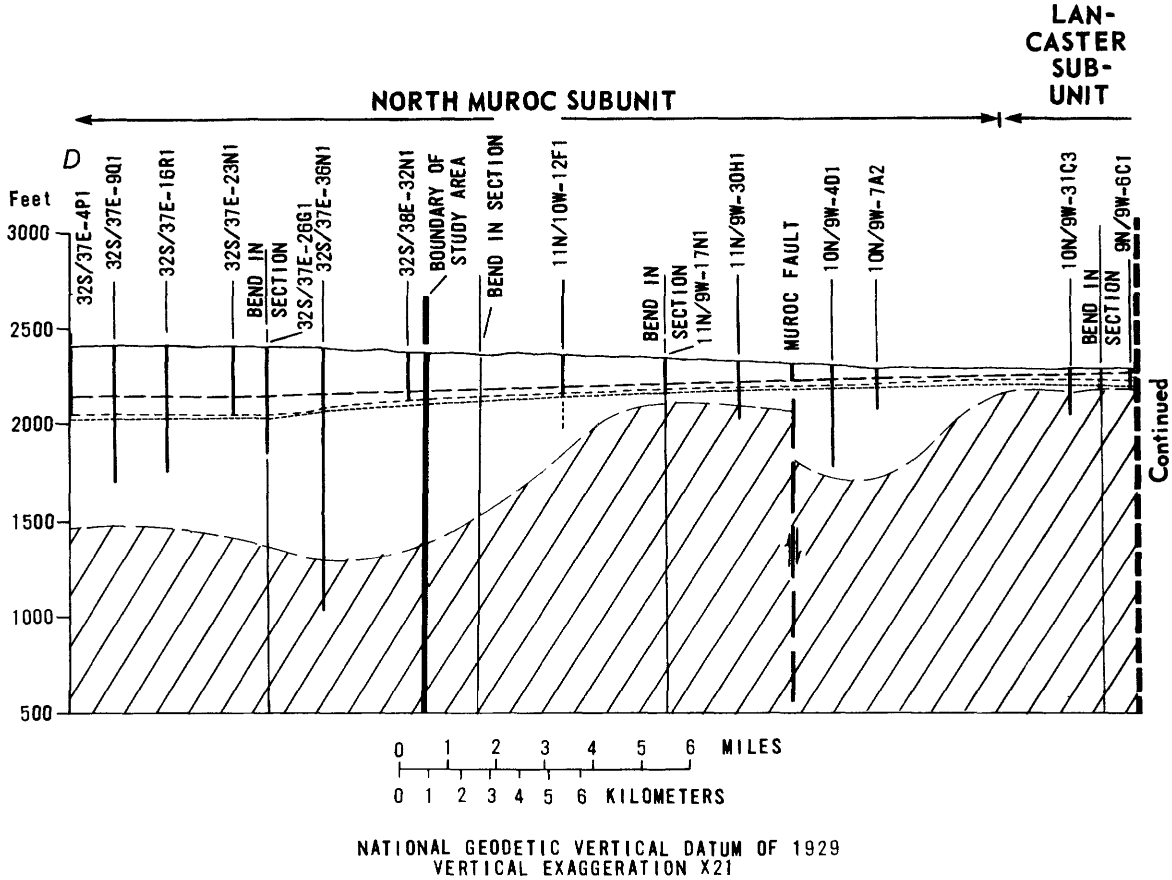


FIGURE 9.--Generalized geologic section D-D' showing water-level profiles. Location of line of section shown on Plate 1.

The two major ground-water bodies in the Lancaster subunit, the principal and the deep aquifer, are separated by a series of overlapping lacustrine layers which are mostly clay. The lacustrine deposits are shown diagrammatically in figures 3 and 9 as a single layer. The lacustrine layers extend continuously from the Buttes almost to the Neenach subunit. Results of a mathematical model in the area indicate that water moved downward from the principal aquifer into the deep aquifer along the west and south edges of the lacustrine deposits (Durbin, 1978). In the historical past, water moved upward through the lacustrine deposits from the deep aquifer (where confined) into the principal aquifer; at present (1983) most of the upward movement takes place in areas of heavy pumping from the principal aquifer.

According to Durbin (1978):

> Ground water in the Antelope Valley ground-water basin moves centripetally from the base of the San Gabriel and Tehachapi Mountains toward the north-central part of the Lancaster subbasin. Before the extensive pumping of ground water, the water table for the principal aquifer was near land surface in the north-central part of the Lancaster subbasin, and ground-water discharge occurred because of direct evapotranspiration of ground water in this area. Pumping of ground water and the subsequent increase in depth to the water table stopped this discharge.

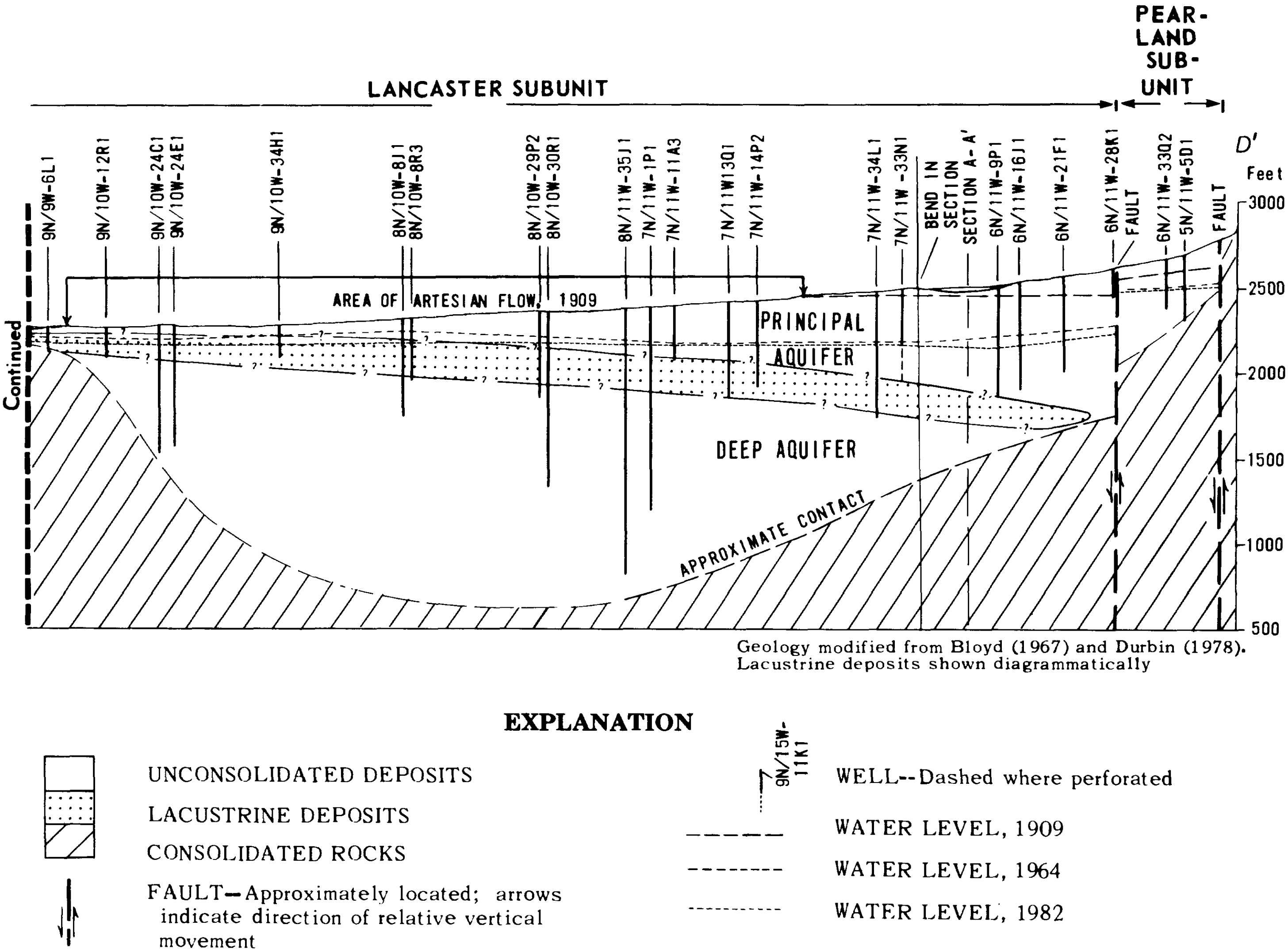


FIGURE 9.--Continued.

Ground water in the Neenach, West Antelope, and Finger Buttes subbasins moves into the Lancaster subbasin. At the western limit of the lacustrine deposits, part of this water moves over the lacustrine deposits and within the principal aquifer, and part moves under the lacustrine deposits and within the deep aquifer.

Ground water in the Buttes and Pearland subbasins also moves into the Lancaster subbasin. However, the upper surface of the lacustrine deposits is below the path of the inflowing water, and this water moves into the Lancaster subbasin wholly over the top of the lacustrine deposits and within the principal aquifer.

North Muroc.--The North Muroc subunit is separated from the Lancaster subunit by a ridge of consolidated rock that is buried beneath the northern part of Rogers Lake. The approximate boundaries of the west, north, east, and southeast sides are discontinuous hills of consolidated rock which flank the subunit. Ground water moves north and west to a recently developed pumping depression located near North Edwards. North of this depression the direction of flow is generally north into the Fremont basin (outside of Antelope Valley) and possibly into the Peerless subunit. Water levels have declined 10 feet or less since 1964 (fig. 9). Well 11N/10W-12F1 (fig. 5) shows an 8-foot decline in water levels from 1967 to 1981. The specific capacity of wells ranges from 20 to 40 (gal/min)/ft of drawdown (fig. 4). Water use in the subunit is for urban (North Edwards and smaller communities) and military purposes. Sewage disposal ponds are within and near this subunit. It should be noted that the disposal ponds are of much less concern than ponds located in other subunits of Antelope Valley because the soil structure allows for little percolation. The suggested monitoring networks were designed for this consideration.

Peerless.--The south, west, and north boundaries of the Peerless subunit are the consolidated rock of bordering hills. The east boundary is the eastern limit of highly developed water-bearing deposits. These boundaries cannot be located as precisely as those formed by distinct formations or faults. Water levels have declined 150 feet in the center of this subunit where the general movement of ground water is centripetal toward a pumping depression (pl. 2). This decline is caused by extensive pumping where wells have a specific capacity of a high of 60 (gal/min)/ft of drawdown (fig. 4). The water in this subunit is used for agricultural and municipal purposes.

Hard-Rock Areas

Generally the hard-rock areas are of little economic importance and contain only a small amount of available ground water. No data are available for ground-water levels, specific capacity of wells, or direction of ground-water movement.

Rosamond-Bissell.--This hard-rock area supplies limited recharge from its hill areas to the surrounding subunits of Antelope Valley. The only major development here is a part of Edwards Air Force Base along its east boundary, which includes one industrial disposal site.

Randsburg-Castle Butte.--The Randsburg-Castle Butte hard-rock area is located along the east border of the Fremont Valley. This area has extensive mining activity north of the community of Boron. Two sewage disposal ponds are located within the area (pl. 3). Edwards Air Force Base operates a jet propulsion laboratory on the south boundary.

Hi Vista.--The Hi Vista hard-rock area is located along the east boundary of Antelope Valley. This area supports some agriculture and scattered residential dwellings although most of the area is rangeland (pl. 3).

Foothill.--The northern part of the Foothill hard-rock area extends along the south boundary of the Lancaster subunit where it joins with an area south, previously unnamed, but referred to in this report as the Foothill hard-rock area (south). These two areas contain extensive agricultural land and some scattered rural communities, the largest and only one named is Juniper Hills. This area is a source of recharge or inflow to the Lancaster subunit.

WATER QUALITY

Ground water in the western and southern parts of Antelope Valley contains lower concentrations of dissolved solids than ground water in the northeastern part. Figure 10 depicts approximate lines of equal dissolved solids and direction of ground-water movement as developed through available water-quality data from years 1964 to 1982. High concentrations of dissolved solids, boron, and fluoride generally occur in the subunits or hard-rock areas with shallow water levels of less than 100 feet. In general, throughout Antelope Valley ground-water quality has remained unchanged, and no specific trends of change are apparent. Table 2 provides the reader with a guide to the recommended maximum contaminant levels (MCL) on selected water-quality constituents for public water supplies.

Water of the principal aquifer is the main source of ground water for Antelope Valley and is generally suitable for domestic, irrigation, and most industrial uses. This water has dissolved-solids concentrations that range from about 200 to 800 mg/L. Higher concentrations of dissolved solids occur in parts of deeper aquifers (mostly unused) where water from the younger alluvium has leaked into this aquifer. Because of concentrations of solutes resulting from evaporation of ground and surface water, water in the younger alluvium beneath the playas of the area may have dissolved-solids concentrations as high as 28,000 mg/L (Bloyd, 1967). The hardness of the ground water generally ranges from 50 to 200 mg/L, although water from wells in the Rogers Lake area has hardness as high as 1,950 mg/L (Dutcher and others, 1962).

Concentrations of chemical constituents in representative wells in Antelope Valley are shown in the water-quality diagrams of figure 11. These diagrams show what the ionic type is for water of a particular well. Wells with similar chemical concentrations are easily identified. The larger diagrams (higher concentrations of cations and anions) indicate that high dissolved-solids concentrations and high specific-conductance values will be evident in those waters. Characteristically, the ground water in Antelope Valley is a calcium bicarbonate type near the mountains, whereas it is a sodium bicarbonate or sodium sulfate type in the central or lower areas of the valley (fig. 11).

Water-quality data for selected wells are given in table 3 by subunit and hard-rock areas. The wells in table 3 are all ideal or actual network wells included in this report. These wells probably represent the water-quality conditions of the subunit or hard-rock area. The locations of the wells in table 3 are shown in plate 2.

EXPLANATION

UNCONSOLIDATED DEPOSITS

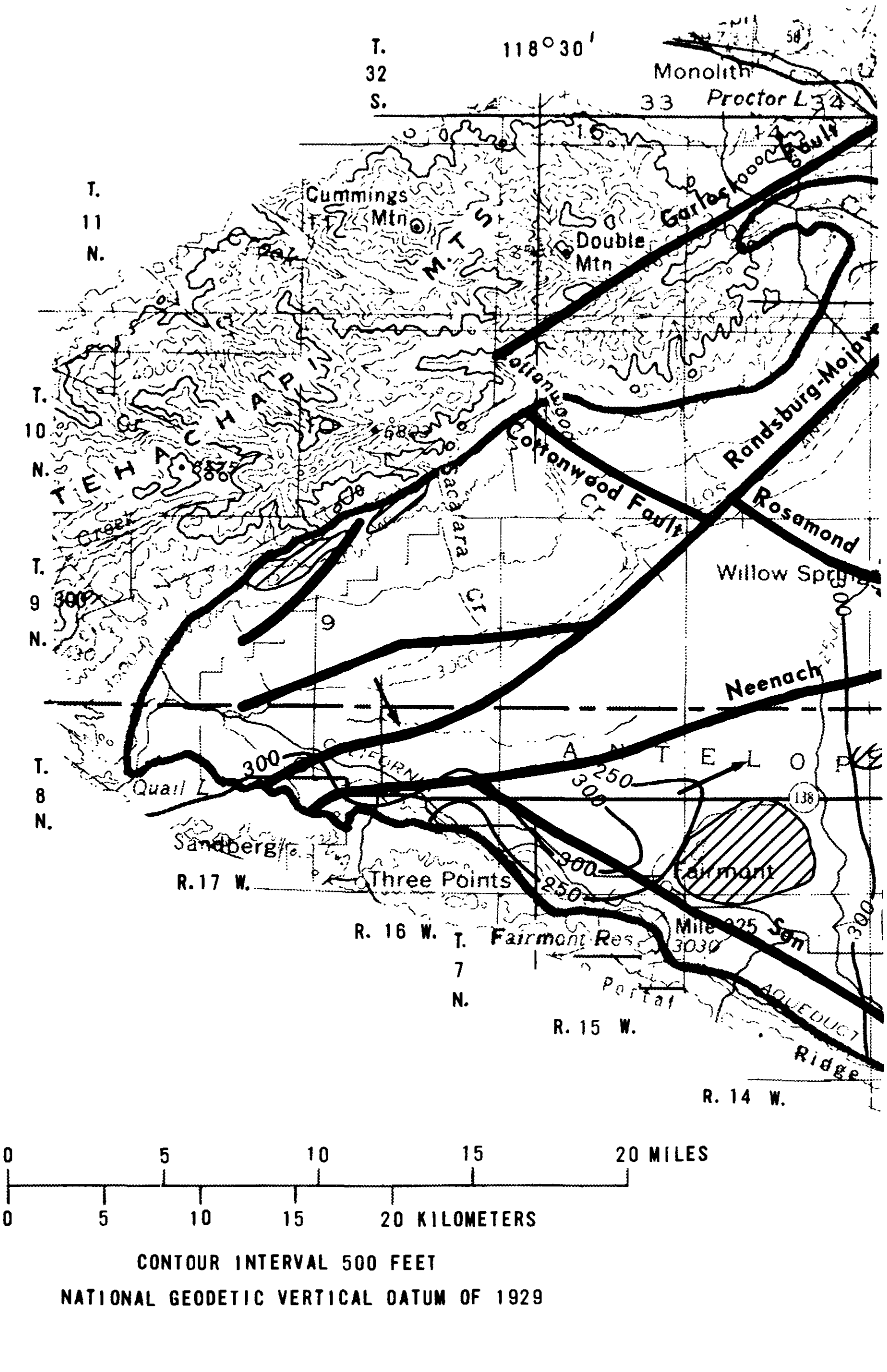
CONSOLIDATED ROCKS

BOUNDARY OF STUDY AREA

FAULT

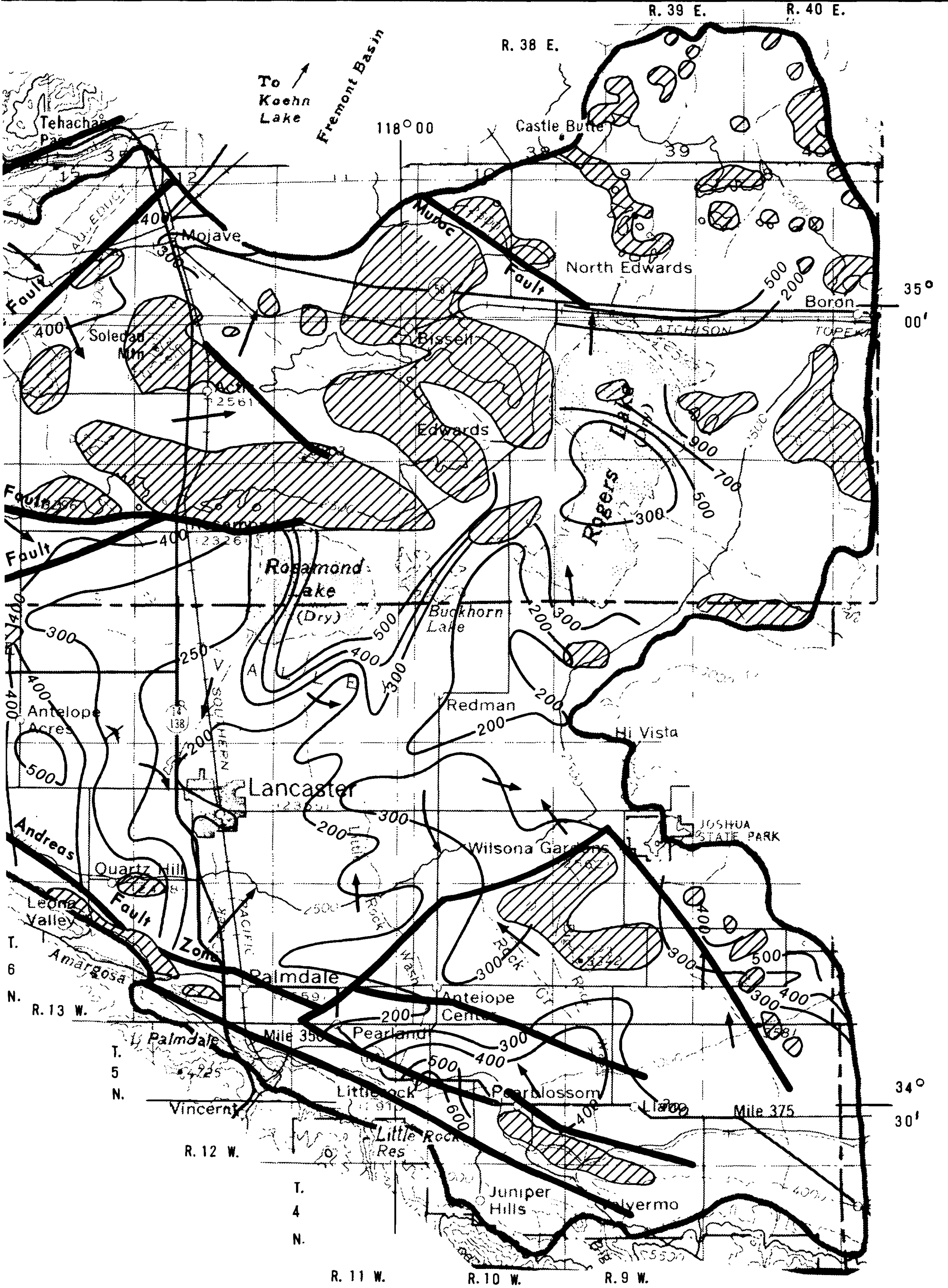
400 LINE OF EQUAL DISSOLVED-SOLIDS CONCENTRATION--Interval variable, in milligrams per liter

DIRECTION OF GROUND-WATER MOVEMENT



Base from U. S. Geological Survey
State of California, south half
1:500,000

FIGURE 10.--Dissolved-solids concentration, 1964-82.



R. 39 E.
R. 40 E.
R. 38 E.
To Koehn Lake
Fremont Basin
118° 00
Castle Butte
Tehachapi Pass
Mojave
Muroc Fault
North Edwards
Boron
35° 00'
ATCHISON
TOPEKA
Soledad Mtn
Bissell
Edwards
Rogers Lake
Rosamond Lake (Dry)
Buckhorn Lake
Redman
Hi Vista
Antelope Acres
Lancaster
Wilsona Gardens
JOSHUA STATE PARK
Andreas Fault Zone
Quartz Hill
Leona Valley
Amargosa
Palmdale
Antelope Center
Pearland
Mile 350
Pearblossom
Llano
Mile 375
Littlerock
Little Rock Res
Vincent
Juniper Hills
Valyermo
Little Rock Wash
T. 6 N.
T. 5 N.
T. 4 N.
R. 13 W.
R. 12 W.
R. 11 W.
R. 10 W.
R. 9 W.
34° 30'

TABLE 2. - Public water supply criteria

[McKee and Wolf, 1963; National Academy of Sciences, National Academy of Engineering, 1973; U.S. Environmental Protection Agency, 1977]

Constituent or characteristic	Maximum contaminant level of constituent
Micrograms per liter	
Arsenic, As	50
Boron, B	750
Cadmium, Cd	10
Chromium, Cr^{+6}	50
Lead, Pb	50
Manganese, Mn	50
Mercury, Hg	2
Selenium, Se	10
Milligrams per liter	
Barium, Ba	1
Chloride, Cl	250
Cyanide, CN	0.2
Copper, Cu	1
Dissolved solids	500
Fluoride, F	[1]0.4-2.4
Hardness	300
Iron, Fe	0.3
Nitrate-nitrogen, N	10
Nitrate, NO_3	44
Sulfate, SO_4	250
Zinc, Zn	5
Micromhos per centimeter at 25°C	
Specific conductance	800

[1]Depends on annual average of maximum daily air temperature

The relations between water quality and the feasibility of the use of water for irrigation are not simple. Specific constituents in irrigation water are especially undesirable, and some may be damaging even when present only in small quantities. Boron is essential in plant nutrition; however, a small excess over the needed amount is toxic to some types of plants. Some plants are specifically affected by excess sulfate and some are adversely affected by magnesium. An irrigation water having a high proportion of sodium to total cations tends to place sodium ions in the exchange positions on the soil-mineral particles, more commonly known as the sodium hazard in irrigation waters. Generalizations regarding sensitivity of crops to concentration limits of specific constituents in irrigation waters are beyond the scope of this report. The reader is instead referred to Hem (1970) for a more detailed description.

Ground-water quality in the Finger Buttes, West Antelope, and Neenach subunits varies from calcium bicarbonate to sodium bicarbonate type (fig. 11). Concentrations of dissolved solids are less than 400 mg/L (fig. 10). Historical water-quality data indicate that water quality in the West Antelope and Neenach subunits has not been degraded (Hatai, 1979). No historical data were located for the Finger Buttes subunit. Table 3 includes data from one well of the West Antelope subunit and two wells of the Neenach subunit which show that no constituents exceed the MCL of the public water supply criteria (table 2).

Ground-water supplies in the Willow Springs, Gloster, and Chaffee subunits are moderately mineralized. The highest concentration of dissolved solids (about 400 mg/L, as shown in fig. 10) occurs in the northern part of the Chaffee subunit. The highest quality water comes from wells drilled in the younger alluvium underlying the higher slopes in the southern and south-western parts of the area where the dissolved-solids concentration ranges from 220 to 500 mg/L. The water-quality types are sodium and calcium bicarbonate and calcium sulfate (fig. 11). Ground water from alluvial fan deposits contains higher fluoride concentrations than water in the central part of the subunits (Kunkel and Dutcher, 1960). Major ground-water quality changes are not evident from the water-quality data for these subunits (table 3). Also, no particular water-quality problems are evident from the data in table 3 for these subunits.

Water-quality data from one well in the Oak Creek subunit are shown in table 3. Specific conductance values change by as much as 100 percent from one year to the next, as is true of some of the other water-quality characteristics. Concentrations of boron, dissolved solids, hardness, and fluoride exceed the MCL of public water-supply criteria (table 2). This well is shallow and is completed in soluble mineral deposits. Infiltrating runoff probably mixes with the ground water and dilutes its dissolved-solids concentrations.

The ground water in the Pearland subunit is acceptable for human consumption (tables 2 and 3), with some exceptions. In the vicinity of Littlerock (well 5N/11W-12Q1S), concentrations of nitrates exceed the MCL in public water supply criteria (table 2) and may be attributed to nitrogen fertilizers used on orchards. Dissolved-solids concentrations (fig. 10) normally range from 200 to 600 mg/L for this subunit. Both the dissolved-solids and the nitrate concentrations are gradually increasing in this area. High sulfate concentrations reported along parts of the San Andreas fault may be caused by local gypsum deposits (Hatai, 1979). Data on three other wells of this subunit (table 3) indicate no apparent problems.

Ground water in the Buttes subunit has a dissolved-solids range (fig. 10) of 200 to 500 mg/L. Data indicate (four wells in table 3) only levels of fluoride exceed the MCL in public water supply criteria (table 2). The high fluoride is associated with geologic units in the northeastern part of the subunit.

The chemical quality of ground water in the principal and deep water-bearing zones in the Lancaster subunit falls into two general types. The water in the principal aquifer (above the lacustrine deposits) is in general a calcium bicarbonate to sodium bicarbonate type (fig. 11). Water from wells in the eastern part of the basin, in this same aquifer, is considerably higher in alkalies than the water in the central part of the subunit (table 3). This suggests solution of sodium and sulfate as the water passes through the generally sandy materials interbedded with the playa deposits, and that the water contains an excess of soluble sodium salts. The water in the deeper aquifer (beneath the lacustrine deposits) is in general a sodium bicarbonate type. Generally, the concentration of dissolved solids for the deeper aquifer is about 220 mg/L and for the principal aquifer between 200 and 500 mg/L (fig. 10), and averages about 250 mg/L.

TABLE 3.--Water-quality data for selected wells in Antelope Valley

[Local identifier: See section on "Well-Numbering System;" --, no data; <, actual value is known to be less than the value shown]

LOCAL IDENTI-FIER	DATE OF SAMPLE (YR-MO-DAY)	TIME	SPE-CIFIC CON-DUCT-ANCE (UMHOS)	HARD-NESS (MG/L AS CACO3)	CALCIUM, DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	BICAR-BONATE FET-FLD (MG/L AS HCO3)	ALKA-LINITY FIELD (MG/L AS CACO3)	SULFATE, DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)	NITRO-GEN, NITRATE TOTAL (MG/L AS NO3)	BORON, DIS-SOLVED (UG/L AS B)
WEST ANTELOPE SUBUNIT															
008N016W05M01S	65-06-02	--	520	192	24	32	45	231	189	67	20	.2	332	11	380
	70-06-01	--	526	190	58	11	39	212	174	62	20	.3	354	12	250
	71-06-16	1430	545	180	57	10	39	228	187	64	17	.1	--	--	410
	72-06-12	1900	547	190	57	11	38	220	180	70	17	.3	--	--	410
NEENACH SUBUNIT															
008N016W18H01S	50-08-23	--	360	104	30	7.0	--	183	150	21	11	--	--	12	110
	53-06-04	--	376	98	32	4.4	44	177	145	19	12	.7	247	16	0
	54-10-19	--	377	105	32	6.0	42	183	150	17	9	.9	251	12	130
	56-03-08	--	437	48	16	2.0	81	216	177	24	11	.8	300	8.2	350
	56-12-18	--	390	65	--	--	--	218	179	--	14	--	--	--	--
	57-03-06	--	480	53	--	--	--	221	181	--	15	--	--	--	--
	58-09-04	--	443	54	14	5.0	77	216	177	21	15	.4	278	.00	[1]800
	59-07-09	--	428	49	--	--	--	217	178	--	14	--	--	--	--
	61-06-11	--	417	49	--	--	--	210	172	--	10	--	--	--	--
	62-06-17	--	407	45	14	2.0	83	193	158	25	12	.7	315	9.0	120
	65-06-02	--	410	62	18	4.0	78	214	176	23	11	1.0	284	11	270
	68-06-04	--	424	50	15	3.0	77	206	169	24	9	.9	265	11	300
	69-05-21	1530	423	45	13	3.0	80	193	158	29	13	.9	258	12	240
	71-05-06	1230	428	49	14	3.4	79	204	167	26	12	1.0	313	9.5	210
009N014W31K01S	70-06-01	--	336	90	30	3.7	37	158	--	19	12	.2	217	10	0
	71-06-16	1200	355	100	33	4.5	32	163	--	18	12	.1	--	--	40
	72-06-12	1815	363	91	31	3.3	41	170	--	23	11	.3	--	--	40
	73-05-22	0930	336	86	29	3.2	38	154	--	20	11	.3	--	--	60
	74-05-02	--	338	89	30	3.3	37	155	--	20	11	.3	--	--	40
	75-05-07	--	341	88	29	3.8	37	157	--	24	12	.2	--	--	40
	77-08-09	1535	340	76	26	2.8	39	150	--	19	12	.3	200	10	<20
	78-06-07	1435	855	63	22	2.0	46	150	--	21	11	.3	--	--	40
	80-06-25	1130	340	84	28	3.3	42	--	--	23	32	.2	--	--	50
	81-08-17	1700	320	67	23	2.3	45	--	--	21	14	.3	--	--	40
	82-06-22	1200	350	89	30	3.4	44	--	130	23	12	.3	--	--	40
WILLOW SPRINGS SUBUNIT															
010N013W32D01S	68-06-04	--	557	164	46	12	53	205	--	67	21	.3	292	4.8	100
	73-05-24	1310	541	170	48	11	53	217	--	64	18	.4	--	--	80
	74-05-02	--	546	170	50	11	53	218	--	71	22	.4	--	--	150
	75-05-07	--	535	150	44	9.6	56	220	--	71	16	.3	--	--	130
	77-08-10	1205	600	190	55	12	55	220	--	65	35	.2	370	9.3	100
	78-06-07	1135	595	180	54	11	52	220	--	63	25	.3	--	--	140
	79-04-24	1350	510	160	46	10	58	--	--	68	16	.3	325	3.5	100
	80-06-25	1305	560	180	54	12	56	--	--	66	39	.3	--	--	210
	81-06-11	1100	560	190	58	12	51	--	--	68	53	.2	--	--	140
	82-06-22	1400	640	200	60	13	58	--	170	66	52	.3	--	--	150

[1] This boron value seems erroneous in the author's opinion because it exceeds every other sample taken at that site by at least 220 percent.

TABLE 3.--Water-quality data for selected wells in Antelope Valley--Continued

LOCAL IDENTI-FIER	DATE OF SAMPLE (YR-MO-DAY)	TIME	SPE-CIFIC CON-DUCT-ANCE (UMHOS)	HARD-NESS (MG/L AS CACO3)	CALCIUM, DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	BICAR-BONATE FET-FLD (MG/L AS HCO3)	ALKA-LINITY FIELD (MG/L AS CACO3)	SULFATE, DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)	NITRO-GEN, NITRATE TOTAL (MG/L AS NO3)	BORON, DIS-SOLVED (UG/L AS B)
						GLOSTER SUBUNIT									
010N012W15M03S	82-06-22	1430	695	190	63	8.1	82	--	140	200	18	.7	--	--	240
	73-05-22	1535	369	92	27	5.9	36	117	--	59	14	.4	--	--	180
	74-05-02	--	370	91	26	6.3	39	117	--	63	15	.6	--	--	120
	75-05-07	--	341	90	26	6.1	39	118	--	61	15	.3	--	--	90
	76-05-19	0922	365	90	26	6.1	41	117	--	62	14	.2	--	--	130
	77-08-10	1240	390	92	27	5.8	41	120	--	61	15	.4	280	3.2	<20
	78-06-07	1055	390	91	26	6.3	41	120	--	60	13	.4	--	--	120
	79-04-24	1510	360	93	28	6.0	46	--	--	61	15	.3	289	3.4	100
	80-06-25	1335	360	90	26	6.0	40	--	--	61	14	1.3	--	--	160
	81-06-11	1145	360	91	27	5.8	41	--	--	60	14	.3	--	--	110
	82-06-22	1500	355	87	25	5.9	44	--	95	58	11	.4	--	--	120
010N013W21H01S	73-05-24	--	700	190	61	8.0	75	182	--	180	12	.8	--	--	300
	73-05-24	1315	700	190	61	8.0	75	182	--	180	12	.8	--	--	300
	74-05-02	--	706	190	63	8.0	74	174	--	190	11	1.3	--	--	280
	75-05-07	--	725	180	60	7.9	79	182	--	190	11	.7	--	--	230
	76-05-19	0920	665	180	59	8.1	74	169	--	190	12	.7	--	--	260
	77-08-10	1225	710	190	62	7.9	75	170	139	190	12	.6	500	3.4	200
	78-06-07	1110	720	200	64	8.6	73	170	--	170	12	.7	--	--	260
	79-04-24	1430	625	181	62	6.0	82	--	--	191	12	.7	502	2.5	300
	80-06-25	1320	660	180	60	8.0	73	--	--	190	9.9	.6	--	--	310
	81-06-11	1115	580	180	61	7.8	70	--	--	190	10	.6	--	--	200
						CHAFFEE SUBUNIT									
011N012W22F01S	73-03-00	--	420	96	30	5.0	53	140	115	77	14	.3	249	1.2	520
						OAK CREEK SUBUNIT									
011N014W14B01S	70-06-03	--	740	243	38	36	76	376	--	69	17	1.6	424	3.0	310
	71-06-17	0945	1010	380	79	45	77	566	--	65	20	1.3	--	--	540
	72-06-13	1000	977	380	77	46	80	559	--	79	19	1.4	--	--	520
	73-05-23	1030	1750	750	120	110	150	1160	--	70	32	1.0	--	--	1600
	74-05-01	1500	2630	1100	170	170	230	1880	--	57	50	1.5	--	--	3000
	75-05-07	--	1025	390	77	48	84	569	--	74	19	1.1	--	--	440
	76-05-19	0948	1065	450	86	57	89	659	--	72	20	1.0	--	--	640
	77-08-10	1405	1170	480	98	58	90	690	--	78	21	.9	710	4.4	100
	78-06-07	1010	1600	700	130	91	130	1020	--	66	30	1.0	--	--	1300
	79-04-25	0830	850	350	71	42	75	--	388	80	18	1.4	543	8.0	800
	80-06-25	1445	820	340	69	41	69	--	--	67	16	.1	--	--	510
	81-06-11	1330	900	340	70	40	69	--	--	68	15	1.2	--	--	350
	82-06-23	0830	1320	530	96	71	98	--	680	73	22	1.1	--	--	900

TABLE 3 --Water-quality data for selected wells in Antelope Valley--Continued

LOCAL IDENTI-FIER	DATE OF SAMPLE (YR-MO-DAY)	TIME	SPE-CIFIC CON-DUCT-ANCE (UMHOS)	HARD-NESS (MG/L AS CACO3)	CALCIUM, DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	BICAR-BONATE FET-FLD (MG/L AS HCO3)	ALKA-LINITY FIELD (MG/L AS CACO3)	SULFATE, DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)	NITRO-GEN, NITRATE TOTAL (MG/L AS NO3)	BORON, DIS-SOLVED (UG/L AS B)
							PEARLAND SUBUNIT								
005N009W25A01S	64-05-14	--	416	117	27	12	42	157	139	57	11	.4	266	1.0	0
	65-06-08	--	402	117	27	12	42	178	146	56	6.0	.3	260	2.0	50
	67-04-19	1300	430	117	27	12	42	173	142	54	7.0	--	245	1.4	0
	71-04-26	1510	417	121	27	13	41	172	141	59	8.8	.4	258	4.0	0
	72-03-15	1215	424	126	29	13	41	173	142	58	8.1	.4	242	4.0	10
	73-02-27	--	389	114	24	13	42	173	142	57	6.0	.2	213	.4	<20
	74-05-29	0900	416	110	27	11	40	170	139	58	10	.3	245	.0	<20
	75-04-11	1330	415	120	28	12	43	170	139	58	7.8	.3	253	2.8	70
	76-04-29	1215	404	110	28	10	43	170	139	60	5.7	.4	230		<20
	77-04-28	1105	414	120	29	11	42	180	148	56	6.0	.3	262	1.4	60
	78-05-24	1410	408	115	28	11	42	170	141	56	6.1	.3	209	1.4	100
005N010W16J01S	71-04-27	1415	614	219	65	14	36	174	--	82	49	.4	341	12	40
	72-03-13	1000	562	202	58	14	41	164	--	84	48	.2	338	11	50
	73-03-09	--	529	185	53	13	41	150	--	78	45	.2	318	10	<20
	74-05-29	1040	565	180	57	10	40	160	--	75	43	.3	363	7.7	<20
	75-04-09	1230	552	180	55	10	40	160	--	72	41	.4	332	9.0	<20
	76-04-29	1545	547	180	58	9.0	42	160	--	74	39	.4	330	7.8	30
	77-05-02	1350	533	180	54	10	41	170	--	67	36	.3	367	8.0	70
	78-05-24	1205	493	158	50	8.1	43	156	--	64	37	.2	298	7.2	<20
005N011W12001S	60-03-00	--	1000	--	<154	--	41	268	--	125	53	--	640	33	800
	60-08-00	--	930	--	<144	--	44	232	--	150	64	--	600	24	200
	61-05-00	--	860	--	<154	--	41	238	--	187	50	--	550	19	100
	63-06-19	--	--	390	115	25	47	197	--	196	45	.2	650	26	--
	65-12-27	--	1000	460	140	29	45	280	--	230	44	.1	676	30	90
	71-04-27	1045	1000	436	120	33	42	244	--	223	42	.3	655	44	0
	71-07-21	--	--	370	100	25	47	200	--	200	37	.2	640	26	--
	71-11-22	--	--	470	140	28	44	240	--	230	42	.2	740	46	--
	71-12-01	--	--	470	140	32	55	240	--	230	49	.1	775	41	--
	71-12-16	--	--	470	130	34	41	240	--	230	41	.1	730	44	--
	72-01-05	--	--	470	140	31	43	230	--	220	40	.1	685	60	--
	72-02-02	--	--	460	140	29	43	240	--	230	44	.1	740	45	--
	72-02-16	--	--	450	130	31	37	230	--	220	39	.1	680	40	--
	72-03-13	0945	974	380	106	28	76	268	--	224	43	.3	660	46	50
	72-07-04	0930	--	290	80	23	71	180	--	180	37	.3	615	33	--
	72-07-17	1600	--	480	140	33	48	240	--	230	41	.2	790	44	--
	72-07-31	1400	--	480	140	34	49	250	--	230	43	.2	805	45	--
	72-08-21	--	--	470	140	30	45	230	--	240	40	.2	760	44	--
	72-09-11	--	--	490	140	32	48	240	--	240	41	.2	780	47	--
	72-10-24	--	--	480	140	32	48	240	--	230	40	.2	765	42	--
	73-03-01	--	934	438	131	27	47	285	--	221	41	.2	687	45	<20
	74-06-03	1430	987	360	120	17	50	220	--	200	38	.3	645	40	40
	75-04-09	1330	1130	510	150	34	46	310	--	230	42	.3	810	58	190
	76-05-05	0930	1071	48	140	31	51	310	--	230	39	.5	720	56	<20
	77-05-04	1410	1094	490	150	31	47	310	--	230	38	.3	758	58	<20
	78-05-24	1045	918	396	110	29	45	210	--	220	40	.2	632	45	<20
006N011W32P01S	50-09-15	--	300	115	33	8.0	--	150	123	22	5.0	--	--	.50	20
	73-07-30	--	328	36	14	2.0	54	160	130	21	10	.2	197	4.4	--
	74-06-28	--	289	18	6.0	.8	56	140	115	19	10	.2	173	4.4	130

TABLE 3.--Water-quality data for selected wells in Antelope Valley--Continued

LOCAL IDENTI- FIER	DATE OF SAMPLE (YR-MO-DAY)	TIME	SPE- CIFIC CON- DUCT- ANCE (UMHOS)	HARD- NESS (MG/L AS CACO3)	CALCIUM, DIS- SOLVED (MG/L AS CA)	MAGNE- SIUM, DIS- SOLVED (MG/L AS MG)	SODIUM, DIS- SOLVED (MG/L AS NA)	BICAR- BONATE FET-FLD (MG/L AS HCO3)	ALKA- LINITY FIELD (MG/L AS CACO3)	SULFATE, DIS- SOLVED (MG/L AS SO4)	CHLO- RIDE, DIS- SOLVED (MG/L AS CL)	FLUO- RIDE, DIS- SOLVED (MG/L AS F)	SOLIDS, RESIDUE AT 180 DEG. C DIS- SOLVED (MG/L)	NITRO- GEN, NITRATE TOTAL (MG/L AS NO3)	BORON, DIS- SOLVED (UG/L AS B)
							BUTTES SUBUNIT								
005N008W25H01S	67-04-19	1315	576	234	59	21	24	180	158	126	4.0	--	358	1.3	0
	72-03-15	1110	567	237	60	21	25	181	160	129	5.6	.4	365	1.0	10
	73-02-27	--	531	232	60	20	28	195	160	128	3.0	.2	340	1.4	<20
	74-05-28	1345	584	230	61	20	26	200	164	130	3.5	.3	359	.90	<20
	75-04-11	1430	556	230	62	19	26	190	156	130	5.0	.3	377	1.8	<20
	76-04-29	1245	558	230	62	19	28	200	164	130	2.8	.4	350	.50	<20
	77-04-25	1510	568	240	63	20	27	200	164	130	2.0	.3	410	1.6	<20
	78-07-12	1350	578	234	61	20	26	200	164	130	3.4	.2	405	1.4	100
006N008W19M01S	72-03-14	0930	510	61	19	3.5	82	110	90	125	14	2.1	313	.50	160
	73-03-06	--	477	57	16	4.1	83	110	90	123	12	1.3	297	2.1	130
	74-06-05	1040	524	57	19	2.1	82	110	90	120	13	1.6	299	1.9	<20
	75-04-08	1530	495	56	17	2.9	82	110	90	120	9.9	1.8	311	2.3	200
	76-04-28	1210	493	57	18	3.0	84	110	90	120	8.2	1.8		1.2	150
	77-04-26	1230	480	58	18	3.0	79	120	98	120	8.0	1.7	326	2.2	160
	78-05-18	1315	478	58	18	3.1	80	110	90	120	7.1	2.0	342	2.3	200
005N009W05C01S	72-03-15	1515	407	107	29	8.6	41	139	114	64	9.5	.6	253	.00	60
	73-03-06	--	380	169	46	13	15	182	150	48	3.0	.2	212	2.2	120
	74-05-29	0930	599	94	31	4.4	80	120	98	140	26	1.0	384	.50	180
	75-04-11	1030	453	100	32	6.0	53	140	115	87	15	.5	299	1.6	<20
	76-04-29	1100	613	96	32	3.9	91	110	90	140	33	1.1	370	.20	170
	77-04-26	1630	512	100	30	6.0	68	130	107	100	22	.9	370	1.4	140
006N009W28P02S	74-04-29	--	607	120	38	5.9	77	127	--	150	24	1.5	--	--	290
	75-05-05	--	613	210	58	15	44	160	--	140	21	.5	--	--	120
	76-05-18	1700	600	220	61	17	40	158	--	140	22	.3	--	--	110
	77-08-08	1715	650	190	55	13	56	140	--	150	25	.7	420	7.4	100
	78-06-08	1620	655	140	43	7.5	82	130	--	140	28	1.3	--	--	280
	79-04-23	1210	650	160	47	10	77	--	--	170	32	1.1	446	6.6	300
	80-06-24	1110	580	120	40	5.8	83	--	--	160	37	1.6	--	--	310
	81-06-09	1515	590	110	36	4.0	86	--	--	150	23	1.6	--	--	280
	82-06-21	1330	585	100	34	4.6	89	--	100	150	23	1.7	--	--	280

TABLE 3.--Water-quality data for selected wells in Antelope Valley--Continued

LOCAL IDENTI-FIER	DATE OF SAMPLE (YR-MO-DAY)	TIME	SPE-CIFIC CON-DUCT-ANCE (UMHOS)	HARD-NESS (MG/L AS CACO3)	CALCIUM, DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	BICAR-BONATE FET-FLD (MG/L AS HCO3)	ALKA-LINITY FIELD (MG/L AS CACO3)	SULFATE, DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)	NITRO-GEN, NITRATE TOTAL (MG/L AS NO3)	BORON, DIS-SOLVED (UG/L AS B)
						LANCASTER SUBUNIT									
009N013W27K01S	73-02-13	--	540	--	--	--	--	--	--	--	--	--	--	--	--
	73-05-22	1300	426	100	30	6.4	52	142	--	48	26	.7	--	--	210
	74-05-02	--	428	99	29	6.5	48	140	--	52	26	.7	--	--	240
	75-05-07	--	436	99	29	6.5	50	140	--	54	27	.6	--	--	200
	77-08-09	1805	430	95	28	6.1	50	140	--	52	27	.6	260	6.2	100
	78-06-07	1400	460	100	30	7.0	51	140	--	54	27	.6	--	--	230
	79-04-24	1235	870	318	88	24	72	--	--	145	124	.1	585	11	200
	80-06-25	1200	540	150	43	11	54	--	--	77	55	.4	--	--	310
009N012W21A01S	75-05-08	--	945	370	110	22	56	270	--	150	67	.4	--	--	270
	77-08-09	1825	970	380	120	23	57	290	--	170	62	.4	630	14	200
	78-06-07	1325	910	330	98	21	52	260	--	120	56	.5	--	--	300
	79-04-24	1315	700	275	82	17	53	--	--	127	44	.5	522	8.5	400
	80-06-25	1240	645	250	74	15	47	--	--	120	38	.5	--	--	410
	81-06-10	1545	590	210	65	12	46	--	--	100	31	.5	--	--	260
	82-06-22	1330	550	190	55	12	46	--	150	90	27	.6	--	--	310
007N011W18N01S	73-05-15	1200	847	320	95	19	55	269	--	130	56	.2	--	--	120
	74-04-30	1045	819	310	93	18	52	257	--	130	54	.2	--	--	130
	75-05-06	--	810	320	97	18	58	274	--	140	56	.1	--	--	110
	76-05-18	0830	550	210	65	12	38	186	--	78	31	<.1	--	--	80
	77-08-09	1200	640	220	69	12	39	190	--	86	36	.1	370	8.1	<20
	78-06-08	1030	455	160	48	8.8	28	150	--	57	23	.1	--	--	40
	79-04-23	1405	520	212	65	12	37	--	--	84	38	.1	383	8.0	<20
	80-06-24	1405	430	160	49	8.7	27	--	--	60	26	.1	--	--	50
	81-06-10	1030	460	180	56	8.9	27	--	--	69	30	.1	--	--	30
	82-06-21	1730	435	150	48	7.4	33	--	120	59	21	.2	--	--	40
006N012W24C01S	63-04-26	--	337	45	13	3.0	53	110	90	8.0	8.0	.4	185	.00	200
	67-10-09	--	311	60	16	5.0	50	160	131	24	12	--	268	.00	--
	69-08-20	--	303	47	14	3.0	51	150	123	20	9.0	.4	249	5.3	--
	72-07-11	--	238	70	11	10	38	140	126	16	8.5	.3	161	.75	--
	73-07-30	--	327	44	15	3.0	52	140	115	22	15	.4	196	3.6	--
	74-06-28	--	310	43	12	3.4	50	140	115	22	12	.2	186	3.3	120
006N011W20G02S	72-05-10	--	240	110	34	5.4	25	120	98	33	18	.1	179	1.9	--
	72-07-11	--	227	130	40	8.3	3.6	140	115	13	8.5	.2	145	1.1	--
	73-07-30	--	333	80	24	4.0	41	166	140	18	5.0	.3	200	6.6	--
	74-06-28	--	273	69	20	4.6	28	140	115	16	5.0	.2	164	6.0	150
007N011W33Q01S	73-05-14	1630	331	130	41	7.4	16	156	--	29	6.9	.3	--	--	<20
	74-05-02	--	255	91	28	5.0	16	127	--	17	6.1	1.0	--	--	<20
	76-05-17	1537	265	92	28	5.3	17	126	--	21	8.1	.3	--	--	40
	77-08-09	1300	340	120	39	6.5	19	150	--	25	12	.2	200	3.4	<20
	78-06-08	1320	280	97	30	5.3	17	130	--	19	8.0	.1	--	--	<20
	79-04-23	1315	260	93	29	5.0	18	--	--	18	7.0	.1	164	2.7	<20
	80-06-24	1450	275	93	29	5.1	17	--	--	21	5.9	.2	--	--	50
	81-06-10	0930	270	92	31	3.6	18	--	--	19	8.9	.2	--	--	10
	82-06-21	1600	265	98	30	5.5	20	--	100	21	9.4	.2	--	--	20
008N010W22P03S	73-05-24	1130	360	130	38	8.1	25	149	--	52	9.1	.5	--	--	80
	74-04-29	--	360	130	38	7.8	24	151	--	53	4.5	1.0	--	--	90
	75-05-05	--	366	120	36	8.1	25	153	--	52	4.9	.3	--	--	60
	77-08-09	1025	380	120	37	7.8	27	150	--	52	6.2	.3	220	2.4	<20
	78-06-08	0910	375	120	36	8.3	26	150	--	52	5.0	.3	--	--	80
	79-04-23	1620	340	128	38	8.0	27	--	--	51	5.0	.3	228	2.0	<20
	80-06-24	1245	345	120	34	7.7	25	--	--	53	2.9	.3	--	--	110
	81-06-09	1715	330	120	36	7.7	24	--	--	51	5.3	.3	--	--	80
	82-06-21	1545	350	130	37	8.0	29	--	120	50	4.6	.3	--	--	80

TABLE 3.--Water-quality data for selected wells in Antelope Valley--Continued

LOCAL IDENTI- FIER	DATE OF SAMPLE (YR-MO-DAY)	TIME	SPE- CIFIC CON- DUCT- ANCE (UMHOS)	HARD- NESS (MG/L AS CACO3)	CALCIUM, DIS- SOLVED (MG/L AS CA)	MAGNE- SIUM, DIS- SOLVED (MG/L AS MG)	SODIUM, DIS- SOLVED (MG/L AS NA)	BICAR- BONATE FET-FLO (MG/L AS HCO3)	ALKA- LINITY FIELD (MG/L AS CACO3)	SULFATE, DIS- SOLVED (MG/L AS SO4)	CHLO- RIDE, DIS- SOLVED (MG/L AS CL)	FLUO- RIDE, DIS- SOLVED (MG/L AS F)	SOLIDS, RESIDUE AT 180 DEG. C DIS- SOLVED (MG/L)	NITRO- GEN, NITRATE TOTAL (MG/L AS NO3)	BORON, DIS- SOLVED (UG/L AS B)
							LANCASTER SUBUNIT--CONTINUED								
007N009W19H02S	73-05-24	1020	420	120	34	7.6	42	144	--	70	9.4	.6	--	--	40
	74-04-29	1435	419	110	33	7.7	41	145	--	73	9.0	.5	--	--	100
	76-05-18	0830	419	110	32	7.6	44	148	--	69	7.5	.4	--	--	70
	77-08-08	1900	460	94	25	7.7	53	130	--	83	12	.5	270	1.0	100
	78-06-08	1250	445	120	34	8.0	44	140	--	74	8.8	.4	--	--	60
	79-04-23	1530	390	111	31	8.0	43	--	--	73	9.0	.3	261	3.5	<20
	80-06-24	1150	410	110	32	7.4	45	--	--	74	9.0	.4	--	--	90
	81-06-09	1600	360	110	31	7.2	43	--	--	70	6.9	.4	--	--	50
	82-06-21	1430	390	110	31	7.1	45	--	120	64	6.7	.4	--	--	60
007N011W03E03S	73-05-15	1115	257	64	22	2.3	27	106	--	28	7.2	.5	--	--	<20
	73-06-25	1115	257	64	22	2.3	27	106	--	28	7.2	.5	--	--	<20
	74-04-30	0945	252	67	23	2.2	28	107	--	27	6.6	.4	--	--	40
	75-05-05	1628	259	69	24	2.3	29	107	--	31	7.8	.3	--	--	60
	77-08-09	1120	300	70	24	2.4	29	100	--	30	9.5	.4	180	3.4	<20
	78-06-08	1005	265	69	23	2.7	26	110	--	18	6.1	.2	--	--	30
	79-04-23	1650	250	63	22	2.0	30	--	--	30	8.0	.2	173	2.6	<20
	80-06-24	1335	255	73	25	2.6	25	--	--	22	5.4	.2	--	--	70
	81-06-09	1745	300	70	24	2.4	29	--	--	43	9.6	.3	--	--	30
007N010W30E01S	72-03-16	--	472	194	59	11	21	175	144	82	12	--	--	4.0	90
	74-06-06	1100	504	191	60	10	23	175	143	81	13	.4	301	2.3	0
	76-04-26	1200	449	190	59	9.4	23	178	146	70	8.9	.6	291	2.1	50
	77-05-03	1320	438	175	57	8.0	23	179	147	64	9.0	.3	292	3.0	70
	78-05-19	1115	437	174	55	9.1	24	171	144	63	8.8	.3	353	2.8	0
009N010W24C01S	56-04-30	--	576	--	--	--	--	--	--	--	41	--	--	--	--
	57-04-10	--	530	--	--	--	--	--	--	--	34	--	--	--	--
	57-10-02	--	537	--	--	--	--	--	--	--	33	--	--	--	--
	58-04-10	--	478	54	16	3.4	88	165	135	74	24	.6	--	--	--
	58-06-24	--	573	61	22	1.5	99	164	135	80	45	.5	--	.40	400
	61-09-14	--	492	51	15	3.3	88	164	135	74	26	.6	325	.40	400
	62-10-24	--	452	46	73	6.8	95	168	138	69	22	.0	372	.90	200
	63-12-12	--	403	36	13	.9	73	144	121	53	12	.6	270	.40	200
	64-10-09	--	414	39	12	2.2	75	151	124	59	12	.6	275	.40	400
	65-12-28	--	472	43	14	1.9	86	156	128	70	20	.9	313	.50	200
	66-04-28	--	461	42	14	1.7	86	161	132	66	19	.6	298	.00	300
	66-10-25	--	405	36	12	1.5	76	150	123	62	12	.7	270	.30	300
	67-10-24	--	449	46	16	1.5	80	153	125	68	18	.6	290	1.6	100
	69-11-12	--	416	44	15	1.6	75	148	121	59	13	.8	277	.40	--
	71-06-04	--	444	72	25	2.3	64	155	127	61	21	.5	272	.40	--
	72-02-01	1350	512	90	32	2.5	66	146	120	67	45	.3	276	--	--
	75-03-19	1400	432	67	23	2.3	65	150	123	62	19	.5	282	--	--

TABLE 3.--Water-quality data for selected wells in Antelope Valley--Continued

LOCAL IDENTI-FIER	DATE OF SAMPLE (YR-MO-DAY)	TIME	SPE-CIFIC CON-DUCT-ANCE (UMHOS)	HARD-NESS (MG/L AS CACO3)	CALCIUM, DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	BICAR-BONATE FET-FLD (MG/L AS HCO3)	ALKA-LINITY FIELD (MG/L AS CACO3)	SULFATE, DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)	NITRO-GEN, NITRATE TOTAL (MG/L AS NO3)	BORON, DIS-SOLVED (UG/L AS B)
							NORTH MUROC SUBUNIT								
011N008W35D01S	55-08-25	--	1180	100	33	4.4	230	232	190	144	184	.4	754	.00	1000
	58-07-09	--	--	--	--	--	--	--	--	--	240	--	990	--	1000
	59-10-20	--	--	--	--	--	--	--	--	--	108	--	876	--	1600
011N009W24B02S	55-08-05	--	750	135	39	9.2	112	177	145	120	78	.8	479	8.8	3000
	58-07-09	--	--	--	--	--	--	--	--	--	78	--	495	--	2100
	59-01-16	--	--	--	--	--	--	--	--	--	82	--	470	--	2200
	59-10-06	--	--	--	--	--	--	--	--	--	82	--	497	--	3000
	61-08-10	--	--	--	--	--	--	--	--	--	80	--	517	--	2200
	62-07-16	--	725	144	45	7.6	97	165	135	83	83	--	549	15	2000
010N009W05B01S	64-06-16	--	1100	84	26	4.6	200	264	217	104	147	1.1	661	3.3	700
	64-10-09	--	1150	81	25	4.5	220	269	221	107	162	1.0	693	.20	700
	65-12-29	--	845	40	9.4	4.0	172	256	210	86	82	1.4	522	.50	500
	66-04-28	--	1170	66	19	4.5	236	302	248	105	148	.9	688	.00	800
	66-10-25	--	1040	38	11	2.6	221	310	254	103	110	1.1	672	.40	900
	67-10-24	--	1360	86	25	5.6	268	328	269	122	192	.8	--	1.7	700
	69-11-12	--	1060	59	17	4.0	214	296	243	109	122	1.3	644	.10	--
	71-06-04	--	1050	50	15	3.0	210	299	245	110	120	.7	618	.30	--
	72-02-02	0920	1070	54	15	4.0	210	300	246	110	120	1.0	620	--	--
	72-06-13	1300	1110	62	18	4.1	200	318	261	110	120	1.1	--	--	730
	75-03-00	0915	998	84	28	3.3	190	290	238	100	100	1.0	595	--	--
							PEERLESS SUBUNIT								
032S039E33R01M	58-09-03	--	945	160	51	8.0	149	342	281	86	74	.8	599	26	690
	61-08-03	--	908	159	49	9.0	150	330	271	89	78	.8	630	19	1000
	62-05-31	--	885	150	47	8.0	145	329	270	87	74	.9	618	19	890
	67-11-30	1250	944	135	41	8.0	154	327	268	83	73	1.2	601	20	970
	68-06-03	--	1000	151	48	8.0	158	352	289	97	73	1.1	604	22	1400
	69-05-26	1130	917	152	46	9.0	155	345	283	83	72	1.1	531	20	1020
	71-05-05	1030	934	154	45	10	156	351	288	85	72	.8	608	24	1160
							ROSAMOND-BISSELL HARD-ROCK AREA								
009N010W16C02S	52-04-03	--	1160	340	--	--	--	--	--	--	139	--	--	--	--
	62-06-05	--	2540	815	233	57	258	162	133	518	465	.8	1840	9.6	600
	62-10-25	--	1830	549	154	40	188	159	130	358	309	.9	1220	4.8	500
	75-03-19	1012	686	150	41	11	80	160	131	120	52	1.3	428	--	--
							RANDSBURG-CASTLE BUTTE HARD-ROCK AREA								
011N008W03Q01S	56-05-14	--	794	124	34	9.6	117	185	152	88	84	.8	588	27	480
011N008W22E01S	51-12-21	--	1460	170	--	--	--	--	--	--	212	--	--	--	--
	52-04-02	--	1150	109	29	8.9	206	207	170	148	167	.6	709	1.3	14000
	55-08-17	--	1260	129	32	12	230	224	184	160	189	.6	756	1.9	15000
	56-05-15	--	1190	110	28	9.7	201	166	136	159	183	.6	707	6.8	11000
	58-02-18	--	--	--	--	--	--	--	--	--	194	--	674	--	7700
	58-07-09	--	--	--	--	--	--	--	--	--	184	--	582	--	8900
	59-01-26	--	--	--	--	--	--	--	--	--	194	--	851	--	8600
	59-10-06	--	--	--	--	--	--	--	--	--	192	--	1090	--	7600
011N007W31P02S	56-05-17	--	2020	213	67	11	339	212	174	316	316	.9	1240	22	2200

TABLE 3.--Water-quality data for selected wells in Antelope Valley--Continued

LOCAL IDENTI-FIER	DATE OF SAMPLE (YR-MO-DAY)	TIME	SPE-CIFIC CON-DUCT-ANCE (UMHOS)	HARD-NESS (MG/L AS CACO3)	CALCIUM, DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	BICAR-BONATE FET-FLD (MG/L AS HCO3)	ALKA-LINITY FIELD (MG/L AS CACO3)	SULFATE, DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)	NITRO-GEN, NITRATE TOTAL (MG/L AS NO3)	BORON, DIS-SOLVED (UG/L AS B)
						HI VISTA HARD-ROCK AREA									
006N008W09P01S	72-03-15	1545	1270	387	101	33	111	126	103	394	83	1.1	857	20	280
	73-03-01	--	1180	384	101	32	125	128	105	399	79	.7	867	19	290
	74-06-05	0930	1370	400	100	33	130	120	98	420	83	1.2	915	19	220
	75-04-08	1430	1270	390	110	31	120	120	98	410	81	1.1	914	21	440
	76-04-28	1030	1240	380	100	30	130	140	115	440	54	1.1	880	8.7	260
	77-04-25	1910	1227	380	100	29	130	140	115	430	53	1.2	928	9.4	310
	78-05-18	1400	1220	380	100	30	130	140	115	440	55	1.3	832	10	300
						FOOTHILL HARD-ROCK AREA (NORTH)									
008N016W13N01S	73-05-22	1030	369	32	11	1.1	76	148	--	42	10	.7	--	--	70
	74-04-30	1515	367	29	10	.9	73	145	--	47	9.5	1.3	--	--	140
	75-05-06	--	471	140	45	7.8	44	204	--	50	14	.3	--	--	90
	76-05-18	1115	345	29	9.8	1.1	70	148	--	46	8.7	.7	--	--	110
	77-08-09	1635	400	29	10	1.0	70	150	--	44	10	.7	240	6.7	<20
	78-06-07	1510	400	39	13	1.5	72	150	--	43	9.6	.6	--	--	60
	79-04-24	1115	350	53	18	2.0	67	--	--	42	10	.5	247	11	300
	80-06-25	1050	395	91	29	4.6	46	--	--	28	18	.5	--	--	60
	81-06-10	1430	350	74	24	3.4	54	--	--	33	13	.5	--	--	40
	82-06-22	1130	365	42	14	1.6	70	--	120	34	12	.5	--	--	50
006N013W04H01S	72-03-14	1215	1010	390	95	37	61	260	213	170	36	1.2	648	100	100
	73-03-05	--	938	380	91	38	71	300	246	150	35	.9	637	100	80
	74-06-07	1300	1090	400	98	38	72	330	268	150	35	1.2	701	100	50
	75-04-17	1130	916	340	83	33	65	290	--	110	48	1.5	623	69	110
	76-04-22	0945	634	218	54	20	51	229	--	56	40	1.4	286	26	120
	77-04-21	1145	765	288	71	27	59	278	--	78	49	1.2	531	46	150
	78-05-19	1000	925	350	86	33	68	278	--	110	67	1.3	532	57	200
						FOOTHILL HARD-ROCK AREA (SOUTH)									
006N012W34N01S	71-01-00	--	1180	490	140	35	100	220	180	350	110	.5	867	12	440
	72-07-00	--	1180	650	170	53	78	190	156	430	140	.6	989	11	--
	73-07-30	--	1400	550	140	39	98	210	172	260	160	.5	838	6.6	--
	74-06-28	--	1380	520	130	48	76	180	148	260	180	.6	827	6.6	210
004N010W23C01S	71-04-29	1520	345	170	43	15	9.0	200	177	16	3.0	.1	185	.40	10
	72-03-13	1210	388	190	46	18	12	230	189	24	5.0	.1	215	.00	10
	73-03-07	--	398	180	48	15	16	230	189	24	5.0	.2	207	5.8	<20
	74-05-28	0930	407	190	51	15	8.0	230	189	17	3.2	.2	226	.00	<20
	78-07-14	0955	368	160	44	12	14	200	164	20	4.1	.2	184	1.1	<20
005N010W34N02S	71-04-28	1220	1220	420	95	44	130	270	221	370	54	1.5	821	2.0	140
	72-03-13	1500	1290	430	96	46	110	260	213	370	57	1.3	880	1.5	100
	73-03-08	--	1210	420	93	47	130	270	221	380	56	1.1	883	2.2	80
	76-05-05	1030	1262	420	97	44	130	270	225	380	54	1.9	880	2.6	--
	77-04-20	1550	1289	420	100	41	120	270	221	370	53	1.6	907	2.8	--
	78-07-14	1035	1240	400	93	41	129	250	213	370	55	1.7	847	1.8	100
005N011W16R02S	73-02-27	--	2116	974	247	87	181	330	271	892	107	--	--	2.6	130
	74-05-29	1500	2531	995	260	84	251	362	297	1142	45	--	--	1.3	230
	75-04-09	1630	2649	1079	286	89	262	348	286	1242	50	1.0	--	4.0	330
	76-04-22	1305	2795	1202	321	97	278	352	289	1339	57	1.1	--	3.0	280
	77-04-20	1205	2900	1173	312	96	268	355	291	1319	52	--	--	3.6	330
	78-07-13	1015	3020	1150	227	142	270	351	288	1330	54	--	--	3.4	400

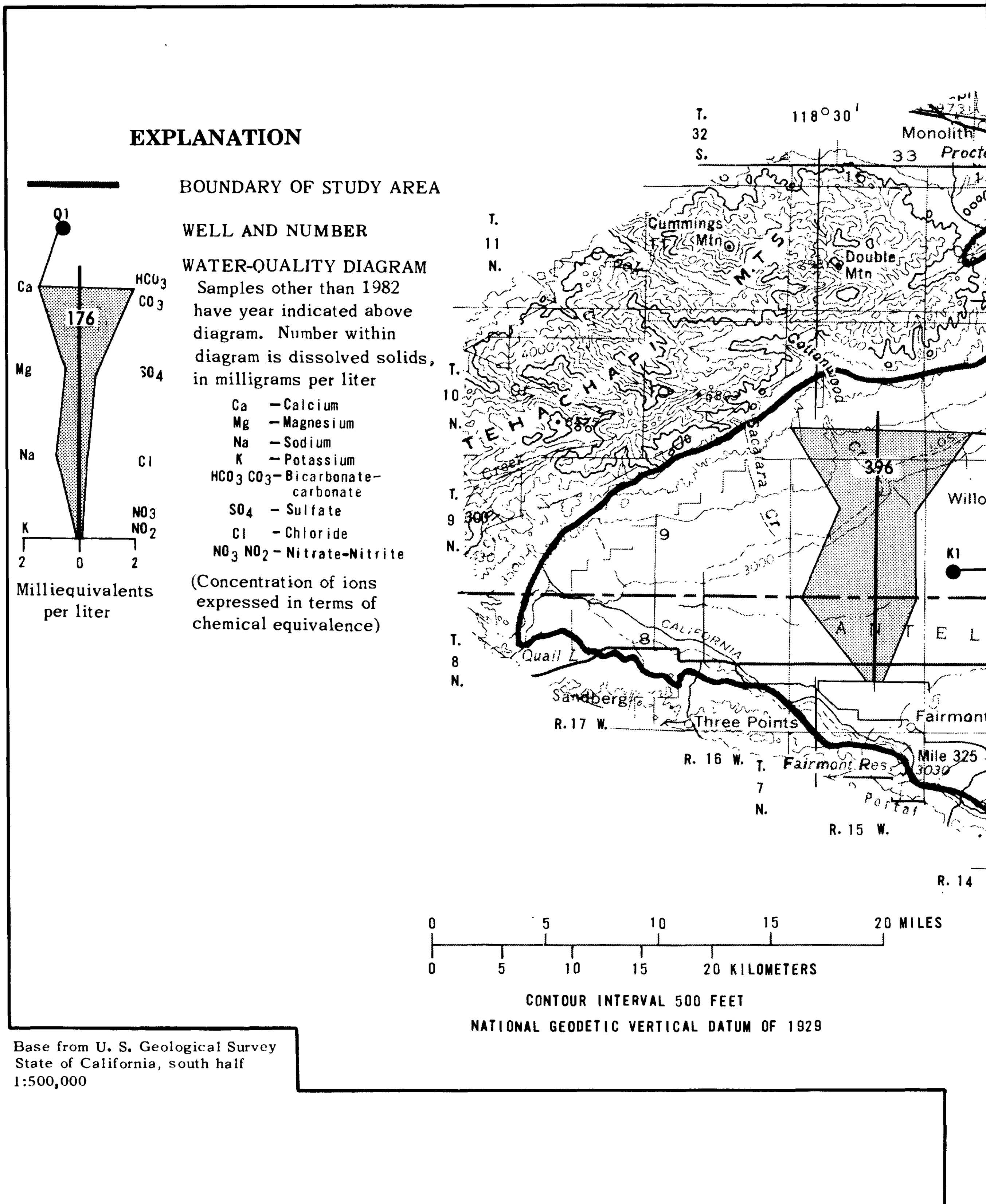
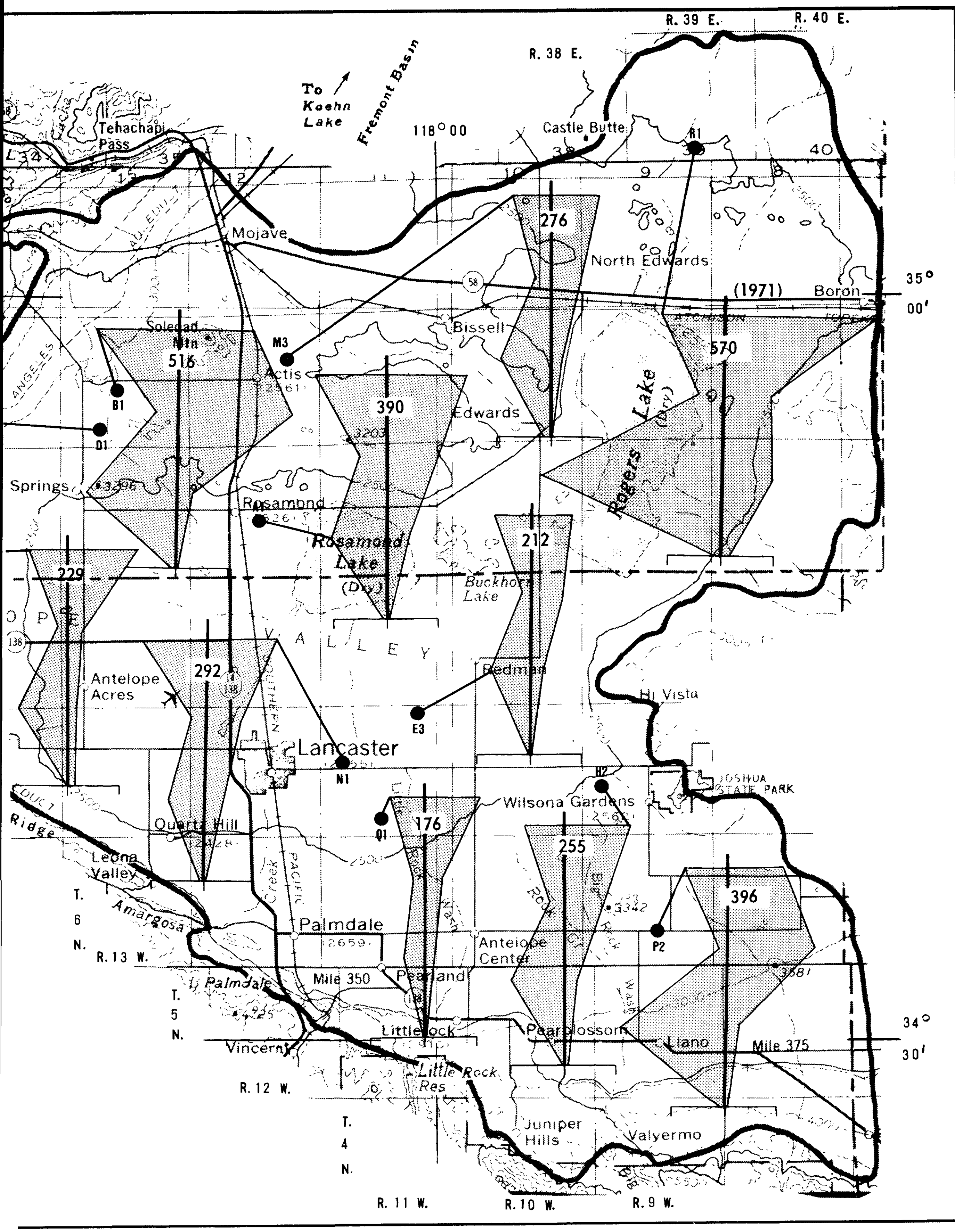


FIGURE 11.—Water-quality diagrams, 1982.


R. 39 E.
R. 40 E.
R. 38 E.
To Koehn Lake
Fremont Basin
Tehachapi Pass
118° 00
Castle Butte
R1
40
Mojave
276
North Edwards
(1971)
Boron
35°
00′
Soledad Mtn
516
M3
Actis
Bissell
570
B1
390
Edwards
D1
Rogers Lake (Dry)
Springs
Rosamond
Rosamond Lake (Dry)
212
229
Buckhorn Lake
V A L L E Y
292
Antelope Acres
Redman
Hi Vista
E3
Lancaster
N1
H2
JOSHUA STATE PARK
Wilsona Gardens
Q1
176
255
Quartz Hill
Leona Valley
Ridge
396
T. 6 N.
Amargosa
Palmdale
P2
Anteiope Center
R. 13 W.
Palmdale
Mile 350
Pearland
T. 5 N.
Littlerock
Pearblossom
Llano
Mile 375
34°
30′
Vincent
Little Rock Res
R. 12 W.
T. 4 N.
Juniper Hills
Valyermo
R. 11 W.
R. 10 W.
R. 9 W.

Water-quality data for 11 wells in the Lancaster subunit show that the general quality of water in the subunit is acceptable for human consumption (table 3). Exceptions to this are wells 9N/13W-27K1S, 9N/12W-21A1S, and 7N/11W-18N1S where levels of hardness and specific conductance have been found to exceed the MCL in public water-supply criteria.

The shallow, perched water body (pl. 2) contains inferior quality water when compared to other water bodies in the area. This minor aquifer will probably be the first to develop major ground-water-quality problems in Antelope Valley. The higher than normal dissolved-solids and nitrate concentrations in this aquifer are related to percolation of sewage effluent and mineralized irrigation-return water. In the future, this deterioration of water quality could affect the principal aquifer. The anticipated increase in urban population in the Lancaster subunit will cause an increasing need for disposal of industrial and domestic sewage. Further, many of the hundreds of wells in the subunit act as direct pathways between the poorer quality perched water body and the principal aquifer. The deeper aquifer should remain unaffected and its use will probably not increase because the cost to reach it is not justified. In the network design this aquifer was not suggested for monitoring.

In the northern part of the North Muroc subunit, ground water is generally of poor quality for domestic (tables 2 and 3) and agricultural use, but it is of better quality in the southern part. Analyses of water from three wells in this subunit are given in table 3. Dissolved solids (fig. 10) range from 500 to 900 mg/L, but historical records (not in table 3) show concentrations as high as 1,200 mg/L. Isolated wells show increasing concentrations of magnesium (not in table 3), sulfate (well 10N/9W-5B1S), and chloride (well 11N/9W-24B2S) that may be caused by local natural conditions (mineral deposits) near the well.

The ground water in the North Muroc subunit also contains fairly high concentrations of boron and fluoride, which can be attributed to the rich borate deposits in the area. High boron concentrations can also be attributed to Tertiary saline lake deposits northeast of Rogers Lake. Nitrate concentrations as NO_3 in the ground waters of the subunit, are generally low (less than 15 mg/L). Typically, ground water of the subunit is classified as a sodium bicarbonate chloride type.

Arsenic occurs naturally in the ground water of the North Muroc and Peerless subunits, but since mining of borate began in 1926, man has brought arsenic-bearing minerals to the ground surface, thus making the source for arsenic more available and the movement into the ground-water system more likely. Water with high arsenic and boron concentrations has moved beyond the dikes of the U.S. Borax and Chemical Corp. waste-disposal ponds (located approximately 5 miles northwest of the town of Boron), although this has not caused contamination of wells in the area (Doyle, 1969). Data on arsenic concentrations are not included in this report because little historical sampling exists for that trace constituent in the ground-water wells of Antelope Valley.

The characteristic water type of the Peerless subunit is sodium bicarbonate (fig. 11). Data are not available to develop lines of equal concentrations of dissolved solids for this subunit. Analyses from one well (table 3) show boron and dissolved-solids concentrations and specific-conductance values exceed the MCL in public water supply criteria (table 2).

Because the Rosamond-Bissell hard-rock area has little activity and development, not much is known about water-quality conditions. Water-quality data on one well (table 3) show that chloride, dissolved-solids, and sulfate concentrations and specific-conductance values exceed the MCL in the public water supply criteria (table 2). This well is a good example of a possible false interpretation stemming from the historical record. The author feels that the improvement in water quality from 1952 to 1975 was not because of imported water, as may be the case in some locations of Antelope Valley. Most likely, the change reflects a change in collection and analysis methods and agencies. The need for further sampling is evident before specific conclusions may be drawn.

Ground water in the community of Boron in the Randsburg-Castle Butte hard-rock area has a concentration of boron in excess of 2,000 µg/L; elsewhere in Antelope Valley, ground water generally has a boron concentration of less than 500 µg/L. This is evident in two out of three wells' water-quality analyses presented in table 3. It should be noted that the data for this area were obtained at least 20 years ago. The data also indicate that concentrations of chloride, dissolved solids, and sulfate at times exceeded the MCL in the public water supply criteria (table 2).

Water from one well in the Hi Vista hard-rock area (table 3) indicates that concentrations of dissolved solids, hardness, and sulfate and values of specific conductance exceeded the MCL in the public water supply criteria (table 2). This well is typical of those in hard-rock areas where alluvial fan deposits influence water-quality conditions. The somewhat elevated nitrate levels may be caused by contamination from septic tanks.

High fluoride concentrations associated with the San Andreas fault are evident in one well in the southern part of the Foothill hard-rock area (table 3). The dissolved-solids, hardness, and sulfate concentrations exceed the MCL in the public water supply criteria (table 2) and are probably associated with local deposits of gypsum. Generally, the water quality of the wells in the Foothill hard-rock area's northern part is better than that of wells in the southern part.

Historical surface-water-quality data exist for three sites in Antelope Valley. A range of concentration values for selected dissolved chemical constituents of these sites are given in table 4.

Data show that the water quality of the streams (surface water) in Antelope Valley is, in general, suitable for domestic use. Major development is nonexistent along the stream courses of the area; therefore, the threat of surface-water-quality degradation is minimal. Based on the information presented in table 4, the conclusion of this report is that at this time, it is not necessary to include surface-water-quality sampling sites as part of this ground-water-quality monitoring network design.

Big and Little Rock Creeks account for more than 50 percent of the runoff recharge to Antelope Valley. At these sites none of the chemical constituents sampled (table 4) exceed the MCL of public water supply criteria (table 2).

Water-quality data for the California Aqueduct site indicate that the water is generally of good quality (table 4). The maximum range value observed for chloride and dissolved solids (these exceed the MCL of public water supply criteria of table 2) were both sampled September 21, 1977. Through most of 1977 the water quality of the aqueduct was poor in comparison to both earlier and more recent years' data.

TABLE 4. - Range of values for selected dissolved chemical data from surface-water sites

[Data in milligrams per liter, except for boron in micrograms per liter]

Site	Sodium	Sulfate	Chloride	Fluoride	Dissolved solids	Nitrate	Boron
Big Rock Creek[1]	9-28	22-187	0-23	0-0.9	232-456	0-12.6	0-500
Little Rock Creek[1]	9-48	9-66	2-10	0.1-0.7	140-345	0-3.5	0-500
California Aqueduct near Pearblossom[2]	30-195	12-115	3-307	0.1-0.7	72-859	0.1-12.0	20-540

[1]Data collected from 1951 through 1963 (California Department of Water Resources, 1968).

[2]Data collected from 1972 through 1981 (available through U.S. Environmental Protection Agency's STORET data network).

LAND USE

The three most extensive land uses in Antelope Valley are agricultural, residential, and industrial (pl. 3). Agricultural areas are widespread but acreage has declined since the mid-1960's because of urban growth. The major residential areas are in the central and southern parts of the valley, adjacent to the labor-intensive industries (North County Citizens Planning Council, 1977).

Agricultural land in Antelope Valley tends to be located away from the communities and is fairly diversified, with emphasis on exported livestock and feed production. Wheat and barley are dry-farmed in the western part of the valley, but alfalfa (a nitrogen fixator, therefore a source of nitrate contamination to ground water) is farmed across the area and is the main irrigated crop. Orchards in the southern region, near Quartz Hill and Littlerock, are fertilized with nitrates, phosphates, and other nutrients that are capable of percolating into the water table.

The residential communities that are rural and of low-population density include Littlerock, Sun Village, Pearblossom, Pinon Hills, Juniper Hills, Valyermo, Vincent, Wilsona Gardens, Redman, Willow Springs, Aerial Acres, Green Valley, and Leona Valley. Domestic wastewater for these communities is disposed of generally by percolation from individual leach lines and septic tanks. The main residential concentrations are the communities of Lancaster, Quartz Hill, and Palmdale, which are generally, but not totally, serviced by city sewage disposal facilities. Sewered urban wastes are treated at various sanitation plants. Table 5 shows the current (1982) list of sewage discharge permits issued by the California Regional Water Quality Control Board--Lahontan Region. In most cases, actual discharge is lower than designed. Accidental spills at the discharge disposal sites could degrade water quality in the valley. These sites, of primary interest in the development of this monitoring program, are specifically shown in plate 3.

Manufacturing for the aerospace industry is the main economic activity in the area. Edwards Air Force Base, the world's largest flight test center, is located east of Rosamond. This site remains the most favorable location for NASA space shuttle landings. There are an estimated 350 flying days per year at Edwards Air Force Base. The U.S. Air Force Flight Production Center (Plant 42) is a primary production testing facility for a number of civil aircraft companies. Additionally, an international airport is planned for future location in Palmdale. Hence, with the presence of the aviation industry and the military, spilling or dumping of raw fuels, solvents, oils, or plating liquids might happen.

The mining industry is located on the northern fringes of the valley. Borate is mined in several locations near Boron and Kramer. Erosional debris of the borate deposits, including the accessory mineral realgar, a sulfide of arsenic, may be carried by streams downgradient through the north end of the North Muroc subunit and then through the gap to Fremont Valley (Doyle, 1969). If percolation should occur from the borate plant evaporation ponds, high boron and arsenic could be induced into the ground-water system.

Additional mining includes salt extraction from ground-water brine near Saltdale. Rock, gravel, and sand are quarried in the southeastern part of the valley. Cement is produced at plants near Mojave and Gorman along the mountain front. Clay used for the manufactor of drilling mud formerly was mined from Rosamond and Rogers Lakes (California Department of Water Resources, 1980). All these activities pose little threat to the quality of the ground water in the area.

TABLE 5. - Sewage disposal sites

[Written communication, 1982, M. B. Wochnick, California Regional Water Quality Control Board, Lahontan Region]

Operator	Design capacity in million gallons per day	General location and subunit or hard-rock area
Mojave Public Utility District	0.60	11N/12W-22 (Chaffee subunit)
Rosamond City Sanitation District	.25	9N/12W-27 (Lancaster subunit)
Lancaster-Piute Ponds, Los Angeles County Sanitation District No. 14	6.5	8N/12W-11, 12, 13, 14, 15 (Lancaster subunit)
Palmdale, Los Angeles County Sanitation District No. 20	3.1	6N/11W-16 (Lancaster subunit)
Palmdale (reclamation site), Los Angeles Department of Airports	3.1	6N/11W-9 (Lancaster subunit)
Palmdale, Air Force Plant No. 42	.57	7N/11W-31 (Lancaster subunit)
Edwards Air Force Base (sewage)	1.7	9N/9W-18, 19; 9N/10W-13, 24 (Lancaster subunit)
Edwards Air Force Base (industrial)	.0015	10N/10W-25; 10N/9W-30 (Rosamond-Bissell hard-rock area)
Desert Lake Community Sanitation District	.2	11N/8W-34 (North Muroc subunit)
Boron Community Sanitation District	.21	11N/8W-36 (Randsburg-Castle Butte hard-rock area)
Park Knolls (subdivision)	.015	11N/8W-36 (Randsburg-Castle Butte hard-rock area)

NETWORK DESIGN

Presently, there is no single ground-water-quality monitoring network for the entire Antelope Valley area. Eleven Federal, State, local, and private agencies maintain separate ongoing surveillance programs in which data are collected at 121 specific well locations. Additional wells in the study area currently are not part of any water-quality network identified in the phase 2 catalog discussed under "Introduction."

Plate 2 shows the location of each site suggested through this network design study. Three types of symbols are used: ideal sites, ideal wells, and actual wells. Ideal sites are those locations where there are no wells, but where monitoring is suggested. Ideal wells are existing wells not presently being monitored. The actual wells are those wells that are presently being monitored and that are at or near a location selected for the ideal network. Historical data in the U.S. Geological Survey WATSTORE computer storage system for the suggested actual well network are given in table 3 and plate 2. The class of well (see "Introduction") was considered, but in many cases only class 3 or 4 wells were available for selection.

Table 6 gives locations of ideal sites, ideal wells and actual wells, the sampling categories to be monitored, and the frequency of monitoring. The ideal network was designed to monitor all sites listed in table 5 and the network objectives. Such a network would require drilling 13 new observation wells and using 20 wells not now being monitored by any agency. The wells and sites selected are listed by subunits and areas in the same order as presented in the text. Where possible, individual sampling sites are presented in downgradient order, north to south or west to east. Current network information, if known, includes the agency monitoring the well, the type and frequency of analysis, the total depth of the well, the perforated interval, and the well classification (well class). In the actual network, only about 2 percent of the wells are class 1, 45 percent are class 2, 45 percent are class 3, and 8 percent are class 4. A suggested perforation interval was included where the actual one is not known. The reason for monitoring the proposed or actual well is also listed. The number and type of site for each monitoring reason is summarized in table 7. This table, even though it is somewhat general, will be useful to the State Board in making appropriate future alterations to the network design. The effectiveness of the proposed actual network will depend on how well the data-collection regimen is followed.

TABLE 6. - Proposed Antelope Valley

State well No. or site: Asterisk (*) indicates proposed well sites for ideal network (ideal site), number intended to show location only, official number would be assigned by CDWR when and if well is completed; double asterisk (**) indicates existing well which is not now a part of a water-quality network (phase 1 or 2) (ideal well); wells without an asterisk are in actual network (actual well).

Collecting agency: BCSD, Boron Community Service District; CDWR, California Department of Water Resources; DLCS, Desert Lake Community Service District; EAFB, Edwards Air Force Base; LASD, Los Angeles County Sanitation District; MPUD, Mojave Public Utility District; PWD, Palmdale Water District; QHWD, Quartz Hill Water District; RCWD, Rosamond Community Water District; USBC, U.S. Borax and Chemical Co.; USGS, U.S. Geological Survey.

Perforated interval: The number in parentheses indicates suggested interval if unknown. The upper 50 to 100 feet of this interval also indicates at what depth the water-quality sample should be taken, if possible, unless otherwise indicated in table.

State well No. or site	Present sampling program: Collecting agency	Present sampling program: Sampling categories	Present sampling program: Frequency	Depth of well, in feet	Perforated interval, in feet	Well class
FINGER BUTTES						
8N/17W-4D1S**	USGS	Water level only	Semiannual	530	--	3
10N/15W-32A1S**	USGS	----do.----	Annual	>212	--	4
WEST ANTELOPE						
8N/17W-8A*	--	--	--	500	200-500	--
8N/16W-5M1S**	--	--	--	1,000	350-1,000	2
NEENACH						
8N/16W-18H1S**	--	--	--	250	--	3
9N/14W-31K1S	USGS	Common	Annual	675	--	3
9N/13W-14Q1S**	USGS	Water level only	-do.--	>203	--	4

water-quality-monitoring network

Well class: Detailed explanation of well classification may be found in the approach section of this report.
Priority: Priority class explained in the network design section of this report.
Sampling categories:

Common: Physical tests and common constituents include water level; sampling depth; pH; specific conductance; temperature; total alkalinity, dissolved solids, hardness; and noncarbonate hardness; dissolved constituents, boron, calcium, chlorine, fluorine, iron, magnesium, manganese, nitrite, nitrate, phosphate, phosphorus, potassium, silica dioxide, sodium, sulphate.

Minor: Physical tests and minor constituents include water level; sampling depth; dissolved silver, arsenic, barium, cadmium, chromium, copper, mercury, lead, selenium, and zinc.

Toxic/misc.: Toxic and miscellaneous constituents include phenol; oil and grease; bacteria; detergents, methylene blue active substance (MBAS); chromium hexavalent; pesticides; potassium, total phosphorus, cyanide; total and dissolved organic carbon, nitrogen, sulphur; carbon tetrachloride (CCl_4); perchloroethylene (PCE); and trichloroethylene (TCE).

Suggested sampling program			Reasons for monitoring
Priority	Sampling categories	Frequency	
SUBUNIT			
II	Common	Annual	Upgradient in the subunit, baseline water quality of the western part of the subunit, recharge from Tehachapi Mts., downgradient of California Aqueduct.
	Minor	Initial year, then every 5 years	
	Toxic/misc.	----do.-----------	
I	Common	Annual	Upgradient in the subunit, baseline water quality for the eastern part, recharge from Tehachapi Mts.
SUBUNIT			
II	Common	Annual	Upgradient of agricultural land use.
I	-do.--	-do.--	Downgradient of agricultural land use and ground-water flow into Neenach subunit.
	Minor	Initial year, then every 5 years	
	Toxic/misc.	----do.-----------	
SUBUNIT			
II	Common	Annual	Upgradient in the subunit, baseline water quality, recharge from San Gabriel foothills.
I	-do.--	-do.--	Downgradient of agricultural land use in subunit.
I	-do.--	-do.--	Downgradient of inflow from Willow Springs subunit and outflow into the Lancaster subunit.
	Minor	Initial year, then every 5 years	
	Toxic/misc.	----do.-----------	

TABLE 6. - Proposed Antelope Valley

State well No. or site	Present sampling program: Collecting agency	Sampling categories	Frequency	Depth of well, in feet	Perforated interval, in feet	Well class
						WILLOW SPRINGS
10N/13W-32D1S	USGS	Common	Annual	900	(150-250)	3
9N/13W-13A*	--	--	--	500	200-500	--
						GLOSTER
10N/12W-15M3S	USGS	-do.--	-do.--	175	(50-175)	3
10N/13W-21B1S	USGS	Common	Annual	750	(50-200)	3
11N/12W-26J1S**	USGS	Water level only	-do.--	225	(50-225)	3
						CHAFFEE
11N/12W-8B*	--	--	--	500	250-500	--
11N/12W-22F1S	MPUD	Common	Intermittent	381	205-381	2
11N/13W-24A1S**	--	--	--	490	260-360	2

water-quality-monitoring network--continued

Suggested sampling program			Reasons for monitoring
Priority	Sampling categories	Frequency	
SUBUNIT			
II	Common	Annual	Upgradient of urban activity, baseline water quality.
III	-do.--	-do.--	Downgradient of urban and agricultural land use and outflow into the Lancaster subunit. Well 9N/13W-14Q1S of the Neenach subunit may provide duplicate information content.
SUBUNIT			
I	Common Minor Toxic/misc.	Annual -do.-- -do.--	Downgradient of urban and mining land use and recharge from the Soledad Mts.
II	Common Minor	Annual Initial year, then every 5 years	Upgradient in the subunit, downgradient of a quarry pit and recharge from the unnamed buttes to the northwest. High levels of sulfate, fluoride, and dissolved solids have been found. Note: Well may be too deep to monitor effects of quarry pit.
III	Common	-do.--	Downgradient in subunit and inflow into Chaffee subunit. Well 11N/12W-22F1S of the Chaffee subunit may provide duplicate information content.
SUBUNIT			
II	Common	Annual	Upgradient, baseline water quality.
I	-do.-- Minor Toxic/misc.	-do.-- -do.-- -do.--	Upgradient of Mojave, downgradient of Mojave Public Utility District sewage site.
II	Common	-do.--	Upgradient of Mojave and golf course. High nitrate levels have been detected probably due to urban activity.

TABLE 6. - Proposed Antelope Valley

State well No. or site	Present sampling program: Collecting agency	Sampling categories	Frequency	Depth of well, in feet	Perforated interval, in feet	Well class
						OAK CREEK
11N/14W-14B1S	USGS	Common	Annual	60	30-60	2
10N/15W-26A*	--	--	--	300	200-300	--
12N/12W-31N*	--	--	--	300	200-300	--
						PEARLAND
4N/7W-19L*	--	--	--	500	200-500	--
5N/9W-25A1S	CDWR	Common	Annual	542	442-542	2
5N/10W-16J1S	CDWR	-do.--	-do.--	235	(100-200)	3
5N/11W-12Q1S	CDWR	-do.--	-do.--	450	(100-200)	3
5N/11W-2Q2S	CDWR	-do.--	-do.--	190	170-190	2
6N/11W-32P1S	PWD	-do.--	-do.--	473	158-188 214-222 224-248 458-473	2

water-quality-monitoring network--continued

Suggested sampling program			Reasons for monitoring
Priority	Sampling categories	Frequency	
SUBUNIT			
II	Common Minor Toxic/misc.	Annual Initial year, then every 5 years ----do.-----------	Upgradient, baseline water quality, and recharge from Oak Creek. High levels of hardness, alkalinity, fluoride, boron, iron, and dissolved solids have been detected. Note: Well is located outside the boundary of the subunit.
II	Common	Annual	Upgradient, baseline water quality, and recharge from Tehachapi Mts.
I	-do.-- Minor Toxic/misc.	-do.-- -do.-- -do.--	Downgradient of the mining activity south of site 11N/14W-14B1S, and outflow of the study area.
SUBUNIT			
III	Common	Annual	Upgradient of Pinon Hills, baseline water quality, and recharge from San Gabriel Mts. Well 5N/8W-25H1S of the Buttes subunit may provide duplicate information content.
I	-do.--	-do.--	Upgradient of Pearblossom, downgradient of Pinon Hills and the southeast agriculture.
I	-do.-- Minor Toxic/misc.	-do.-- -do.-- -do.--	Downgradient of Pearblossom and upgradient of Littlerock.
I	Common	-do.--	Centered directly in agricultural land use. Well shows high sulfate, nitrate, and dissolved iron levels.
III	-do.--	-do.--	Downgradient of agricultural area of Littlerock. Well 5N/11W-12Q1S and well 6N/11W-32P1S may provide duplicate information content.
I	-do.-- Minor Toxic/misc.	Semiannual ----do.--- ----do.---	Downgradient of outflow to the Lancaster subunit. Note: If water level is below 160 feet, an annual sampling frequency should be adopted.

TABLE 6. - Proposed Antelope Valley

State well No. or site	Present sampling program: Collecting agency	Sampling categories	Frequency	Depth of well, in feet	Perforated interval, in feet	Well class
						BUTTES
5N/8W-25H1S	CDWR	Common	Annual	500	--	3
6N/8W-19M1S	CDWR	-do.--	-do.--	222	70-222	2
5N/9W-5C1S	CDWR	-do.--	-do.--	--	--	4
6N/9W-28P2S	USGS	-do.--	-do.--	731	240-731	2
6N/10W-17N1S**	USGS	Water level only	-do.--	>203	(200-300)	4
6N/10W-5H2S	CDWR	Common	-do.--	--	(250-450)	4
						LANCASTER
8N/15W-18H1S**	USGS	Water level only	Annual	295	283-295	2
9N/13W-27K1S	USGS	Common	-do.--	550	(200-300)	3
8N/14W-15G1S**	USGS	Water level only	-do.--	469	228-469	2

water-quality-monitoring network--continued

Suggested sampling program			Reasons for monitoring
Priority	Sampling categories	Frequency	
SUBUNIT			
II	Common Minor Toxic/misc.	Annual -do.-- -do.--	Upgradient, baseline water quality.
II	Common	-do.--	Upgradient of agricultural and urban land use south of Lovejoy Buttes, downgradient to inflow from Hi Vista area.
III	-do.--	-do.--	Downgradient of agricultural and urban land use south of Lovejoy Buttes, upgradient of Antelope Center. Well 6N/9W-28P2S may provide duplicate information content.
I	-do.--	Semiannual	Downgradient of specific agriculture located to the southeast. High sulfate and fluoride values have been detected.
III	-do.--	Annual	Downgradient, agricultural use to the south. Well 6N/10W-5H2S may provide duplicate information content.
I	-do.-- Minor Toxic/misc.	-do.-- -do.-- -do.--	Downgradient of subunit, upgradient of outflow to the Lancaster subunit. Note: semiannual frequency should be adopted if perforation interval is found to be less than 150 feet.
SUBUNIT			
II	Common	Annual	Upgradient, baseline water quality, downgradient of inflow from Foothill area (north) and Neenach subunit.
II	-do.-- Minor Toxic/misc.	-do.-- -do.-- -do.--	Upgradient, baseline water quality, downgradient of inflow from Neenach and Willow Springs subunit.
I	Common Toxic/misc.	-do.-- -do.--	Downgradient of agricultural land use.

TABLE 6. - Proposed Antelope Valley

State well No. or site	Present sampling program: Collecting agency	Sampling categories	Frequency	Depth of well, in feet	Perforated interval, in feet	Well class
						LANCASTER
7N/14W-13A1S**	USGS	----do.----	-do.--	519	249-519	2
8N/13W-20B1S**	USGS	----do.----	-do.--	610	232-610	2
6N/13W-3H*	--	--	--	500	300-500	--
7N/12W-30Q2S	QHWD	Common	Annual	401	281-401	2
9N/12W-21A1S	USGS	-do.--	-do.--	181	(100-181)	3
9N/12W-21N1S	RCWD	-do.--	Intermittent	--	(100-200)	
8N/12W-21C1S**	--	--	--	>150	(100-200)	4
8N/12W-10J1S**	USGS	Water level only	Annual	91	(30-91)	3
8N/12W-14R1S**	USGS	----do.----	-do.--	404	254-404	2

ater-quality-monitoring network--continued

Suggested sampling program			Reasons for monitoring
riority	Sampling categories	Frequency	
UBUNIT--continued			
II	Common	-do.--	Upgradient of Antelope Acres, downgradient of inflow from Foothill area (north).
II	-do.--	-do.--	Downgradient of the urban land use northeast of Antelope Acres.
III	Common	Annual	Upgradient of Quartz Hill. Well 6N/13W-4H15 of the Foothill area (north) may provide duplicate information content.
I	-do.-- Minor Toxic/misc.	-do.-- -do.-- -do.--	Downgradient of Quartz Hill.
II	Common	-do.--	Upgradient of Rosamond and community sewage site. High hardness values have been detected.
I	-do.-- Minor Toxic/misc.	-do.-- -do.-- -do.--	Downgradient of Rosamond and community sewage site. Note: semiannual sampling frequency should be adopted if perforation interval is found to be less than 100 feet.
III	Common	-do.--	Downgradient of sewage treatment site. Well 8N/12W-14R1S may provide duplicate information content.
I	-do.-- Minor Toxic/misc.	Semiannual ----do.--- ----do.---	Upgradient of Lancaster Piute Ponds sewage disposal site and located at a depth to be representative of the semiperched shallow water body of the subunit.
I	Common Minor, Toxic/misc.	Annual -do.-- -do.--	Downgradient of Lancaster Piute Ponds sewage disposal site and is important for monitoring possible leakage from the shallow water body into the principal aquifer. Note: semiannual sampling frequency should be adopted if, after initial sampling, contamination problems (i.e., concentrations exceed beneficial uses) are indicated.

TABLE 6. - Proposed Antelope Valley

State well No. or site	Present sampling program: Collecting agency	Sampling categories	Frequency	Depth of well, in feet	Perforated interval, in feet	Well class
						LANCASTER
7N/12W-8J*	--	--	--	300	100-300	--
7N/12W-28G*	--	--	--	300	100-300	--
7N/11W-18N1S	USGS	Common	Annual	290	60-289	2
6N/12W-24C1S	PWD	--	--	1,275	504-900	2
6N/12W-1H1S	CDWR	Common	Annual	581	(300-581)	3
6N/11W-6H1S**	LASD	-do.--	Semiannual	449	(300-449)	3
6N/11W-20G2S	PWD, LASD	-do.-- -do.--	Annual Semiannual	694	310-694	2
7N/11W-33Q1S	USGS	-do.--	Annual	700	318-700	2
8N/10W-22P3S	USGS	-do.--	-do.--	200	(50-200)	3
7N/9W-19H2S	USGS	-do.--	-do.--	600	(350-600)	3

water-quality-monitoring network--continued

Suggested sampling program			Reasons for monitoring
Priority	Sampling categories	Frequency	
SUBUNIT--continued			
II	Common Minor Toxic/misc.	-do.-- -do.-- -do.--	Upgradient of Lancaster, downgradient of agriculture.
II	Common Minor Toxic/misc.	-do.-- -do.-- -do.--	Downgradient of Lancaster.
I	Common Minor Toxic/misc.	Semiannual ----do.--- ----do.---	Monitor the shallow, semiperched water body. NOTE: sample to be collected in the top part of the perforated casing at a depth of 60 ft.
II	Common Minor Toxic/misc.	Annual -do.-- -do.--	Downgradient of Palmdale, upgradient of Air Force Plant No. 42.
II	Common	-do.--	Upgradient of Air Force Plant No. 42 and its sewage disposal site.
I	-do.-- Minor Toxic/misc.	-do.-- -do.-- -do.--	Downgradient of Palmdale sewage disposal site and golf course.
II	Common	-do.--	Upgradient of golf course and Palmdale No. 20 sewage disposal site, and downgradient of Palmdale and inflow, if any, from Pearland subunit.
I	-do.-- Minor Toxic/misc.	-do.-- -do.-- -do.--	Downgradient of the Air Force Plant No. 22 and Palmdale sewage disposal reclamation use site.
I	Common	-do.--	Downgradient of agricultural land use in the eastern part of the subunit.
II	-do.--	-do.--	Upgradient, baseline water quality for southeastern part and inflow from Buttes subunit.

TABLE 6. - Proposed Antelope Valley

State well No. or site	Present sampling program: Collecting agency	Sampling categories	Frequency	Depth of well, in feet	Perforated interval, in feet	Well class
						LANCASTER
7N/11W-3E3S	USGS	-do.--	-do.--	370	(150-370)	3
7N/10W-30E1S	CDWR	-do.--	-do.--	595	195-595	2
9N/8W-6J1S	EAFB	-do.--	-do.--	363	147-363	2
9N/10W-24C1S	EAFB	-do.--	-do.--	733	156-733	2
						NORTH MUROC
11N/8W-35D1S	DLCS	Common	Intermittent	606	96-606	2
11N/8W-32A1S	BCSD	-do.--	--	530	281-530	2
11N/9W-24B2S	USBC	-do.--	Intermittent	542	96-542	1
10N/9W-5B1S	EAFB	-do.--	Annual	500	100-500	2
11N/10W-12F1S**	USGS	Water level only	-do.--	>180	(100-300)	4

water-quality-monitoring network--continued

Suggested sampling program			Reasons for monitoring
Priority	Sampling categories	Frequency	
SUBUNIT--continued			
II	-do.-- Toxic/misc.	-do.-- -do.--	Upgradient of heavily used agricultural land to the east.
I	Common Toxic/misc.	-do.-- -do.--	Downgradient of agricultural land use.
II	Common	-do.--	Upgradient, baseline water quality for the northeastern part of the subunit.
II	-do.--	-do.--	Downgradient of pumping depression (northeast) and Edwards sewage disposal site.
SUBUNIT			
III	Common	Annual	Upgradient of the subunit. High levels of sodium, chloride, boron, and dissolved solids have been detected. If inflow occurs, well may be useful for monitoring effects of mining in the Randsburg-Castle Butte area.
III	-do.-- Minor Toxic/misc.	-do.-- -do.-- -do.--	Downgradient of Desert Lake sewage disposal site.
III	Common	-do.--	Downgradient if outflow occurs to the Peerless subunit, upgradient of North Edwards. High levels of nitrate and dissolved solids, and very high levels of boron have been detected.
II	-do.-- Minor Toxic/misc.	-do.-- -do.-- -do.--	Downgradient (if ground-water flow is north) of sewage disposal ponds located at northwest end of Rogers Lake, or if inflow from the Lancaster subunit exists. High levels of sodium, chloride, and boron have been detected.
II	Common Minor Toxic/misc.	-do.-- -do.-- -do.--	Downgradient of outflow to Fremont Valley.

TABLE 6. - Proposed Antelope Valley

State well No. or site	Present sampling program: Collecting agency	Sampling categories	Frequency	Depth of well, in feet	Perforated interval, in feet	Well class
					PEERLESS	
32S/39E-33R1M**	--	--	--	300	(100-300)	3
					ROSAMOND-BISSELL HARD-ROCK	
9N/10W-16C2S	EAFB	Common	Annual	217	(100-217)	3
10N/10W-23B*	--	--	--	500	100-500	--
10N/9W-30K*	--	--	--	500	100-500	
					RANDSBURG-CASTLE	
11N/8W-3Q1S	USBC	Common	Intermittent	414	266-414	2
11N/8W-22E1S**	--	--	--	400	200-400	2
11N/7W-31P2S**	--	--	--	500	300-500	2
10N/8W-22J*	--	--	--	500	300-500	--

water-quality-monitoring network--continued

Suggested sampling program			Reasons for monitoring
Priority	Sampling categories	Frequency	
SUBUNIT			
II	Common Minor Toxic/misc.	Annual -do.-- -do.--	Downgradient located in the pumping depression of the subunit.
HARD-ROCK AREA			
II	Common Minor Toxic/misc.	Annual -do.-- -do.--	Downgradient of Edwards Flight Test Center and outflow into the Lancaster subunit. High levels of sodium, chloride, sulfate, boron, and dissolved solids have been detected.
II	Common	-do.--	Upgradient of Edwards Air Force Base industrial disposal site. NOTE: Perforation interval and total depth of well could be less; this should be determined at time of drilling.
I	-do.-- Minor Toxic/misc.	Semiannual ----do.--- ----do.---	Downgradient of Edwards Air Force Base industrial disposal site. NOTE: Perforation interval and total depth of well could be less; this should be determined at time of drilling. Annual frequency should be adopted if water level is found to be more than 200 feet.
BUTTE HARD-ROCK AREA			
III	Common Minor	Annual -do.--	Upgradient of extensive mining operations. High levels of boron, fluoride, nitrate, and dissolved solids have been detected.
I	Common Minor Toxic/misc.	Semiannual ----do.--- ----do.---	Downgradient of mining activity and directly below tailing ponds. NOTE: Annual frequency should be adopted if water level is found to be more than 200 feet.
III	Common Minor Toxic/misc.	Annual -do.-- -do.--	Downgradient of Boron and upgradient of the sewage disposal sites at Boron and Park Knolls.
II	----do.----	Semiannual	Downgradient of the Edwards Air Force Base Jet Propulsion Laboratory. NOTE: Perforation interval and total depth of well could be less; this should be determined at time of drilling. Annual frequency should be adopted if water level is found to be more than 200 feet.

TABLE 6. - Proposed Antelope Valley

State well No. or site	Present sampling program: Collecting agency	Sampling categories	Frequency	Depth of well, in feet	Perforated interval, in feet	Well class
						HI VISTA
9N/8W-34K*	--	--	--	200	50-200	--
6N/8W-9P1S	CDWR	Common	Annual	98	(50-98)	3
						FOOTHILL HARD-ROCK
8N/16W-13N1S	USGS	Common	Annual	425	(200-425)	3
6N/13W-4H1S	CDWR	-do.--	-do.--	--	(200-400)	4
						FOOTHILL HARD-ROCK
6N/12W-34N1S	PWD	Common	Annual	400	(200-400)	3
4N/10W-23C1S	CDWR	-do.--	-do.--	157	61-157	2
5N/10W-34N2S	CDWR	-do.--	-do.--	80	(10-80)	3
5N/11W-16R2S	CDWR	-do.--	-do.--	32	(0-32)	3

water-quality-monitoring network--continued

Suggested sampling program			Reasons for monitoring
Priority	Sampling categories	Frequency	
HARD-ROCK AREA			
II	Common	Annual	Upgradient, baseline water quality (northern area).
II	-do.--	-do.--	Upgradient, baseline water quality (southern area). High levels of sulfates and dissolved solids have been detected.
AREA (north)			
II	Common	Annual	Upgradient, baseline water quality, re-recharge from San Gabriel Mts.
II	-do.-- Minor Toxic/misc.	-do.-- -do.-- -do.--	Upgradient of inflow to Quartz Hill and Lancaster, baseline water quality and recharge from San Gabriel Mts.
AREA (south)			
II	Common Minor Toxic/misc.	Annual -do.-- -do.--	Upgradient of inflow to Palmdale, baseline water quality, recharge from San Gabriel Mts. High levels of chloride, sulfate, and hardness have been detected.
III	Common	-do.--	Upgradient of Juniper Hills, baseline water quality and recharge from San Gabriel Mts.
II	-do.--	-do.--	Downgradient of Juniper Hills. High levels of sulfate, fluoride, and dissolved solids have been detected.
II	-do.--	-do.--	Upgradient, baseline water quality. High levels of sulfate, fluoride, and dissolved solids have been detected.

TABLE 7. - Assessment of network

Reason for monitoring	Ideal site[1]	Ideal well No. of sites[2]	Actual wells[3]	Total
Ambient conditions	6	3	8	17
Nonpoint conditions				
Agricultural land use				
Downgradient sites	1	4	5	10
Urban development				
Upgradient sites	1	2	7	10
Downgradient sites	2	5	11	18
Mining activity				
Upgradient sites	0	0	2	2
Downgradient sites	1	1	2	4
Point-source conditions				
Upgradient sites	1	2	4	7
Downgradient sites	1	3	5	9
Total	13	20	44	77

[1]Suggested site for ideal network where well does not now exist (would require drilling).

[2]Existing well suggested for ideal network that is not part of an existing network.

[3]Existing well suggested for the actual working network (well is listed in the phase 2 catalog).

Sampling priority.--Because budgetary restraints can be the main limiting factor in data collection, a monitoring priority classification is necessary. Based on discussion with the Regional Board and local water agencies, a priority list was formulated for each of the monitoring objectives. Priority classes range from I to III with I being of highest priority. A column showing the assigned priority for each well or site is given in table 6. Plate 2 shows the network system. Generally, priorities were assigned using the following guidelines:

Priority I.--Sites located in flow path of a potential contamination source. These sources can be either point sources (sewage disposal sites, mining, industrial, and aviation sites) or nonpoint sources (agricultural areas, golf courses, septic tank leach fields, and boundary flow between adjacent ground-water subbasins).

Priority II.--Sites located in areas where no historical ground-water-quality data exist, such as baseline water-quality sites.

Priority III.--Sites located in the same path of flow as another well (thus possibly duplicating information) or in an area where ground-water quality is known to be poor.

Sampling categories.--Water-quality standards or guidelines exist for a variety of water uses, which include drinking, domestic, commercial, industrial, irrigation, stock-watering applications, and water-contact recreation. These criteria provide a basis for the choice of characteristics to be included in the monitoring program for ground-water quality in Antelope Valley. Additionally it should be noted that it is usually less costly to determine a standard list of sampling categories than to determine three or four constituents separately.

The suggested sampling program for the designed network includes three types of sampling categories: common, minor, and toxic/miscellaneous. The common constituents are those most commonly analyzed for in general-surveillance ground-water investigation programs of the U.S. Geological Survey. These constituents include common field-sampling categories, cations, anions, major dissolved ions, and nutrient concentrations (table 6). Monitoring for these constituents would detect most water-quality changes caused by the current land use in Antelope Valley. The suggested minor and toxic/miscellaneous sampling categories include trace elements and toxic and organic compounds for which baseline levels are, for the most part, unknown. They may already exist in some ground-water supplies or be introduced with future developments in the basin. This report does not explain the reason and specific significance of each suggested constituent in the proposed monitoring analysis. Radiochemical analysis was not suggested in the basin or specifically around the numerous faults. No evidence of radioactivity exists; therefore, the additional expense required for this type of sampling on a regular basis is not justified.

Sampling frequencies.--The proposed initial sampling frequencies (table 6) followed a standard format throughout the network design. They were suggested so as to be compatible with (1) present monitoring frequencies, (2) suggested sampling categories, (3) the water-yielding zones, and (4) the present land use of the surrounding area. Ground water from a shallow zone (less than 50 feet below land surface) is most likely to exhibit seasonal fluctuations in quality, making semiannual sampling advisable, at least initially. In contrast, water from a deeper zone (more than 200 feet below land surface) would be expected to show little, if any, seasonal variation in quality, which would justify a more economical annual sampling frequency. Water from an intermediate zone (50-200 feet below land surface) may fall into either of the above seasonal variation categories. Current land use was an important consideration as downgradient wells can detect changes in supplies of drinking and irrigation water and mining effluents.

The long-term assignment of sampling frequency should be flexible depending on water-quality information obtained during early stages of the monitoring program. Data obtained at a particular well during the first year of monitoring may indicate that a reduction of sampling frequency (from semiannual to annual) would provide adequate information for that well. Similarly, the frequency for a particular group of determinations (toxic and miscellaneous, for example) can be reduced (from semiannual or annual to every 5 years) where data indicate that the quality of a specific well's water remains virtually unchanged with time.

SUMMARY AND CONCLUSIONS

The fundamental objective of this report was to design an actual monitoring ground-water network using an ideal network as a guide. The network design process used to construct the suggested monitoring program consisted of: (1) determining the geohydrologic characteristics of the basin that comprise the current hydrologic knowledge available for Antelope Valley, (2) identifying and locating potential contamination sources through data on land use and existing water-quality conditions, (3) establishing a criteria for selecting monitoring wells, (4) developing an ideal network by site and selecting actual wells that conform as nearly as possible to it, (5) establishing priorities for network sites, (6) selecting the sampling categories and frequencies necessary to monitor and adequately reflect the project objectives, and (7) commenting on the results.

When the suggested network has been established, it will provide the State Water Resources Control Board and the California Regional Water Quality Control Board--Lahontan Region with a coordinated, workable tool to monitor ground-water-quality trends and degree of threat from various contamination sources in Antelope Valley. The objectives of the report were met as well as could be expected under restraints including no data collection, inadequate well-log information, and the possibility of inaccurate historical data.

Implementation of the actual network will require liaison with eleven local, Federal, State, and private agencies. The Los Angeles County Sanitation District has been suggested as a source of data for a candidate well in the ideal network, and one candidate well for the actual well. Twelve wells in the ideal network are presently being monitored by the U.S. Geological Survey for water levels only. Information about ownership is not available for six wells that are being considered for the ideal network; however, this can be determined at the appropriate county tax assessor's office.

Few potential ground-water contamination problems exist in Antelope Valley. The three designed networks presented in this report are to monitor the following categories: (1) point-source contamination; (2) nonpoint-source contamination; and (3) ambient water-quality conditions. The point-source sites identified are sewage disposal, mining, industrial, and aviation sites. The nonpoint-contamination sites are used to monitor the diffused contamination sources, which are agricultural, urban, mining and military activities; golf courses; septic-tank use; ground-water inflow; and the shallow perched water body located in the Lancaster subunit. The ambient condition sites are used to establish baseline water-quality conditions, evaluate long-term trends in ground-water quality and recharge from surrounding mountains.

The reason each suggested site has been selected for monitoring when related to one or more of the three monitoring categories will aid in modifying the actual network. Reevaluation and modification of the network, is planned 5 years after implementation has begun.

The project limitations include the general lack of: (1) adequate well-log information and accurate phase 2 catalog information; (2) funding to drill new wells in the proposed ideal sites; and (3) geohydrologic data such as water levels, water quality, and specific capacities of wells in all the hard-rock areas and some of the subunits of Antelope Valley.

The class of wells selected for the proposed actual network does not meet ideal conditions, but the information gained would meet most of the network's objectives. The actual network probably would not detect contamination from many now-unidentified potential point sources. This report contains an adequate amount of information on its development to fully enable the State Board to make appropriate future modifications to the network design, sampling categories monitored, and frequency of analysis.

SELECTED REFERENCES

Blankenbaker, G. G., 1978, Map of Antelope Valley-East Kern Water Agency area California, showing ground-water subunits and areas, location of wells, and lines of equal depth to water for spring 1978: U.S. Geological Survey Open-File Map 78-937, scale 1:62,500.

Bloyd, R. M., Jr., 1967, Water resources of the Antelope Valley-East Kern Water Agency area, California: U.S. Geological Survey Open-File Report, 73 p.

California Department of Water Resources, Southern District, 1968, Ground water and waste-water quality study, Antelope Valley, Los Angeles and Kern Counties: A report to Lahontan Regional Water Quality Control Board, no. 6, 95 p.

----- 1980, Planned utilization of water resources in Antelope Valley: State of California district report, 71 p.

Chandler, T. S., 1972, Water-resources inventory, spring 1966 to spring 1971, Antelope Valley-East Kern Water Agency area, California: U.S. Geological Survey Open-File Report, 14 p.

Dibblee, T. W., Jr., 1967, Areal geology of the western Mojave Desert, California: U.S. Geological Survey Professional Paper 522, 153 p.

Doyle, A. A., 1969, Report on arsenic occurrence in the North Muroc hydrologic basin, Kern County, California: California State Water Resources Control Board and Lahontan Regional Water Quality Control Board, 48 p.

Durbin, T. J., 1978, Calibration of a mathematical model of the Antelope Valley ground-water basin, California: U.S. Geological Survey Water-Supply Paper 2046, 51 p.

Dutcher, L. C., Bader, J. S., Hiltgen, W. J., and others, 1962, Data on wells in the Edwards Air Force Base area, California: California Department of Water Resources Bulletin 91-6, 209 p.

Dutcher, L. C., and Worts, C. F., Jr., 1963, Geology, hydrology, and water supply of Edwards Air Force Base, Kern County, California: U.S. Geological Survey Open-File Report, 251 p.

Hatai, K. K., 1979, A preliminary evaluation of ground-water quality in the Antelope Valley: California Department of Water Resources, 23 p.

Hem, J. D., 1970, Study and interpretation of the chemical characteristics of natural water (2d ed.): U.S. Geological Survey Water-Supply Paper 1473, 363 p.

Hughes, J. L., 1975, Evaluation of ground-water degradation resulting from waste disposal to alluvium near Barstow, California: U.S. Geological Survey Professional Paper 878, 33 p.
Johnson, H. R., 1911, Water resources of Antelope Valley, California: U.S. Geological Survey Water-Supply Paper 278, 92 p.
Koehler, J. H., 1966, Data in water wells in the eastern part of the Antelope Valley area, Los Angeles County, California: California Department of Water Resources Bulletin 91-12, 17 p., 6 apps.
Kunkel, Fred, and Dutcher, L. C., 1960, Data on water wells in the Willow Springs, Gloster, and Chaffee areas, Kern County, California: California Department of Water Resources Bulletin 91-4, 85 p.
Lamb, C. E., 1976, Map of the Antelope Valley-East Kern Water Agency area, California, showing ground-water subunits and areas, and water-quality diagrams: U.S. Geological Survey Open-File Map, scale 1:62,500.
----- 1980, Map of the Antelope Valley-East Kern Water Agency area, California, showing ground-water subunits and areas, location of wells, and water-level contours for spring 1979: U.S. Geological Survey Open-File Map 80-1222, scale 1:62,500.
Lewis, R. E., and Miller, R. E., 1968, Geologic and hydrologic maps of the southern part of Antelope Valley, California: U.S. Geological Survey Open-File Report, 21 p.
McKee, J. E., and Wolf, H. W., eds., 1963, Water quality criteria: The Resources Agency of California, State Water Resources Control Board, 548 p.
Moyle, W. R., Jr., 1965, Water wells in the western part of the Antelope Valley area, Los Angeles and Kern Counties, California: California Department of Water Resources Bulletin 91-11, 16 p., 6 apps.
----- 1969, Water wells and springs in the Fremont Valley area, Kern County, California: California Department of Water Resources Bulletin 91-16, 13 p., 5 apps.
National Academy of Sciences, National Academy of Engineering, 1973 [1974], Water quality criteria 1972: U.S. Environmental Protection Agency EPA R3-73-033, 594 p.
North County Citizens Planning Council, 1977, North Los Angeles County general plan, Los Angeles County Department of Regional Planning, 57 p.
Rantz, S. E., 1969, Mean annual precipitation in the California region: U.S. Geological Survey Open-File Report, 2 map sheets.
Snyder, J. H., 1955, Ground water in California--The experience of Antelope Valley: University of California, Division of Agricultural Science, Giannini Foundation ground-water report no. 2, 171 p.
Thompson, D. G., 1929, The Mojave Desert region, California, a geographic, geologic, and hydrologic reconnaissance: U.S. Geological Survey Water-Supply Paper 578, 759 p.
U.S. Environmental Protection Agency, 1977, quality criteria for water, 1976: 256 p.
VanDenburgh, A. S., Seitz, H. R., Durbin, T. J., and Harrill, J. R., 1982, Proposed monitoring network for ground-water quality, Las Vegas Valley, Nevada: U.S. Geological Survey Open-File Report 80-1286, 25 p.
Weir, J. E., Jr., Crippen, J. R., and Dutcher, L. C., 1964, A progress report and proposed test-well drilling program for the water-resources investigation of the Antelope Valley-East Kern Water Agency area, California: U.S. Geological Survey Open-File Report, 134 p.