Geohydrology of the Escondido Hydrologic Subarea, San Diego County, California

By Linda R. Woolfenden

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 88-4223

Prepared in cooperation with the
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD,
SAN DIEGO REGION

Sacramento, California
1989

DEPARTMENT OF THE INTERIOR

MANUEL LUJAN, JR., Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information write to:

District Chief
U.S. Geological Survey
Federal Building, Room W2234
2800 Cottage Way
Sacramento, CA 95825

Copies of this report can be purchased from:

U.S. Geological Survey
Books and Open-File Reports Section
Building 810
Federal Center, Box 25425
Denver, CO 80225

CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS

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

Multiply inch-pound unit	By	To obtain metric unit
acre-foot (acre-ft)	0.001233	cubic hectometer
foot (ft)	0.3048	meter
gallon per minute (gal/min)	0.06309	liter per second
inch (in.)	25.4	millimeter
inch per hour (in/h)	25.4	millimeter per hour
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

Abbreviations used:

mg/L - milligram per liter
µS/cm - microsiemen per centimeter at 25 degrees Celsius (°C).
µg/L - micrograms per liter

Altitude datum: In this report "sea level" refers to the 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 Sea Level Datum of 1929.

Geohydrology of the Escondido Hydrologic Subarea, San Diego County, California

By Linda R. Woolfenden

ABSTRACT

The San Diego region is undergoing rapid growth with a corresponding increase in the demand for water. In 1975, the California Regional Water Quality Control Board, San Diego Region, developed a basin plan for the region to help protect the quantity and quality of water. To update the plan, data were collected to determine current (1987) hydrologic conditions, particularly water quality, in the Escondido hydrologic subarea.

Water-level measurements indicate that ground water was within 20 feet of land surface. Ground-water movement is downgradient from the highly weathered crystalline rocks into the alluvium. Ground water moves from north to south in Reidy Canyon and from east to west in the alluvium near Escondido.

Dissolved-solids concentration in water from wells sampled in 1987 ranged from 720 to 4,500 milligrams per liter. Water from all 20 wells sampled in 1987 had dissolved-solids concentrations greater than 500 milligrams per liter, which is the U.S. Environmental Protection Agency recommended limit for drinking water. Water from 12 wells had dissolved-solids concentrations equal to or greater than 1,000 milligrams per liter.

Nitrate (as nitrogen) concentration ranged from 1.1 to 86.0 milligrams per liter in 1987. Water from 14 wells had nitrate (as nitrogen) concentrations greater than 10 milligrams per liter, the Environmental Protection Agency recommended limit for drinking water.

INTRODUCTION

The San Diego region is undergoing rapid growth with a corresponding increase in demand for water. To help protect water quality and quantity in the region, a basin plan identifying factors that influence water demand and water quality was prepared by the California Regional Water Quality Control Board, San Diego Region (California Regional Water Quality Control Board, San Diego Region, 1975). With the passage of time, it is necessary to update the basin plan on the basis of current hydrologic conditions, particularly water quality. Reports evaluating hydrologic conditions in the region covered by the basin plan have been completed for: the San Dieguito, San Elijo, and San Pasqual hydrologic subareas (Izbicki, 1983); the Mission, Santee, and Tijuana hydrologic subareas (Izbicki, 1985); and the Soledad, Poway, and Moosa hydrologic subareas (Evenson, 1989). The subject of this study was the Escondido hydrologic subarea (fig. 1).

Purpose and Scope

The purpose of this report, prepared in cooperation with the California Regional Water Quality Control Board, San Diego Region, is to present the results of a study to refine the understanding of the ground-water system within the Escondido hydrologic subarea in San Diego County. The study was designed to determine current (1987) water-quality conditions and provide geohydrologic information that can be used to update water-quality standards of the basin plan for the Escondido hydrologic subarea.

The study involved: (1) compiling existing geologic, land-use, and hydrologic data; (2) inventorying 24 wells and measuring water levels in 13 wells; and (3) collecting and analyzing water samples from 20 wells and two sites along Escondido Creek for determination of major cations and anions.

Description of Study Area

The 44-square-mile Escondido hydrologic subarea is about 40 miles northeast of San Diego in north-central San Diego County (fig. 1). The city of Escondido is in the south-central part of the subarea.

Escondido Creek traverses the southern part of the subarea. Flow in Escondido Creek is regulated at Lake Wohlford, east of the study area (fig. 1). Surface runoff and irrigation return, however, maintain perennial flow in the creek. The land generally slopes from east to west, and land-surface altitudes range from 2,240 feet above sea level in the northeast corner of the study area to 420 feet in the west where Escondido Creek exits the subarea.

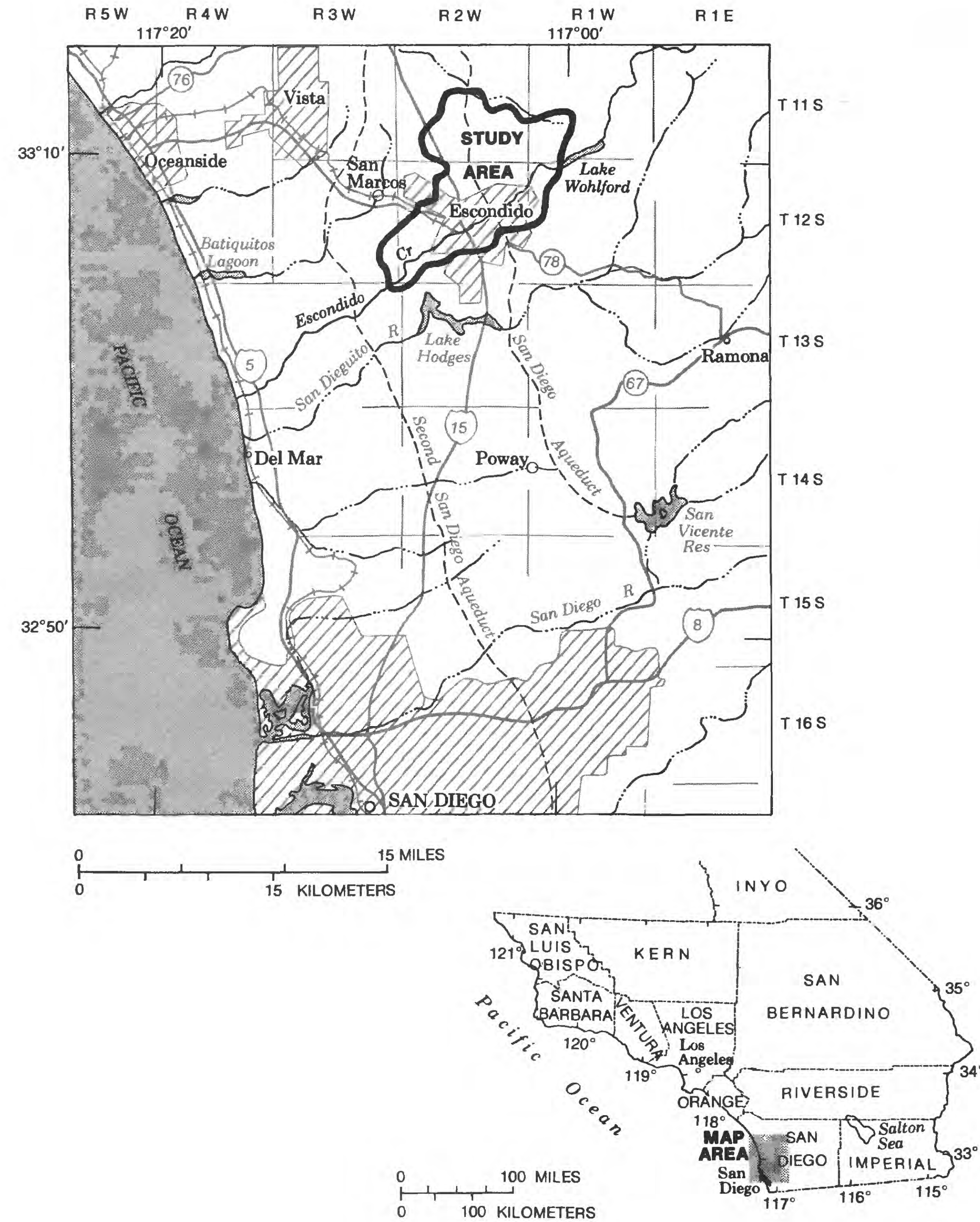


FIGURE 1.—Location of study area.

The subarea has a semiarid climate, with warm, dry summers and mild winters. Precipitation is unevenly distributed throughout the year, and most occurs between November and April. Annual precipitation for the 1931-87 period of record ranged from 6.15 inches in 1968 to 33.83 inches in 1978, with an average of 15.80 inches (fig. 2). In 1987, precipitation was 16.32 inches, somewhat above the annual average.

Three major soil associations are in the subarea. Fallbrook-Vista and Cieneba-Fallbrook soils are found in upland areas, and Visalia-Tujunga soils are found on the valley floor (U.S. Soil Conservation Service, 1973). Soil infiltration capacities throughout most of the Fallbrook-Vista and Cieneba-Fallbrook associations are moderate (0.6 to 2.0 in/h) to high (20 in/h). Infiltration capacities throughout the Visalia-Tujunga associations generally are high, ranging from 2.0 to 6.3 in/h for Visalia soils to greater than 20 in/h for Tujunga soils (U.S. Soil Conservation Service, 1973).

The subarea includes both urban and agricultural areas. Six categories of land use, as a percentage of total area, are shown in figure 3. The categories are native vegetation, irrigated agriculture, residential, commercial-industrial, unirrigated agriculture, and other. Native vegetation, which includes brushland and grassland, covers more than one-half (53 percent) of the subarea. Irrigated agriculture, which covers 15 percent of the subarea, includes fruit and avocado trees and a few small vineyards. Residential areas cover 13 percent of the subarea and include urban, suburban, and rural households (California Department of Water Resources, 1986). Population in the subarea is about 110,000 (estimated from San Diego County population data) and is concentrated in the south-central part of the subarea near the city of Escondido. Commercial-industrial areas cover 8 percent of the subarea. Unirrigated agriculture includes feedlots and dairies and covers 1 percent. Other land uses, which include vacant lots, lakes, and freeways and major roads, cover 10 percent of the subarea (California Department of Water Resources, 1986).

Sources of public water supply for the subarea are Lake Wohlford and diversions of water from northern California mixed with water from the Colorado River. Use from July 1986 through June 1987 was 25,600 acre-ft. Thirty-five to forty percent of this water was used for agriculture. Use of water from wells owned by the Escondido Department of Public Works was discontinued in 1977 because of high nitrate concentrations (Glen Peterson, Escondido Department of Public Works, oral commun., 1988). Small quantities of ground water are used for irrigation and for selected domestic purposes at a few residences. Rincon del Diablo Water District is the only other water purveyor in the subarea.

The Escondido Department of Public Works is the only sewering agency operating in the study area. Sewage is treated at a waste-treatment facility (fig. 4) and transported to the ocean by means of a sewage outfall pipe (Glen Peterson, oral commun., 1988).

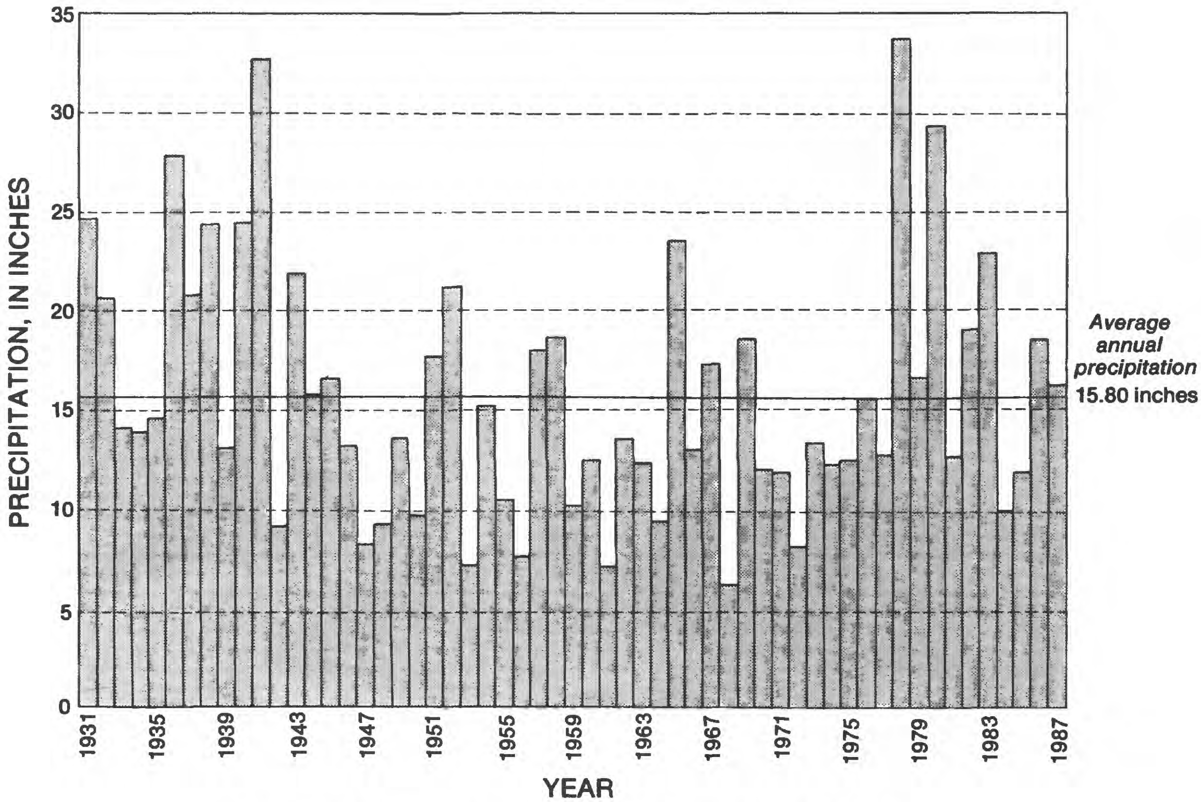


FIGURE 2.—Annual precipitation at Escondido, 1931-87.

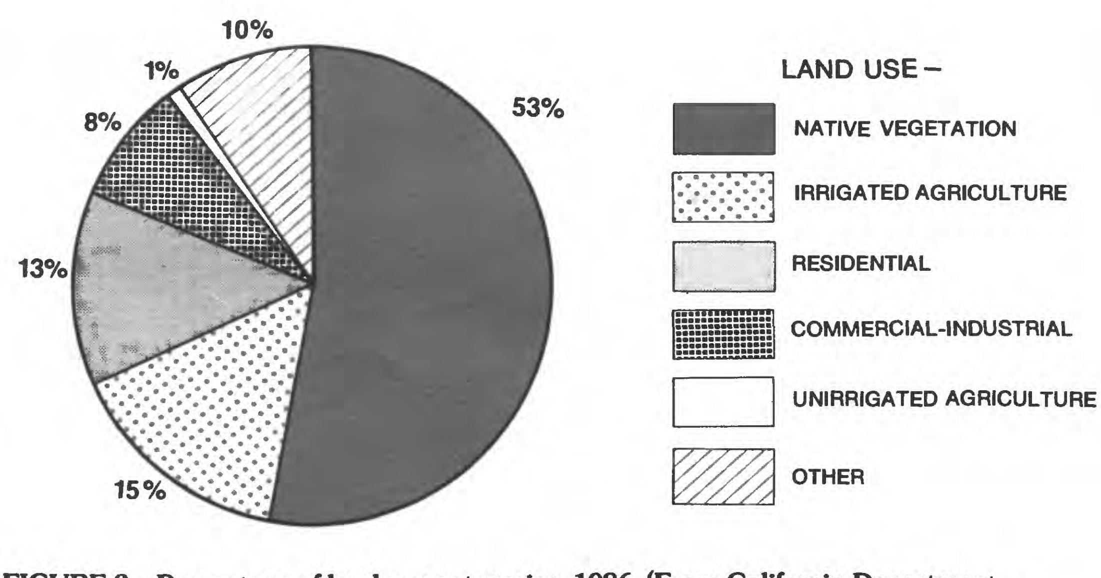
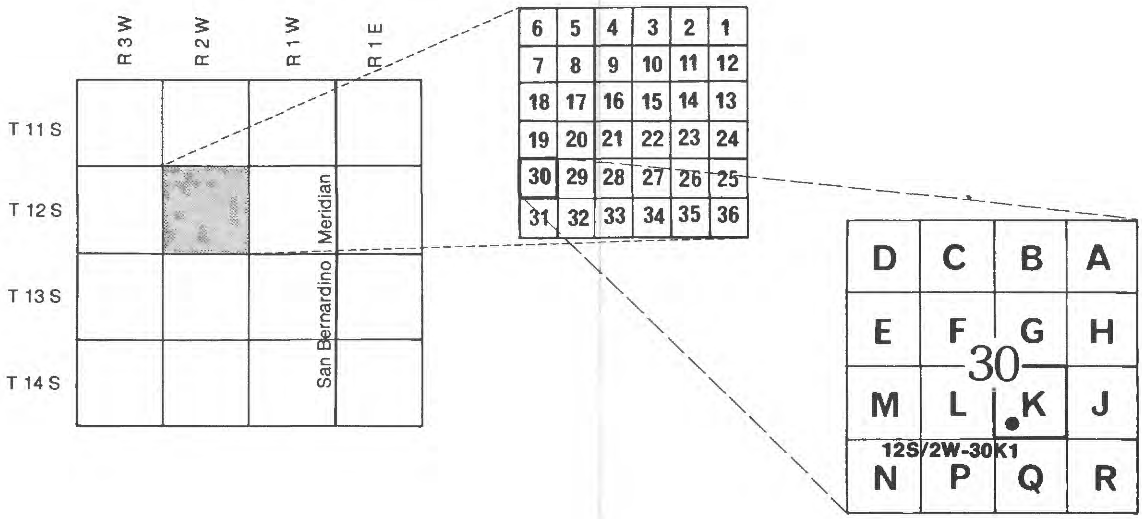


FIGURE 3.—Percentage of land-use categories, 1986. (From California Department of Water Resources, 1986.)

Well-Numbering System

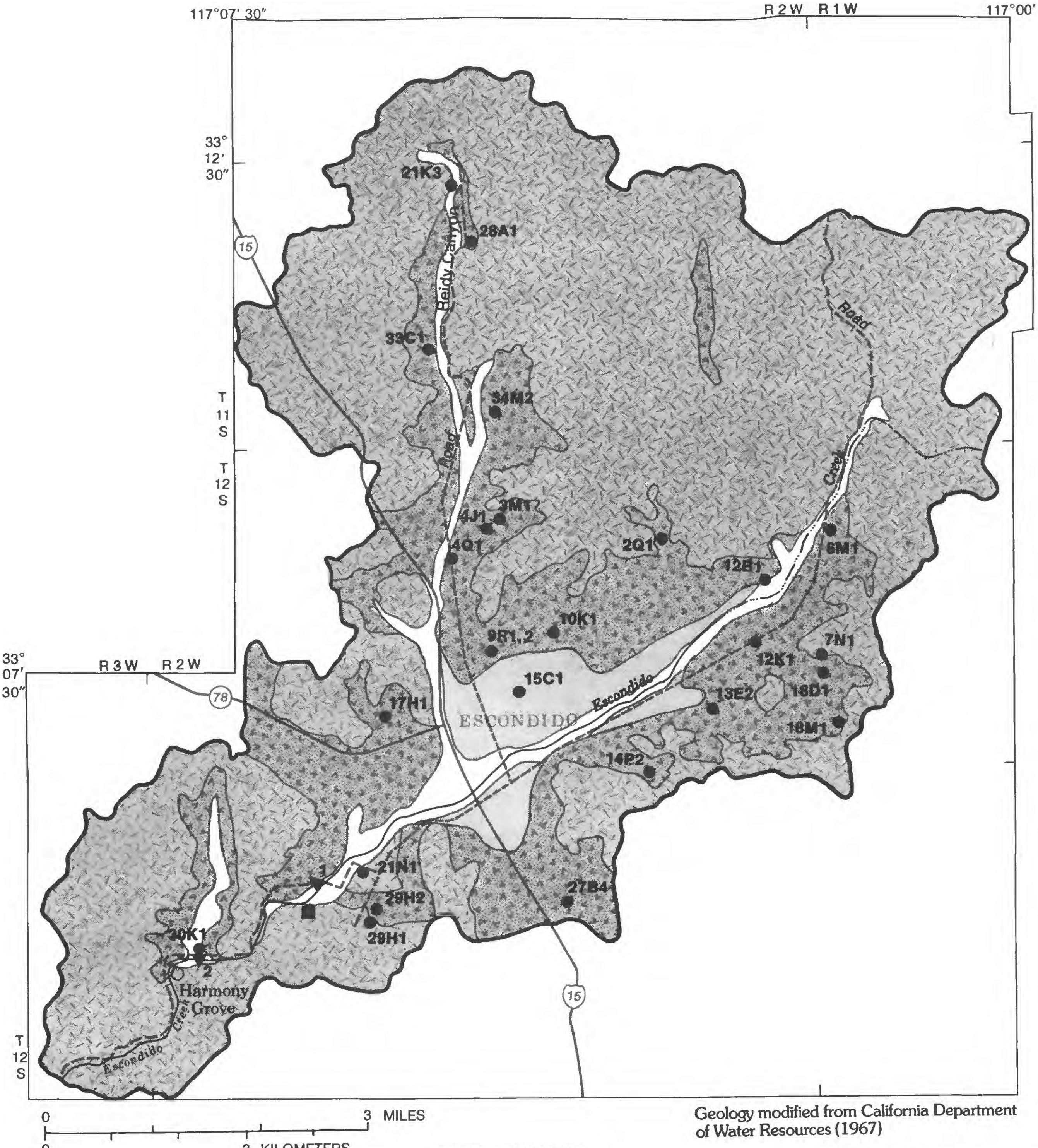
Wells are numbered according to their location in the rectangular system for the subdivision of public land. For example, in the number 12S/2W-30K1 the part of the number preceding the slash indicates the township (T. 12 S.), the part between the slash and the hyphen indicates the range (R. 2 W.), the number between the hyphen and the letter indicates the section (sec. 30), and the letter indicates the 40-acre subdivision of the section. Within the 40-acre tract wells are numbered serially, as indicated by the final digit. Thus, well 12S/2W-30K1 is the first well to be listed in the SW 1/4 SE 1/4 sec. 30, T. 12 S., R. 2 W., San Bernardino base line and meridian, as shown in the diagram below:



GEOLOGIC SETTING

The geology of the subarea has been described by the California Department of Water Resources (1967) and is shown in figure 4. The subarea lies entirely within the Peninsular Ranges province. The consolidated rocks consist of crystalline rocks of the southern California batholith, small exposures of metamorphic rocks, and highly weathered crystalline rocks (known locally as residuum). The crystalline rocks are of Cretaceous age and underlie most of the subarea. These rocks include granodiorites, tonalites, and small exposures of gabbros and diorites. The metamorphic rocks are of Jurassic age and occur as scattered remnants of roof pendants within the crystalline rocks. There are no faults within the study area.

The unconsolidated deposits occur along streams and other low-lying areas. These deposits are of Quaternary age and are referred to as older alluvium and younger alluvium. The Pleistocene older alluvium includes river-terrace deposits and undifferentiated continental deposits. The Holocene younger alluvium consists of stream deposits (fig. 4).



Geology modified from California Department of Water Resources (1967)

EXPLANATION

QUATERNARY

- YOUNGER ALLUVIUM – (Holocene) Gravel, sand, silt, and clay
- OLDER ALLUVIUM – (Pleistocene) Nonmarine gravel, sand, and silt, partially cemented and weathered

CRETACEOUS

- RESIDUUM – Crystalline rocks, deeply weathered

CRETACEOUS AND JURASSIC

- CRYSTALLINE ROCKS – Undifferentiated granodiorites, Green Valley Tonalite, and undifferentiated gabbros and diorites (Cretaceous) and hybrid and undifferentiated metamorphic rocks (Jurassic)

- CONTACT
- HYDROLOGIC SUBAREA BOUNDARY
- ▼1 SURFACE-WATER SAMPLING SITE AND NUMBER
- ● 29H1 WELL AND NUMBER
- ■ WASTE-TREATMENT FACILITY

FIGURE 4.–Geology and location of wells, surface-water sampling sites, and waste-treatment facility.

GEOHYDROLOGY

Ground-Water System

Description of Water-Bearing Units

The water-bearing units in the study area are crystalline rocks, residuum, and alluvium. Surface exposures are 65 percent, 25 percent, and 10 percent, respectively. Most of the active wells in the subarea tap aquifers composed of fractured crystalline rock or residuum.

The crystalline rocks include undifferentiated granodiorites and Green Valley Tonalite. These rocks are resistant to weathering and form prominent hills and ridgetops. Large exposures of granodiorite crop out in the northern part of the subarea. Green Valley Tonalite is exposed near the southern boundary of the subarea and west of the city of Escondido. The crystalline rocks are weathered to only a few feet and may be tapped by shallow wells (such as well 12S/2W-21N1). Weathered and fractured crystalline rocks yield small to large quantities of water to wells (5 to 100 gal/min).

Deeply weathered exposures of crystalline rocks form residuum, which is thickest in lowland and hilly topography. Drillers' logs indicate that maximum thickness of the residuum is about 110 feet. In the subarea, the residuum yields small to moderate quantities of water to wells (1 to 30 gal/min).

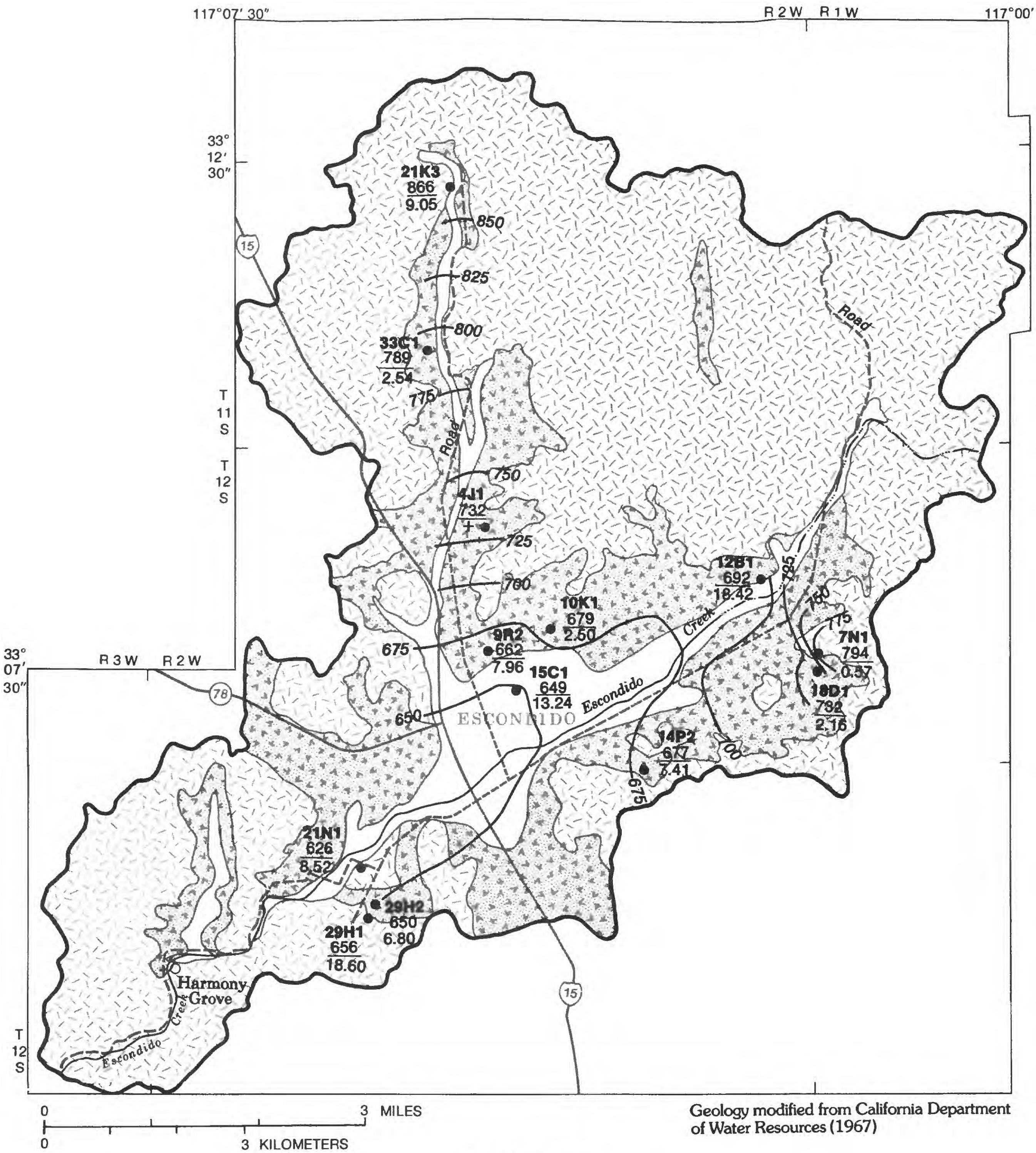
The alluvium is exposed near the city of Escondido at the base of the residuum, along Escondido Creek, in Reidy Canyon, and near Harmony Grove. Drillers' logs indicate that maximum thickness of the alluvium is about 80 feet. The alluvium yields moderate to large quantities of water to wells (12 to 65 gal/min).

Occurrence and Movement of Ground Water

Figure 5 shows altitude of the water table and depth to ground water during spring 1987. The water-table contours shown in figure 5 are drawn assuming hydraulic connection between the different water-bearing units, but this may not be the case everywhere.

Water-level measurements were made during May and June 1987 in 13 nonpumped wells. Water levels in all 13 wells were within 20 feet of land surface and ranged from flowing (0.5 to 1 gal/min) at well 12S/2W-4J1 to 18.60 feet below land surface at well 12S/2W-29H1.

Water-table altitudes ranged from 866 feet above sea level in well 11S/2W-21K3 to 626 feet in well 12S/2W-21N1. Ground water moves from the residuum into the alluvium along stream channels. In the alluvium of Reidy Canyon, ground water moves from north to south toward the main part of the alluvium at Escondido. Ground water in the alluvium near Escondido generally moves from east to west.



EXPLANATION

ALLUVIUM

RESIDUUM

CRYSTALLINE ROCKS

CONTACT

HYDROLOGIC SUBAREA BOUNDARY

—650— WATER-TABLE CONTOUR – Shows altitude of water table. Approximately located. Contour interval 25 feet. Datum is sea level

14P2 ● 677 / 7.41 WELL – Upper number is well number. Middle number is altitude of water table, in feet above sea level. Lower number is depth below land surface, in feet. + indicates flowing

FIGURE 5.– Water-table altitudes and depth to water, spring 1987.

Natural Recharge and Discharge

Ground water in the subarea is recharged by infiltration of precipitation and streamflow in Escondido Creek and in small channels. Some of the water moves downward into the fractures and weathered zones of the crystalline rocks; some is held as soil moisture and consumed by evapotranspiration; and some infiltrates past the root zone and recharges the residuum and alluvium. There is no recharge along most of Escondido Creek because the channel is lined with concrete throughout most of the subarea. Some recharge through the stream deposits may occur in the unlined channel downstream from surface-water sampling site 1 (fig. 4). Also, some recharge of the residuum and alluvium probably occurs as leakage from the crystalline rocks.

Natural discharge of ground water from the study area is through underflow and transpiration from phreatophytes. A small quantity of ground water is pumped from wells for irrigation and domestic purposes. Discharge from underflow occurs at the basin boundary near Harmony Grove where Escondido Creek leaves the subarea. Ground water in this area may resurface as streamflow as a result of constriction of permeable alluvium by less permeable crystalline rocks in the stream channel. Natural discharge from phreatophytes occurs along Escondido Creek where natural channel conditions exist. Cottonwoods (*Populus fremontii*), willows (*Salix* species), and cattails (*Typha angustifolia*) grow along the creek in these areas.

Water Quality

In June, July, and September 1987, water from 20 wells and from Escondido Creek at two locations was sampled for chemical analyses of major anions and cations. Selection of sampling sites was based primarily on availability of active wells. Areal distribution and accessibility also were considered. Base flow in Escondido Creek was sampled for major anions and cations at the same time at both sites. Chemical analyses for 1963-64 and 1987 are given in table 1, and water-quality data for selected sites are shown in figures 6 and 7.

Surface Water

Historical water-quality data for Escondido Creek, collected near Harmony Grove, date from 1950 to 1981. Until 1973, wastewater was discharged into Escondido Creek from a wastewater-treatment plant in Escondido, resulting in year-round base flow. After 1973, discharges of wastewater into the creek were discontinued and base flow was attributed to irrigation return water and urban runoff from the Escondido and Harmony Grove areas (Izbicki, 1983).

Water-quality data reflect the influence of increased irrigation return water. Between 1950 and 1972, 58, 125, and 61 samples were collected and analyzed for dissolved solids, chloride, and sulfate, respectively, during base-flow conditions (table 2). Minimum concentrations of these constituents were 835 mg/L for dissolved solids, 130 mg/L for chloride, and 180 mg/L for sulfate. For 1974-81, analysis of 24 samples collected during base-flow conditions indicated that minimum concentrations of these constituents increased to 1,020 mg/L for dissolved solids, 260 mg/L for chloride, and 200 mg/L for sulfate; dissolved-solids concentrations ranged from 1,020 to 1,380 mg/L (Izbicki, 1983). In 1964, the concentration of dissolved solids during base-flow conditions at Harmony Grove was 1,230 mg/L (fig. 6).

On September 1, 1987, samples were collected during base-flow conditions at sites 1 and 2 near Harmony Grove upstream from the historical sampling site. Dissolved-solids concentrations were 1,000 and 1,100 mg/L, respectively (fig. 7), showing little change from historical values.

Results of chemical analysis of water from Lake Wohlford on November 4, 1987 (Glen Peterson, Escondido Department of Public Works, written commun., 1988), are as follows (all constituents are in milligrams per liter):

Total hardness	Sodium	Potassium	Calcium	Magnesium
154	75	4	44	11

Chloride	Bicarbonate	Sulfate	Nitrate (as nitrogen)	Dissolved solids
48	199	68	0.45	389

The water-quality data for Lake Wohlford represent the quality of surface flow in Escondido Creek before the water enters the subarea. Dissolved-solids concentration for Lake Wohlford was 389 mg/L, which is considerably less than the September 1987 dissolved-solids concentration of 1,000 mg/L for Escondido Creek 1 mile upstream from Harmony Grove (site 1). This suggests that irrigation return flow and urban runoff within the subarea have significantly increased the dissolved-solids concentration in the stream.

Throughout the period of record (1950-81), water in Escondido Creek generally was a mixed chemical type, dominated by sodium and chloride (Izbicki, 1983). Analysis of a water sample collected in 1987 from Escondido Creek near Harmony Grove (site 2) shows a similar composition. Water from sampling site 1 upstream from Harmony Grove is classified as sodium chloride sulfate type (fig. 7).

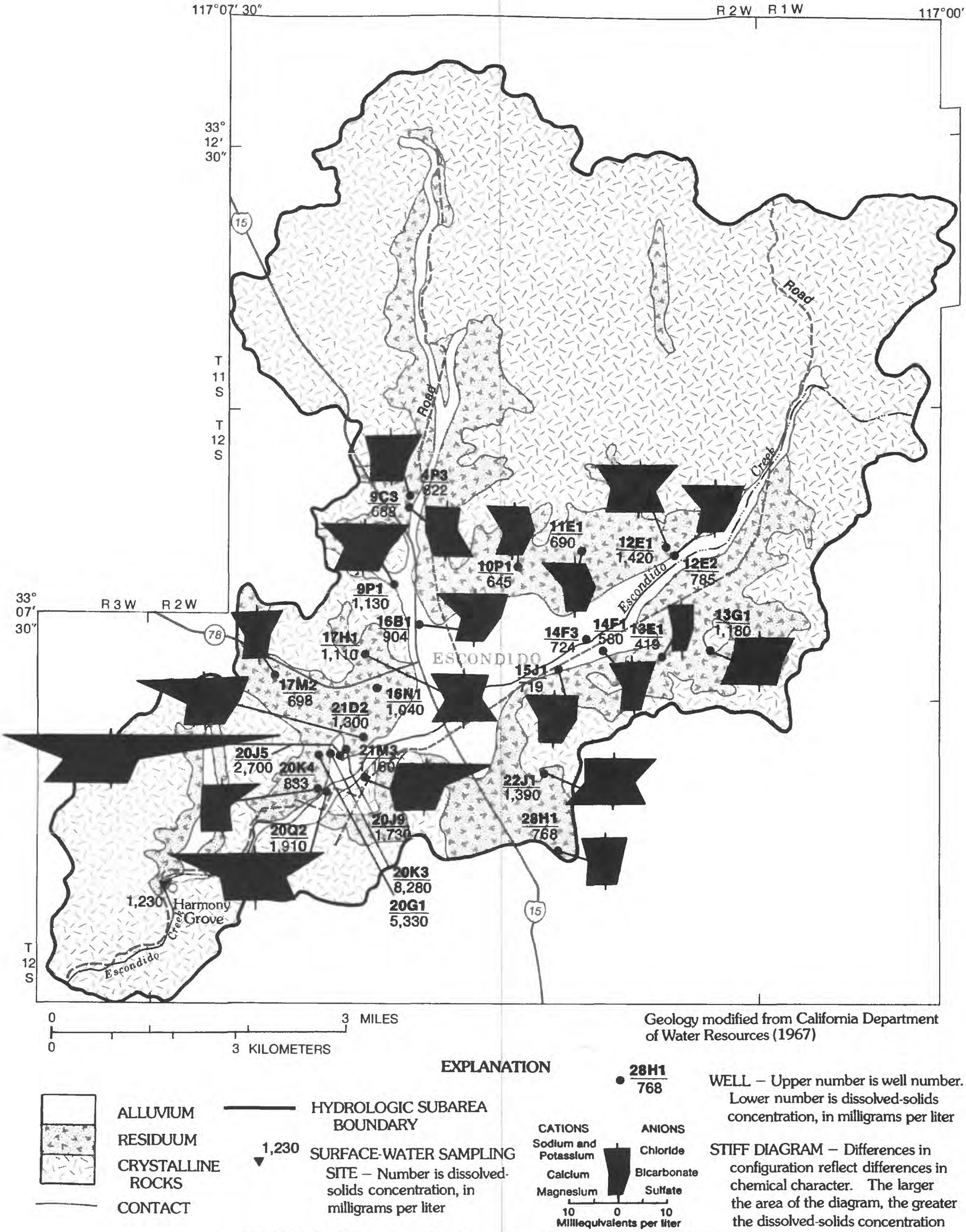


FIGURE 6.—Water-quality data for selected sites, 1963-64.

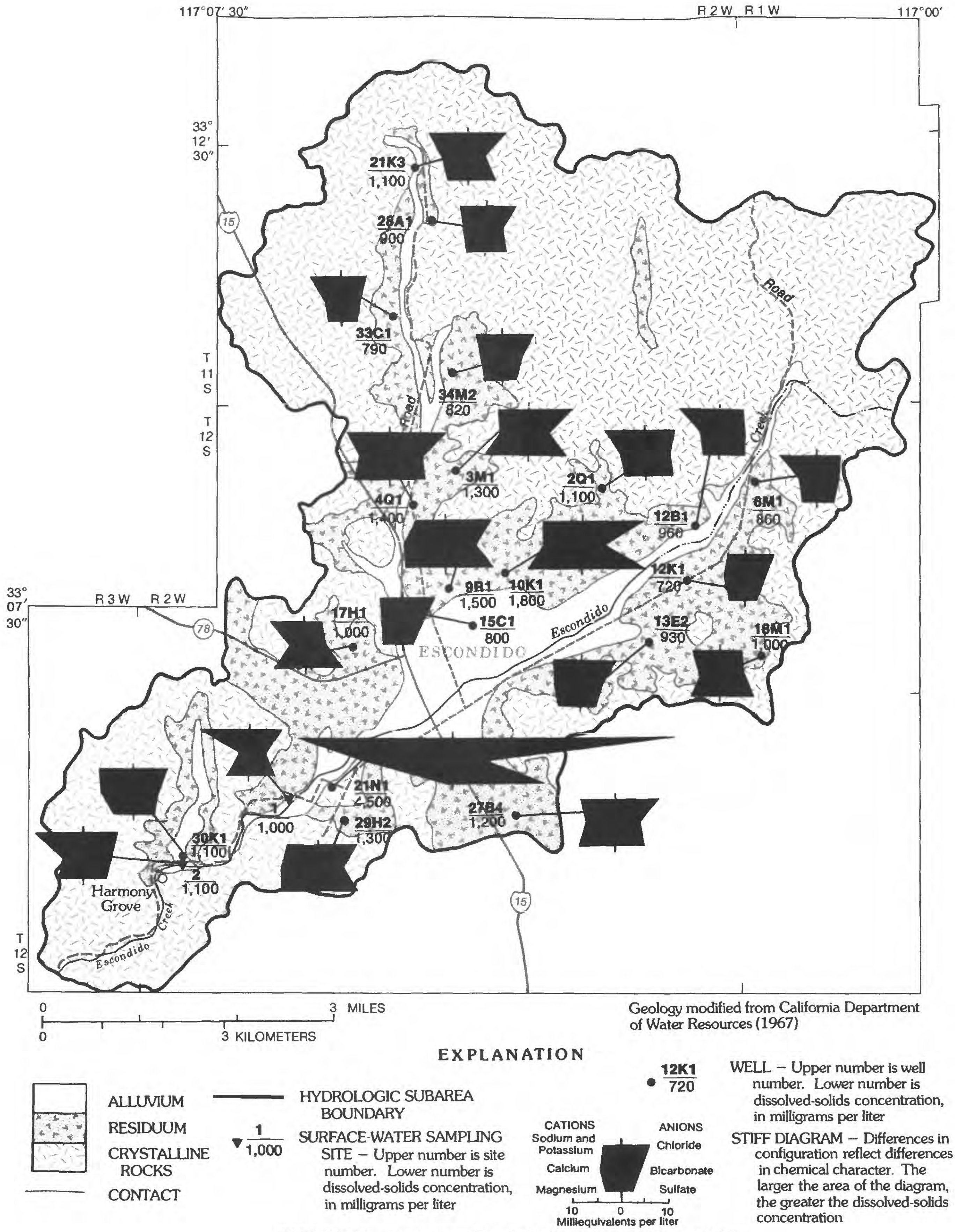


FIGURE 7.—Water-quality data for selected sites, 1987.

Table 1.--Water-quality data, 1963-64 and 1987

[Data for 1963-64 are from California Department of Water Resources, unpublished. µS, microsiemens per centimeter at 25 °C; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; --, no data. The analysis for each well is displayed as one line on three consecutive pages]

Well No.	Date	Time	Specific conduct-ance (µS/cm)	Specific conduct-ance, lab (µS/cm)	pH (stand-ard units)	pH, lab (stand-ard units)	Temp-erature (°C)
11S/2W-21K3	06-15-87	1030	2,150	1,900	6.7	7.1	17.5
11S/2W-28A1	06-17-87	1415	1,560	1,500	6.9	7.0	21.5
11S/2W-33C1	06-15-87	1120	1,490	1,390	7.2	7.3	20.0
11S/2W-34M2	06-17-87	1445	1,620	1,520	7.2	7.3	21.5
12S/1W-6M1	06-17-87	1545	1,540	1,460	7.0	7.5	20.0
12S/1W-18M1	06-16-87	1100	1,610	1,610	6.9	7.5	22.0
12S/2W-2Q1	07-02-87	1230	1,700	1,820	6.7	7.2	--
12S/2W-3M1	06-15-87	1230	2,450	2,280	--	7.2	22.0
12S/2W-4P3	07-02-63	0845	--	1,135		7.6	--
12S/2W-4Q1	06-15-87	1330	2,730	2,610	6.9	7.5	22.0
12S/2W-9C3	07-02-63	0945	--	980	--	7.8	--
12S/2W-9P1	07-02-63	1015	--	1,655	--	7.8	--
12S/2W-9R1	06-15-87	1430	2,570	2,390	7.0	7.1	21.0
12S/2W-10K1	06-16-87	1515	3,300	2,930	6.9	7.0	21.5
12S/2W-10P1	01-09-63	1630	--	1,083	--	7.4	--
12S/2W-11E1	01-09-63	0900	--	1,074	--	7.4	--
12S/2W-12B1	06-16-87	0900	1,650	1,630	7.2	7.1	21.0
12S/2W-12E1	07-02-63	--	--	1,790	--	7.6	--
12S/2W-12E2	11-08-63	--	--	1,300	--	7.6	--
12S/2W-12K1	06-17-87	1610	1,360	1,260	7.3	7.5	--
12S/2W-13E1	07-03-63	1115	--	667	--	7.9	21
12S/2W-13E2	06-16-87	1000	1,860	1,820	7.1	7.3	20.0
12S/2W-13G1	01-09-63	1420	--	1,890	--	7.3	--
12S/2W-14F1	11-08-63	--	--	940	--	7.5	--
12S/2W-14F3	01-08-63	--	--	1,266	--	7.1	--
12S/2W-15C1	06-16-87	1215	1,540	1,520	7.2	7.3	22.0
12S/2W-15J1	06-06-63	--	--	1,220	--	7.6	--
12S/2W-16B1	07-02-63	1115	--	1,365	--	7.9	--
12S/2W-16N1	06-06-63	--	--	1,618	--	7.7	--
12S/2W-17H1	07-02-87	1030	1,520	1,640	6.7	7.4	--
12S/2W-17H1	06-24-64	--	--	1,670	--	7.4	27
12S/2W-17M2	06-06-63	--	--	1,188	--	7.5	--
12S/2W-20G1	06-06-63	--	--	9,000	--	7.0	--
12S/2W-20J5	06-06-63	--	--	4,665	--	7.1	--
12S/2W-20J9	06-06-63	--	--	2,994	--	7.4	--
12S/2W-20K3	06-06-63	--	--	13,568	--	6.5	--
12S/2W-20K4	11-08-63	--	--	1,330	--	6.8	--
12S/2W-20Q2	06-06-63	--	--	3,061	--	7.1	--
12S/2W-21D2	11-08-63	--	--	2,000	--	7.8	--
12S/2W-21M3	07-03-63	0915	--	1,960	--	7.3	--
12S/2W-21N1	06-16-87	1240	9,500	7,980	6.7	6.9	21.5
12S/2W-22J1	07-02-63	1545	--	1,890	--	7.7	--
12S/2W-27B4	06-17-87	1615	2,150	2,130	7.1	7.2	22.0
12S/2W-28H1	07-02-63	1430	--	1,140	--	7.6	22.0
12S/2W-29H2	06-16-87	1445	2,180	2,170	7.2	7.4	21.0
12S/2W-30K1	06-16-87	1400	2,050	1,830	7.4	7.6	20.5
Surface-water site							
Escondido Creek 1	09-01-87	1300	1,475	1,480	8.4	8.7	--
Escondido Creek 2	09-01-87	1100	1,950	1,960	8.1	8.1	--

Table 1.--Water-quality data, 1963-64 and 1987--Continued

Well No.	Hardness (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Alkalinity, total field (mg/L as $CaCO_3$)	Alkalinity, lab (mg/L as $CaCO_3$)
11S/2W-21K3	480	110	51	190	0.90	190	196
11S/2W-28A1	450	100	49	130	6.9	191	209
11S/2W-33C1	320	76	32	150	2.2	211	209
11S/2W-34M2	440	96	49	120	3.2	204	215
12S/1W-6M1	310	70	34	190	1.2	245	242
12S/1W-18M1	540	93	75	130	4.2	262	266
12S/2W-2Q1	490	110	52	190	2.7	--	270
12S/2W-3M1	790	120	120	140	5.6	219	183
12S/2W-4P3	--	82	52	123	4.0	--	183
12S/2W-4Q1	590	110	76	200	3.4	342	338
12S/2W-9C3	--	88	27	100	5.0	--	117
12S/2W-9P1	--	78	73	227	2.0	--	290
12S/2W-9R1	930	190	110	160	3.8	305	323
12S/2W-10K1	1,000	170	140	170	5.5	236	245
12S/2W-10P1	--	41	41	116	2.0	--	226
12S/2W-11E1	--	43	21	157	2.0	--	221
12S/2W-12B1	400	88	44	190	.80	264	272
12S/2W-12E1	--	125	89	197	5.0	--	173
12S/2W-12E2	--	54	45	165	1.0	--	233
12S/2W-12K1	410	94	42	92	3.7	197	202
12S/2W-13E1	--	38	25	63	2.0	--	128
12S/2W-13E2	550	120	60	140	6.1	236	232
12S/2W-13G1	--	124	98	116	9.0	--	260
12S/2W-14F1	--	46	33	104	4.0	--	149
12S/2W-14F3	--	65	31	143	1.0	--	221
12S/2W-15C1	450	94	53	110	3.0	218	220
12S/2W-15J1	--	65	35	137	2.0	--	239
12S/2W-16B1	--	62	53	185	3.0	--	285
12S/2W-16N1	--	63	45	220	6.0	--	224
12S/2W-17H1	500	71	79	160	6.8	--	232
12S/2W-17H1	--	87	75	165	6.0	--	184
12S/2W-17M2	--	51	39	129	4.0	--	130
12S/2W-20G1	--	650	435	660	15	--	456
12S/2W-20J5	--	200	174	531	7.0	--	270
12S/2W-20J9	--	118	92	388	4.0	--	332
12S/2W-20K3	--	970	795	940	16	--	296
12S/2W-20K4	--	93	56	97	4.0	--	65
12S/2W-20Q2	--	146	79	420	17	--	342
12S/2W-21D2	--	70	57	330	2.0	--	--
12S/2W-21M3	--	150	74	160	5.0	--	183
12S/2W-21N1	2,500	370	380	750	2.6	373	371
12S/2W-22J1	--	125	125	153	3.0	--	235
12S/2W-27B4	670	130	85	180	1.2	259	270
12S/2W-28H1	--	74	47	115	4.0	--	193
12S/2W-29H2	770	150	95	150	3.4	285	201
12S/2W-30K1	550	140	48	150	5.7	284	275
Surface-water site							
Escondido Creek 1	400	61	60	230	2.9	184	116
Escondido Creek 2	520	90	71	230	3.3	217	187

Table 1.--Water-quality data, 1963-64 and 1987--Continued

Well No.	Sulfate, dis-solved (mg/L as SO_4)	Chlo-ride, dis-solved (mg/L as Cl)	Fluo-ride, dis-solved (mg/L as F)	Solids, sum of consti-tuents, dis-solved (mg/L)	Nitro-gen, NO_2+NO_3 dis-solved (mg/L as N)	Boron, dis-solved (μg/L as B)	Iron, dis-solved (μg/L as Fe)	Manga-nese, dis-solved (μg/L as Mn)
11S/2W-21K3	300	290	0.30	1,100	1.7	90	8	120
11S/2W-28A1	220	230	.30	900	1.1	80	4	190
11S/2W-33C1	170	180	.50	790	13.0	100	11	4
11S/2W-34M2	130	250	.30	820	9.0	70	6	32
12S/1W-6M1	190	180	.60	860	13.0	140	6	2
12S/1W-18M1	360	160	.30	1,000	2.9	200	8	4
12S/2W-2Q1	300	220	.50	1,100	11.0	180	5	<1
12S/2W-3M1	400	330	.20	1,300	30.0	130	20	20
12S/2W-4P3	115	230	.04	822	[1]14.7	10	--	--
12S/2W-4Q1	370	430	.50	1,400	14.0	160	20	90
12S/2W-9C3	290	94	.60	688	1.0	40	--	--
12S/2W-9P1	160	351	.90	1,130	[1]5.4	50	--	--
12S/2W-9R1	470	330	.30	1,500	16.0	100	20	<10
12S/2W-10K1	640	470	.40	1,800	21.0	130	20	10
12S/2W-10P1	96	114	.70	645	[1]8.8	100	--	--
12S/2W-11E1	116	90	.70	690	[1]6.9	0.00	--	--
12S/2W-12B1	260	180	.30	960	16.0	130	6	1
12S/2W-12E1	267	293	.80	1,420	[1]64.6	.00	--	--
12S/2W-12E2	87	224	.10	785	[1]8.6	190	--	--
12S/2W-12K1	110	210	.70	720	5.0	40	7	1,000
12S/2W-13E1	40	90	.50	419	[1]7.9	30	--	--
12S/2W-13E2	150	260	.30	930	36.0	70	6	<1
12S/2W-13G1	187	269	.40	1,180	[1]36.1	60	--	--
12S/2W-14F1	63	177	.20	580	[1]4.2	130	--	--
12S/2W-14F3	59	212	.50	724	[1]6.3	50	--	--
12S/2W-15C1	110	240	.30	800	20.0	90	5	<1
12S/2W-15J1	72	180	.50	719	[1]9.3	110	--	--
12S/2W-16B1	102	254	.60	904	[1]7.0	70	--	--
12S/2W-16N1	202	226	.50	1,040	[1]18.1	80	--	--
12S/2W-17H1	390	140	.30	1,000	11.0	4	4	5
12S/2W-17H1	317	181	.20	1,110	[1]39.1	80	--	--
12S/2W-17M2	70	208	.70	698	[1]15.8	720	--	--
12S/2W-20G1	249	2,920	.50	5,330	[1]13.6	17,000	--	--
12S/2W-20J5	185	1,290	.50	2,700	[1]24.8	210	--	--
12S/2W-20J9	133	720	.70	1,730	[1]7.9	210	--	--
12S/2W-20K3	139	5,120	.60	8,280	[1]18.1	1,800	--	--
12S/2W-20K4	102	286	.20	833	[1]26.2	270	--	--
12S/2W-20Q2	432	535	.70	1,910	[1]5.4	970	--	--
12S/2W-21D2	238	334	.60	1,300	24.0	--	--	--
12S/2W-21M3	102	507	.50	1,160	[1]2.7	30	--	--
12S/2W-21N1	1,000	1,700	.30	4,500	86.0	210	50	60
12S/2W-22J1	338	332	.50	1,390	[1]26.9	30	--	--
12S/2W-27B4	290	330	.30	1,200	23.0	100	20	<10
12S/2W-28H1	127	174	.50	768	[1]15.4	20	--	--
12S/2W-29H2	410	290	.30	1,300	15.0	100	20	<10
12S/2W-30K1	240	280	.20	1,100	9.1	150	8	180
Surface-water site								
Escondido Creek 1	280	250	.50	1,000	5.1	250	10	11
Escondido Creek 2	250	270	.50	1,100	5.1	240	15	25

[1]Calculated by dividing nitrate (NO_3) concentration by 4.427.

Table 2.--Summary of water-quality data for base-flow conditions in Escondido Creek at Harmony Grove, 1950-81

[From Izbicki, 1983. ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 °C; °C, degrees Celsius; mg/L, milligrams per liter; <, less than; --, no data]

	1950-72				1974-81			
	Number of observations	Minimum	Median	Maximum	Number of observations	Minimum	Median	Maximum
Instantaneous discharge (ft^3/s)	127	<0.1	1.5	8.0	25	2.0	4.0	7.0
Specific conductance (µS/cm)	126	970	1,980	3,010	25	1,500	1,930	2,180
pH (standard units)	114	6.0	7.4	9.0	25	8.0	8.1	9.0
Calcium (mg/L)	56	50	83	110	1	--	84	--
Magnesium (mg/L)	56	32	44	61	1	--	61	--
Sodium (mg/L)	73	150	260	330	1	--	220	--
Alkalinity as $CaCO_3$ (mg/L)	114	84	214	290	0	--	--	--
Sulfate (mg/L)	61	180	290	360	24	200	270	300
Chloride (mg/L)	125	130	320	460	24	260	330	450
Dissolved solids (mg/L)	58	835	1,260	1,500	24	1,020	1,240	1,380

Ground Water

Water-quality characteristics in the subarea for the period 1963-64 are shown in figure 6. Most of the 26 wells shown were sampled in summer 1963. Well 12S/2W-17H1 was sampled in summer 1964. Historical water-quality data for the subarea were obtained from California Department of Water Resources (1967). Data describing ground-water quality for 1963-64 and 1987 are summarized in table 3. Average values of water-quality data were used because all wells but one (12S/2W-17H1) sampled in 1987 were different from those sampled in 1963-64.

Dissolved-solids concentration of ground water sampled during 1963-64 ranged from 419 to 8,280 mg/L (table 1). The median concentration was 972 mg/L (table 3). Water from only one well sampled in 1963-64 (12S/2W-13E1) had dissolved-solids concentration less than 500 mg/L, the U.S. Environmental Protection Agency (EPA) recommended limit for drinking water (U.S. Environmental Protection Agency, 1986). Water from 13 wells had dissolved-solids concentrations greater than 1,000 mg/L. In general, dissolved-solids concentrations were lower in the eastern part of the subarea and in the northern part near Reidy Canyon. Some wells were completed in crystalline rocks, some in residuum, and some in alluvium; analyses indicate that differences in dissolved-solids concentration among the different aquifer types were small.

Table 3.--Summary of ground-water-quality data, 1963-64 and 1987

[Concentrations in milligrams per liter. Number of samples for 1963-64, 26 (25 for alkalinity, lab); number of samples for 1987, 20]

	1963-64			1987		
Constituents	Minimum	Median	Maximum	Minimum	Median	Maximum
Calcium	38	80	970	70	110	370
Magnesium	21	54.5	795	32	56	380
Sodium plus potassium	65	162	956	96	160	753
Alkalinity, lab	65	224	456	183	237	371
Sulfate	40	130	432	110	295	1,000
Chloride	90	242	5,120	140	255	1,700
Dissolved solids	419	972	8,280	720	1,050	4,500
Nitrate (as nitrogen)	1.0	11.5	64.6	1.1	13.5	86.0

Most of the ground water in the subarea in 1963-64 was classified as a mixed chemical type, dominated by sodium and chloride, as shown in the water-quality diagrams in figure 6. Three wells yielded water of a sodium chloride type (12S/2W-20J5, 12S/2W-17M2, and 12S/2W-9P1). Sodium plus potassium concentrations ranged from 65 to 956 mg/L, with a median of 162 mg/L. Concentrations of sodium and chloride in ground water exceeding the EPA recommended drinking-water limit of 250 mg/L for each (the sodium limit concerns persons on a sodium-restricted diet) were attributed largely to domestic-wastewater disposal practices (California Department of Water Resources, 1967). The effluent contained sodium, chloride, and sulfate (California Department of Water Resources, 1967). Sulfate concentration in ground water ranged from 40 to 432 mg/L, with a median of 122 mg/L.

Magnesium and calcium concentrations in ground water are influenced by the mineralogic composition of the aquifer materials. Magnesium can be correlated with the gabbros in the study area (California Department of Water Resources, 1967), and calcium can be correlated with the tonalites. Magnesium concentration in 1963-64 ranged from 21 to 795 mg/L, with a median of 54.5 mg/L. Calcium concentration in 1963-64 ranged from 38 to 970 mg/L, with a median of 80 mg/L.

Nitrate (as nitrogen) concentration in ground water in 1963-64 ranged from 1.0 to 64.6 mg/L, with a median of 11.5 mg/L. Nitrate concentrations exceeded the EPA recommended limit for drinking water of 10 mg/L (U.S. Environmental Protection Agency, 1986) in water from 13 wells sampled in 1963-64. Elevated nitrate concentrations in ground water were attributed to domestic-waste disposal practices and the use of chemical fertilizers (California Department of Water Resources, 1967).

Water quality and chemical character for 1987 are shown in figure 7. Regional patterns of dissolved-solids concentration for 1987 were generally the same as in 1963-64. However, both the minimum dissolved-solids concentration (720 mg/L) and the median (1,050 mg/L) were higher than in samples collected during 1963-64. All 20 wells sampled in 1987 contained water with dissolved-solids concentrations greater than the EPA recommended limit of 500 mg/L. Water from 12 wells had dissolved-solids concentrations equal to or greater than 1,000 mg/L. Water from well 12S/2W-21N1 had a dissolved-solids concentration of 4,500 mg/L. There was little difference among dissolved-solids concentrations in water from wells completed in crystalline rocks, residuum, and alluvium.

Most of the ground water sampled in 1987 is classified as a mixed chemical type, with sodium the major cation and chloride and sulfate the major anions, as shown by the water-quality diagrams in figure 7. The minimum and median values of all analyzed constituents were higher in 1987 than in 1963-64--except for sodium plus potassium, for which the median remained the same (table 2). The largest increases were in sulfate concentrations. In 1987, the median sulfate concentration in ground water was 295 mg/L. The median concentration of sulfate in ground water during 1963-64 was 130 mg/L. Water from 12 wells sampled in 1987 had sulfate concentrations that exceeded the EPA recommended limit for drinking water of 250 mg/L (U.S. Environmental Protection Agency, 1986).

During 1987, nitrate (as nitrogen) concentration ranged from 1.1 to 86.0 mg/L, with a median of 13.5 mg/L. Water from 14 wells had nitrate (as nitrogen) concentrations that exceeded the EPA recommended limit of 10 mg/L. Elevated dissolved-solids, chloride, sulfate, and nitrate (as nitrogen) concentrations are an indication of contamination from septic systems in unsewered residential areas (Todd and others, 1976), and also may reflect the influence of irrigation return waters.

Increased mineralization of ground water is intensified in the Escondido subarea by the slow movement of ground water through the water-bearing units (California Department of Water Resources, 1967). These rather stagnant conditions result in more time for accumulation of dissolved salts. As mentioned previously, poor quality has limited the use of ground water. Only small quantities are used for irrigation and for selected domestic purposes at a few residences.

SUMMARY

This report presents the results of a study to refine the understanding of the ground-water system in the Escondido hydrologic subarea and to determine current (1987) water-quality conditions.

The public water supply for residents of Escondido is obtained from Lake Wohlford and from diversions from northern California mixed with water from the Colorado River. Use of water from public supply wells south of the study area was discontinued in 1977 because of high nitrate concentrations.

Water levels in the subarea were within 20 feet of land surface. Ground-water altitudes ranged from 866 feet above sea level at the north end of Reidy Canyon to 626 feet in western Escondido. Ground water flows from the residuum into the alluvium. Ground water flows from north to south in the alluvium of Reidy Canyon and from east to west in the alluvium near Escondido.

Natural recharge of ground water in the subarea is from direct percolation of precipitation and of water in Escondido Creek and in small runoff channels. Precipitation in 1987 was 0.52 inch higher than the 1931-87 average of 15.80 inches. Irrigation return flow, which is a source of ground-water contamination, also is a source of recharge.

Sources of natural discharge of ground water from the subarea are underflow and evapotranspiration of phreatophytes. Small quantities of ground water are pumped from wells for irrigation and for selected domestic purposes at a few residences.

Minimum concentrations of dissolved solids, chloride, and sulfate in water from Escondido Creek increased between 1950-72 and 1974-81, reflecting the increased influence of irrigation return water. Current (1987) water-quality conditions generally, however, are not significantly different from historical conditions.

In 1963-64, dissolved-solids concentration in water from 26 wells ranged from 419 to 8,280 mg/L. Regional patterns of dissolved-solids concentration in 1987 were generally the same as in 1963-64. In 1987, dissolved-solids concentration in water from 20 wells ranged from 720 to 4,500 mg/L. Water from all 20 wells sampled in 1987 had dissolved-solids concentrations greater than 500 mg/L, and 12 wells contained water with concentrations equal to or greater than 1,000 mg/L. Domestic waste-disposal practices and the slow movement of ground water through the system contribute to high dissolved-solids concentrations.

Nitrate (as nitrogen) concentration in water from wells sampled ranged from 1.0 to 64.6 mg/L in 1963-64 and from 1.1 to 86.0 mg/L in 1987. Water from 14 wells in 1987 had nitrate (as nitrogen) concentrations greater than the U.S. Environmental Protection Agency recommended limit for drinking water. Probable sources of high nitrate concentrations are contamination from septic systems and irrigation return flow.

Most water sampled in both 1963-64 and 1987 was classified as mixed chemical types. In 1963-64, the dominant cation was sodium and the dominant anion was chloride. In 1987, the dominant cation was sodium and the dominant anions were chloride and sulfate.

SELECTED REFERENCES

California Department of Water Resources, 1967, Ground-water occurrence and quality, San Diego region: California Department of Water Resources Bulletin 106-2, 233 p.

-----1986, San Diego County land use survey: San Marcos 15-minute quadrangle map 71-59; Rancho Santa Fe 15-minute quadrangle map 72-59; Valley Center 15-minute quadrangle map 71-60; Escondido 15-minute quadrangle map 72-60.

California Regional Water Quality Control Board, San Diego Region, 1975, Comprehensive water quality control plan abstract: 58 p.

Izbicki, J.A., 1983, Evaluation of the San Dieguito, San Elijo, and San Pasqual hydrologic subareas for reclaimed water use, San Diego County, California: U.S. Geological Survey Water-Resources Investigations Report 83-4044, 131 p.

-----1985, Evaluation of the Mission, Santee, and Tijuana hydrologic subareas for reclaimed water use, San Diego County, California: U.S. Geological Survey Water-Resources Investigations Report 84-4032, 99 p.

Evenson, K.D., 1989, Water resources of Soledad, Poway, and Moosa basins, San Diego County, California: U.S. Geological Survey Water-Resources Investigations Report 88-4030, 87 p.

National Oceanic and Atmospheric Administration, published monthly and annually (all data prior to 1940 by U.S. Weather Bureau), Climatological data: National Oceanic and Atmospheric Administration, climatological data, monthly publications, and annual summaries.

Todd, D.K., Tinlin, R.M., Schmidt, K.D, and Everett, L.D., 1976, Monitoring ground-water quality: Monitoring methodology: U.S. Environmental Protection Agency-600/4-76-026, 154 p.

U.S. Environmental Protection Agency, 1986, Quality criteria for water: Washington D.C., U.S. Government Printing Office, EPA 44015-86-001.

U.S. Soil Conservation Service, 1973, Soil survey, San Diego County, California: part 1, 104 p.; part 2, 118 p., 76 maps.