



**GROUND WATER  
IN THE  
THOUSAND OAKS AREA,  
VENTURA COUNTY, CALIFORNIA**

**U.S. GEOLOGICAL SURVEY  
Water-Resources Investigations 80-63**



**Prepared in cooperation with the CITY OF THOUSAND OAKS  
and the CONEJO RECREATION AND PARK DISTRICT**

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By James J. French

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August 1980

UNITED STATES DEPARTMENT OF THE INTERIOR

CECIL D. ANDRUS, Secretary

GEOLOGICAL SURVEY

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CONVERSION FACTORS

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The inch-pound system of units is used in this report. For readers who prefer metric units, the conversion factors for the terms used in this report are listed below:

<u>Multiply</u>	<u>By</u>	<u>To obtain</u>
acre	0.4047	hm <sup>2</sup> (square hectometer)
acre-ft (acre-foot)	0.001233	hm <sup>3</sup> (cubic hectometer)
acre-ft/yr (acre-foot per year)	0.001233	hm <sup>3</sup> /yr (cubic hectometer per year)
ft (foot)	0.3048	m (meter)
inch	25.4	mm (millimeter)
mi (mile)	1.609	km (kilometer)
mi <sup>2</sup> (square mile)	2.590	km <sup>2</sup> (square kilometer)
gal/min (gallon per minute)	0.003785	m <sup>3</sup> /min (cubic meter per minute)
(gal/min)/ft (gallon per minute per foot)	0.2070	(L/s)/m (liter per second per meter)

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

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32) / 1.8$$

Additional abbreviations:

μg/L (microgram per liter)  
 mg/L (milligram per liter)

National Geodetic Vertical Datum of 1929 is a geodetic datum derived from the average sea level over a period of many years at 26 tide stations along the Atlantic, Gulf of Mexico, and Pacific Coasts and as such does not necessarily represent local mean sea level at any particular place. To establish a more precise nomenclature, the term "NGVD of 1929" is used in place of "Sea Level Datum of 1929" or "mean sea level."

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ABSTRACT

The ground-water basin beneath the city of Thousand Oaks corresponds closely in area with the surface-water drainage basin of Conejo Valley. Before World War II there was little ground-water development. After World War II, urban development put a stress on the ground-water basin; many wells were drilled and water levels in wells were drawn down as much as 300 feet in places. Beginning in 1963, imported water replaced domestic and municipal ground-water systems, and water levels rapidly recovered to predevelopment levels or nearly so.

Most of the ground water in the Thousand Oaks area is stored in fractured basalt of the middle Miocene Conejo Volcanics. Depending on the degree of occurrence of open fractures and cavities in the basalt, recoverable ground water in the upper 300 to 500 feet of aquifer is estimated to be between 400,000 and 600,000 acre-feet. The yield of water from wells in the area ranges from 17 to 1,080 gallons per minute. Most of the ground water in the eastern part of the valley is high in sulfate and has a dissolved-solids concentration greater than 1,000 milligrams per liter. In the western part of the valley the ground water is mostly of a bicarbonate type, and the dissolved-solids concentration is less than 800 milligrams per liter.

In most areas of Conejo Valley, ground water is a viable resource for irrigation of public lands and recreation areas.

## INTRODUCTION

### Purpose and Scope

This study was made to evaluate the ground-water resources available to the city of Thousand Oaks (fig. 1), so that the city might use ground water to reduce its water-importation requirements. At present (1979) the city imports all its water. The use of ground water to irrigate city-owned land, such as parks and golf courses, is part of a comprehensive water-resources management plan being developed by the city.

To evaluate the resource, this study was designed to:

1. Delineate the ground-water basin or subbasins.
2. Determine the generalized ground-water-flow pattern.
3. Estimate the water-yielding capacity of wells in the aquifer.
4. Estimate the quantity of recoverable ground water in storage.
5. Describe the ground-water quality and its variations.
6. Investigate the feasibility of artificial recharge.

The study was made by the U.S. Geological Survey in cooperation with the city of Thousand Oaks and the Conejo Recreation and Park District.

### Description of the Area

The city of Thousand Oaks is in Conejo Valley on the north slope of the Santa Monica Mountains in the southern part of Ventura County. The city of Thousand Oaks occupies much of the floor of Conejo Valley and the surrounding hills (fig. 2).

The boundary of the ground-water basin beneath Conejo Valley appears to coincide approximately with the surface-water basin but cannot be precisely defined on the basis of available data. For the purpose of this study, the surface-water drainage area of the Conejo Valley, 45 mi<sup>2</sup>, is considered as the area of the ground-water basin.

Conejo Valley ranges in altitude from about 600 ft to 900 ft. Most of the western half of the floor of the valley is between 600 and 700 ft altitude and the eastern half is between 700 and 900 ft. The altitudes of prevailing ridge lines of the drainage divide are between 1,000 and 1,600 ft. The highest point on the drainage divide is at 2,400 ft. The valley floor, about 20 mi<sup>2</sup> in area, is divided by Arroyo Conejo which is sharply incised to less than 300 ft in altitude.

INTRODUCTION

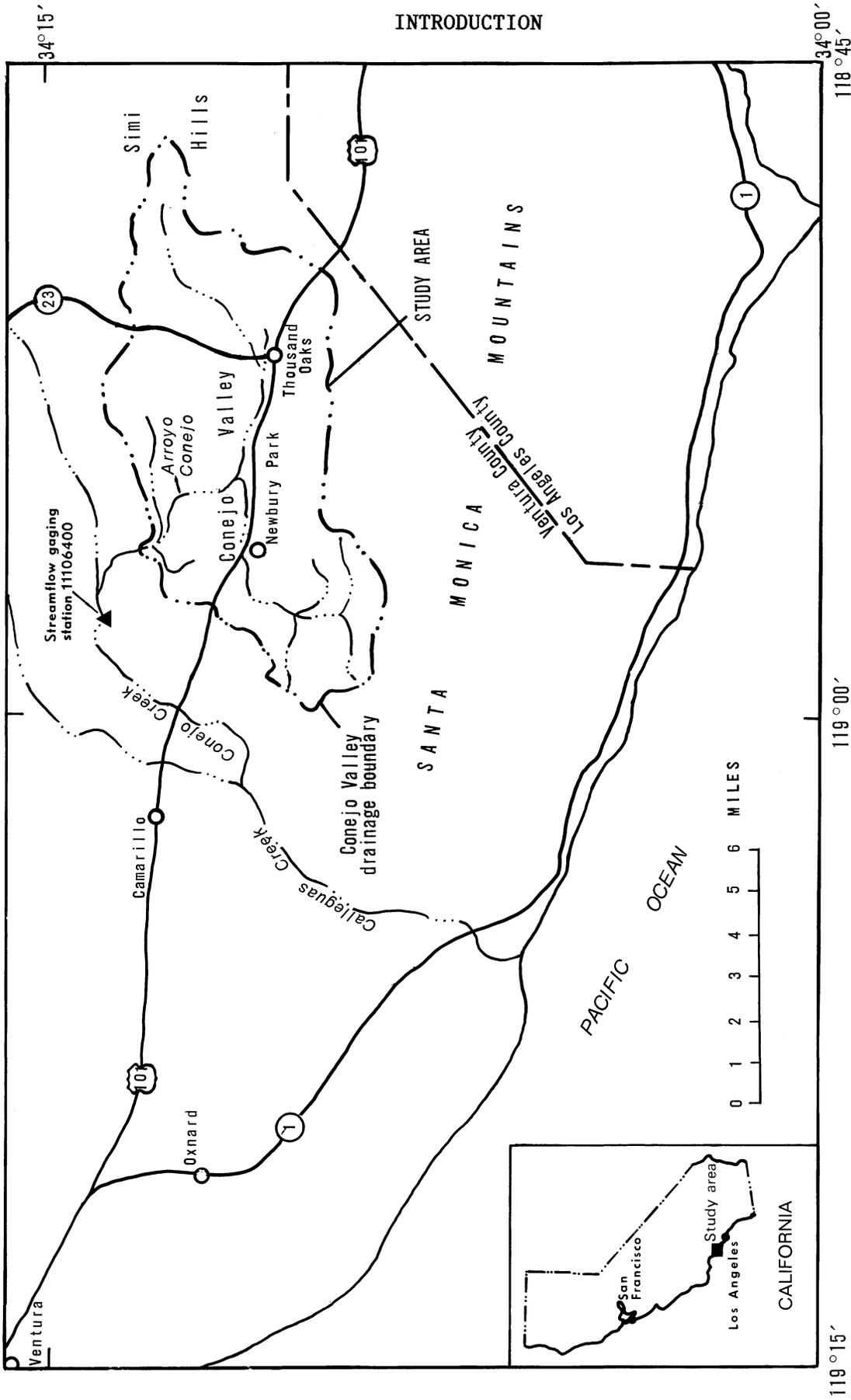
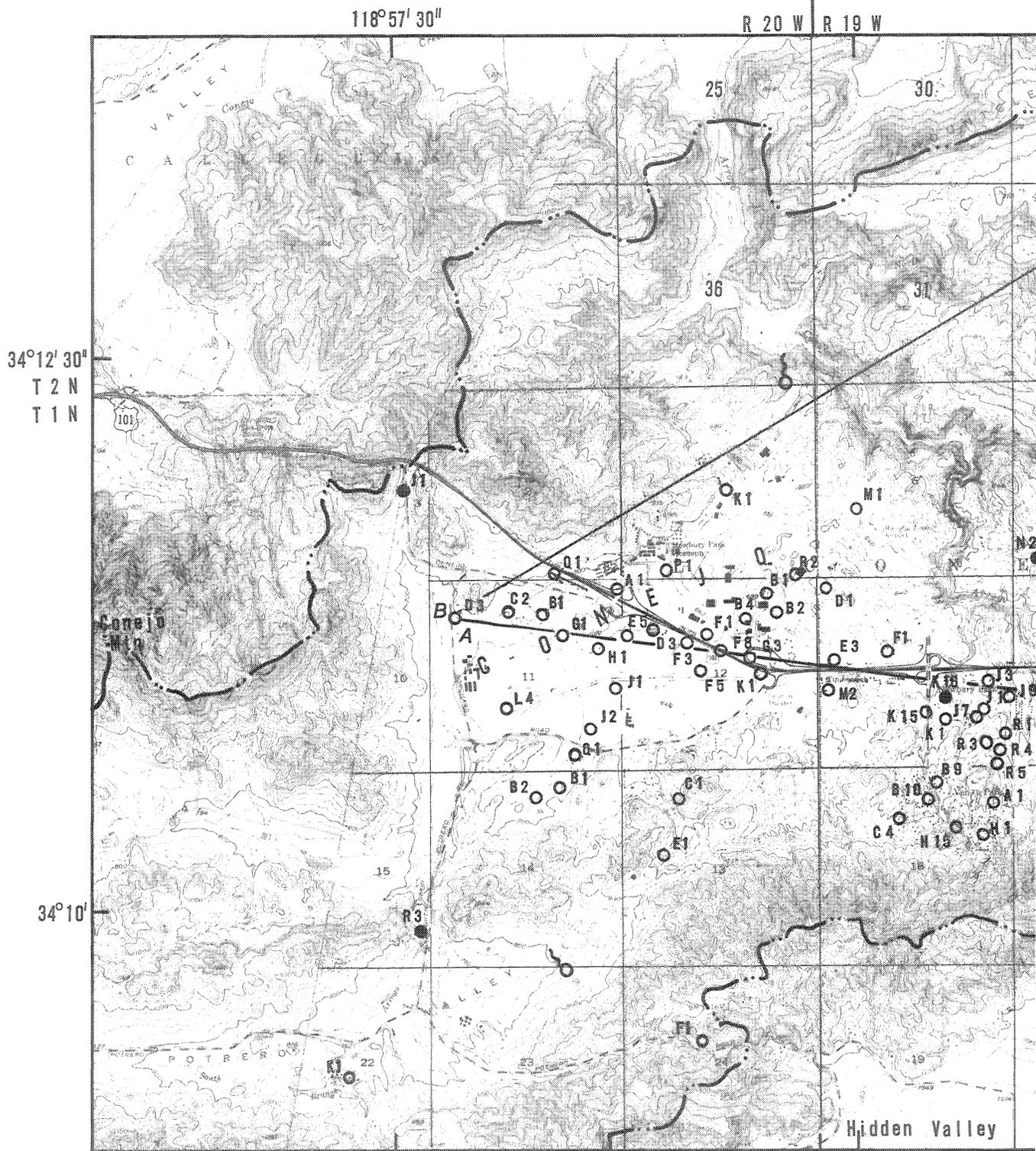


FIGURE 1.--Location of Thousand Oaks area.

GROUND WATER IN THE THOUSAND OAKS AREA, VENTURA COUNTY, CALIF.

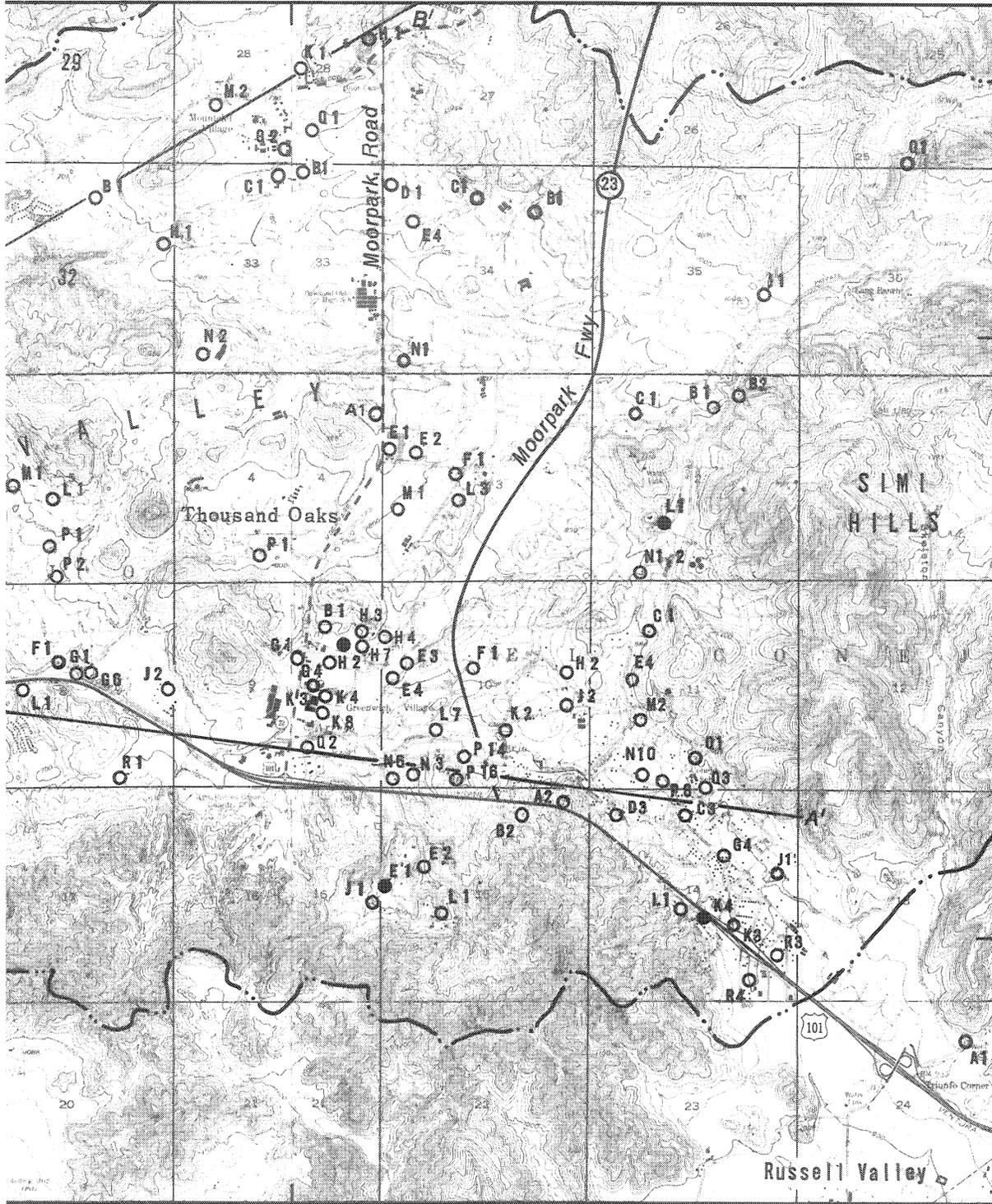


Base from U.S. Geological Survey  
Newbury Park and Thousand Oaks  
1:24,000, photorevised 1967

0 1/2 1 MILE  
CONTOUR INTERVAL 20 FEET  
NATIONAL GEODETIC VERTICAL DATUM OF 1929

FIGURE 2.--Well locations.

118°52' 30"



EXPLANATION

- |      |  |           |                          |
|------|--|-----------|--------------------------|
| ○ J1 | WELL AND NUMBER                                      | A ——— A'  | LINE OF GEOLOGIC SECTION |
| ● E1 | VENTURA COUNTY FLOOD CONTROL MONITOR WELL AND NUMBER | — · · · — | DRAINAGE BASIN BOUNDARY  |
| ○    |  | ○         | SPRING                   |

FIGURE 2.--Continued.

Arroyo Conejo is a north-flowing intermittent stream with head-water areas in the Santa Monica Mountains to the south, the low hills to the west, and the Simi Hills to the east. No through-flowing streams enter Conejo Valley.

Average annual rainfall ranges from 13 inches in the northwestern part of the valley to 17 inches in the mountains to the south. The average annual rainfall for the study area is 14.5 inches. Most of the rain falls in the winter months. Temperatures range from 30° to 110°F. All climatic data are from the California Department of Water Resources (1959).

Use of the Conejo Valley by Indians, Spanish and Mexican land grantees, and early American settlers placed little stress on the ground-water resources of the basin. Agriculture was devoted primarily to grazing livestock and dry farming. After World War I, irrigation wells were dug or drilled, and through the 1930's moderate irrigation still produced no noticeable effect on the ground-water resource. After World War II, many wells were drilled for irrigation and domestic supplies, and ground-water levels began to decline. Development of residential subdivisions and the consequent creation of water service agencies from the late 1940's into the early 1960's, together with the drought of 1945-56, accelerated the decline of water levels. The greatest acceleration of the decline took place between 1958 and 1963. Beginning in 1963, imported water became available and local pumping ceased almost entirely. Consequently, water levels in wells rose sharply, and by the late 1960's they had nearly attained predevelopment levels. The rapid decline and recovery of water levels is indicative of limited ground-water storage capacity for the ground-water basin.

#### Well-Numbering System

The well-numbering system used by the U.S. Geological Survey in California indicates the location of wells according to the rectangular system for the subdivision of public land. For example, in the well 1N/19W-2B2, the first two segments designate the township (T. 1 N.) and the range (R. 19 W.); the third number gives the section (sec. 2); and the letter indicates the 40-acre subdivision of the section, as shown in the accompanying diagram. The final digit is a serial number for wells in each 40-acre subdivision.

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

## GROUND-WATER HYDROLOGY

Precipitation is the source of all naturally occurring water in the basin. Rain that falls on the land surface is absorbed by the soil unless the intensity of the rain exceeds the rate at which the soil will accept it. That which does not infiltrate, or which falls on impermeable surfaces such as streets and parking lots, flows overland as runoff to stream channels or is lost to evaporation. Some of the water that infiltrates the soil remains as soil moisture, to be later removed by transpiration or by evaporation. Water that infiltrates the soil in excess of the soil's ability to retain it by capillary attraction percolates downward to the water table and recharges the ground-water basin.

Ground water in the basin is under water-table (unconfined) conditions and moves in the direction of the hydraulic gradient from areas of high altitude to areas of low altitude. In Conejo Valley the water-table altitude generally ranges from 900 ft in the south to 600 ft at the head of Arroyo Conejo. The present water levels seem to be similar to those of 1951, which are shown in figure 3. Movement of ground water is generally northward from the Santa Monica Mountains, westward from the Simi Hills, and eastward from the ridges on the west side of the basin. Water leaves the Conejo ground-water basin through springs and seeps in Arroyo Conejo and as base flow in Conejo Creek at the bottom of the arroyo.

Movement of ground water through the basin is impeded in places by faults and folds in the rock material which act as dams. Conversely, in some places the movement of ground water may be enhanced by faults, fractures, or cracks which act as conduits in the rock material.

Geology

The rock units shown in figure 4 are modified from mapping by Weber (1967, 1973). The latter is a compilation, with revisions, from many sources. Weber used rock unit names most commonly used in the region. The rock units used in this study are described from oldest to youngest.

Upper Cretaceous, undifferentiated (Ku).--The outcrop of Upper Cretaceous rocks is restricted to a small area in the eastern part of Conejo Valley, but these rocks are also in the northeastern part of the valley, beneath Tertiary rocks. The unit is a compact marine sandstone with low permeability and is not important as a source of ground water.

Sespe Formation, Oligocene (Ts).--The outcrop of the Sespe Formation is restricted to a small exposure in the northeastern part of the valley, but these rocks also underlie Miocene rocks in that part of the valley. The unit is a nonmarine conglomerate and sandstone with low permeability and is not important as a source of ground water.

R.20 W. | R.19 W.



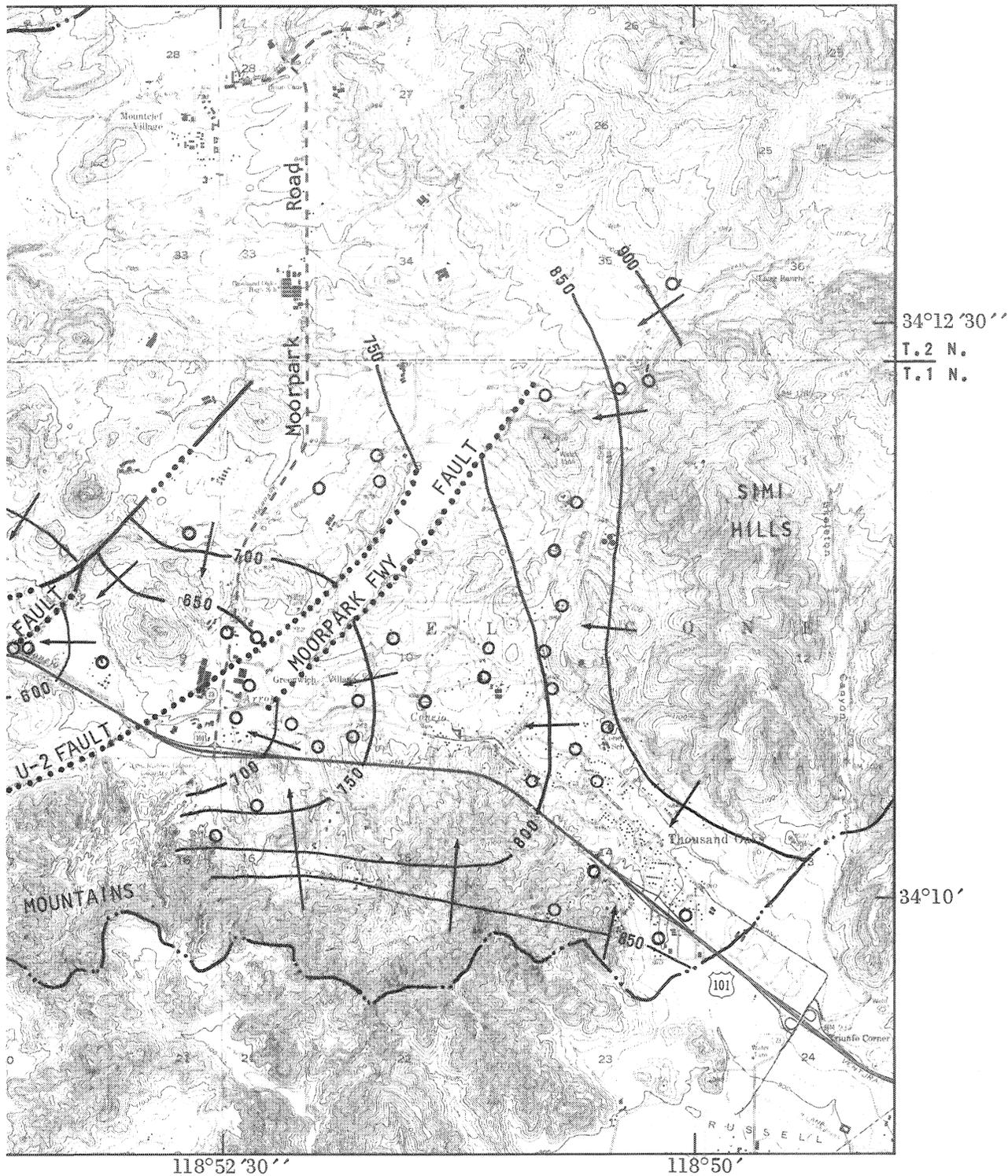
Base from U. S. Geological Survey  
 Newbury Park and Thousand Oaks  
 1:24,000, 1950, photorevised 1967

1 1/2 0 1 MILE

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET  
 NATIONAL GEODETIC VERTICAL DATUM OF 1929

FIGURE 3.--Ground-water



EXPLANATION

- |         |                                    |         |  |
|---------|------------------------------------|---------|--|
| ○       | WELL                               | — 650 — | WATER-LEVEL CONTOUR—Interval 50 feet. National Geodetic Vertical Datum of 1929 |
| ←       | DIRECTION OF GROUND-WATER MOVEMENT | — ··· — | DRAINAGE BASIN BOUNDARY; ALSO APPROXIMATE GROUND-WATER BASIN BOUNDARY          |
| — ··· — | FAULT—Dotted where concealed       |         |  |

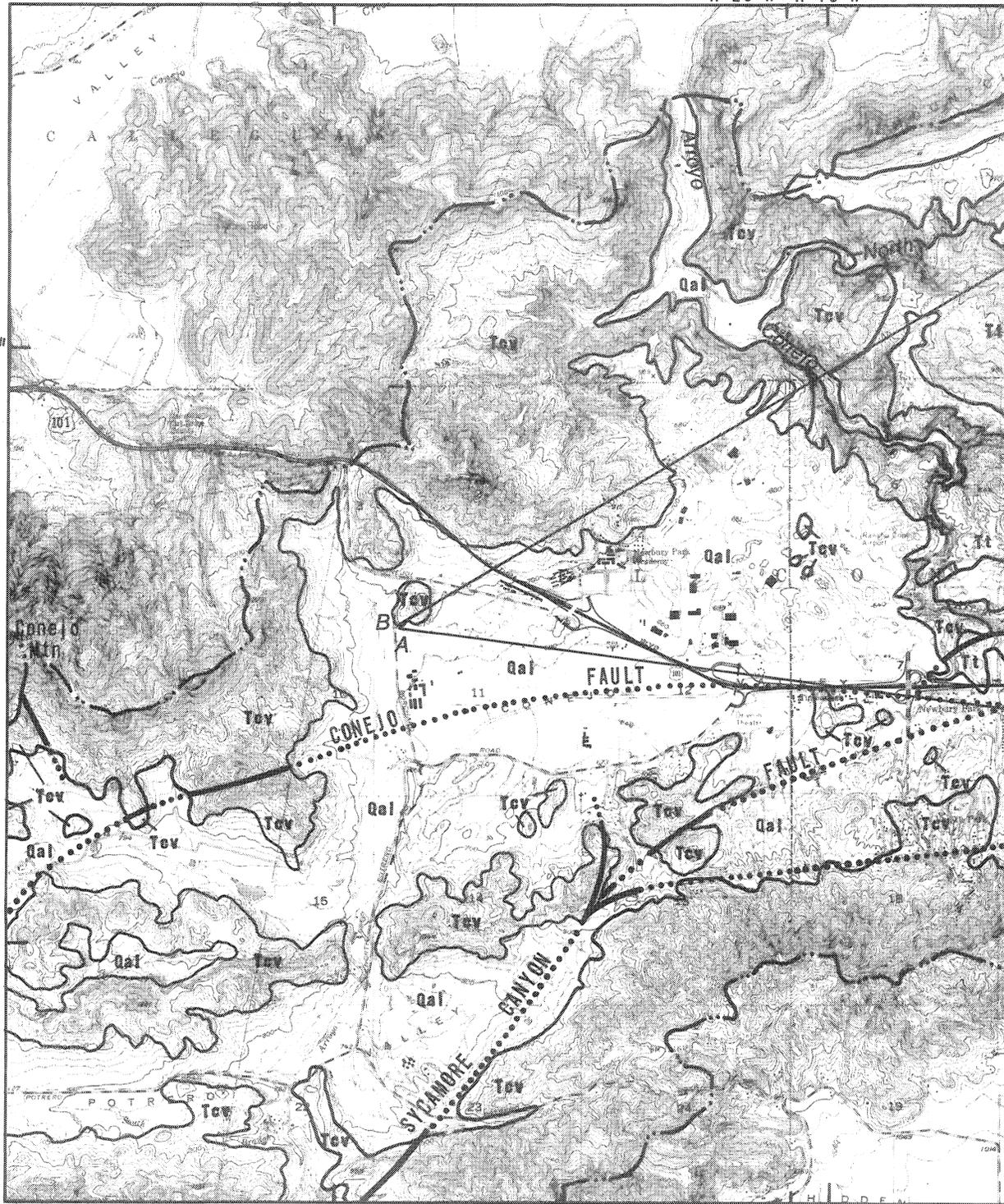
levels, 1951.

118°57'30"

R 20 W R 19 W

34°12'30"  
T 2 N  
T 1 N

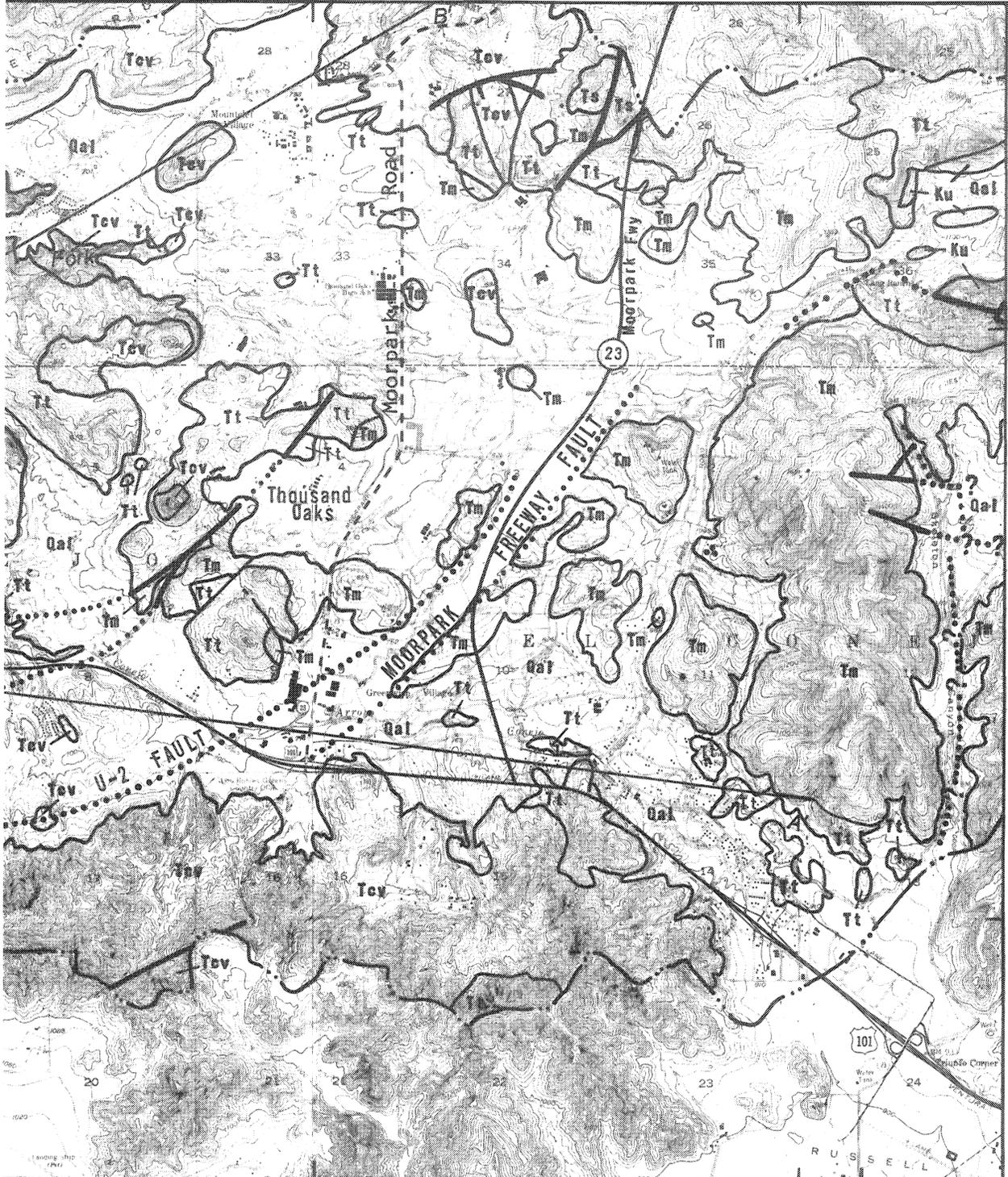
34°10'



Base from U.S. Geological Survey  
Newbury Park and Thousand Oaks  
1:24,000, photorevised 1967

FIGURE 4.--Areal geology.

118° 52' 30"



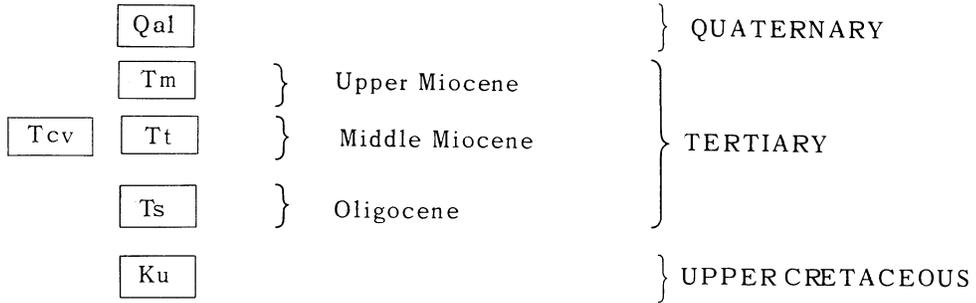
0 1/2 1 MILE

CONTOUR INTERVAL 20 FEET  
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geology modified after  
F. H. Weber, Jr., (1973)

FIGURE 4.--Continued.

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

- Qal

 ALLUVIUM--Includes younger alluvium, colluvium and slopewash, older alluvium, older alluvial fan deposits, and older valley fill and floodplain deposits of Weber (1973)
- Tm

 MODELO FORMATION
- Tcv

 CONEJO VOLCANICS
- Tt

 TOPANGA FORMATION
- Ts

 SESPE FORMATION
- Ku

 UPPER CRETACEOUS, UNDIFFERENTIATED
- CONTACT
- FAULT--Dotted where concealed, queried where doubtful
- LINE OF GEOLOGIC SECTION
- DRAINAGE BOUNDARY

FIGURE 4.--Continued.

Conejo Volcanics, middle Miocene (Tcv).--The Conejo Volcanics crop out in much of the valley. This unit, or its time-equivalent unit, the Topanga Formation, underlies the entire valley except for the small areas where the two older units crop out.

The Conejo Volcanics consist of three lithologic subunits: (1) basalt flows and volcanic sedimentary rocks, (2) andesite flows and volcanic sedimentary rocks, and (3) intrusive rocks (Weber, 1973). These subunits are not shown on the geologic map because over most of the area they were not delineated on the original geologic maps; all three were collectively mapped as Conejo Volcanics. According to Weber (1973), the basalt flows are commonly reddish-brown basalt, gray-blue olivine basalt, and andesitic basalt. The volcanic sedimentary rocks, when drilled, appear as clay and may originally have been volcanic ash. The other subunits consist of volcanic conglomerate, dacite flows, and varied dikes and sills composed mainly of fine-grained and porphyritic basalt, diabase, and perhaps andesite. The total thickness of the Conejo Volcanics is 13,000 ft.

The water-bearing characteristics of the Conejo Volcanics vary greatly among the subunits. The primary permeability of the basalt is generally low, but where it contains fractures or cavities it is the principal water-bearing rock type in the Thousand Oaks area. The volcanic ash or sediments are of low permeability and yield little water to wells.

Few wells are drilled into the andesite flows, so little is known of their hydrologic properties. Renke (1957) said the andesite flows are generally south of the Conejo fault (fig. 4). Most of the wells drilled into this rock type are not good producers of water. The volcanic conglomerate is of very low permeability, consisting of rounded cobbles and pebbles of volcanic origin in a fine-grained matrix of volcanic ash. Where this rock type can be identified in drillers' logs, it seems to produce little or no water.

The intrusive rocks are mainly impermeable basalt and andesite. No wells are known to be drilled into this unit. These rocks probably would yield little water if tapped by a well.

Topanga Formation, middle Miocene (Tt).--The Topanga Formation crops out over much of the eastern half of the valley except where covered by the Modelo Formation or alluvium. The Topanga Formation is time equivalent to the Conejo Volcanics and occurs both interbedded with it and in fault contact with it. The Topanga Formation is also intruded by dikes and sills of the Conejo Volcanics.

The Topanga Formation consists of conglomerate and sandstone with some siltstone and shale and interbedded volcanic rocks. The constituents commonly are derived from the underlying volcanic rocks (Weber, 1973). Total thickness of the Topanga Formation is 9,000 ft.

The water-bearing characteristics of the unit are not well understood, because few wells can be identified only with this aquifer. Most wells drilled into outcrops of this unit extend through it into the volcanic rocks

beneath. Most of these wells are moderate to good producers of water (200 to 500 gal/min). Wells that probably penetrate only the Topanga Formation are only moderate producers of water (50 to 120 gal/min). Besides the presence of interbedded volcanic rocks, the unit is intensely folded and faulted, so that positive identification of the Topanga Formation or the Conejo Volcanics in well drillers' logs is not always possible.

Modelo Formation, middle and upper Miocene (Tm).--Except where covered by alluvium, the Modelo Formation crops out over much of the eastern third of the valley. It consists of shale, siltstone, and sandstone. Usually these rocks are thin bedded or finely laminated, and although they are brittle and highly fractured, most of the fractures are filled with silica.

The unit yields moderate quantities of water to wells (as much as 320 gal/min), but much of the water is of poor quality.

Alluvium, Quaternary (Qal).--Alluvium blankets much of the floor of Conejo Valley and occupies the bottoms of stream channels. The alluvium consists of unconsolidated deposits of boulders, cobbles, pebbles, sand, silt, and clay deposited by streams. It is seldom more than 100 ft thick. Some of the alluvium may have been deposited by streams unrelated to the present-day drainage system. Sometime in the geologic past the Conejo Valley drained eastward, possibly into Triunfo Creek (California Water Resources Board, 1953). This ancestral drainage pattern was changed as Arroyo Conejo eroded headward into the valley from Santa Rosa Valley and captured the drainage.

Wells that tap only the alluvium are of small capacity (10 to 20 gal/min, so it is not known whether the alluvium could sustain production in a higher capacity well (at least 100 gal/min) for very long.

Where the alluvium contains ground water, it is usually underlain by clayey volcanic ash beds or the Modelo Formation, either of which retards the downward movement of ground water.

Although the pre-Quaternary rock units described above were deposited as horizontal or nearly horizontal beds, they have been altered to their present form by folding, faulting, and erosion. This structural adjustment has a marked effect on the movement of ground water beneath Conejo Valley. The fault lines on the geologic map (fig. 4) show where the rock units have been displaced by movements of the earth's crust. When the rocks adjacent to the faults move, as in an earthquake, they create intense heat of friction at or near the fault and commonly result in fusion at the fault, forming a welded zone of very low permeability. These zones can act as dams or barriers to the movement of ground water. Conversely, the rock at or near some faults may be fractured or brecciated, forming highly permeable zones where ground water can move freely. The rock may even be separated at the fault allowing water to move along the faulted zone as in a conduit.

In the Conejo Valley the rocks are cut by four main faults (fig. 4), the Conejo, Sycamore Canyon, U-2, and Moorpark Freeway faults (Leighton and Associates, 1974) and many unnamed minor faults. Apparently none of the faults cut the alluvium, which has been deposited since the faults were active.

### Water Levels and Ground-Water Movement

Before settlement and the consequent use of water by settlers, the ground-water basin was in a naturally balanced state. Over the long term, ground-water recharge from precipitation equaled discharge. Ground-water levels stayed nearly constant, Arroyo Conejo had perennial flow through much of its length, and springs flowed in the valley.

Settlement in the valley began about 100 years ago with the establishment of large ranches. Later the small community of Newbury Park was established. By 1940 there were fewer than 20 water wells in the valley. During the 1940's, principally after World War II, more than 100 wells were drilled. Most served domestic and garden needs, but some were drilled for agricultural irrigation. Twenty-five percent of the wells in the valley were drilled in the first half of the 1950's. Pumping began to put a stress on the ground-water basin, as shown by the declining water table (fig. 5). In the second half of the 1950's, urbanization increased and many small water companies were formed. During that time about 40 wells were drilled, most of them for municipal supply for the burgeoning population. The stress on the ground-water basin increased, with the result that the declining water table permitted water of poor quality to be drawn, probably laterally, into the area of pumping. Some wells were abandoned because of the poor quality of the water.

Development continued into the 1960's, and stress on the ground-water system continued to increase. Figure 6 shows the effect, on ground-water levels, of the use of ground water from 1951 to 1962. In that period the maximum decline in water level was more than 300 ft. Beginning in 1963, imported water became available and was incorporated into the city of Thousand Oaks water supply. The relief of stress on the ground-water basin was dramatic; water levels rose rapidly, so that by the end of the 1960's they were at or near their predevelopment level (fig. 5). The water-level records for wells 1N/19W-9H2 and 14K4 are representative of the effects shown by many other well records. In some areas water levels rose above predevelopment levels, possibly caused by over-irrigation of lawns, with the result that waterlogging occurred and some swimming pools, patios, house slabs, and sidewalks have cracked (Leighton and Associates, 1974).

Changes in water level are being monitored by the Ventura County Flood Control District. Currently, depth to water is measured in nine wells, and water samples for chemical analysis are collected from three wells. Construction data and availability of other data for these monitor wells are given in table 1; their location is shown in figure 2.

Some of the faults described in the section on geology have considerable effect on the movement of ground water. Figure 6 shows the decline in water level in sec. 9, T. 1 N., R. 19 W., to be more than 300 ft on the northwest side of the U-2 fault but zero on the southeast side. In some wells in the Greenwich Village area the water level rose during the period 1951-62. Most of the wells in this area were low-capacity shallow domestic wells that do not withdraw much water. Many of these wells were abandoned when Ventura County

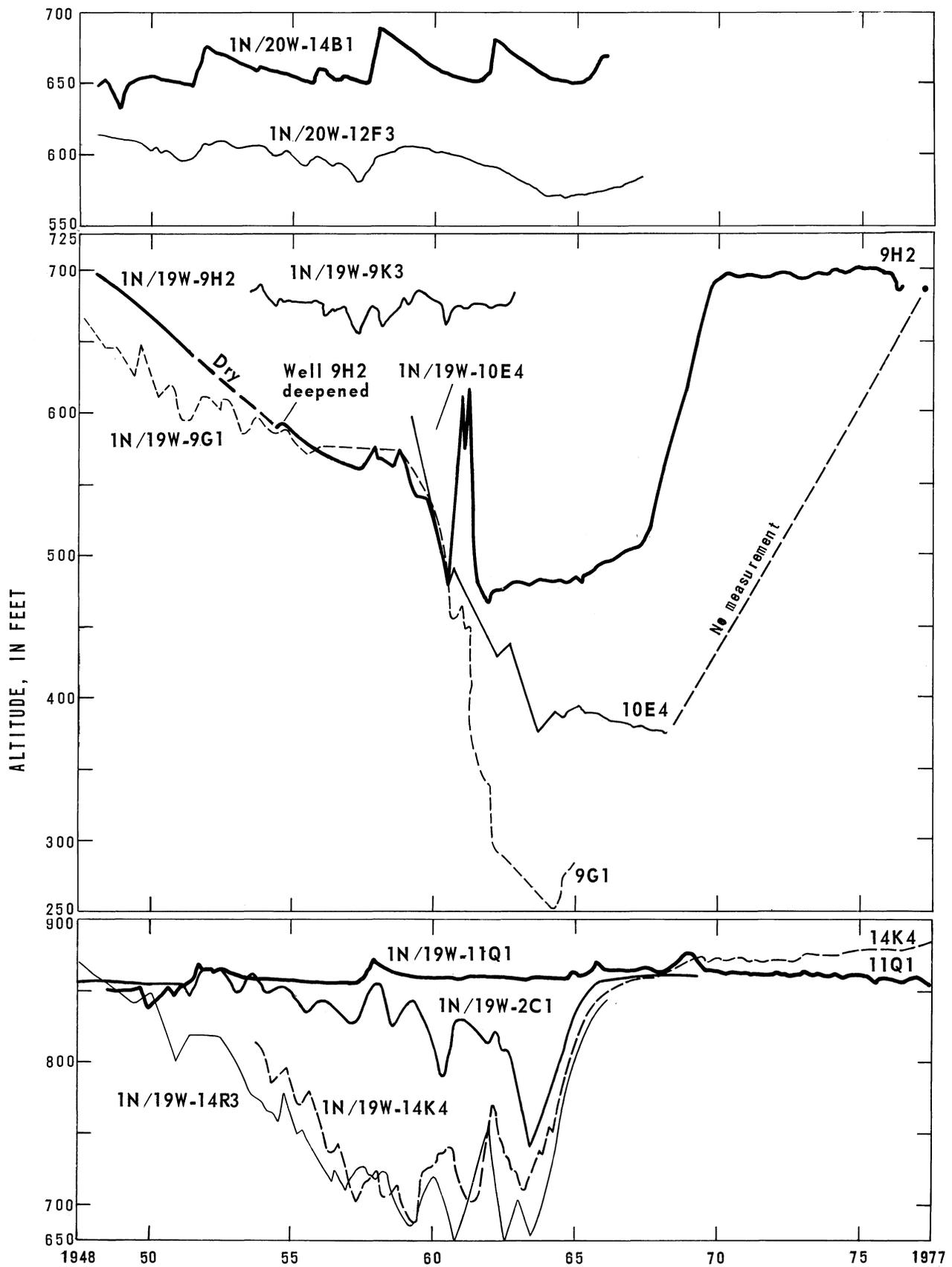


FIGURE 5.--Hydrographs of selected wells.

TABLE 1.--Description of Ventura County Flood Control District monitor wells

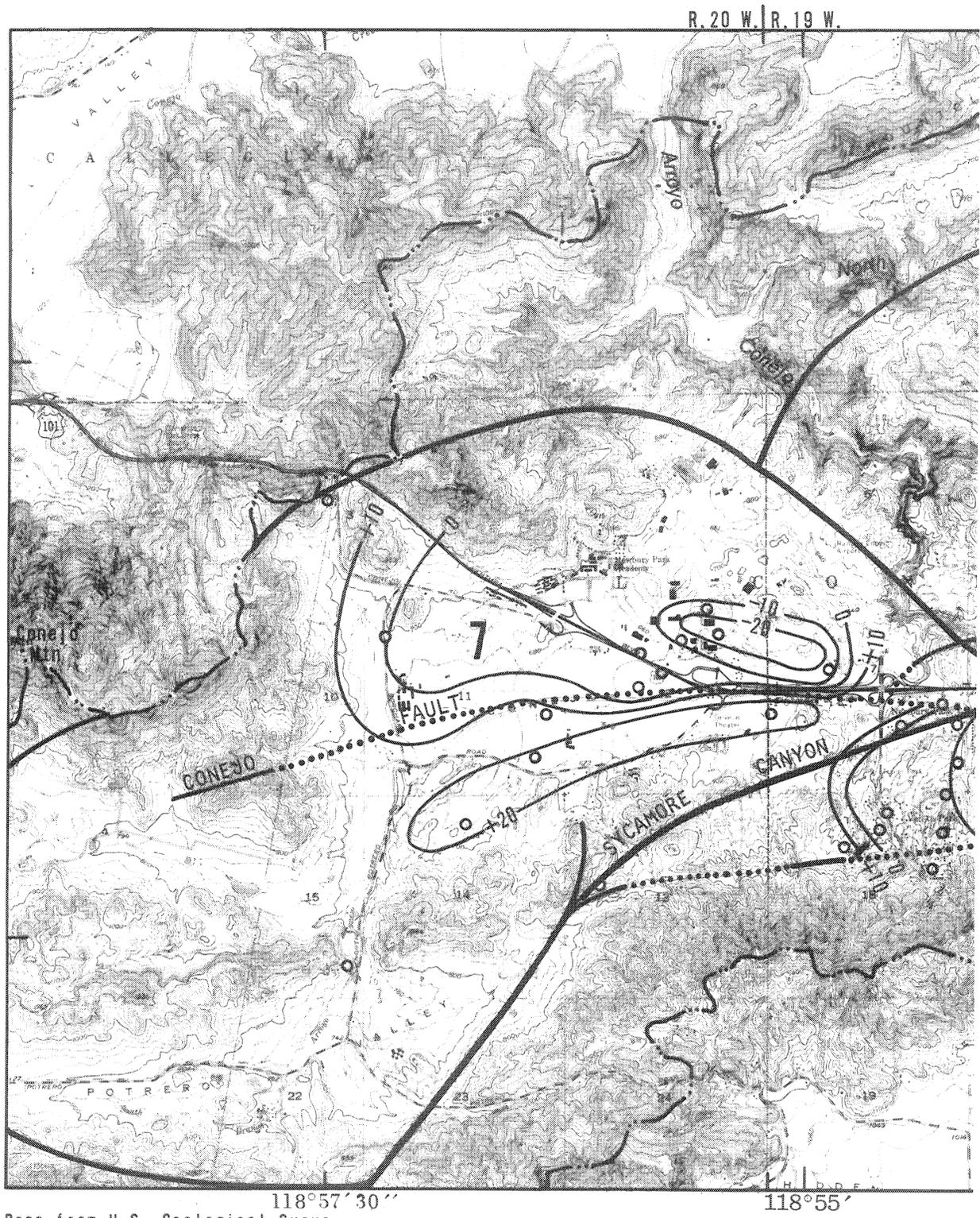
[Well number: (C), monitored for chemical quality. Method drilled: C, cable-tool, R, rotary.  
Other data: C, chemical analyses, L, driller's log, W, water level monitored. See  
fig. 2 for location of wells]

Well number	Owner	Year drilled	Method drilled	Depth of well (feet)	Diameter (inches)	Altitude of land-surface datum (feet)	Other data
1N/19W-2L1	W. H. Rothschild	1941	--	306	--	945.2	CLW
1N/19W-5N2	Lynn Ranch	1951	C	518	12	653.1	CLW
1N/19W-7K16(C)	H. Lee	1965	R	125	8	634.6	CLW
1N/19W-9H2	E. Stallsworth	1954	C	303	12	764.1	CLW
1N/19W-14K4	Ventura County Water Works District 6	1953	C	800	12	907.9	LW
1N/19W-15E1	Forest Cliff Ranch	--	--	74	16	902.6	W
1N/20W-3J1(C)	A. E. Anderson	--	--	120	--	762.9	CW
1N/20W-15R3	Rancho Rieno	1962	R	57	10	720.0	CLW
2N/18W-31K1(C) <sup>1</sup>	Lang Ranch	--	--	--	--	1,149.0	CW

<sup>1</sup>Not shown in figure 2.

Water Works District No. 6 began distributing water, but irrigation of lawns and infiltration from septic tanks continued to recharge the alluvium. Concentration of water production from District No. 6 wells (fig. 6) in sec. 14, T. 1 N., R. 19 W., probably accounts for the decline in water level in that section. The relation of faults and ground-water-level differences is shown also in figure 7.

The city-owned Wilbur Road well 4 (1N/19W-10E4), is unique in that it apparently penetrated the Moorpark Freeway fault (fig. 6). The driller reported that when the drill reached the 660-foot depth, the water level in the well dropped from 30 ft to 180 ft below the land surface. Also, although the water levels in other wells in the area were drawn down as much as 300 ft by 1962, they had recovered to predevelopment levels by 1967. The water level in well 1N/19W-10E4, however, continued to decline to about 390 ft above sea level to 1967 when regular measurements were discontinued (fig. 5). By 1977 the water had recovered to about its predevelopment level. The behavior of the water level in this well is anomalous and unexplainable with present data. The anomaly, which is not shown in figure 6, probably reflects local conditions associated with the Moorpark Freeway fault.



Base from U.S. Geological Survey  
Newbury Park and Thousand Oaks  
1:24,000, 1950, photorevised 1967

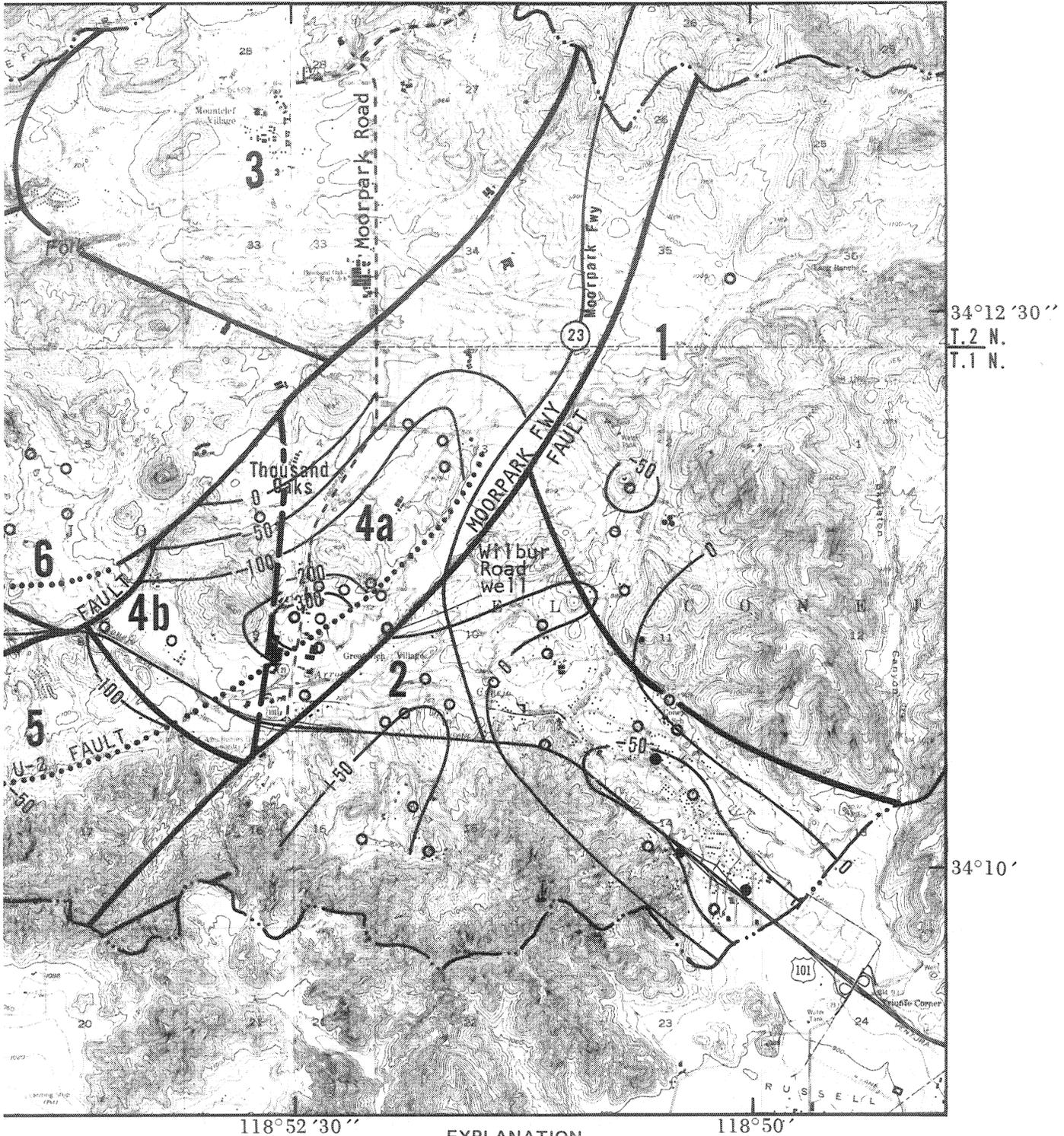
1 1/2 0 1 MILE

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET

NATIONAL GEODETIC VERTICAL DATUM OF 1929

FIGURE 6.--Water-level changes,



EXPLANATION

- |   |                 |   |
|---|-----------------|---|
| <p>..... FAULT—Dotted where concealed</p> <p>—+10— LINE OF EQUAL WATER-LEVEL CHANGE— + indicates rise, — indicates decline. Interval variable</p> <p>———— BOUNDARY OF GROUND-WATER SUBBASIN</p> | <p><b>7</b></p> | <p>SUBBASIN NUMBER</p> <p>..... DRAINAGE BOUNDARY</p> <p>○ WATER-LEVEL DATA POINT<br/>Solid symbols are Ventura County Water Works District 6 wells</p> |
|---|-----------------|---|

1951-62, and subbasin locations.

The effects of other faults on the movement of ground water are not so pronounced as along the U-2 fault, but some evidence of fault control of water level is shown in figure 3 by the Sycamore Canyon fault near Newbury Park.

Because they affect ground-water movement, the faults were used in conjunction with differences in the water-bearing characteristics of the rock types to divide the ground-water basin into seven subbasins (fig. 6).

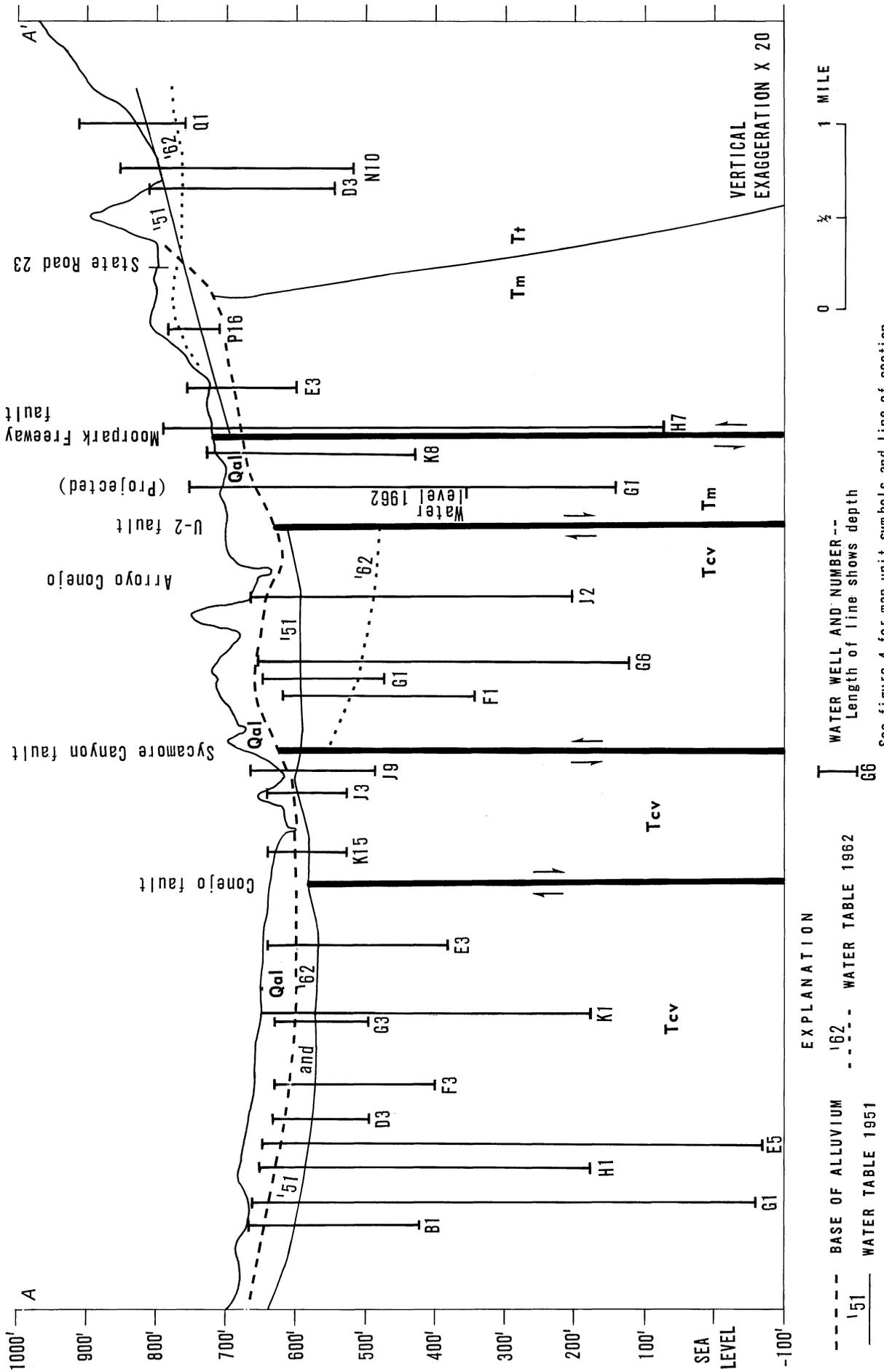
Section B-B' (fig. 8) shows that although Arroyo Conejo cuts into the rock units well below the water table the water table is only slightly affected. If the rock units were sufficiently permeable to allow free transmission of water, the water table might be only a few feet above the bottom of the arroyo. The section shows that the water table is everywhere about 300 ft or more above the bottom of the arroyo, indicating that the water-bearing rocks are not very permeable. The sides of the arroyo have many ground-water seeps and areas of vegetation high above the bottom of the arroyo. The U.S. Geological Survey Newbury Park 7½-minute topographic quadrangle (1950, revised 1967) shows a spring at an altitude of 530 ft in sec. 36, T. 2 N., R. 20 W. These seeps and springs are further indications that the poorly permeable rocks do not transmit water freely to the arroyo but allow it to seep out slowly.

#### Availability of Ground Water

In studying the hydrology of a ground-water basin, one method of determining how much water is available for development is to consider any ground-water outflow from the basin as surplus water and therefore available for use. Most of the ground water that leaves Conejo Valley drains out through Arroyo Conejo.

Beginning in October 1972, daily measurements of flow in Conejo Creek have been made by the Ventura County Flood Control District at their gaging station (11106400), shown in figure 1. The record is not long enough to use with any degree of certainty, but for lack of any other data it can be used for a gross estimate of annual ground-water discharge from Conejo Valley. About 2,000 acre-ft/yr of ground water now flows into Arroyo Conejo and drains out of the basin; it also is the quantity of water that could be withdrawn from the basin without diminishing the quantity in storage.

If the transmissivity of the aquifers were high, withdrawal of ground water would have an effect on the quantity of outflow in the arroyo. Because the hydraulic connection between the aquifers and the arroyo is poor, removal of water by a well could severely reduce water in storage in the vicinity of a well but might not significantly affect flow in the arroyo for several decades. For this reason it is not possible to estimate the quantity of water that can be withdrawn annually from the basin. Estimates of annual production for any proposed wells must be based on data from wells in the vicinity of the proposed well.



EXPLANATION

- - - - BASE OF ALLUVIUM
- - - - '62 WATER TABLE 1962
- - - - '51 WATER TABLE 1951
- WATER WELL AND NUMBER ---  
Length of line shows depth

See figure 4 for map unit symbols and line of section  
 FIGURE 7.--Geologic section A-A'.

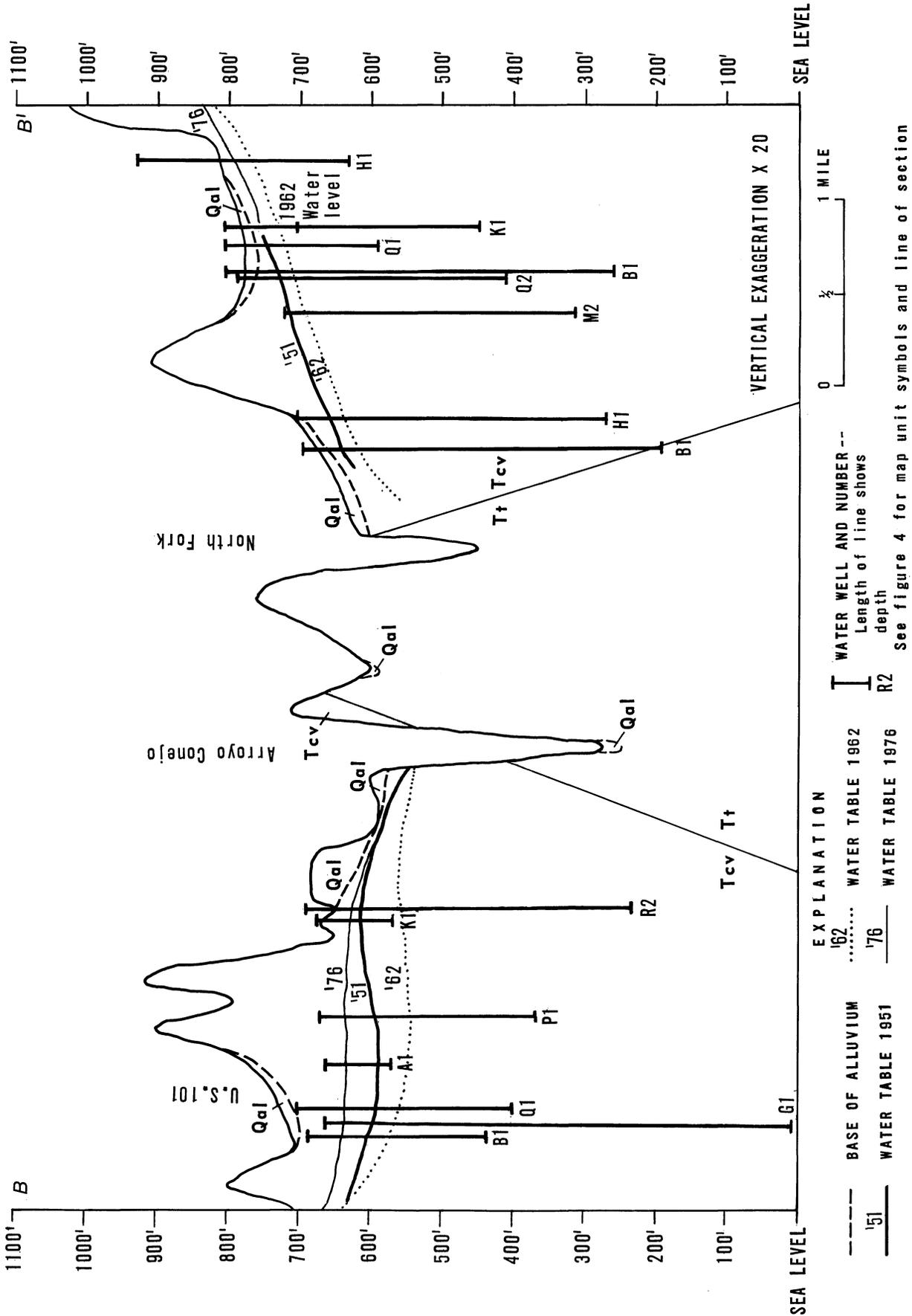


FIGURE 8.--Geologic section B-B'.

### Aquifer Properties

The change in water level in response to pumping and the rate at which wells yield water are affected by physical properties of the rocks that make up the aquifer. Although each of these properties, such as hydraulic conductivity, grain size, degree of fracturing, degree of filling of fractures and voids, cannot be measured everywhere in the basin, some of these can be estimated with a fair degree of confidence in most parts of the basin.

The ground-water storage capacity, as used in this report, is the volume of water that would drain by gravity from the saturated materials in the basin if the present water level were lowered to a depth designated as the average bottom of the aquifer.

In determining the storage capacity in the basin the total volume of the aquifer materials that are saturated with ground water is multiplied by the specific yield. Specific yield is the ratio of the volume of water a saturated rock will yield by gravity to its own volume (Meinzer, 1923).

The average specific yield at a particular well location was derived as follows: (1) drillers' terms used on well logs were grouped into six lithologic classes; (2) specific-yield values, based largely on work reported by Davis, Green, Olmsted, and Brown (1959), were assigned to the six lithologic classes (table 2); (3) the thickness of each lithologic unit reported in the driller's log for that well was multiplied by the assigned specific yield; and (4) the sum of the products was divided by the total thickness of the lithologic units in the well.

To account for the unknown influence of fractures and connected cavities in the basalt units, a dual calculation was used. Where the basalt is not fractured it is dense and probably yields little or no water. Where the basalt is fractured, it may be only slightly fractured or the fractures may not be interconnected and yield only slightly more water than unfractured basalt. Where the basalt is highly shattered and has interconnected cavities, it might yield water copiously. The dual calculation involved, first, assuming that all the basalt was dense and assigning it to the clay classification, specific yield 3, and second, assuming that all the basalt was fractured and assigning it to the volcanic classification, specific yield 10. All other materials retained their assigned values. In this manner the range in average specific yield and, consequently, the range in the storage capacity were determined.

To determine the quantity of water in storage, the basin was divided into subbasins. As mentioned previously, faults were used as subbasin boundaries where they had a noticeable effect on ground-water movement. Other boundaries were selected by correlating wells with similar water yields and similar rock types. Seven subbasins were delineated in this manner (fig. 6). The surrounding hills and mountains were included as parts of the ground-water subbasins in spite of a lack of well data, because these areas contribute ground water to the basin. Subbasin 4 was divided into 4a and 4b because, although

water-level data indicate they are part of the same subbasin, the average specific yield in 4b was substantially higher than in 4a, as indicated by a greater thickness of basalt reported in wells in 4b.

For storage computations the average bottom of the aquifer was designated as 500 ft below land surface, except in subbasins 5 and 7. In subbasin 5 the wells are 300 ft or less in depth, and in subbasin 7 the deepest well depth is 450 ft. Therefore, the average bottoms of subbasins 5 and 7 are designated as 300 ft and 450 ft below land surface, respectively. Water may be in storage below those depths, but well data are not available. Therefore, the storage capacity shown for subbasins 5 and 7 in table 3 may be underestimated.

Using values shown in table 2 for the six categories of water-bearing material, the average specific yield was computed for each subbasin (table 3). Lithologic descriptions from 152 drillers' logs were used. The area, in acres, of each subbasin was multiplied by the thickness of saturated material (from the water table to the average bottom of the subbasins) to obtain the total volume of saturated materials. This product was multiplied by the average specific yield for the subbasin.

Total estimated storage capacity in the upper 300 to 500 ft of the aquifers in the Conejo Valley ground-water basin ranges from about 400,000 acre-ft, assuming the basalt is not fractured, to about 600,000 acre-ft, assuming that all the basalt is fractured. The true value is somewhere within this range.

The ground water in storage is of no use if it cannot be extracted. Data for 55 wells were used to determine the specific capacity and the yield of wells. Specific capacity is the ratio of the yield of a well to the drawdown. (Drawdown is the difference between the pumping water level and the nonpumping or static water level.)

Specific-capacity values in the 55 wells for which data are available ranged from 0.1 (gal/min)/ft of drawdown to 85 (gal/min)/ft. The average for all 55 wells was about 10 (gal/min)/ft. There does not seem to be any correlation with depth; that is, deep wells have neither consistently higher nor consistently lower specific capacities than shallow wells.

The main determining factor for high or low specific capacities was recognized by comparison of drillers' logs of wells; wells drilled through a few hundred feet of basalt usually had higher specific capacities than wells that penetrated little or no basalt.

Yields of wells, as would be expected, range somewhat parallel to specific capacity; that is, the higher yielding wells usually had a higher specific capacity. The yield of the 55 wells ranged from 17 gal/min to 1,080 gal/min. The average yield was 250 gal/min. There does not seem to be any reliable correlation with depth, although wells less than 300 ft deep averaged 170 gal/min and wells more than 300 ft deep averaged 270 gal/min. The deeper wells have more saturated thickness and so would probably maintain their yield longer than the shallower wells.

TABLE 2.--Specific yields used to estimate ground-water storage capacity

Material	Assigned specific yield (percent)
Gravel, sand and gravel, and related coarse gravelly deposits	25
Sand, medium to coarse-grained, loose, and well-sorted	25
Sand, fine-grained, tight sand, and tight gravel	10
Silt, clay, and gravel, sandy clay, sandstone, and conglomerate	5
Clay and related very fine-grained deposits, including volcanic rocks	3
Volcanic deposits except where described as tight, dense, or fine grained	10

TABLE 3.--Storage capacity

Sub-basin	Number of well logs	Depth (ft)	Total volume (acre-ft)	Unfractured volcanic rocks		Fractured volcanic rocks	
				Average specific yield (percent)	Storage capacity (acre-ft)	Average specific yield (percent)	Storage capacity (acre-ft)
1	4	500	1,800,000	3.9	70,000	3.9	70,000
2	33	500	1,290,000	3.8	49,000	6.0	80,000
3	21	500	1,040,000	4.0	42,000	7.7	79,000
4a	23	500	500,000	3.7	19,000	4.9	26,000
4b	6	500	270,000	4.0	11,000	7.3	20,000
5	28	300	325,000	4.0	14,000	5.6	19,000
6	3	500	700,000	4.2	25,000	8.8	63,000
7	34	450	3,250,000	4.3	140,000	8.3	270,000
<b>Total</b>	<b>152</b>		<b>9,000,000</b>	<b>4.0</b>	<b>370,000</b>	<b>6.6</b>	<b>627,000</b>

### Chemical Quality of the Ground-Water

Rocks of the Earth's crust are attacked and dissolved by water both on the land surface and below the ground. The chemistry of ground water is thus strongly influenced by the mineralogy of the rocks through which it passes.

The mineral constituents commonly reported in water analyses are calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, silica, and iron (table 4). Additional constituents that are often measured in ground water are also listed in table 4: fluoride, nitrate, and boron.

Chemical analyses for 113 wells, collected from 1952 to 1977, were used in this study. Table 4 consists of 29 representative analyses of well water and one analysis of water from Arroyo Conejo. Besides the constituents previously mentioned, table 4 also contains values of specific conductance, pH, hardness, and sodium-adsorption ratio (SAR), which are characteristics commonly used to describe water quality.

Ground water in the Thousand Oaks area is of two general chemical types: in the eastern half of the area the predominant constituents are mainly calcium, magnesium, and sulfate, whereas in the western half they are calcium, sodium, and bicarbonate. Figure 9A shows water-quality types based on ion composition for each of the ground-water subbasins and for surface water in Arroyo Conejo. Subbasin 5 is quite sharply divided between sulfate and bicarbonate water-quality types as shown in figure 9B. There is no evidence of a ground-water barrier to separate the two water types. Neither do the drillers' logs of wells indicate a great difference in rock type. Probably the difference in chemical types is caused by marine rocks predominating to the east and nonmarine volcanic rocks to the west.

A		B		C	
Ground water from each subbasin		Difference in water within subbasin 5		Water from shallow and deep wells	
Subbasin	Well	Well	Well	Well	Depth, in feet
1	1N/19W-2C1	1N/19W-18B9	1N/19W-3L3	700	
2	1N/19W-15B2	1N/19W-18H15 (East)	1N/19W-4A1	120	
3	2N/19W-33C1	1N/19W-18H15 (West)	1N/19W-10E3	150	
4	1N/19W-4A1		1N/19W-10E4	850	
5	1N/19W-7R3				
6	2N/19W-33N2				
7	1N/20W-3J1				
SW--Surface water in Arroyo Conejo					

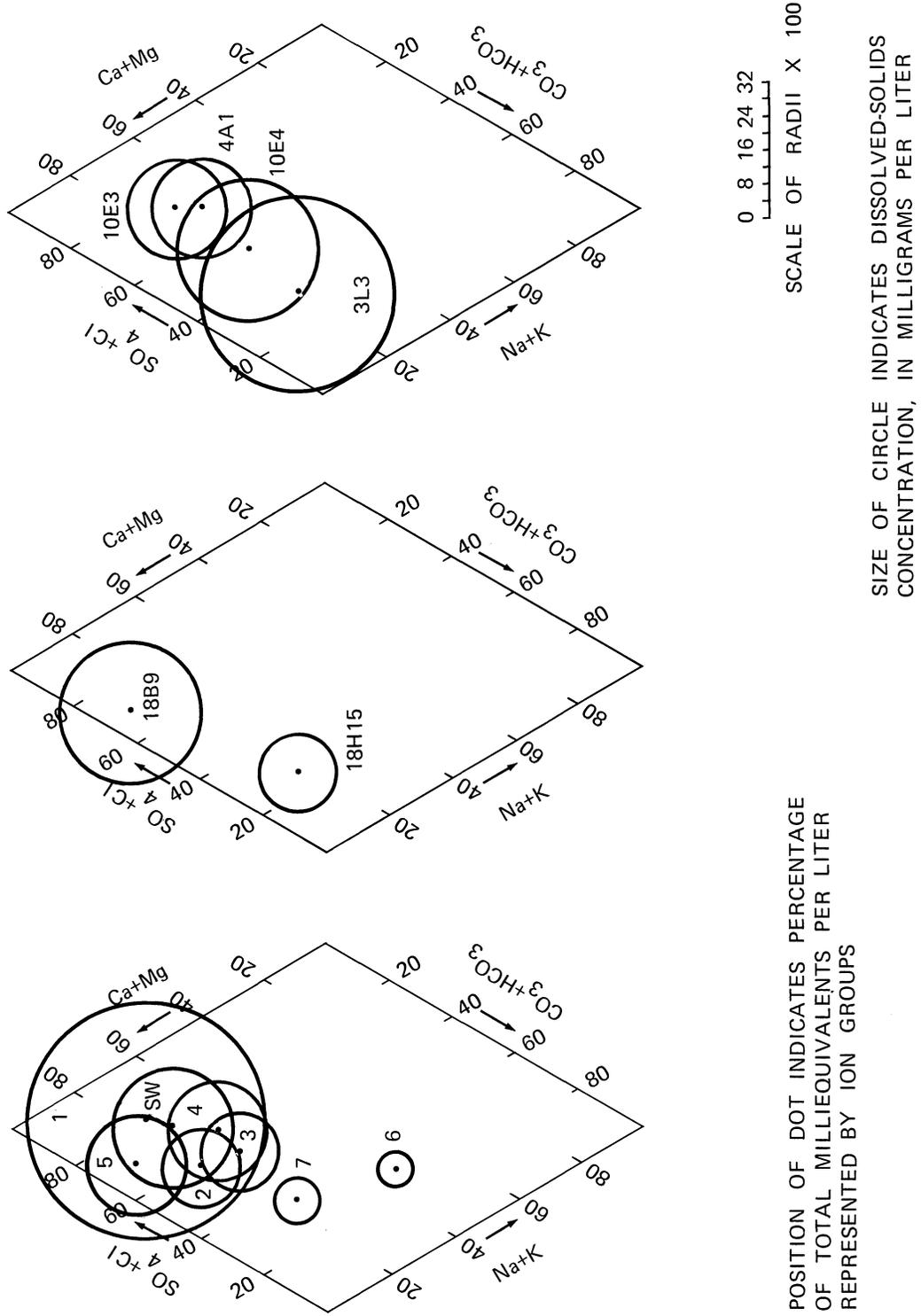


FIGURE 9.--Ground-water chemical quality.

TABLE 4.--Chemical

[Analyzing agencies: DWR, California Department of Water Resources; VCFCD, Ventura County Flood Control District; Chemical analyses are in milligrams]

Well number	Name or owner	Date of sample	Well depth (ft)	Depth of first perforation (ft)	Specific conductance ( $\mu\text{mho/cm}$ at 25°C)	pH (units)	Hardness as $\text{CaCO}_3$	Dissolved calcium	Dissolved magnesium
Wells									
1N/19W-2C1	Conejo Valley Water Co.	03-19-64	466		2,990	7.7	1,500	320	170
1N/19W-2L1	W. H. Rothschild	08-25-60	306	80	1,670	7.3	740	160	86
1N/19W-3E1	Conejo Valley Water Co.	10-30-59	635	70	1,530	7.6	530	96	73
1N/19W-3L3	Conejo Valley Water Co.	02-01-60	700	100	2,550	7.4	1,300	260	160
1N/19W-4A1	Conejo Ranch	01-11-56	120	80	1,280	7.8	580	89	74
1N/19W-5N2	Ted Lynn	08-30-54	518	150	1,060	7.5	370	89	36
1N/19W-7J1	I. Goldband	08-30-54	100	75	1,340	7.5	690	140	84
1N/19W-7K1	E. Clough	08-30-54	85		1,080	7.3	480	85	64
1N/19W-7K16	C. L. Jones	07-26-57	125	37	1,040	8.2	510	110	61
1N/19W-7R3	L. Gobel	07-24-52	175	17	1,240	7.1	730	140	90
1N/19W-8R1	City of Thousand Oaks	04-14-77	208		2,430	7.5	1,200	270	140
1N/19W-9H2	E. Stallsworth	01-11-56	303	185	1,650	7.9	760	130	100
1N/19W-10E3	C. Dester	01-11-56	150	28	1,430	7.7	680	140	74
1N/19W-10E4	Ventura County Water District	07-29-76	850	22	1,910	7.3	50	110	140
1N/19W-15B2	Rolling Oaks Ranch	05-06-58	400	50	989	7.3	520	100	61
1N/19W-15L1	Rolling Oaks Ranch	08-20-57	380	28	1,110	8.2	130	20	20
1N/19W-18A1	G. C. Reddall	08-27-54	103		3,100	7.7	1,600	270	240
1N/19W-18B9	W. H. Etchison	06-27-54	110		1,720	7.9	840	150	110
1N/19W-18H15	Robinson	06-27-54	101	75	883	7.4	420	90	48
1N/20W-1K1	A. Friedrich	07-22-53	106	75	601	8.3	210	36	29
1N/20W-3J1	A. E. Anderson	09-23-65	120		744	8.2	300	51	41
1N/20W-11C2		07-23-52			671	7.9	76	14	10
1N/20W-13C1	S. Faskins	07-29-60	315	60	619	8.0	280	51	36
1N/20W-15R3	Rancho Rieno	09-27-67	57	25	867	8.3	350	74	41
2N/18W-31K1	Lang Ranch	07-06-77	300		1,740	7.9	700	150	76
2N/19W-33C1	C.L.C. College	08-28-58	108	58	1,200	7.5	440	71	63
2N/19W-33N2		06-24-54			670	7.8	170	41	16
2N/19W-34D1	Conejo Valley Water Co.	03-18-64	535	175	1,140	7.4	240	38	35
2N/19W-34E4	Conejo Valley Water Co.	03-19-64	322		1,810	7.5	780	150	100
Surface-water sample from Arroyo Conejo									
2N/19W-31N		05-29-74			1,880	8.3	790	140	110

Figure 10 shows the dissolved-solids concentration in water from many wells. Most of the analyses of sulfate-type water show dissolved-solids concentrations not much below 1,000 mg/L, while the bicarbonate-type analyses nearly all indicate 800 mg/L or less. The zone of high dissolved-solids concentration (more than 2,000 mg/L) south of Thousand Oaks coincides with the U-2 fault, and could reflect the movement of water upward from depth along this fault.

analyses of water

USGS, U.S. Geological Survey; PCC, Pacific Chemical Consultant Co. laboratory; FGL, Fruit Growers Laboratory, Inc. per liter except where noted]

Dis- solved sodium	So- dium adsorp- tion ratio	Dis- solved potas- sium	Dis- solved bicar- bonate	Dis- solved sulfate	Dis- solved chloride	Dis- solved fluoride	Dis- solved silica	Dis- solved solids	Total ni- trate as NO <sub>3</sub>	Dis- solved boron (µg/L)	Iron (µg/L)	Ana- lyzing agency
Wells--Continued												
220	2.5		450	1,200	190	0.8		2,610		470	5,800	FGL
110	1.8	5	400	520	62	.3	18	1,300	7.5	480		VCFCD
190	3.6		340	490	110	.4		1,150		330	500	FGL
190	2.3		390	1,000	160	.4		2,130		200	1,600	FGL
110	2.1	2	320	370	99	.4		970	.6			unknown
84	1.9	1	330	160	87	.7		650	1.2	500		PCC
37	.6	1	370	400	42	.1		1,150	5.4	500		PCC
53	1.1	0	360	180	70	.1		809	11	150		DWR
56	1.1	1	330	180	100	.2	30	720	8.0	400		DWR
38	.6	2	320	430	50	.3	--	1,060	0	20		USGS
100	1.2		410	620	350			2,010				FGL
140	2.3	4	510	480	120	.2		1,270	.8	200		DWR
120	2.0	5	570	320	82	.5		1,060	4.5	220		DWR
120	1.8		370	620	120	.4		1,500		200	2,300	FGL
27	.5	2	280	300	24	.1	60	780	2.2			DWR
200	7.6	1	470	150	36	.2	50	698	0	60		DWR
180	1.9	10	310	1,700	53	.2		2,810	8.1	220		PCC
81	1.2	3	380	630	46	.2		1,520	2.5	70		PCC
43	.9	1	460	43	62	.1		670	21	100		PCC
47	1.4	1	230	25	52	.1	65	390	19	180		USGS
47	1.2	0	280	110	41	.4		450	.5	30		DWR
110	5.7	1	280	25	40	.1		410	14	170		DWR
38	1.0	1	300	42	41	.1	37	370	.1	20		DWR
58	1.3	1	290	100	65	.4		570	20	60		DWR
110	1.8	4	360	530	50	.4		1,260	.7	40		VCFCD
89	1.9	1	290	130	160	.3	50	780	35	80		DWR
74	2.5	2	290	22	45	.3		383	16	170		DWR
150	4.2		210	280	92	.5		747		250		FGL
120	1.5		340	570	130	.5		1,380		380		FGL
Surface-water sample from Arroyo Conejo--Continued												
120	1.8	2	340	470	180	0.7		1,320	0.5	310		USGS

Another influence on the chemical quality of the ground water is the recharge, movement, and discharge of water through the basin. Although natural recharge has replenished the basin with rainwater since the basin was formed perhaps 100,000 or more years ago (Cleveland, 1973), little of this recharge reaches the deep deposits.





A possible indication of this replenishment is shown in figure 9C. Although areally there is much variation in mineral content, in general the shallower wells yield water of lesser mineral content than do the nearby deeper wells, which could reflect a flushing or dilution of the sulfate water with recharge water. This relation seems to hold throughout the basin.

Because the primary interest of this report is directed toward irrigation water rather than potable water for public supply, only irrigation water limitations are discussed.

The occurrence of high concentrations of sodium in irrigation water tends to lower the permeability of fine-grained soils. The use of the SAR (table 4) of a water as an index to its suitability for irrigation is generally preferable to the use of percent sodium (U.S. Salinity Laboratory Staff, 1954). A graph of SAR with the specific conductance of water samples (fig. 11) enables classification of the water as to salinity hazard and sodium (alkali) hazard. The classification of irrigation water quoted below is from the U.S. Salinity Laboratory Staff (1954, p. 79-81).

Most water analyses plotted on the graph show a low sodium hazard (S1). "Low-sodium water can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium." Two analyses plotted in the medium sodium hazard (S2). "Medium-sodium water will present an appreciable sodium hazard in fine-textured soils having high cation-exchange-capacity, especially under low-leaching conditions, unless gypsum is present in the soil. This water may be used on coarse-textured or organic soils with good permeability."

The bicarbonate-type water shows a medium-salinity hazard (C2). "Medium-salinity water can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control." Most of the analyses of the sulfate-type water plotted in figure 11 show a high salinity hazard (C3). "High-salinity water cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected."

Four analyses were rated as very high salinity (C4). "Very high-salinity water is not suitable for irrigation under ordinary conditions but may be used occasionally under very special circumstances. The soils must be permeable, drainage must be adequate . . . and very salt-tolerant crops should be selected."

The classification of irrigation water can be of best value when used with an analysis of soil conditions. The soil summary given in table 5 is adapted from a soil survey of the Ventura area (Edwards and others, 1970). The locations mentioned in the table are shown in figure 12.

The relation of water quality to use in particular areas will be discussed in the section on "Development Potential."

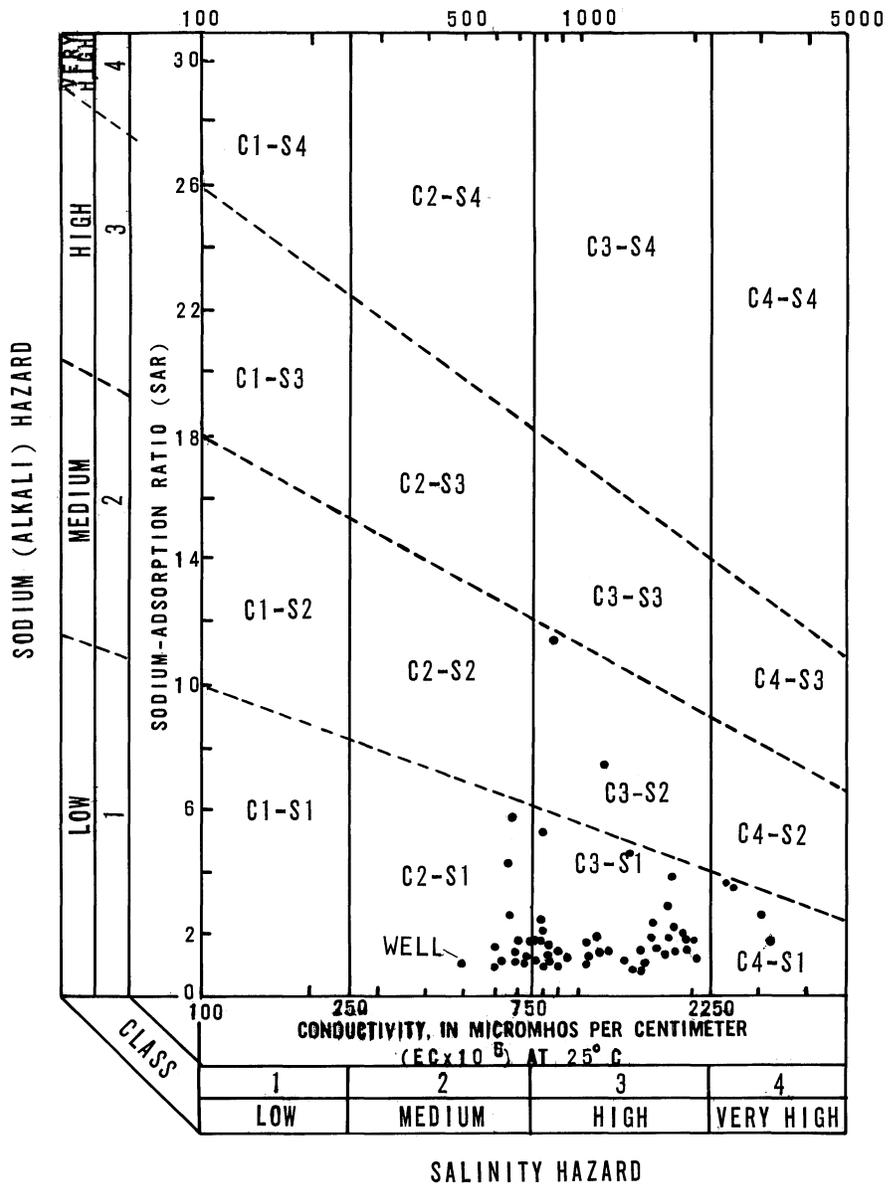


FIGURE 11.--Irrigation-water classification.

TABLE 5.--Hydrologic soil groups which underlie existing or proposed recreation areas

---

Group B:	Newbury, Borchard, Michael, Danielson Ranch, and Dos Vientos
Characteristics:	Moderate infiltration rate
	Moderately deep soil
	Moderately well-drained to well-drained
	Moderately coarse texture
	Moderate rate of water transmission
Group C:	Los Robles Golf Course, Conejo Creek, Arboles, and Oakbrook
Characteristics:	Slow infiltration rate
	Soil layer impedes downward movement of water
	Moderately fine textured
	Slow rate of water transmission
Group D:	Arboretum, Thousand Oaks, Waverly, and North Ranch
Characteristics:	Very slow infiltration rate
	Clay with shrink-swell potential
	Clay pan or thin soil
	Very slow rate of water transmission

---

#### DEVELOPMENT POTENTIAL

The development of a ground-water supply for watering parks, parkways, golf courses, and other public-use land is generally feasible. In certain areas the prospects are marginal, and in at least one area the chemical quality of the water may be harmful to plants.

The following summary lists, by subbasin, the prospects for ground-water development at existing or proposed recreation areas of interest to the city and the Park District (fig. 12). Probable depth to water, probable well depth required for desired water yield, expected water yield, the chemical quality of the water, and the hydrologic evaluation of the sites are discussed.

Subbasin 1 has three recreation areas: Oakbrook, North Ranch, and Old Meadows. In each of these areas the depth to water is about 50 ft, the well depth is about 400 ft, and the expected yield is about 200 gal/min. In all three, however, the dissolved-solids concentration of the water exceeds 2,600 mg/L. The principal constituents are calcium and sulfate. The salinity hazard is very high and the hydrologic soil group is D (table 5).

Because of the poor chemical quality, the ground water in none of these recreation areas is considered suitable for development.

Subbasin 2 has parts of two recreation areas, the southern part of the Conejo Creek area and the eastern tip of Los Robles golf course. In the Conejo Creek area the depth to water is about 60 ft, the well depth is 600 to 800 ft, and the expected yield is about 100 gal/min. The dissolved-solids

concentration in the ground water is more than 1,000 mg/L, principally calcium and sulfate. The salinity hazard is high and the hydrologic soil group is C.

The ground water in this area is considered suitable for development. The soil type, Sorrento silty clay loam (Edwards and others, 1970), is suitable for grasses, citrus, walnuts, and urban development.

The golf course area will be described in the discussion of subbasin 4.

Subbasin 3 has two recreation areas, Thousand Oaks Park and Arboles. The probable depth to water is between 50 and 100 ft, the well depth is 300 to 400 ft, and the expected yield is about 100 gal/min. Dissolved solids, principally calcium and sulfate, total about 700 mg/L. The salinity hazard is medium and the hydrologic soil group is D.

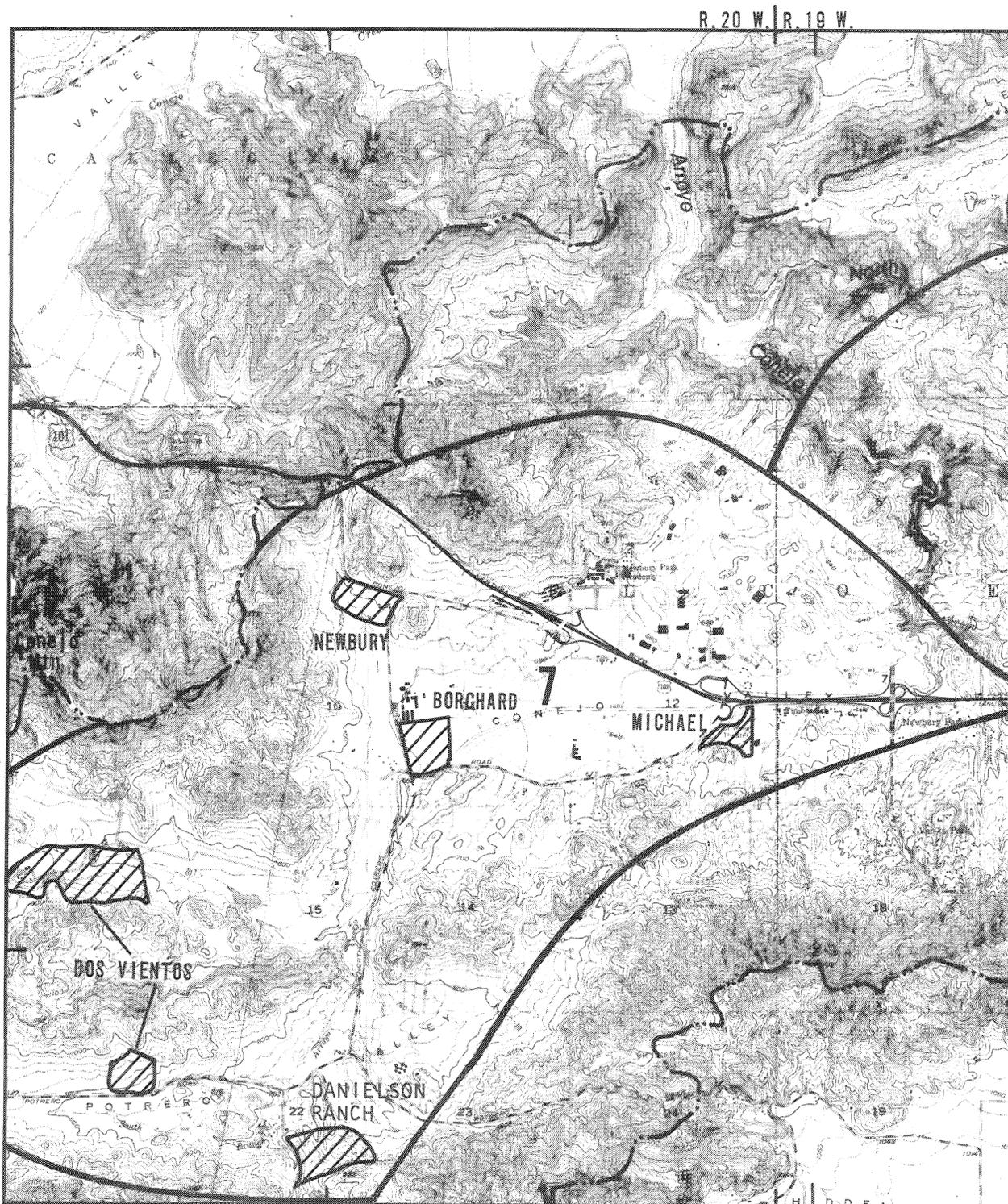
The ground water in these areas is suitable for development. The soil type, Cropley clay (Edwards and others, 1970), has low permeability but is suitable for grasses, citrus, and urban development.

Subbasin 4 has all or parts of four recreation areas: Waverly, Conejo Creek, Arboretum, and Los Robles golf course. Probable depth to water ranges from 100 to 150 ft, depending on the altitude of a prospective well site. Well depth is about 400 ft in all four areas, and expected yield is about 200 gal/min. The ground water generally contains more than 1,000 mg/L in dissolved solids, mostly calcium and sulfate. The salinity hazard is high, and the hydrologic soil group is D north of U.S. Highway 101 and C south of the highway.

The ground water in these areas is suitable for development. The soil types are Cropley clay (Los Robles golf course), Sorrento silty clay loam (Waverly and Conejo Creek), and Hambright rocky clay loam (Arboretum). The Hambright is a steep soil suitable primarily for rangeland, watershed, and urban development.

Except for a small part of Los Robles golf course, subbasin 5 has no proposed recreation areas. The golf course was discussed in the section on subbasin 4. Most of subbasin 5 is mountainous brush country and the rest is rapidly developing urban area. Depth to water is less than 50 ft except in the mountainous area, where the depth is unknown. No wells in this subbasin have been drilled deeper than 200 ft, so an adequate depth cannot be estimated. Probably 50 to 100 gal/min is the expected yield. The quality of the water ranges from about 2,800 mg/L dissolved solids of a calcium sulfate type in the eastern part of the subbasin to about 500 mg/L dissolved solids of a calcium bicarbonate type in the west. The salinity hazard is high in the eastern part of the subbasin and medium in the west, and the hydrologic soil group is C.

The ground water in this subbasin is suitable for development. Ground water west of Ventu Park is of better quality than that to the east (figs. 9B and 10). The soil types are Gilroy clay loam, which is suitable for rangeland on the steeper slopes and citrus, field crops, and urban development; Hambright rocky clay loam, suitable for rangeland; and Cropley clay, which occurs on a small area.



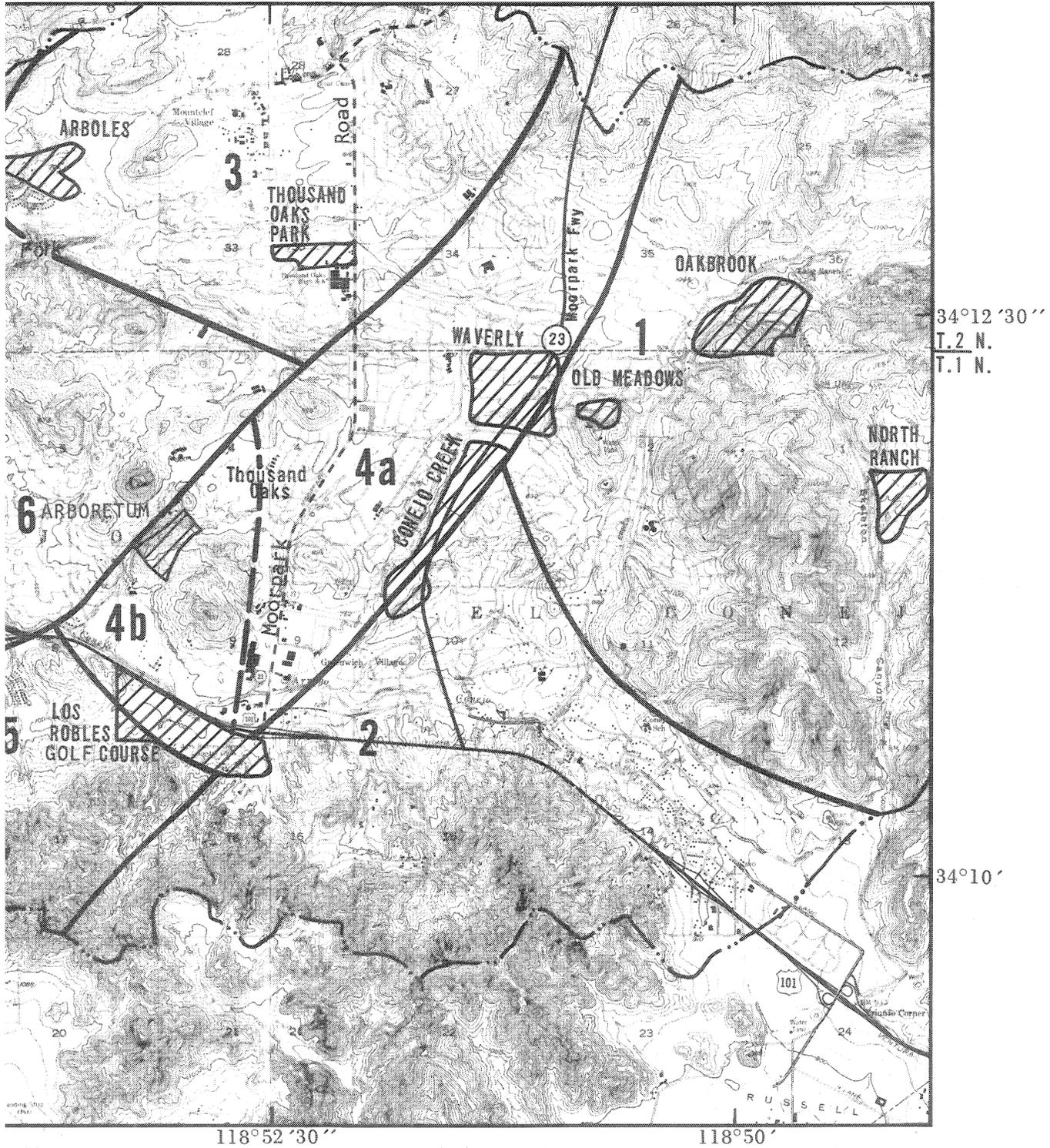
Base from U.S. Geological Survey  
 Newbury Park and Thousand Oaks  
 1:24,000, 1950, photorevised 1967



1 .5 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET  
 NATIONAL GEODETIC VERTICAL DATUM OF 1929

FIGURE 12.--Sites of potential



EXPLANATION



RECREATION AREA OF INTEREST  
FOR POTENTIAL GROUND-WATER  
DEVELOPMENT

2

SUBBASIN NUMBER



BOUNDARY OF GROUND-WATER  
SUBBASIN



DRAINAGE BOUNDARY

ground-water development.

Subbasin 6 has no proposed recreation areas. There is not enough data available to estimate depth to water, adequate well depth, or expected yield. The chemical quality of the water is good, about 500 mg/L dissolved solids, principally calcium and bicarbonate. The salinity hazard is medium and the hydrologic soils groups are C and D.

The ground water is suitable for development, but more data are needed before development plans proceed. The soil types are Cropley, Gilroy, Hambrite, Huerhuero, Linne, Nacimiento, and Rincon. Most of these soils are suitable for vegetables, citrus, avocados, field crops, grasses, and urban development. The rocky areas and steep slopes are suitable for rangeland and watershed.

Subbasin 7 has five recreation areas: Dos Vientos, Danielson Ranch, Michael, Borchard, and Newbury. The depth to water is about 50 ft, optimum well depth is 150 to 200 ft, and the expected yield is about 100 gal/min. The chemical quality of the water is good; dissolved solids generally range from 400 to 550 mg/L, principally calcium bicarbonate. The salinity hazard is medium and the hydrologic soil groups are B and C.

The ground water in these areas is suitable for development. The soil types, Cropley clay and Vina loam, are suitable for grasses, citrus, vegetables, field crops, and urban development. Other soil types which are present in the hilly areas are suitable mostly for rangeland, watershed, and urban development.

#### ARTIFICIAL-RECHARGE POTENTIAL

Natural recharge is the infiltration of precipitation into the soil and percolation to the water table. Under natural conditions long-term recharge equals long-term discharge. Withdrawal of water from a ground-water basin may result in discharge exceeding recharge and a consequent decline of water levels in the basin. Two ways in which to stop depletion of the ground water in storage are to reduce withdrawals or to artificially recharge the ground-water basin.

An example of the first way to stop depletion of ground water is illustrated by the reaction of water levels in Conejo Valley after imported water became available and well pumping was curtailed (fig. 5). When pumping ceased water levels recovered to near predevelopment conditions. Probably in places this recovery was hastened by infiltration of imported water used for watering lawns, parks, and golf courses. This inadvertent form of artificial recharge has, in places, brought water levels above predevelopment levels.

Because the water levels are near predevelopment state, a program of artificial recharge to conserve water may not yet be needed in Conejo Valley. In areas of shallow ground water, no underground space is available to store water. In areas where water levels are deep and storage space is available, water added to the basin would, given sufficient time, move from points of artificial recharge toward lower areas where ground water is shallow and could cause waterlogging. Waterlogging would be manifested by swampy areas, seeps

or springs, and possibly expanding soils. These effects could damage structures or render some areas unsuitable for most purposes.

If the city of Thousand Oaks or the Conejo Recreation and Park District develop ground water for irrigation of their lands, there could be an opportunity for localized use of artificial recharge to replenish ground-water storage, to maintain economic pumping lifts, and to make use of reclaimed water.

Several important conditions must be met for an area to be considered suitable for artificial recharge:

1. Surface infiltration rates in the recharge area must be high enough to accept recharge water.
2. The storage capacity of the ground-water basin must be adequate to accommodate recharge water.
3. The transmissivity of the water-bearing materials must be sufficient to allow movement of recharge water.
4. The area of recharge must be located so that recharge water will move to the area of extraction.
5. Recharge water must be available.

In general the soil in nearly all of Conejo Valley is classified as hydrologic group C or D (Edwards and others, 1970). Group C soils have a slow infiltration rate when thoroughly wetted. Group D soils have a very slow infiltration rate when thoroughly wetted. Any program of localized artificial recharge should be investigated on a site-by-site basis.

## SUMMARY

The evaluation of the six objectives presented in the introduction is summarized in this section:

1. Delineate the ground-water basin or subbasins. The ground-water basin beneath the city of Thousand Oaks corresponds closely with the surface-water drainage basin of Conejo Valley. On the basis of geologic structure and water-bearing characteristics of the rock units that make up the ground-water basin, the basin was divided into seven subbasins.
2. Determine the generalized ground-water-flow-pattern. Ground water moves from beneath the surrounding hills and mountains toward Arroyo Conejo, to which it ultimately discharges and through which the basin is drained to the north.
3. Estimate the water-yielding capacity of wells in the aquifer. The specific capacity calculated for water wells in the basin ranged from 0.1 to 85 (gal/min)/ft and averaged 10 (gal/min)/ft. The yield of wells ranged from 17 to 1,080 gal/min and averaged 250 gal/min.
4. Estimate the quantity of recoverable ground water in storage. Depending on the degree of occurrence of open fractures and cavities in the basalt, the recoverable water in the upper part (300-500 ft) of the aquifer is estimated to be between 400,000 and 600,000 acre-ft.

5. Describe the ground-water quality and its variations. Most of the ground water is high in sulfate and has a dissolved-solids concentration near or above 1,000 mg/L. In the western part of the valley the ground water is mostly a bicarbonate type, and the dissolved-solids concentration is less than 500 mg/L.

6. Investigate the feasibility of artificial recharge. In most places in the valley the water table is too shallow to provide storage space for recharge water; however, if the city begins to lower the water table by pumping for irrigation, some possibilities for artificial recharge may develop.

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