WATER RESOURCES OF THE DESCANSO AREA, SAN DIEGO COUNTY, CALIFORNIA

By Lowell F.W. Duell, Jr.

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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	0.4047	hectare
acre-foot (acre-ft)	0.001233	cubic hectometer
acre-foot per year (acre-ft/yr)	0.001233	cubic hectometer per year
foot (ft)	0.3048	meter
foot per day (ft/d)	0.3048	meter per day
foot squared per day (ft^2/d)	0.09290	meter squared per day
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
gallons (gal)	0.003785	cubic meter
gallon per day (gal/d)	0.003785	cubic meter per day
gallon per minute (gal/min)	0.06309	liter per second
inch (in.)	25.4	millimeter
inch per year (in/yr)	25.4	millimeter per year
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

OTHER ABBREVIATIONS USED

mg/L = milligrams per liter
μg/L = micrograms per liter
μS/cm = microsiemens per centimeter

DEFINITIONS

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.

"Water year" refers to the 12-month period October 1 through September 30 and is designated by the calendar year in which it ends and which contains 9 of the 12 months. Thus, the year ending September 30, 1988, is called the 1988 water year.

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ABSTRACT

The Descanso area in south-central San Diego County has a potential for additional residential development that would increase demands on water resources. The area includes about 8 square miles of the upper Sweetwater River basin. Current residents rely entirely on water pumped from wells for their water supply. The Descanso area contains most of the population, and most of the ground-water pumpage in the basin occurs there. Hydrologic information was collected during water year 1988 (October 1987 to September 1988) to evaluate the effects of current pumping on ground-water levels in the Descanso area.

The Sweetwater River is the principal stream draining the area. Most precipitation normally occurs between November and April, and runoff occurs mainly between January and May. For water year 1988, precipitation at the Descanso Ranger Station was 94 percent of normal, and flow volume in the Sweetwater River near Descanso was 98 percent of normal.

The ground-water system in the area consists of aquifers in metamorphic and granitic bedrock and in the overlying regolith (weathered bedrock). Most wells penetrate both aquifers, but the regolith is the source of most water pumped from wells. In stream valleys and on hillsides, the water table usually occurs in the regolith. On hilltops, the water table may be in bedrock below the regolith. The general direction of ground-water movement is from northeast to southwest.

Ground-water levels were nearly the same at the end of water year 1988 as at the beginning. Water levels in wells generally rose from October 1987 through May 1988 and declined from May through September 1988.

Ground water in storage in 1988 was estimated to be 800 to 2,000 acre-feet in the regolith and 300 to 3,000 acre-feet in bedrock. The estimates of storage represent the maximum amount of ground water that theoretically could be recovered if the system were completely drained. The actual amount of recoverable ground water is much less because of various physical limitations (including well spacing and well yields), as well as economic, legal, and environmental constraints. During water year 1988, recharge to the ground-water system from infiltration of precipitation and streamflow was estimated to be about 1,000 acre-feet, and pumpage was estimated to be about 170 acre-feet.

Ground-water quality generally is suitable for domestic drinking water. However, concentrations of iron and manganese, although nontoxic, exceeded California maximum contaminant levels for domestic drinking water in some wells. Dissolved-solids concentrations in water samples from 10 wells ranged from 247 to 424 milligrams per liter. The most abundant cation was calcium, and the most abundant anion usually was bicarbonate.

The effects of pumping on ground-water storage were minimal during water year 1988. During periods of drought when there is little or no ground-water recharge, some of the ground water in storage could be used to meet water needs.

INTRODUCTION

Most of San Diego County is experiencing rapid population growth. The Descanso area, in the south-central part of the county (fig. 1), has a potential for additional residential development that would increase demands on the water resources. Current residents rely entirely on water pumped from privately owned domestic or community wells for their water supply. Planning for new development is restricted by the lack of information on the water resources. The need for additional information prompted a study of the water resources of the Descanso area by the U.S. Geological Survey in cooperation with the County of San Diego, Department of Planning and Land Use.

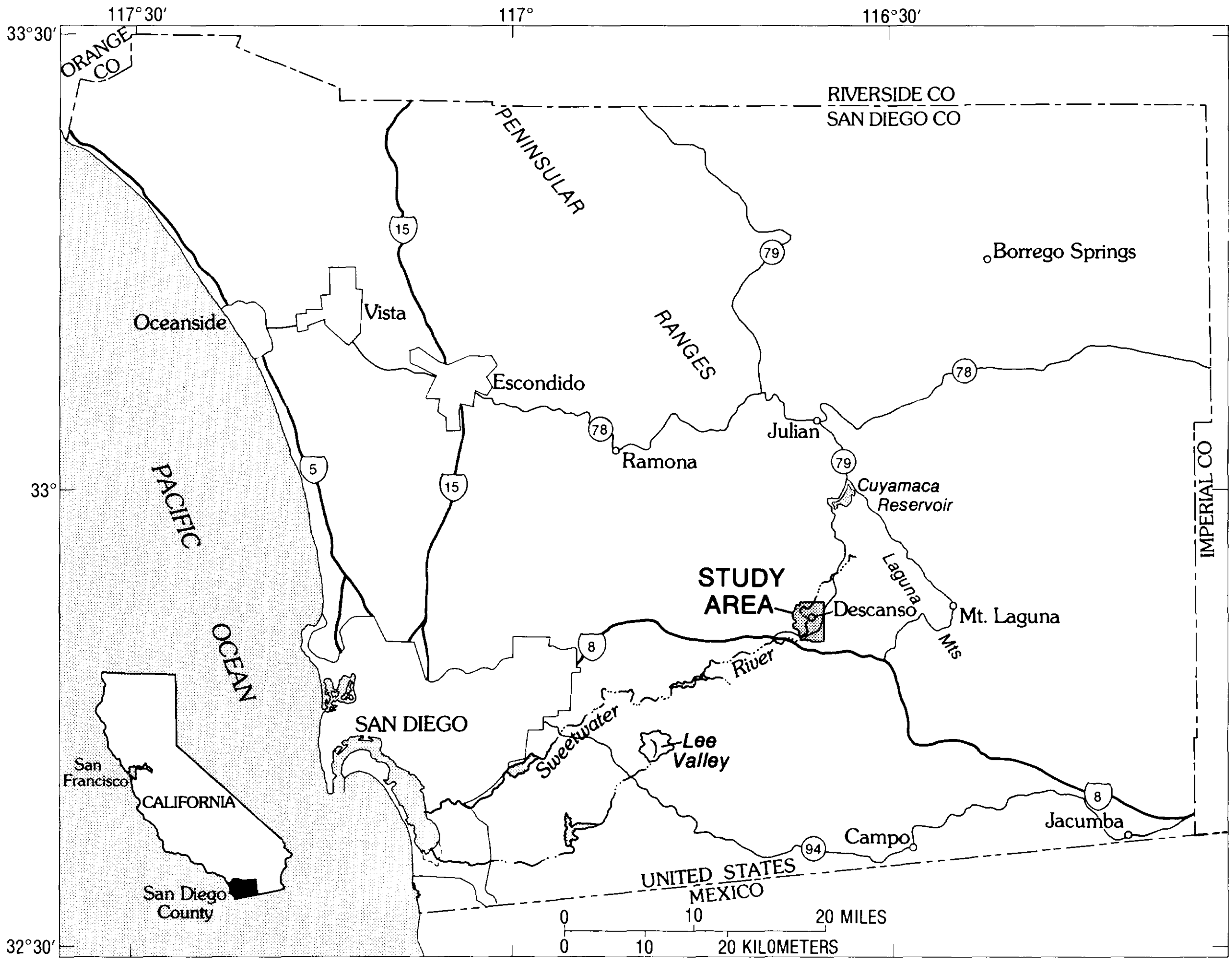


Figure 1. Location of study area.

The Descanso area is in the southern part of the upper Sweetwater River basin (fig. 2). The northern part of the basin is occupied by Cuyamaca State Park and thus has little potential for future development. The Descanso area contains most of the population, and most of the ground-water pumpage from the upper Sweetwater River basin occurs there.

PURPOSE AND SCOPE

The purpose of this study was to define surface- and ground-water conditions and to evaluate the effects of current ground-water pumping on ground-water levels in the Descanso area. Most of the data were collected in the Descanso area; however, additional data were collected upgradient and downgradient of the area.

The report describes: (1) the seasonal variability of streamflow and chemical quality of the Sweetwater River near Descanso; (2) occurrence and movement of ground water; (3) ground-water storage, recharge, and discharge; (4) chemical quality of ground water; and (5) drawdown of the water table that could be

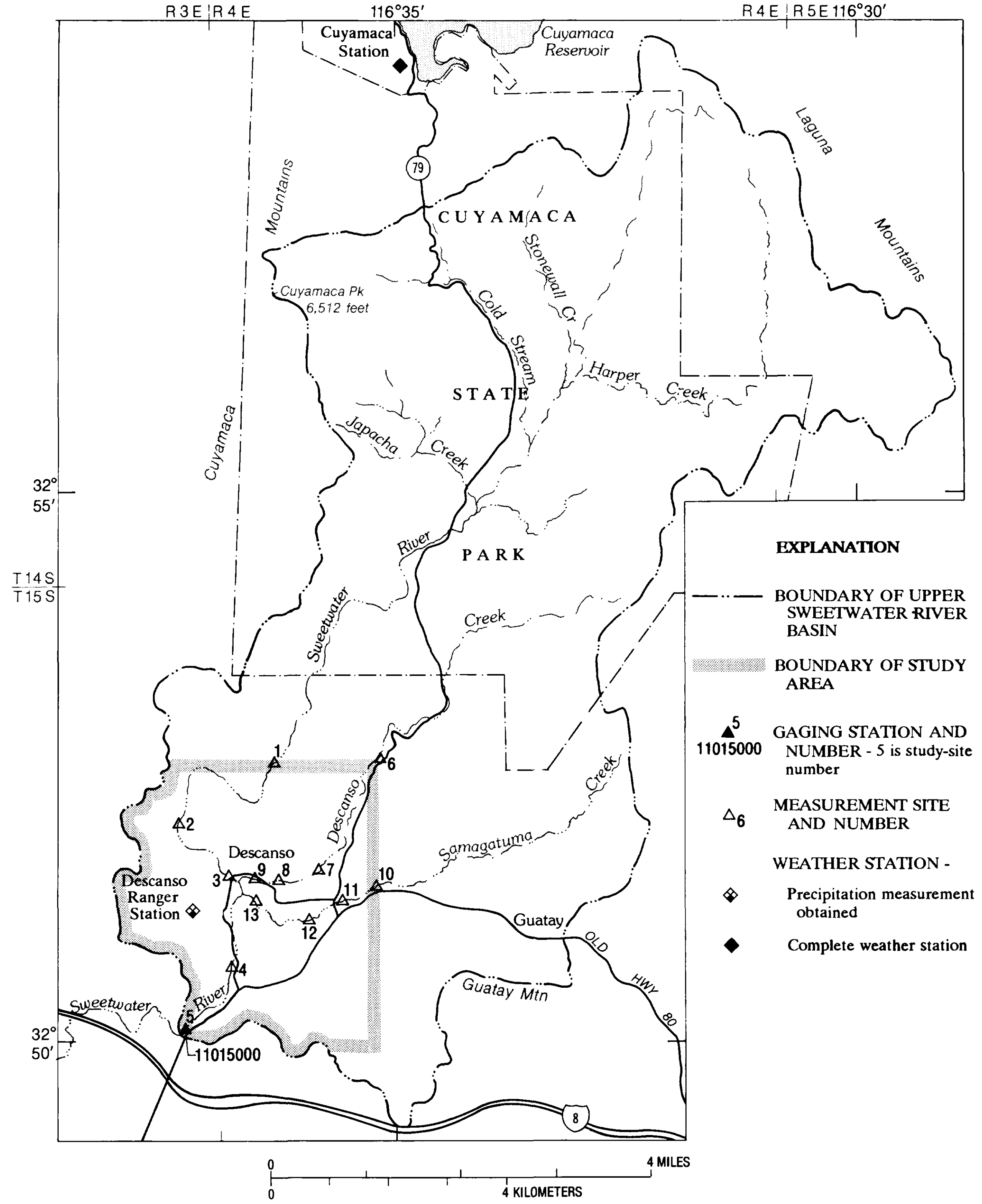


Figure 2. Descanso area, upper Sweetwater River basin, and location of streamflow-measurement sites and weather stations.

expected around hypothetical pumped wells for various hydraulic conditions.

Data for this study were collected during water year 1988 (October 1, 1987, to September 30, 1988). All annual values in this report are for the water year, unless otherwise noted.

FIELD AND LABORATORY METHODS

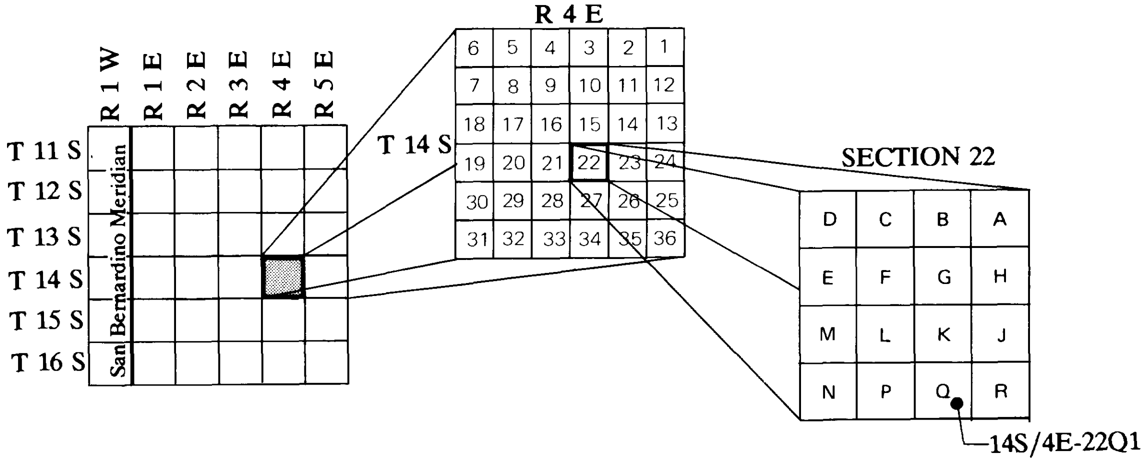
Stream-discharge measurements were made and surface- and ground-water samples were collected using standard U.S. Geological Survey field techniques (U.S. Geological Survey, 1977). Water samples were analyzed for dissolved inorganic chemicals and dissolved macronutrients (nitrogen and phosphorus) by the U.S. Geological Survey laboratory in Arvada, Colorado. The methods used for laboratory analysis are those described by Fishman and Friedman (1989).

ACKNOWLEDGMENTS

Appreciation is expressed to the Descanso Community Water District for allowing access to wells and for supplying hydrologic data, to the Cuyamaca State Park and the many land owners who allowed access to their property, and to the U.S. Forest Service for providing precipitation data in a timely manner. Without their cooperation this study and report could not have been completed.

WELL-NUMBERING SYSTEM

Wells are numbered according to their location in the rectangular system for subdivision of public land. For example, in well number 14S/4E-22Q1, that part of the number preceding the slash indicates the township (T. 14 S.); the number and letter following the slash indicate the range (R. 4 E.); the number following the hyphen indicates the section (sec. 22); and the letter (Q) indicates the 40-acre subdivision of the section according to the lettered diagram below. The final digit (1) is a serial number for wells in each 40-acre subdivision. The area covered by this report lies in the southeast quadrant of the San Bernardino base line and meridian. Township and range are given along the margin of maps in this report. Thus, wells on maps are identified by the section number and the letter and serial number of the 40-acre subdivision in that section (for example, 22Q1).



DESCRIPTION OF STUDY AREA

LOCATION AND GENERAL FEATURES

The study area, referred to herein as the Descanso area, is about 30 miles east of San Diego (fig. 1) and includes about 8 mi^2 of the upper Sweetwater River basin (fig. 2). Altitude of land surface ranges from about 3,300 to 4,100 feet above sea level.

The Sweetwater River is the principal stream in the area. The river is the only surface-water outflow from the study area, and it is an important source of ground-water recharge. The river has a relatively flat gradient through most of the study area, but it steepens and has a nearly V-shaped channel where it exits the study area. The river is ephemeral; it flowed 250 days during 1988 at the Sweetwater River near Descanso gaging station (U.S. Geological Survey station 11015000 [study site 5 in fig. 2]). Two major tributaries to the Sweetwater River in the Descanso area are Descanso Creek and Samagatuma Creek; both creeks are ephemeral.

A survey of San Diego County in 1986 by the California Department of Water Resources (1987) provided information on current land use on 1:24,000-scale U.S. Geological Survey topographic maps. The survey showed land in the area to be mostly undeveloped and occupied by native-vegetation communities designated as coastal sage scrub, creosotebush scrub, southern oak woodland, valley grassland, and yellow pine. Dense stands of phreatophytes (mainly cottonwood and willow) grow along some of the stream channels.

POPULATION AND WATER SUPPLY

The population of the Descanso area is estimated to be about 1,400 full-time residents (Joey Perry, Department of Planning and Land Use, County of San Diego, oral commun., 1988). Most of the people live in or near the unincorporated community of Descanso (fig. 2).

The first community water system was started in the 1880's (Historical Committee of the Friends of the Descanso Library, 1988). The Descanso Community Water District had about 300 service connections in 1988. All water for the Water District is obtained from wells. The primary means of sewage disposal is by septic tanks.

GEOLOGY

The Descanso area is entirely within the Peninsular Ranges batholith of southern California and Baja California. The geology has been described by Everhart (1951) and in a map series that includes the Cuyamaca Peak quadrangle (Todd, 1977), the Descanso quadrangle (Hoggatt and Todd, 1977), and Viejas Mountain quadrangle (Todd, 1978). Metamorphic and granitic bedrock underlies the area. The metamorphic rocks consist of metasedimentary, volcanic, and metavolcanic rocks of Triassic to Jurassic age. The granitic rocks, which intruded the metamorphic and volcanic rocks and underlie most of the area, are of Cretaceous age. A regolith, unconsolidated material formed by in-place weathering of the bedrock, forms a relatively thin (average thickness about 50 feet) surface layer in most places. Alluvium of Quaternary age is present in several of the stream valleys; it probably is less than 10 feet thick in most places.

PRECIPITATION

The Descanso Ranger Station (fig. 2) is the only location in the study area where daily precipitation is measured. The Cuyamaca Station (fig. 2), which is about 10 miles north of the Descanso Ranger Station, is the nearest location outside the study area where daily precipitation is measured. The stations are U.S. National Oceanographic and Atmospheric Administration weather stations. Data for these stations were published by the U.S. Department of Agriculture (1934) and U.S. Department of Commerce (1953, 1954-89).

Most precipitation at the Descanso Ranger Station normally occurs between November and April, as shown in figure 3. Snow occasionally occurs in the winter months, and summer precipitation normally occurs as local thunderstorms. Monthly precipitation during January 1896 to August 1902, January 1909 to March 1916, and July 1932 to September 1988 was used to compute the long-term median monthly values shown in figure 3. Most precipitation during 1988 occurred between October and January and in April; during February and March, precipitation was less than the long-term median values.

Annual precipitation at the Descanso Ranger Station during 1897-1901, 1909-15, and 1933-88 (a period of record of 68 years) is shown in figure 4. Data are incomplete or not available for other water years. Precipitation ranged from 7.2 inches in 1961 to 47.2 inches in 1983; the mean value for the period was 24.1 inches. The 1988 precipitation was 22.7 inches, which is 94 percent of the long-term mean value.

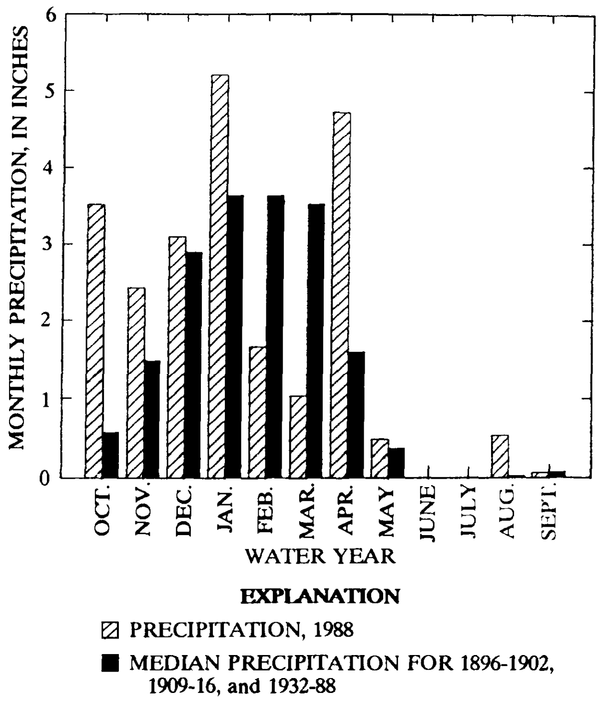


Figure 3. Monthly precipitation, water year 1988, and median monthly precipitation, water years 1896-1988, at Descanso Ranger Station.

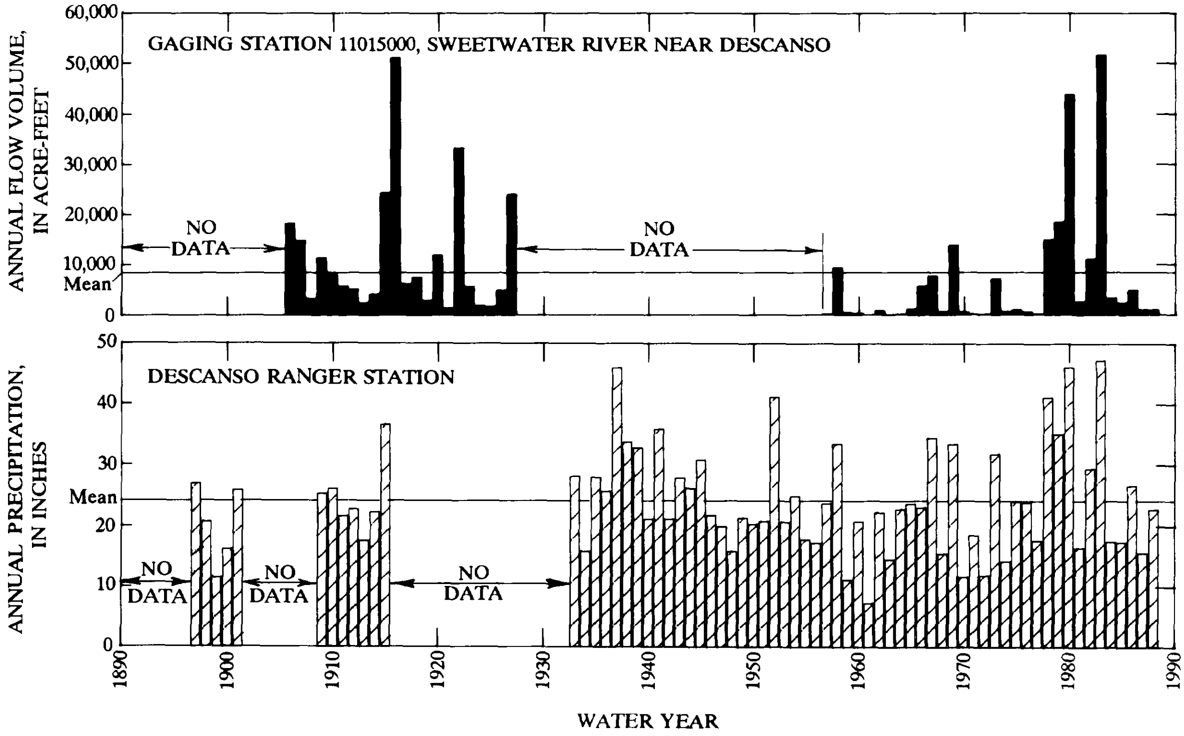


Figure 4. Annual flow volume at gaging station 11015000, Sweetwater River near Descanso, and annual precipitation at Descanso Ranger Station, water years 1897-1988.

Precipitation in the area varies with altitude and exceeds 30 in/yr at altitudes above 4,000 feet (Rantz, 1969). The Descanso Ranger Station is at an altitude of 3,400 feet, and the Cuyamaca Station is at an altitude of 4,640 feet.

Precipitation at the Cuyamaca Station, during the same 68-year period of record as that for the Descanso Ranger Station, ranged from 12.1 inches in 1961 to 74.4 inches in 1983 and averaged 36.1 inches. The mean precipitation at the Cuyamaca Station for 1888-1988 (101 years) was 34.2 inches.

SURFACE WATER

DISCHARGE

Discharge is computed by the U.S. Geological Survey for the stream-gaging station, Sweetwater River near Descanso (fig. 2). At the gaging station, the river drains about 45.4 mi^2 of the upper Sweetwater River basin. Altitude of the gaging station is 3,269 feet above sea level. Flow in the river at the gaging station was not regulated during 1988; however, some diversion from the river occurred prior to 1976 about 0.3 mile upstream from the station. The diversions, which were less than 0.5 ft^3/s, occurred at irregular intervals and were used to maintain cattle-watering ponds. The streamflow record for 1957-88 was determined from a recording gage and was adjusted to include the diversion. The record is rated "fair" (that is, about 95 percent of the daily mean discharge values are accurate within 15 percent). The streamflow record for 1906-27 was determined from nonrecording gages at several sites about 0.1 mile upstream from the present station and was unadjusted for the diversion. The record for 1906-27 is rated as "poor" (daily mean discharge values are of less than "fair" accuracy). Streamflow data were not collected during 1928-56.

Flow at the gaging station generally was greater during 1906-27 than during 1957-88 (fig. 4). The median annual flow volume was 5,900 acre-ft during 1906-27 and 960 acre-ft during 1957-88. During the 54-year period of record, annual flow volume ranged from 3.2 acre-ft in 1961 to 51,600 acre-ft in 1983. Flow volume in 1988 was 940 acre-ft, which is 98 percent of the 1957-88 median annual flow volume. Zero-flow days averaged 6 per year during 1907-27 (for 1906, only monthly flow values were available) and 115 per year during 1957-88. There were 116 zero-flow days at the gaging station in 1988.

The smaller flow volume and increased number of zero-flow days during 1957-88 may have been due, in part, to less precipitation during 1957-88 and to changes in upstream water use (for example, changes in ground-water pumpage). However, some of the change also could be due to use of different methods to collect the streamflow data.

Flow in the Sweetwater River near Descanso is seasonal. Most of the flow normally occurs from November to June (fig. 5) during and shortly after the main rainfall period. Distribution of flow during 1988 was fairly normal in comparison with the long-term distribution (median monthly flow volumes during 1957-88).

Discharge measurements were made at selected sites in February and April 1988 (table 1) in order to determine gaining and losing reaches of the Sweetwater River and tributaries. Some reaches of the river gained water from the ground-water system and some lost water. Descanso and Samagatuma Creeks lost water along their lower reaches. Streamflow losses along the Sweetwater River and Descanso and Samagatuma Creeks totaled 0.69 ft^3/s in February and 0.47 ft^3/s in April between sites 1, 6, and 10 at the upper end of the study area and site 5 (the gaging station) at the lower end.

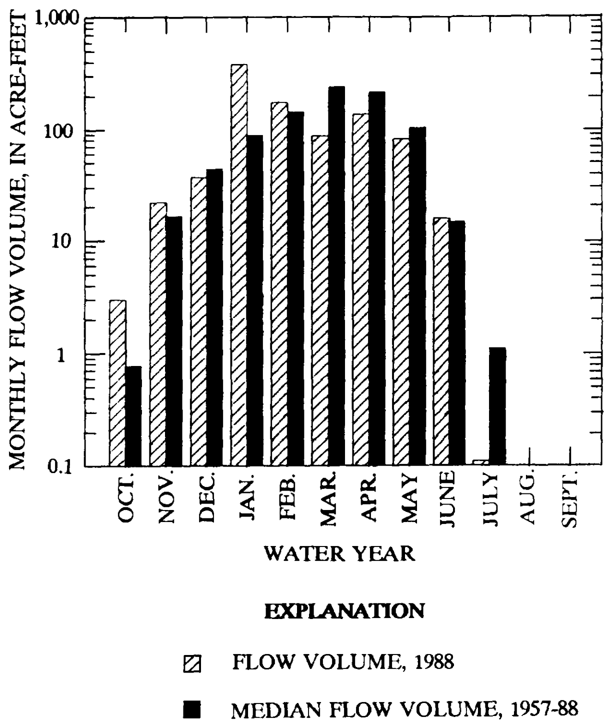


Figure 5. Monthly flow volume, water year 1988, and median monthly flow volume, water years 1957-88, at gaging station 11015000, Sweetwater River near Descanso.

WATER QUALITY

Water samples representing a broad range of flow were collected at the Sweetwater River gaging station in November 1987, February 1988, and May 1988 (table 2) to document the seasonal variability in chemical quality of water. Dissolved-solids concentrations were 430 mg/L on November 10, 1987; 277 mg/L on February 12, 1988; and 283 mg/L on May 10, 1988. There was little variation in the relative percentages of dissolved inorganic chemical constituents, as illustrated by the diagrams in figure 6. In the three samples collected at the gaging station, calcium was the most abundant cation and bicarbonate the most abundant anion.

Table 1.--*Discharge and field electrical conductivity at selected surface-water sites, February and April 1988*

[Study site No.: Location of sites is shown in figure 2. Q; discharge, in cubic feet per second. EC; electrical conductivity, in microsiemens per centimeter at 25 degrees Celsius. --, no data; <, less than]

	Study site No. (fig. 2)	February 18-19		April 11-12	
		Q	EC	Q	EC
Sweetwater River	1	2.4	430	0.61	440
	2	1.2	435	.22	440
	3	1.4	429	.40	430
	4	1.3	485	.60	473
	5	2.0	486	.59	545
Descanso Creek	6	.14	417	.05	445
	7	.00	--	.00	--
	8	<.03	670	.00	--
	9	.00	--	.00	--
Samagatuma Creek	10	.15	790	.40	830
	11	.06	630	<.03	803
	12	--	--	<.03	660
	13	.00	--	.00	--

Table 2.--*Physical and chemical data for Sweetwater River near Descanso and for selected wells*

[μS/cm, microsiemens per centimeter at 25 °C; °C, degrees Celsius; ft^3/s, cubic feet per second; mg/L, milligrams per liter; μg/L, micrograms per liter; NA, not applicable; <, less than]

Surface-water site or State well No.	Date	Depth of well (feet)	Altitude of land surface (feet above sea level)	Discharge, instantaneous (ft^3/s)	Electrical conductivity (μS/cm)	pH (standard units)	Temperature (°C)	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 $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)
Sweetwater River near	11-10-87	NA	3,269	0.44	673	7.2	14.0	59	22	50	1.8	128	120
Descanso (gaging	02-12-88	NA	3,269	2.0	485	7.8	15.0	42	14	34	1.9	91	62
station 11015000)	05-10-88	NA	3,269	1.3	490	7.9	20.0	39	14	34	1.2	101	66
14S/4E-22Q1	02-09-88	500	4,120	NA	516	8.0	18.5	53	12	30	3.5	90	91
15S/3E-13G2	02-09-88	59	3,432	NA	396	8.1	15.5	32	11	30	1.5	100	49
15S/3E-24G3	02-11-88	165	3,465	NA	415	7.7	16.0	33	12	30	4.8	132	24
15S/3E-25K4	02-11-88	400	3,310	NA	458	7.5	17.5	38	15	30	3.7	140	21
15S/3E-26K2	02-09-88	315	3,145	NA	656	8.0	18.5	48	27	37	4.0	120	30
15S/4E-9G1	02-11-88	178	3,880	NA	685	7.6	16.0	82	14	40	2.7	235	36
15S/4E-18R1	02-12-88	300	3,520	NA	384	7.9	18.0	38	8.0	30	4.4	145	12
15S/4E-19H2	02-09-88	321	3,485	NA	678	7.5	17.5	67	22	39	5.9	200	62
15S/4E-19N2	02-11-88	465	3,385	NA	552	7.5	17.0	58	14	35	4.0	155	57
15S/4E-21R1	02-12-88	300	3,960	NA	527	7.3	16.0	64	22	16	1.7	210	15

Surface-water site or State well No.	Date	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Solids, sum of constituents, dissolved (mg/L)	Nitrogen, NO_2+NO_3, dissolved (mg/L an N)	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, ammonia + organic, dissolved (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Phosphorus, ortho, dissolved (mg/L as P)	Boron, dissolved (μg/L as B)	Iron, dissolved (μg/L as Fe)	Manganese, dissolved (μg/L as Mn)
Sweetwater River near	11-10-87	69	0.30	31	430	<0.10	0.02	0.40	0.02	0.01	50	44	40
Descanso (gaging	02-12-88	46	.30	22	277	<.10	<.01	.50	.02	<.01	20	48	34
station 11015000)	05-10-88	45	.40	23	283	<.10	.02	<.20	.02	<.01	20	75	22
14S/4E-22Q1	02-09-88	45	.40	28	317	<.10	<.01	<.20	<.10	<.01	40	110	110
15S/3E-13G2	02-09-88	39	.30	33	257	.32	<.01	.30	.30	.02	20	40	3
15S/3E-24G3	02-11-88	34	.20	45	264	<.10	.05	<.20	<.01	<.01	20	1,500	220
15S/3E-25K4	02-11-88	32	.30	50	297	5.30	<.01	.40	.02	.02	40	4	2
15S/3E-26K2	02-09-88	100	.20	76	423	6.60	<.01	.40	.05	.04	50	24	3
15S/4E-9G1	02-11-88	55	.30	38	424	3.50	<.01	.40	<.01	<.01	40	5	13
15S/4E-18R1	02-12-88	27	.30	40	247	<.10	<.01	.30	.01	<.01	10	19	120
15S/4E-19H2	02-09-88	64	.30	35	417	<.10	.03	.30	.03	<.01	20	1,200	280
15S/4E-19N2	02-11-88	47	.40	55	366	<.10	.04	<.20	.02	<.01	60	2,800	230
15S/4E-21R1	02-12-88	31	.10	49	326	.30	<.01	.20	.02	<.01	<10	4	<1

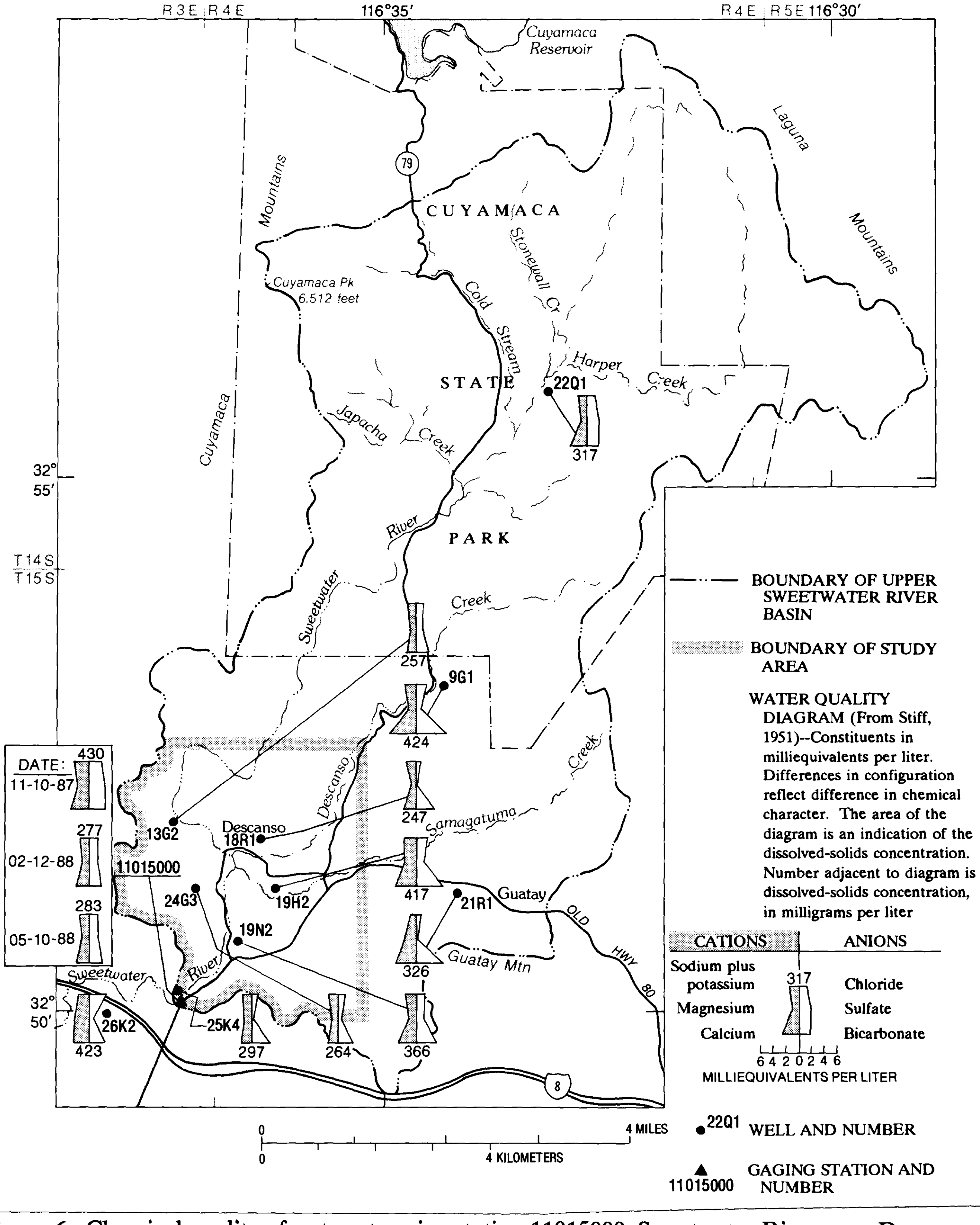


Figure 6. Chemical quality of water at gaging station 11015000, Sweetwater River near Descanso, and from selected wells.

GROUND WATER

OCCURRENCE AND MOVEMENT OF GROUND WATER

Most wells in the Descanso area penetrate the regolith and are drilled into fractured bedrock, but the regolith is the source of most water pumped from wells. Drillers' logs indicate that the thickness of the regolith ranges from 0 to 80 feet and averages about 50 feet. On the basis of studies done in similar areas, such as nearby Lee Valley (fig. 1) (Charles A. Kaehler, U.S. Geological Survey, written commun., 1989), the regolith near the land surface, where granitic rocks are deeply weathered, consists of friable grains and can be expected to act hydraulically much like a partly consolidated sandstone aquifer. With increasing depth, the regolith becomes less friable and acts more like a fractured-bedrock aquifer. In stream valleys and on hillsides, the water table commonly occurs in the regolith. On hilltops, the water table may be in bedrock below the regolith.

Merriam (1951) indicated that the yield of water from wells tapping the metamorphic and granitic bedrock units is largely a function of fracturing. Fracturing of bedrock increases ground-water storage and hydraulic connection with water stored in the regolith. In the Descanso area, most wells that tap bedrock are less than 500 feet deep, which probably is the maximum depth of open and hydraulically connected fractures.

Water levels were measured intermittently in 21 wells in 1988 (table 3) and continuously from January to June 1988 in 3 of those wells (fig. 7). Ten of the wells were completed in the regolith, and 11 of the wells penetrate the regolith and were completed in water-bearing fractures in bedrock. At two sites, water levels in nearby wells completed at different depths indicated that there was less than 5 feet of hydraulic-head difference between the regolith and fractured bedrock. Thus, hydraulic head did not vary significantly with depth, and the measured water levels closely approximated the altitude of the water table.

Depth to ground water and water-level altitude for May 1988 are shown in figure 8. The water table was closer to land surface beneath stream valleys in comparison with hillsides. During May 1988, depth to water in wells ranged from about 2 feet below land surface at well 15S/4E-19H1 (near Samagatuma Creek) to about 46 feet below land surface at well 15S/3E-25K4 (on a hillside about 500 feet from the Sweetwater River). The direction of ground-water movement was similar to that of surface drainage, generally from northeast to southwest (fig. 8).

WATER-LEVEL FLUCTUATIONS

Few data are available to define long-term trends in ground-water levels. Water-level hydrographs (fig. 9) for wells 15S/3E-24G2 and 15S/4E-19D3 were constructed using data supplied by the County of San Diego (John Peterson, Department of Planning and Land Use, written commun., 1988) and measurements made during 1988. Well 15S/3E-24G2, which is unused and hand dug, taps water in the regolith on a hillside about 0.5 mile from the Sweetwater River. The hydrograph for this well shows, in addition to seasonal fluctuations in water level, a general water-level decline of about 20 feet since 1982. This decline in water level may, in part, reflect below-normal precipitation during 1984-85 and 1987-88 following above-normal precipitation during 1978-80 and 1982. But the decline probably is due mainly to nearby pumping.

Well 15S/4E-19D3 taps water-bearing fractures in bedrock, and the water level in the well has declined about 4 feet since 1982. This well is about 500 feet from the Sweetwater River, and the water level probably is less affected by pumping and dry climatic conditions than are water levels in wells farther from the river.

Water-level hydrographs for part of 1988 for three unused wells are shown in figure 7. Well 15S/3E-13G1 was completed in bedrock and is about 200 feet from the Sweetwater River. Well 15S/3E-25K3 is a hand-dug well that taps

Table 3.--*Water levels in selected wells, October 1987 to September 1988*

[Water levels, in feet below land-surface datum. Well locations are shown in figure 8]

State well No.	Date	Water level
15S/3E-12Q3	01-14-88	17.40
	03-07-88	15.13
	03-08-88	15.18
	04-12-88	15.17
	05-10-88	14.85
	06-30-88	15.88
	09-14-88	20.66
15S/3E-13G1	10-13-87	16.07
	01-12-88	14.63
	03-07-88	12.62
	05-11-88	12.67
	06-27-88	13.48
	09-14-88	14.54
15S/3E-13G3	01-12-88	13.06
	03-07-88	12.31
	04-12-88	12.52
	05-11-88	12.33
	06-30-88	12.86
	09-14-88	14.73
15S/3E-24G2	10-13-87	36.63
	01-12-88	35.81
	03-07-88	31.77
	05-16-88	29.65
	06-30-88	31.85
	09-14-88	38.85
15S/3E-24H1	10-09-87	31.07
	01-12-88	30.90
	03-07-88	31.08
	05-16-88	30.95
	09-14-88	31.70
15S/3E-25K3	10-09-87	9.47
	11-10-87	6.18
	01-14-88	6.01
	02-12-88	5.93
	03-07-88	5.93
	04-22-88	6.04
	05-10-88	5.97
	06-27-88	6.20
	09-14-88	9.43
15S/3E-25K4	10-09-87	44.98
	01-15-88	39.04
	03-07-88	40.46
	05-16-88	45.61
	06-30-88	49.16
	09-14-88	46.98
15S/4E-17B2	10-14-87	26.57
	01-14-88	26.06
	03-08-88	24.15
	04-12-88	24.97
	05-16-88	25.33
	06-30-88	25.53
	09-14-88	26.31
15S/4E-17F1	10-14-87	10.94
	02-09-88	6.41
	04-11-88	7.13
	05-16-88	6.73
15S/4E-17P1	10-13-87	35.58
	01-14-88	35.42
	03-08-88	34.68
	04-12-88	33.62
	05-16-88	32.31
	06-30-88	31.24
	09-14-88	33.17
15S/4E-18M3	03-07-88	15.90
	05-11-88	15.52
	06-30-88	15.37
	09-14-88	16.19
15S/4E-18N2	10-13-87	8.62
	01-12-88	4.54
	03-07-88	4.17
	05-11-88	5.10
	06-29-88	3.71
	09-14-88	6.28
15S/4E-18P1	10-19-87	22.45
	01-12-88	23.48
	03-07-88	21.35
	05-11-88	20.67
	06-30-88	20.41
	09-14-88	22.13
15S/4E-19D3	10-13-87	10.85
	01-12-88	9.07
	02-11-88	8.51
	03-07-88	8.76
	05-11-88	9.18
	06-27-88	10.16
	09-14-88	13.80
15S/4E-19D4	10-13-87	2.23
	01-12-88	2.04
	03-07-88	2.33
	05-05-88	1.98
	06-27-88	2.66
	09-14-88	3.63
15S/4E-19D5	05-05-88	8.67
15S/4E-19H1	10-13-87	2.51
	12-12-88	2.41
	03-08-88	2.92
	04-12-88	2.20
	05-10-88	2.18
	06-30-88	2.21
	09-14-88	2.83
15S/4E-19N1	10-15-87	19.95
	01-12-88	19.21
	03-07-88	18.58
	05-11-88	18.37
	09-14-88	20.73
15S/4E-20D2	10-13-87	30.19
	01-14-88	30.00
	03-08-88	29.45
	04-12-88	29.24
	05-16-88	28.58
	06-30-88	30.84
	09-24-88	32.95
15S/4E-20F1	10-14-87	23.57
	01-14-88	22.91
	03-08-88	22.15
	04-12-88	21.76
	05-16-88	21.46
	09-14-88	23.48
15S/4E-30C1	10-15-87	44.26
	01-12-88	38.52
	03-07-88	37.24
	05-16-88	37.74
	09-14-88	43.86

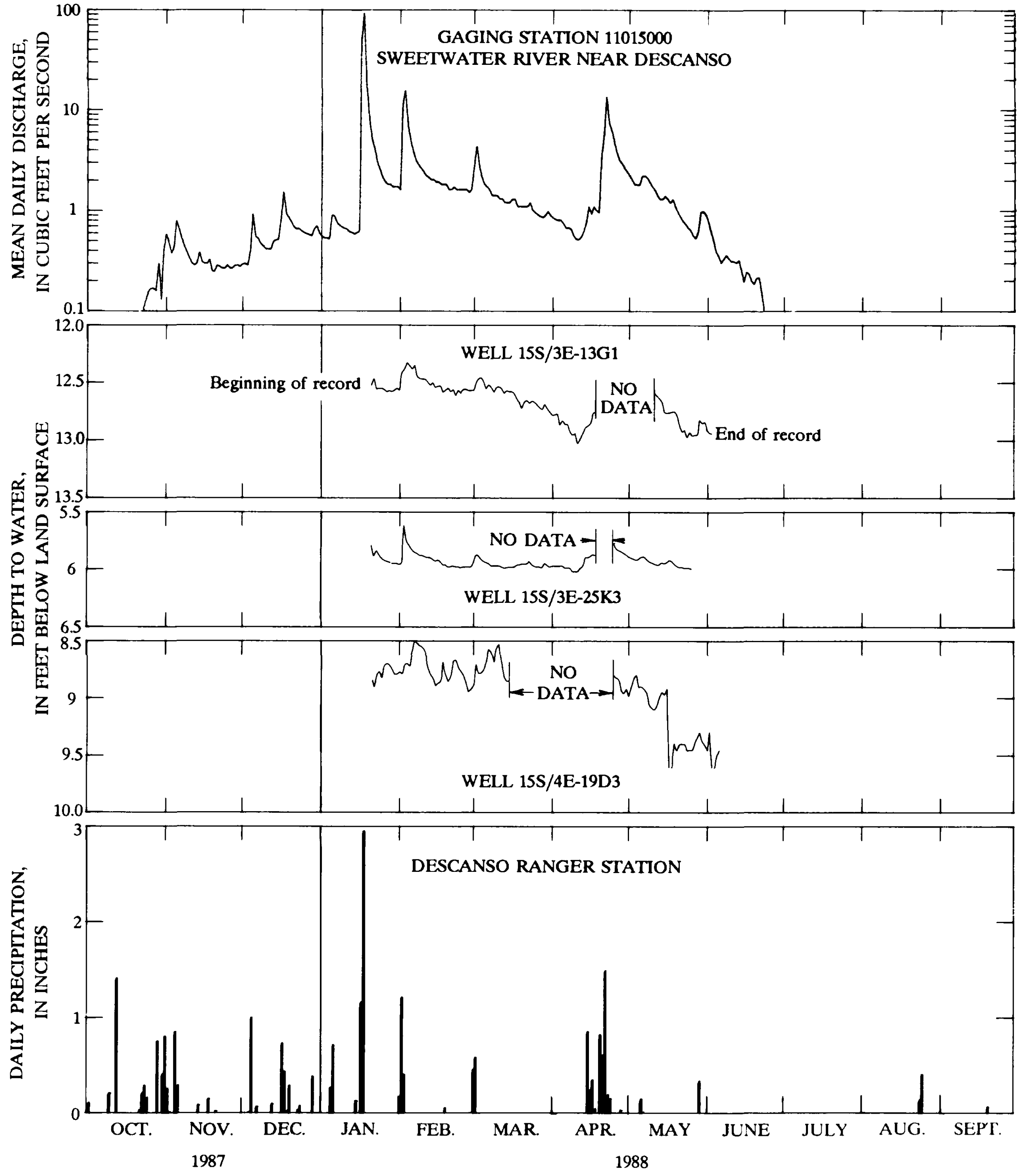
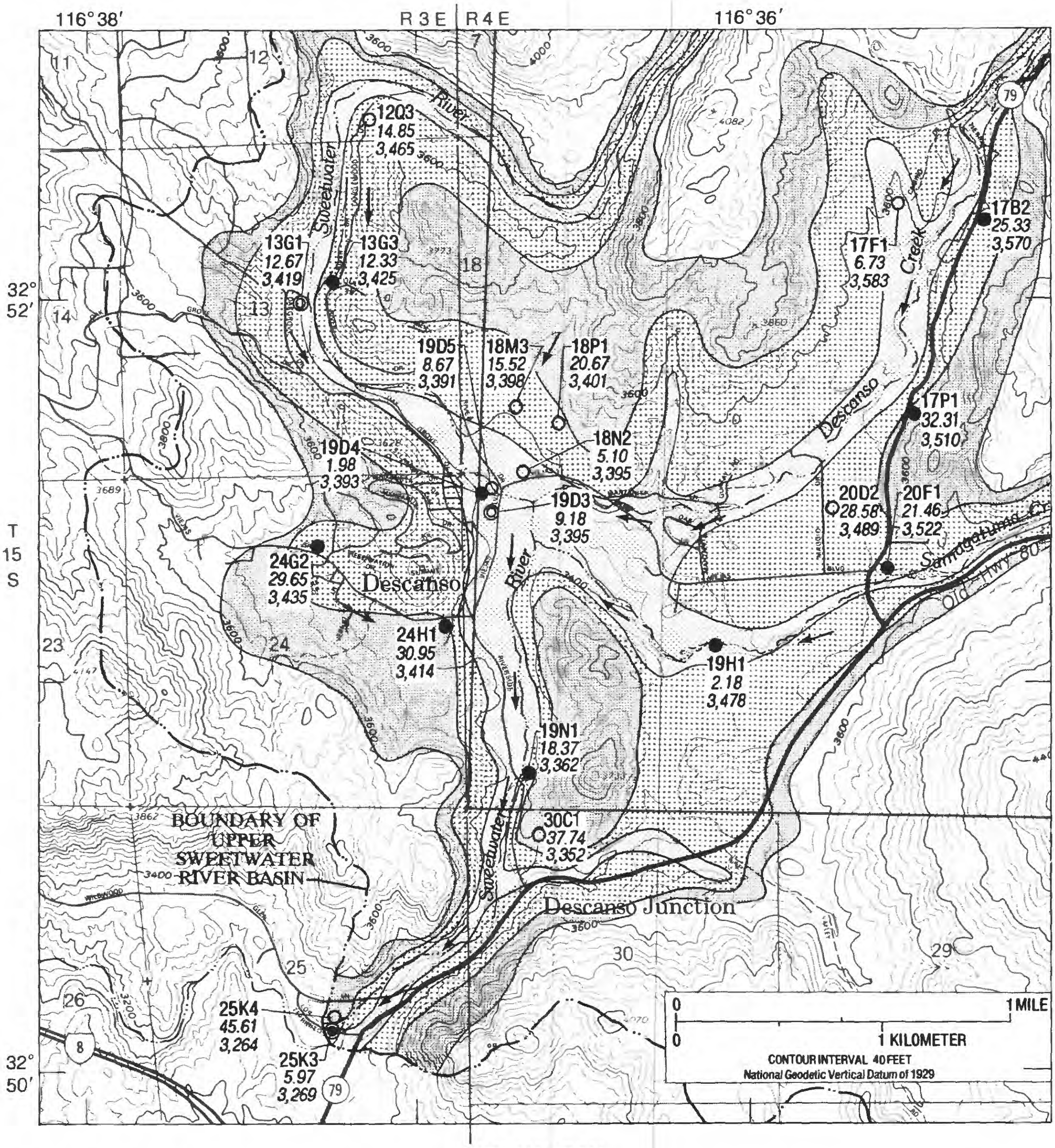


Figure 7. Mean daily discharge of Sweetwater River near Descanso, water levels in selected wells, and daily precipitation at Descanso Ranger Station, water year 1988.



EXPLANATION

APPROXIMATE AREA OF WATER-LEVEL DEPTH, IN FEET BELOW LAND SURFACE

- 0-10
- 10-30
- 30-50

← DIRECTION OF GROUND-WATER MOVEMENT

WELL AND NUMBER--Upper number is well number.
Middle number is depth to water, in feet below land surface, May 1988.
Lower number is altitude of water table, in feet above sea level, May 1988.

Wells penetrating only the regolith		Wells penetrating the bedrock aquifer	
● 19N1 18.37 3,362	Observation well	○ 30C1 37.74 3,352	Observation well
◉ 25K3 5.97 3,269	Well equipped with recorder (hydrograph shown in figure 7)	◎ 19D3 9.18 3,395	Well equipped with recorder (hydrograph shown in figure 7)

Figure 8. Depth to water and water-level altitude in selected wells, May 1988, and direction of ground-water movement.

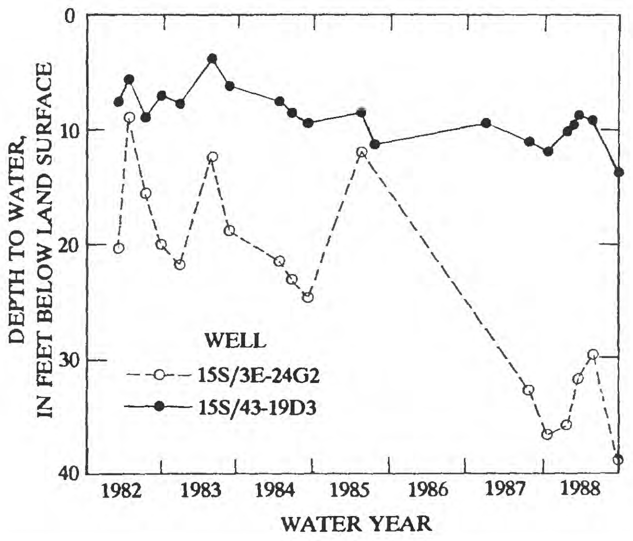


Figure 9. Hydrographs showing water levels in two wells, water years 1982-88.

the regolith and is about 20 feet from the Sweetwater River. Well 15S/4E-19D3, discussed in the previous paragraph, taps the bedrock and is about 500 feet from the river. The hydrographs indicate that water levels in the two wells nearest the river (wells 15S/3E-13G1 and 15S/3E-25K3) fluctuated about 1 foot during January to May 1988, and they reached their highest level during periods of greatest discharge in the river. The water level in well 15S/4E-19D3, which was farthest from the river, was least affected by discharge in the river.

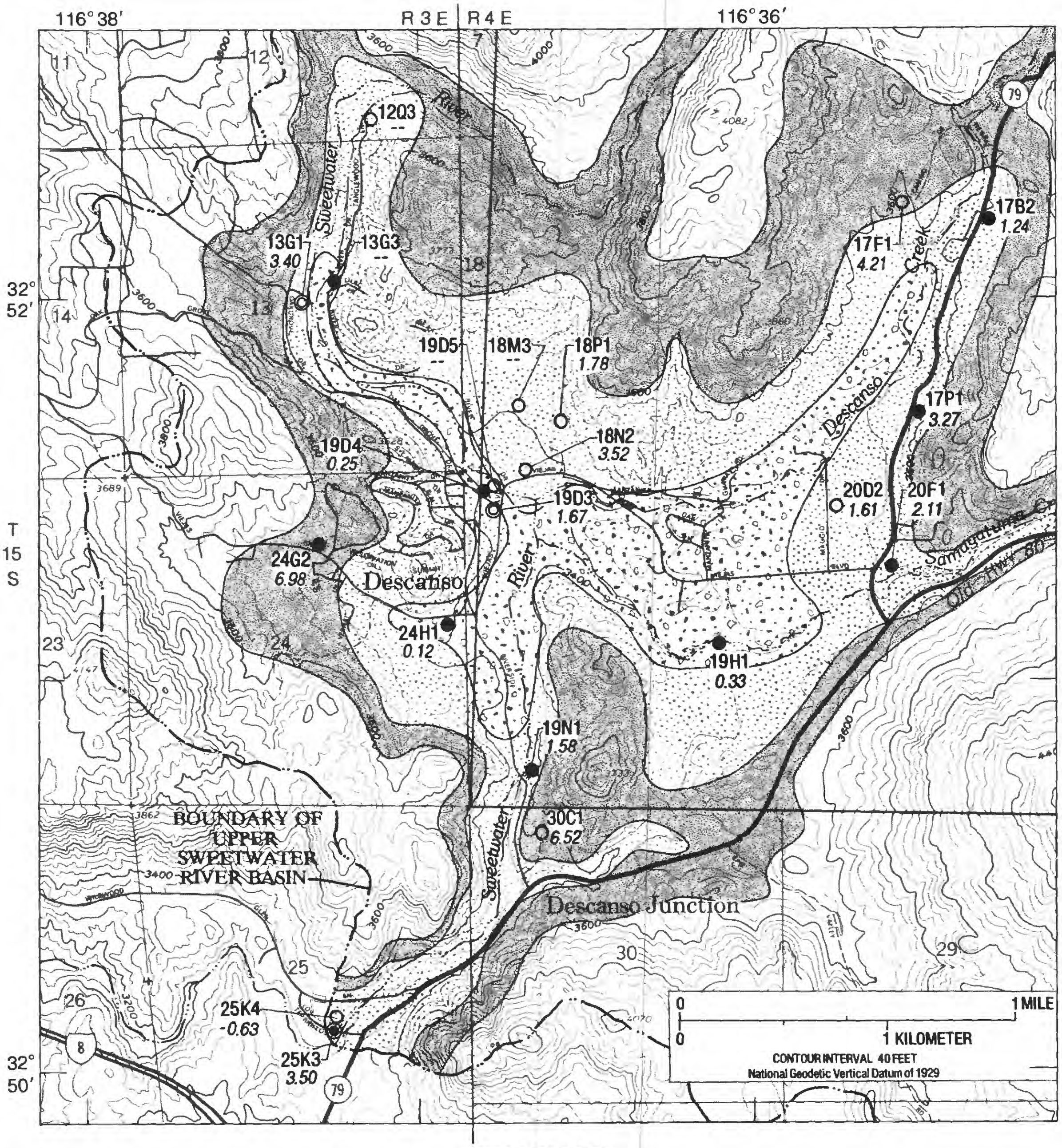
Ground-water levels were nearly the same at the end of 1988 as at the beginning. Water levels in wells that were measured intermittently (table 3) generally rose during October 1987 to May 1988 (the predominant period of ground-water recharge) and then declined during May to September 1988 (the predominant period of ground-water discharge). Most of the precipitation in the area occurred during October 1987 to April 1988 (fig. 7). The general water-level rise during October 1987 to May 1988 is shown in figure 10, and the general water-level decline during May to September 1988 is shown in figure 11.

GROUND-WATER STORAGE

The amount of ground-water storage in the Descanso area cannot be estimated precisely because data on aquifer-storage properties are limited. A number of short-term (less than 8 hours) aquifer tests done on wells tapping weathered granitic rocks (regolith) in Lee Valley in San Diego County (fig. 1) indicate that the specific yield[1] averaged about 0.01 (Charles A. Kaehler, U.S. Geological Survey, written commun., 1989). In several other studies in the United States, the specific yield of weathered granitic rocks averaged about 0.03 (Johnson, 1967).

Assuming that the specific yield of the regolith ranges from 0.01 to 0.03, an estimated value of 800 to 2,000 acre-ft is obtained for water in storage in the regolith during May 1988 (table 4). The estimates are based, in part, on the depth to ground water shown in figure 8. The assumed average depths to water were subtracted from the estimated average thickness of the regolith (50 feet) to obtain the saturated thickness shown in table 4. Multiplying the saturated thickness by the respective areas of equal water-level depth gives the saturated volumes of regolith. The saturated volumes, in turn, are multiplied by the specific yield to obtain the volume of water in storage.

[1]Specific yield is defined as the ratio of (1) the volume of water that a saturated rock or soil will yield by gravity drainage [to wells] to (2) the total volume of the rock or soil.



EXPLANATION

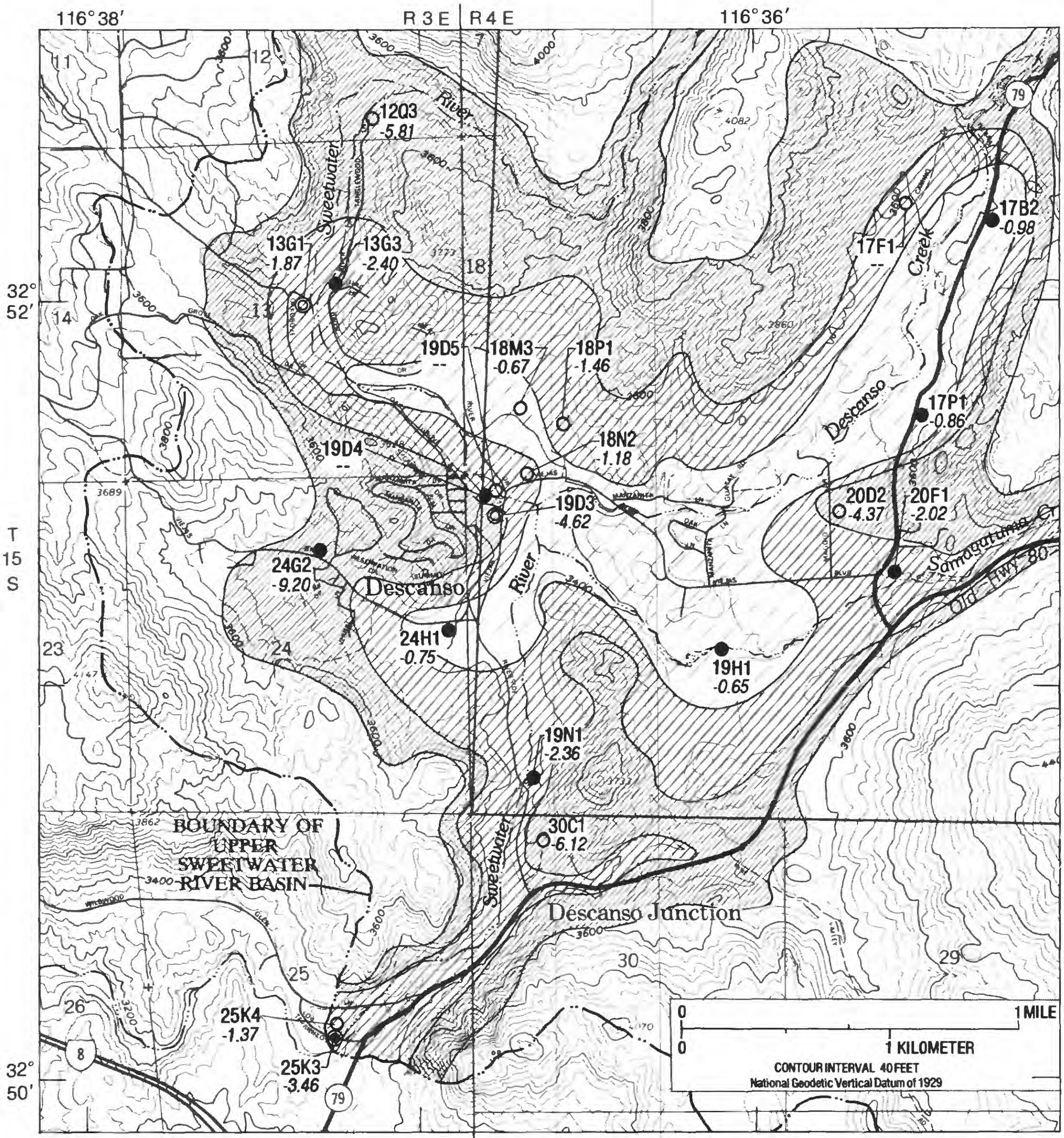
APPROXIMATE AREA OF WATER-LEVEL RISE, IN FEET

- 0-1
- 1-4
- 4-10

WELL AND NUMBER--Upper number is well number, lower number is water-level change, in feet, October 1987 to May 1988

Wells penetrating only the regolith		Wells penetrating the bedrock aquifer	
● 19N1 1.58	Observation well	○ 30C1 6.52	Observation well
◉ 25K3 3.53	Well equipped with recorder (hydrograph shown in figure 7)	◎ 19D3 1.67	Well equipped with recorder (hydrograph shown in figure 7)
		--	No data

Figure 10. Changes in water level from October 1987 to May 1988.



EXPLANATION

APPROXIMATE AREA OF WATER-LEVEL DECLINE, IN FEET

- 0-1
- 1-4
- 4-10

WELL AND NUMBER--Upper number is well number, lower number is water-level change, in feet, May to September 1988

Wells penetrating only the regolith		Wells penetrating the bedrock aquifer	
● 19N1 -2.36	Observation well	○ 30C1 -6.12	Observation well
◉ 25K3 -3.46	Well equipped with recorder (hydrograph shown in figure 7)	◎ 19D3 -4.62	Well equipped with recorder (hydrograph shown in figure 7)
		--	No data

Figure 11. Changes in water level from May to September 1988.

Table 4.--*Estimates of ground-water storage in the regolith, May 1988*

[Estimates are based, in part, on depth to water shown in figure 8. Method of estimation is described in text]

Range in depth to water (feet)	Assumed average depth to water (feet)	Saturated thickness (feet)	Area of equal water-level depth (acres)	Volume of water recoverable from storage (acre-feet)	
				Specific yield 0.01	Specific yield 0.03
0-10	5	45	600	270	810
10-30	20	30	1,500	450	1,350
30-50	40	10	1,000	100	300
Total (rounded to one significant figure)				800	2,000

Little is known of the specific yield of unweathered granitic rocks, except, of course, that the specific yield is zero where the rocks are unfractured. The specific yield of unweathered granitic rocks is dependent not only on degree of fracturing, but also on the hydraulic connection between fractures. In the Descanso area, the specific yield of unweathered bedrock probably is one or two orders of magnitude less than the specific yield of the regolith. Assuming an average saturated thickness of 500 feet and a specific yield of 0.001 to 0.0001, an estimated value of 300 to 3,000 acre-ft is obtained for ground-water storage in 1988 in fractured granitic rocks in the 8-square-mile Descanso area.

Thus, ground water in storage during May 1988 probably ranged from about 1,000 to 5,000 acre-ft (totals rounded to one significant figure). The estimated range in storage represents the maximum amount of water that theoretically could be recovered if the ground-water system were completely drained. The actual amount of recoverable ground water is, of course, much less because of various physical limitations, including well spacing and well yields, in addition to various economic, legal, and environmental constraints. Some of the ground water in storage can be pumped during periods of drought, when there is little or no ground-water recharge, in order to meet water needs.

Change in ground-water storage during 1988 was small (6 to 20 acre-ft), indicating that ground-water recharge and discharge were about equal. The change in ground-water storage was estimated (table 5) using a water-level-change method discussed by Lipinski (1985). The method estimates the quantity of water required to produce a measured water-level rise or decline over a measured area in an aquifer material of estimated specific yield. At all the wells measured, the water table fluctuated within the regolith, and the fractures in bedrock remained saturated.

Water-level measurements in October 1987 and September 1988 were used to construct a water-level-change map (fig. 12). Areas of equal water-level decline and water-level rise were identified for varying increments. The areas of equal water-level change were measured. The average water-level change was assumed to be 0.5 foot in the areas of 0 to 1 foot of water-level change, and 2.5 feet in the areas of 1 to 4 feet of change. Multiplying the areas by the average water-level change gives

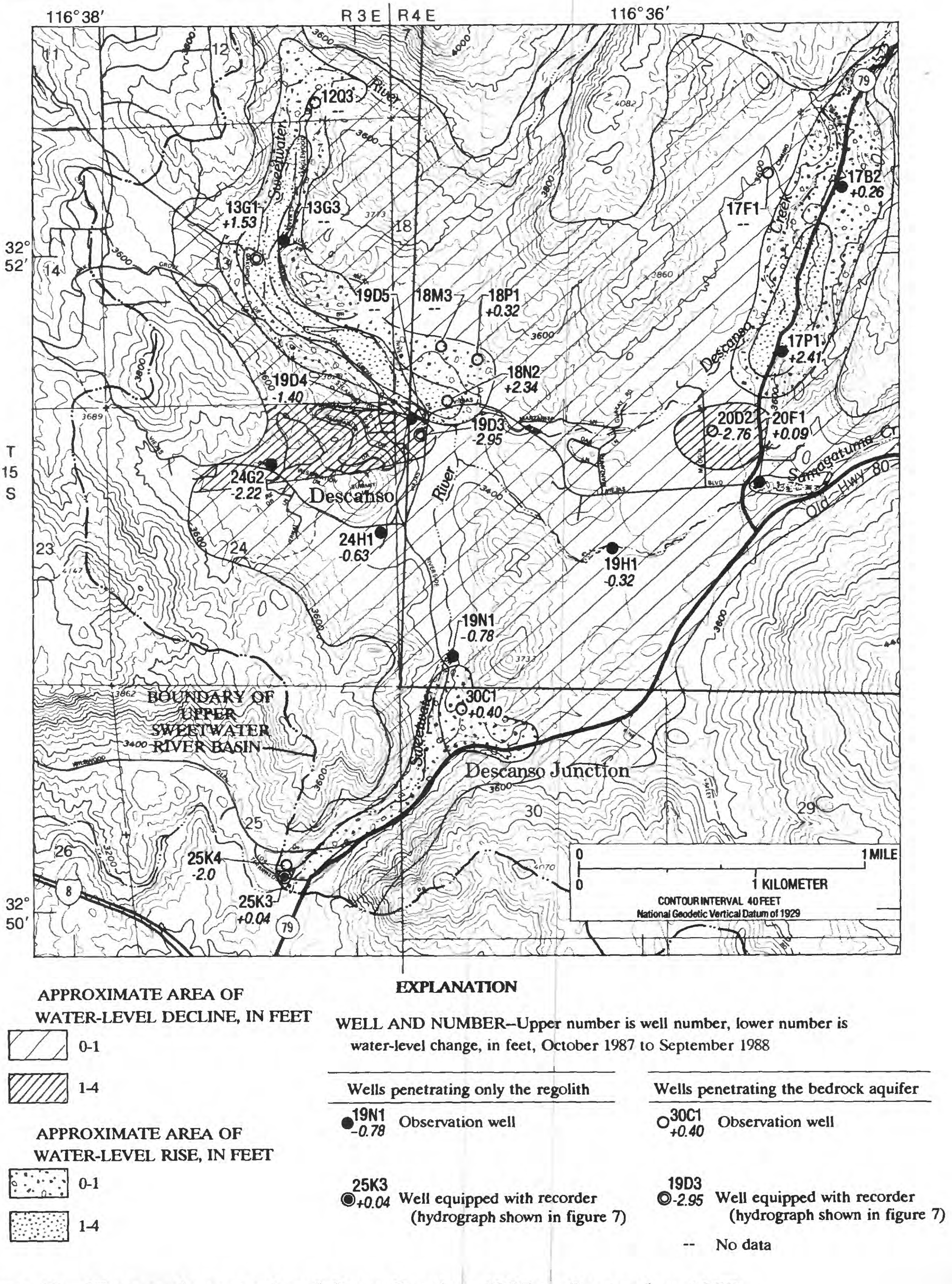


Figure 12. Changes in water level from October 1987 to September 1988.

Table 5.--*Estimated change in ground-water storage during water year 1988*

[Estimates are based on figure 12. Method of estimation is described in text]

Range in water-level rise (feet)	Range in water-level decline (feet)	Area of equal water-level change (acres)	Change in ground-water storage (acre-feet)	
			Specific yield 0.01	Specific yield 0.03
0-1		500	+3	+8
1-4		200	+5	+15
	0-1	2,300	-12	-35
	1-4	100	-2	-8
Total			-6	-20

the change in volume of saturated regolith. Multiplying this change in volume by the specific yield of the regolith (0.01 to 0.03) gives the change in ground-water storage (table 5).

RECHARGE AND DISCHARGE

Natural ground-water recharge in the Descanso area occurs primarily as infiltration of precipitation and of stream water (table 6). Also, some subsurface inflow occurs from the upper Sweetwater River basin. Natural discharge occurs primarily as transpiration of phreatophytes, and there also is some subsurface outflow. Pumpage is the largest manmade discharge from the ground-water system, but part of the water is returned to the system by percolation of water from septic tanks.

Infiltration of precipitation was estimated using an estimate from a study of Lee Valley (fig. 1). The drainage area of the Lee Valley study area is approximately 2 mi^2 and the average precipitation during 1988 was about 20 inches. Infiltration of precipitation in Lee Valley was estimated to be 160 acre-ft during 1988 (Charles A. Kaehler and Paul A. Hsieh, U.S. Geological Survey, written commun., 1989). The drainage area of the Descanso study area is 8 mi^2 and precipitation during 1988 averaged about 23 inches. Adjusting for the differences in precipitation and drainage area, an estimate of 700 acre-ft is obtained for recharge from infiltration of precipitation in the Descanso area:

$$160 \text{ acre-ft} \times \frac{8 \text{ mi}^2}{2 \text{ mi}^2} \times \frac{23 \text{ in.}}{20 \text{ in.}} = 700 \text{ acre-ft (rounded)}.$$

Infiltration of water from streams was estimated using discharge measurements along streams and the discharge record at the Sweetwater River gaging station. Net streamflow loss was determined by subtracting the discharge at the gaging station (site 5 in fig. 2) from the combined discharges of streams entering the study area (sites 1, 6, and 10 in fig. 2). For February 18-19, 1988, the net loss along streams was 0.69 ft^3/s, and for April 11-12, 1988, the net loss was 0.47 ft^3/s. The Sweetwater River flowed 250 days at the gaging station during 1988. Assuming that net streamflow loss during those 250 days averaged 0.6 ft^3/s, an estimate of about 300 acre-ft is

Table 6.--*Estimated components of recharge and discharge in the Descanso area, water year 1988*

[--, no data]

	Acre-feet
RECHARGE	
Infiltration of precipitation	700
Infiltration of stream water	300
Subsurface inflow	--
Percolation of wastewater from septic tanks	60-120
DISCHARGE	
Subsurface outflow	--
Transpiration by phreatophytes	--
Pumpage	170

obtained for recharge to the ground-water system from streamflow (table 6).

Data were insufficient to estimate subsurface inflow and outflow and transpiration of phreatophytes (table 6). However, because there was little change in ground-water storage during 1988, recharge and discharge were nearly equal.

Estimates of recharge from precipitation and streamflow should, at best, be considered order-of-magnitude estimates. Because precipitation and streamflow were nearly normal during 1988, natural recharge and discharge that occurred during the year probably were close to the long-term averages.

The Descanso Community Water District pumps more than one-half of the ground water used in the Descanso area. Pumpage by the Descanso Community Water District, in acre-feet, was 77 in 1985; 82 in 1986; 80 in 1987; and 94 in 1988 (Harold A. Ornellas, Descanso Community Water District, written commun., 1988). Pumpage by the Water District during 1984-88 (fig. 13) generally was highest from May through September. About 750 residents use water supplied by the Descanso Community Water District, and during 1988 per capita ground-water usage averaged about 110 gal/d. Applying this usage rate to the remaining 650 residents, an estimated 67 acre-ft of ground water was pumped from private wells. Total pumpage during 1988 is estimated to have been 170 acre-ft (table 6).

No data on percolation of wastewater from septic tanks were collected for this study. However, Bouwer (1978, p. 413) reported that, typically, 40 to 80 gallons per person per day percolates into ground-water systems from septic tanks. Using Bouwer's estimate, 60 to 120 acre-ft of septic-tank wastewater is estimated to have returned to the ground-water system during 1988 (table 6).

WATER QUALITY

Water samples were collected for chemical analysis from six wells in the Descanso area, three wells upgradient of the area, and one well downgradient. The chemical analyses are given in table 2.

The chemical quality of ground water generally is suitable for domestic drinking water. The concentrations (mean and range) for the analyzed constituents in the 10 samples, along with the California maximum contaminant levels for domestic drinking water (California Department of Health, 1977) are given in table 7.

Table 7.--*Concentration of selected constituents in 10 samples from wells in and near the Descanso area, 1988, and California maximum contaminant levels for domestic drinking water*

[California Department of Health, 1977. NA, not applicable (no maximum contaminant level has been established)]

Constituent	Median	Range[1]	Maximum contaminant level
		Microsiemens per centimeter at 25 °C	
Electrical conductivity	522	384-685	900-1,600
		Standard units	
pH	7.6	7.3-8.1	NA
		Milligrams per liter	
Calcium, dissolved	50	32-82	NA
Magnesium, dissolved	14	8-27	NA
Sodium, dissolved	30	16-40	NA
Potassium, dissolved	3.8	1.5-5.9	NA
Alkalinity, total field	142	90-235	NA
Sulfate, dissolved	33	12-91	[2]240-500
Chloride, dissolved	42	27-100	[2]250-500
Fluoride, dissolved	.30	0.10-0.40	[3]1.4-2.4
Silica, dissolved	42	28-76	NA
Dissolved solids, sum of constituents	322	247-424	[2]500-1,000
Nitrite plus nitrate, dissolved as nitrogen	.20	<0.10-6.6	10
		Micrograms per liter	
Boron, dissolved	30	<10-60	NA
Iron, dissolved	37	4-2,800	300
Manganese, dissolved	62	<1-280	50

[1]See table 2 for individual chemical analyses.

[2]No fixed consumer acceptance contaminant level has been established. The lower constituent concentrations are recommended, and the higher levels are acceptable if it is neither reasonable nor feasible to provide more suitable waters.

[3]Depends on annual average of maximum daily air temperature.

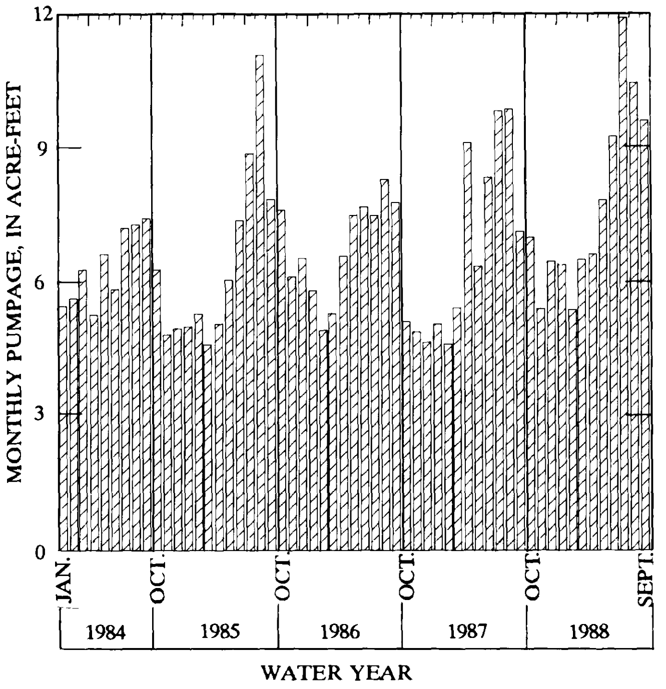


Figure 13. Monthly ground-water pumpage by the Descanso Community Water District, January 1984 to September 1988. (Harold A. Ornellas, Descanso Community Water District, written commun., 1988).

Concentrations of iron and manganese exceeded the maximum contaminant levels in some wells. Concentrations of iron were greater than 300 μg/L in three wells in the Descanso area. Concentrations of manganese were greater than 50 μg/L in five wells, four of which are in the Descanso area. The contaminant levels for iron and manganese are based on esthetic rather than toxicological reasons; therefore, they are not toxic levels.

Dissolved-solids concentrations in the 10 sampled wells ranged from 247 to 424 mg/L. Differences in inorganic chemical composition of water from the wells are illustrated by the diagrams in figure 6. The most abundant cation in all ground-water samples was calcium. The most abundant anion was bicarbonate--except for water from well 15S/3E-26K2, in which chloride was the most abundant.

EFFECTS OF PUMPING

There is concern that ground-water pumping in the Descanso area could cause significant water-level declines during periods of little or no recharge. To estimate the effects of pumping on the ground-water system, time-distance drawdown curves can be used.

The Theis equation (Lohman, 1972, p. 15) was used in this study to estimate water-level declines (drawdown), for a realistic range of transmissivity and specific yield, near hypothetical pumped wells. The Theis equation assumes that: (1) the aquifer is homogeneous and isotropic, (2) the aquifer is infinite in horizontal extent, (3) the pumped well penetrates the entire thickness of the aquifer, (4) diameter of the pumped well is very small, (5) water removed from storage is discharged instantaneously with decline in head, and (6) the aquifer receives no recharge from any source.

The estimated drawdown of the water table that would occur after 30 days, 6 months, and 1 year of continuous pumping from a hypothetical well tapping the regolith is shown in figure 14. The pumping rate of the well was assumed to be 6.2 gal/min, which is equivalent to about 10 acre-ft/yr. Four graphs were drawn--using two values for specific yield (0.01 and 0.03) and two values for transmissivity (240 and 480 ft^2/d). Transmissivity is the mathematical product of the saturated thickness of the aquifer and hydraulic conductivity. Saturated thicknesses of 20 and 40 feet are representative of most of the regolith. The hydraulic conductivity was assumed to be 12 ft/d, which is the estimated average horizontal hydraulic conductivity of the regolith in Lee Valley (Paul A. Hsieh, U.S. Geological Survey, written commun., 1988).

Figure 15 shows the estimated drawdown of the water table that would occur after 30 days, 6 months, and 1 year of continuous pumping from a hypothetical well tapping only bedrock. For this example, it is assumed that the regolith is unsaturated. The pumping rate of the well was assumed to be 0.62 gal/min, which is equivalent to about 1 acre-ft/yr. Four graphs

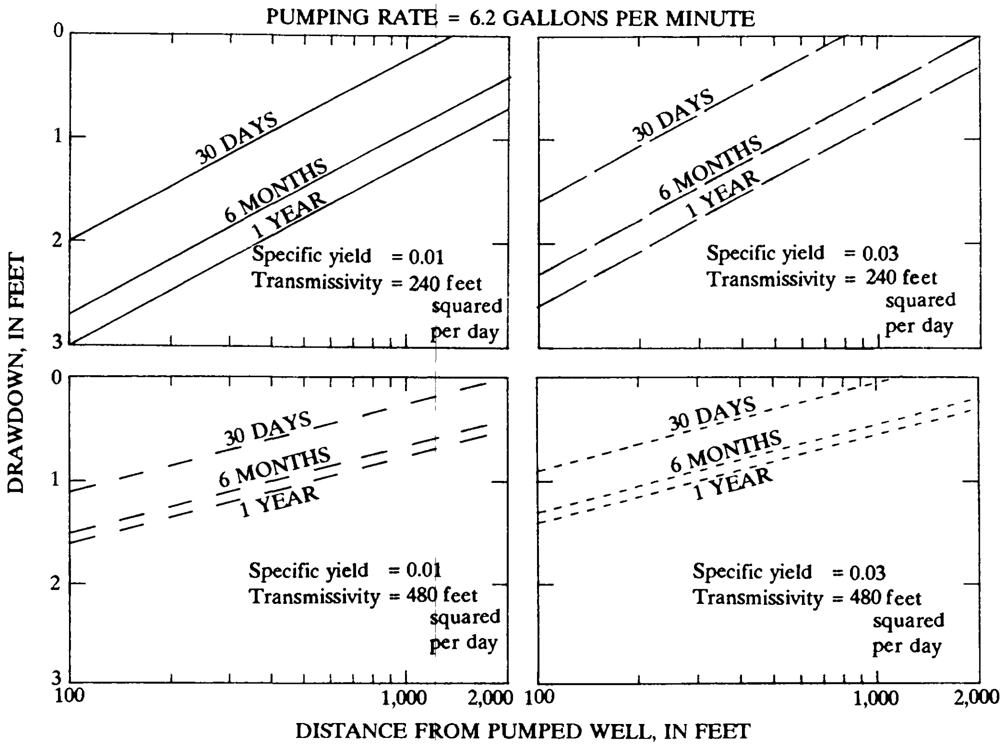


Figure 14. Drawdown produced at various distances from a hypothetical well after 30 days, 6 months, and 1 year of pumping from the regolith.

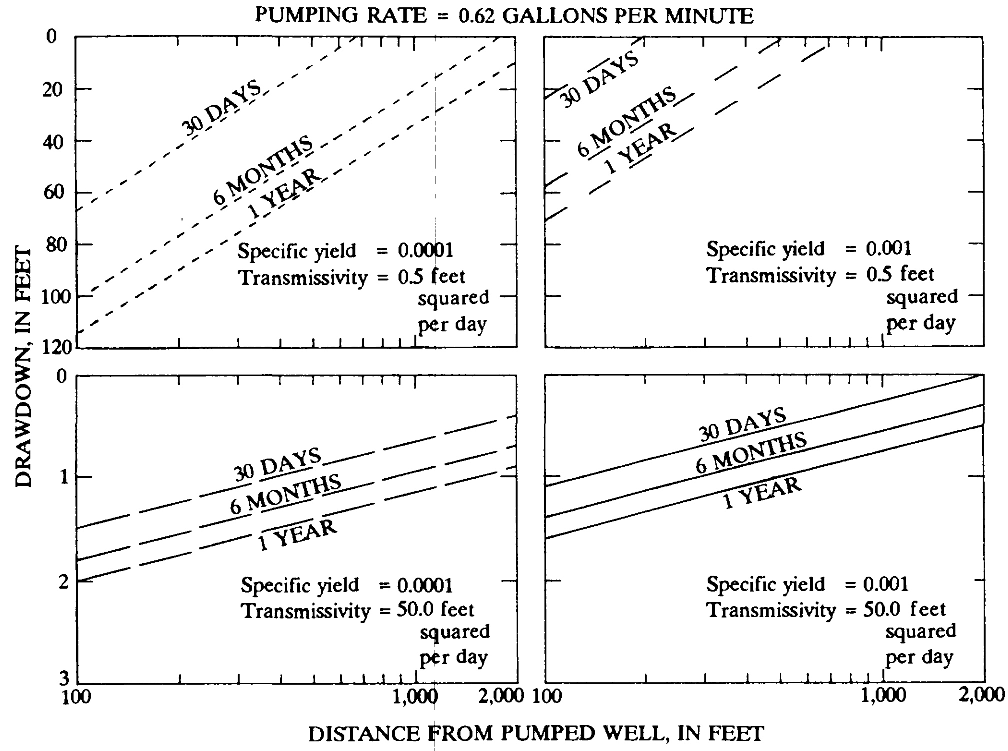


Figure 15. Drawdown produced at various distances from a hypothetical well after 30 days, 6 months, and 1 year of pumping from fractured bedrock.

were drawn--using specific yields of 0.001 and 0.0001 and transmissivities of 0.5 ft^2/d and 50 ft^2/d. These transmissivity values represent a realistic range and are based on an assumed effective depth of fracturing in bedrock of 500 feet and a range in hydraulic conductivity of 0.1 to 0.001 ft/d.

Pumpage has a linear effect on drawdown; therefore, the graphs (figs. 14 and 15) can be used to estimate drawdown for any realistic pumping rate. For example, if the pumping rate is doubled, drawdown also will double.

It should be noted that transmissivity will decrease as saturated thickness decreases (with increased drawdown), and the graphs (figs. 14 and 15) are not valid if pumping dewaters a significant thickness of the aquifer. The graphs do not take into account recharge that normally occurs during winter and spring of most years, and they cannot be used to predict long-term effects of pumping. Also, because a large percentage of pumped water can be returned to the ground-water system by percolation of septic-tank wastewater, the pumping rate used to estimate drawdown may have to be adjusted downward to account for the recirculation of water, particularly if the pumped well and septic-tank leach field are in close proximity.

SUMMARY

During water year 1988, precipitation and streamflow were near normal in the Descanso area. Precipitation at the Descanso Ranger Station was 94 percent of the long-term average. Flow volume in the Sweetwater River at the gaging station was 98 percent of the median annual flow volume for 1957-88.

Ground water in storage was estimated to be 800 to 2,000 acre-ft in the regolith and 300 to 3,000 acre-ft in bedrock. The actual amount of recoverable ground water is much less because of various physical limitations, including well spacing and well yields, in addition to economic, legal, and environmental constraints.

During water year 1988, natural recharge from precipitation and streamflow to the Descanso area ground-water system was estimated to be about 1,000 acre-ft. Pumpage was estimated to be about 170 acre-ft.

Ground-water levels were nearly the same at the end of water year 1988 as at the beginning. Water levels in wells generally rose from October 1987 through May 1988 and declined from May through September 1988. The effects of ground-water pumping on ground-water storage were minimal during water year 1988.

Ground-water quality generally was suitable for domestic drinking water. Dissolved-solids concentrations in water from 10 sampled wells ranged from 247 to 424 mg/L. Concentrations of iron and manganese, although nontoxic, exceeded California maximum contaminant levels for domestic drinking water in some wells.

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