WATER RESOURCES OF SOLEDAD, POWAY, AND MOOSA BASINS, SAN DIEGO COUNTY, CALIFORNIA

By *Kristin D. Evenson*

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 88-4030

Prepared in cooperation with the

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD,

SAN DIEGO REGION

Sacramento, California
1989

DEPARTMENT OF THE INTERIOR

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CONVERSION FACTORS

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

Multiply inch-pound units	By	To obtain
acre	0.4047	hectares
acre-ft (acre-foot)	0.001233	cubic hectometer
acre-ft/yr (acre-foot per year)	0.001233	cubic hectometer per annum
foot	0.3048	meter
ft^3 (cubic foot)	0.02832	cubic meter
ft^3/s (cubic foot per second)	0.02832	cubic meter per second
gal/min (gallon per minute)	0.06308	liter per second
inch	25.4	millimeter
in/h (inch per hour)	25.4	millimeter per hour
mile	1.609	kilometer
mi^2 (square mile)	2.590	square kilometer
Mgal/d (million gallons per day)	0.04381	cubic meter per day

Temperature is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation:

$$°F=1.8(°C)+32.$$

Sea level: 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.

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ABSTRACT

The population of the Soledad basin is expected to increase by about 140 percent by the year 2000, and with this increase the demand for fresh water also will grow. Land uses are divided between urban development in the south and agriculture in the north. Imported water is the sole water supply in the southern part of the basin, and ground water is the sole water supply in the northern part. Concentrations of dissolved solids in ground water range from 1,000 to 2,000 milligrams per liter, exceeding local basin objectives. Concentrations of chloride, sulfate, and iron also commonly exceed basin objectives. Planned uses for reclaimed water include improving ground-water quality by pumping out the present highly mineralized water and replacing it with less mineralized water.

The population and water demand in the Poway basin is expected to increase by the same percentage as the Soledad basin. The Poway basin is a mix of agricultural and urban land uses, and both ground water and imported water constitute the basins' water supply. Concentrations of dissolved solids in ground water range from 500 to 1,000 milligrams per liter, commonly exceeding basin water-quality objectives. Concentrations of chloride also exceed basin objectives. As of 1985, there were no plans for using reclaimed water in the Poway basin.

The population growth in the Moosa basin is expected to be somewhat less than that of the Soledad and Poway basins, yet an increase of 100 percent by the year 2000 is expected. The Moosa basin is rural and has some agricultural land use. Ground water and imported water supply the basins' water needs. Concentrations of dissolved solids in ground water range from 470 to 1,200 milligrams per liter, commonly exceeding basin water-quality objectives. Concentrations of chloride also commonly exceed basin objectives. As of 1985, use of reclaimed water was planned to irrigate two golf courses in the lower part of the basin. This reclaimed water is less mineralized than the ground water and is expected to improve the quality of the water in the alluvial aquifer.

INTRODUCTION

Background

The population in the San Diego area has almost doubled since 1960. With this increase in population, water demand also has increased. The area has a limited local water supply, and most of its water needs are met by imported water. The Colorado River is the principal water supply for San Diego County. In December 1985, the Central Arizona Project began transporting water from the Colorado River to the central part of Arizona to supplement water supplies (U.S. Geological Survey, 1986, p. 146). The amount of water imported to California from the Colorado River was reduced proportionately. Consequently, less water is available for the San Diego area. Local water agencies are looking for ways to supplement the remaining water supplies.

This report was prepared in cooperation with the California Regional Water Quality Control Board (CRWQCB), San Diego Region. The CRWQCB is in the process of evaluating the suitability for use of reclaimed water in each of the hydrologic subareas for the entire county. Previous reports by the U.S. Geological Survey, in cooperation with the County of San Diego and the California Department of Water Resources, have been published as part of this evaluation. The reports covered the San Dieguito, San Elijo, and San Pasqual hydrologic subareas (Izbicki, 1983) and the Mission, Santee, and Tijuana hydrologic subareas (Izbicki, 1985).

Purpose and Scope

The purposes of this report are (1) to describe the water resources in the the Soledad, Poway, and Moosa basins; (2) to define past and present beneficial uses of water in each basin; and (3) to evaluate the suitability of these areas for use of reclaimed water. The report summarizes available data on the quantity and quality of ground, surface, imported, and reclaimed water in the study areas, as well as background information on population, land and water use, geology and soils, and precipitation.

Description of Study Areas

San Diego County is located in southwestern California (fig. 1). The County extends about 70 miles north of the California-Mexico border and 60 to 80 miles east of the Pacific Ocean. The Soledad, Poway, and Moosa basins are located in west-central San Diego County (fig. 1). The Soledad and Poway basins make up the northern part of the Los Penasquitos hydrographic subunit; the two basins share a north-south border, and they are within the northern part of the city of San Diego. The Moosa basin is located 15 miles north of the northern edge of the Poway basin.

The study areas have a Mediterranean-type climate, which is typified by warm, dry summers and cool winters (California Department of Water Resources, 1967). Because of coastal fog, humidity is generally high along the coast during the summer but decreases rapidly inland and is generally low throughout most of the study area. Precipitation is generally low and increases inland from less than 10 inches along the coast to 40 inches in the Agua Tibia Mountains. Most of the rain occurs between November and March.

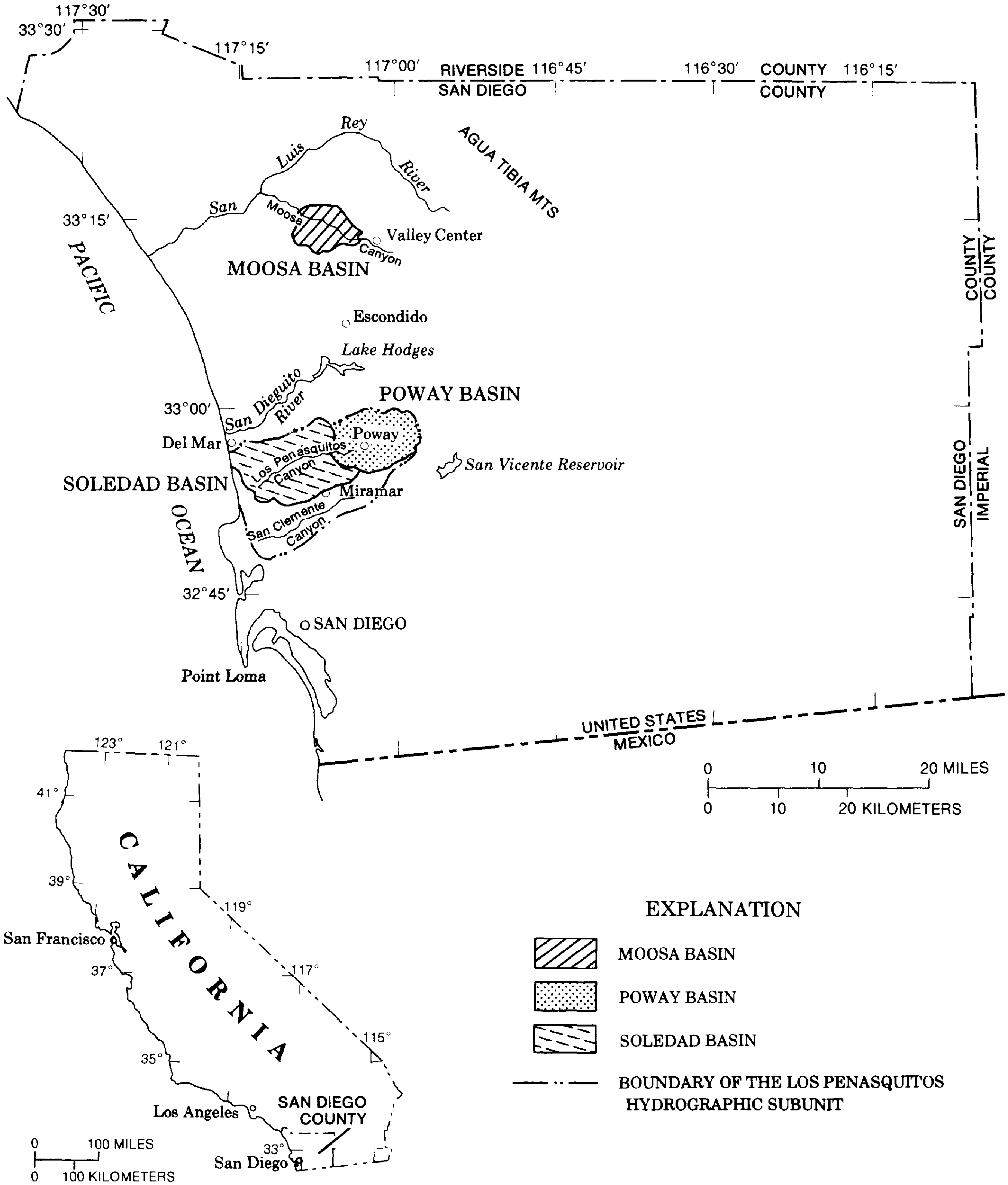
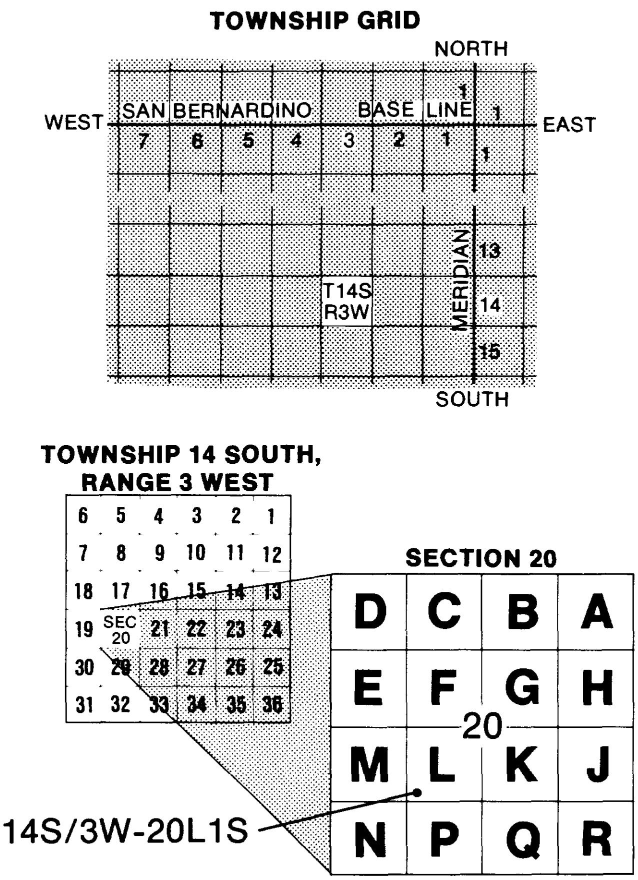


FIGURE 1.—Location of the study areas.

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/3W-20L1S, the number and letter preceding the slash indicate the township (T. 14 S.); the number and letter following the slash indicate the range (R. 3 W.); the number following the hyphen indicates the section (sec. 20); the letter following the section number (L) indicates the 40-acre subdivision of the section; the final digit (1) is a serial number for wells in each 40-acre subdivision; and the final letter (S) indicates the San Bernardino base line and meridian. The following diagram shows the location breakdown of well 14S/3W-20L1S.



DATA COLLECTION

Field Methods

A network of existing water wells and surface-water stations was established to collect data on surface- and ground-water quality, water levels, and streamflow in each of the study basins. Criteria used in selection of sites for this network were (1) availability of information on well construction, (2) ease of sampling, (3) site location, and (4) owner's permission. Ground- and surface-water data were collected during autumn 1984 and spring 1985.

Instantaneous streamflow discharge measurements were made by using a current meter (Carter and Davidian, 1968) on streams that had flow greater than 0.5 ft^3/s. On streams with flow less than 0.5 ft^3/s, a Parshall flume was used to make the discharge measurements.

Surface-water quality samples were collected with a DH48 suspended sediment sampler, which had been painted with nonmetallic paint and fitted with a Teflon[1] nozzle and silicon gasket to minimize contamination when sampling for metals.

Static ground-water level measurements were made with a graduated steel tape. Ground-water quality samples were collected after the well had been pumped so that at least three times the volume of the casing was removed to insure that the sample was representative of the aquifer. Specific conductance (SC) was measured periodically, and samples were collected after SC had stabilized.

At the time the samples were collected, temperature, SC, pH, and alkalinity were measured. Temperature of the sample was taken with a hand-held thermometer; SC and pH were measured with portable meters; and alkalinity was

[1]The use of brand or trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

determined by the electrometric titration process (Brown and others, 1970, p. 42). To insure quality control, all field measurements were made twice. Samples for cations were acidified to a pH of less than 2, and samples for nutrients were stored in opaque bottles and preserved with mercuric chloride. At each sampling site, water also was processed for shipment to the U.S. Geological Survey Central Laboratory in Arvada, Colorado.

Laboratory Methods

Samples were analyzed by methods outlined by Skougstad and others (1979) for alkalinity, boron, calcium, chloride, fluoride, iron, magnesium, nutrients (ammonia, nitrite, nitrite plus nitrate, organic nitrogen, and orthophosphate), residue on evaporation at 180 °C (degrees Celsius), silica, and sulfate. Percent sodium, sodium adsorption ratio, and the sum of dissolved constituents were calculated. At selected sites, samples were also analyzed for selected trace metals and pesticides by using methods outlined by Skougstad and others (1979) and Wershaw and others (1983).

Limited Availability of Data

The number of wells in use in the Soledad, Poway, and Moosa basins has decreased significantly since the 1960's. Comparison of historic data with data collected in 1984-85 is somewhat limited, because many wells that had been sampled in the 1960's and 1970's were not available for sampling in 1984-85.

Because the ground-water-quality network used existing wells, several areas in each of the basins lacked wells available for sampling or measuring. Most notable of these areas were the northwestern part of the Poway basin, the southern and western parts of the Soledad basin, and the southern part of the Moosa basin.

The streams in the Poway basin typically have no flow in the summer and autumn. Therefore, no data representative of autumn conditions are available for the Poway basin.

SOLEDAD BASIN

Location

The Soledad basin (fig. 1) is about 55 mi^2 in area and is bordered on the west by the Pacific Ocean. The eastern border is about 12 miles inland. Black Mountain marks the northeastern boundary and the Miramar Naval Air Station area extends along the southeastern border (fig. 2). Los Penasquitos and Carmel Creeks are the main drainages in the area (fig. 2). Miramar reservoir, a major storage facility containing water from the Colorado River, is located in the southern part of the basin, and Los Penasquitos Lagoon is located at the mouth of Los Penasquitos Creek in the northwestern part of the basin (fig. 2).

Two extremes of land use are found in this basin. The Mira Mesa-Scripps Ranch area in the southeast is a dense urban development, and the Carmel Valley area in the north is a mixture of rural farm and undeveloped land (fig. 2).

Population

The 1980 population of the Soledad basin was 65,390 (San Diego Association of Governments, written commun., 1985). Between 1980 and 2000, the population is expected to increase by 160 percent (table 1). The greatest growth is expected during the 1980's.

As of 1985, the largest population in the Soledad area was in the Mira Mesa-Scripps Ranch area, located in the southern part of the basin (fig. 2). The areas expected to experience the greatest percentage of growth are the adjoining areas to the west, east, and north.

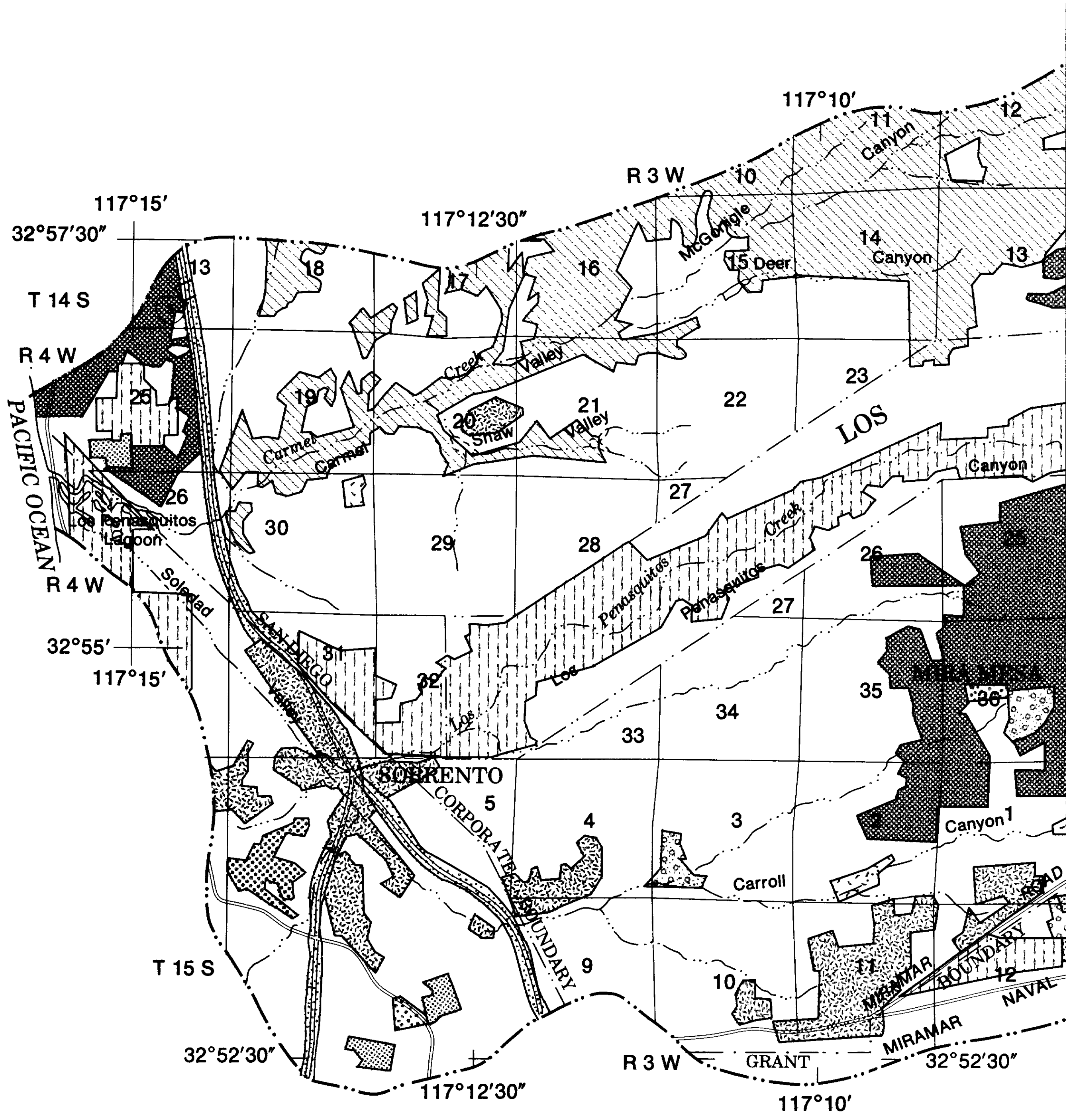
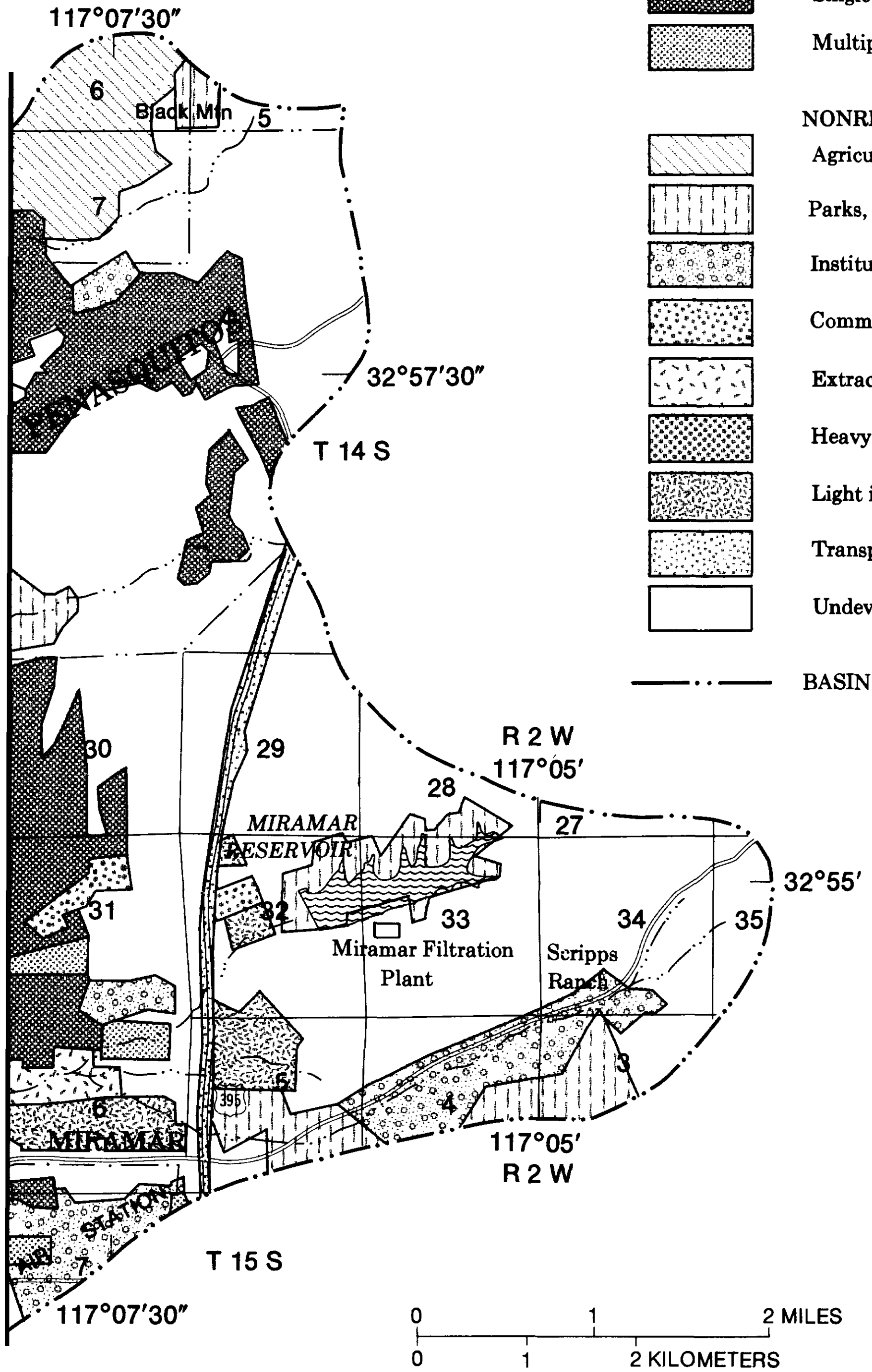


FIGURE 2.—Generalized land use in the Soledad basin (modified from San Diego Association of Governments, 1980).



EXPLANATION

RESIDENTIAL LAND USE

Single family housing

Multiple family housing

NONRESIDENTIAL LAND USE

Agriculture

Parks, commercial recreation

Institutions, education

Commerical and office

Extractive industry

Heavy industry

Light industry

Transportation, communication, and utilities

Undeveloped

BASIN BOUNDARY

TABLE 1.--*Population projections for the Soledad basin*

[From San Diego Association of Governments, written commun., 1985]

Year	Population
1980	65,390
1990	122,000
2000	172,000

TABLE 2.--*Land-use acreage and projections for the Soledad basin*

[From San Diego Association of Governments, written commun., 1985. Values are in acres]

Year	Total	Devel- oped	Resi- den- tial	Non- resi- den- tial	Undeveloped	
					Devel- opable	Un- devel- opable
1980	39,190	8,040	4,330	3,710	14,410	16,740
1990	39,190	12,000	7,000	5,000	11,000	16,740
2000	39,190	17,000	11,000	6,000	6,000	16,740

Land Use

Undeveloped land occupies the greatest area (31,150 acres) in the Soledad basin. As of the 1980 census, about 20 percent of the available land had been developed for urban use. Development of land has been distributed evenly, and residential and nonresidential areas occupy 54 and 46 percent of the total developed land, respectively (San Diego Association of Governments, written commun., 1984). Dominant land uses in the Soledad area are agricultural, residential, and industrial (fig. 2). The most extensive agricultural area is located in the northern part of the basin in the Carmel and Shaw Valleys. Nurseries and field crops are the dominant agricultural uses in this area. Residential uses are concentrated in the eastern and southern parts of the basin, and industrial uses are concentrated in the western and southern parts of the basin. Table 2 shows the total acreage developed for various land uses as of the 1980 census.

Projections from 1980 to 2000 show an increase in the acreage of developed land (table 2). The total acreage of developed land is expected to increase by 100 percent; specifically, acreage of residential land is expected to increase by 144 percent and acreage of nonresidential land by 66 percent.

Water-Quality Objectives

The California Water Code, Division 7, Section 13241, requires that each Regional Water Quality Control Board establish water-quality objectives for the water within its jurisdiction (California Regional Water Quality Control Board, San Diego Region, 1975). These objectives are designed to protect beneficial uses and to prevent misuse. These objectives differ from water-quality standards in that they are defined as goals to be achieved to insure specified beneficial uses, whereas water-quality standards are minimum requirements based on technical information needed to insure specified beneficial uses. Therefore, the objectives are at least as strict as the water-quality standards and may be stricter in selected areas. Water-quality standards for selected constituents established by the State of California are given in tables 3 and 4.

Water-quality criteria and the nondegradation policy of the California State Water Resources Control Board are the basis for the water-quality objectives. The nondegradation policy states:

> Whenever the existing quality is better than the quality established in policies as of the date on which such policies become effective, such

TABLE 3.--*California secondary drinking-water standards*

[From State of California, 1977. Secondary drinking-water standards represent levels which may adversely affect taste, odor, or appearance but do not present a health hazard. Values are in milligrams per liter unless otherwise stated. Specific conductance is in microsiemens per centimeter at 25 degrees Celsius; --, not defined]

Property or constituent	Level: Recommended	Upper	Maximum
Color (units)......	--	--	15
Odor (units).......	--	--	3
Turbidity (units)..	--	--	5
Specific conductance......	900	1,600	2,200
Sulfate............	250	500	600
Chloride...........	250	500	600
Dissolved solids...	500	1,000	1,500
Copper.............	--	--	1.0
Iron...............	--	--	.3
Manganese..........	--	--	.05
Zinc...............	--	--	5.0

existing high water quality will be maintained until it has been demonstrated to the State that any change will be consistent with maximum benefit to the people of the state, will not reasonably affect present and anticipated beneficial use of such water and will not result in water quality less than that prescribed in the policies (California Regional Water Quality Control Board, San Diego Region, 1975).

TABLE 4.--*Limiting concentrations of inorganic chemicals and pesticides*

[From State of California, 1977. Values are in milligrams per liter; MBAS, Methylene blue active substance]

Property or constituent	Limiting concentration
Inorganic chemicals	
Nitrate....................	10
Arsenic....................	.1
Barium.....................	1.0
Cadmium....................	.01
Chromium...................	.05
Lead.......................	.05
Mercury....................	.005
Selenium...................	.01
Carbon (alcohol extract)...	3.0
Carbon (chloroform extract).................	.7
Foaming agent (MBAS).......	.5
Pesticides	
Aldrin.....................	.017
Chlordane..................	.003
DDT........................	.042
Dieldrin...................	.017
Endrin.....................	.001
Heptachlor.................	.018
Heptachlor epoxide.........	.018
Lindane....................	.056
Methoxychlor...............	1.0
Organophosphorous and carbamate compounds......	.1
Toxaphene..................	.05
2,4-D plus 2,4,5-T plus 2,5-TP.............	.1

The California Office of Technical Coordination has established water-quality objectives for municipal and agricultural supplies, water-contact and noncontact recreation, and fresh and salt-water habitats. These objectives, together with the beneficial uses designated for each basin, were combined to create water-quality objectives for each basin. In this report, beneficial uses are discussed under the subheading of the type of water for each basin.

As the water-quality objectives are based on water use, there are different objectives for the surface and ground water in each basin (tables 5 and 6, respectively). In general, ground water has stricter objectives because it is more often used for domestic purposes than is surface water.

In addition to the standards for the constituents presented in tables 5 and 6, maximum limits for pesticides and trace inorganic chemicals in any water used for domestic or municipal supplies have been established by the State of California (1977) (table 4).

TABLE 5.--*Water-quality objectives for inland surface water in the Soledad basin*

[From California Regional Water Quality Control Board, San Diego Region (1979). Concentrations not to be exceeded more than 10 percent during any one year period. Values are in milligrams per liter unless otherwise indicated. JTU, Jackson turbidity unit]

Property or constituent	Objective
Color (units)	20
Odor (units)	None
Turbidity (JTU)	20
Percent sodium	60
Sulfate	250
Chloride	250
Fluoride	1.0
Dissolved solids	500
Nitrogen and phosphorus	([1])
Boron	.5
Iron	.3
Manganese	.05
Methylene blue active substance	.5

[1]Phosphorus concentrations not to exceed 0.1 mg/L in flowing water and 0.025 mg/L in standing bodies of water. Values for nitrogen compounds have not been established; however, natural ratios of nitrogen to phosphorus are to be determined by surveillance and upheld. Where data are lacking a ratio of N>P = 10:1 shall be used (California Regional Water Quality Control Board, San Diego Region, 1979).

Hydrologic System

Geologic Units and Their Water-Bearing Characteristics

Most of the Soledad basin is underlain primarily by sedimentary rocks consisting of conglomerates, sandstones, and shales. Volcanic rocks underlie part of the basin. Seven geologic units are exposed in this basin (fig. 3). In ascending order, they are Santiago Peak Volcanics, gabbro of Cretaceous age, La Jolla Group, Poway Group, Lindavista Formation, Bay Point Formation, and alluvium (Kennedy, 1975). The Bay Point Formation and gabbro occupy a small part of the area and therefore are not discussed in this section.

Santiago Peak Volcanics of Late Jurassic and Early Cretaceous age are the oldest rocks in the basin. These rocks are found throughout the northern

TABLE 6.--*Water-quality objectives for ground water in the Soledad basin*

[From California Regional Water Quality Control Board, San Diego Region (1979). Concentrations not to be exceeded more than 10 percent during any one year period. Values are in milligrams per liter unless otherwise indicated. JTU, Jackson turbidity unit]

Property or constituent	Objective
Color (units)	15
Odor (units)	None
Turbidity (JTU)	5
Percent sodium	60
Sulfate	500
Chloride	500
Fluoride	1.0
Dissolved solids	1,200
Nitrogen (N)	10
Boron	.5
Iron	.3
Manganese	.05
Methylene blue active substance	.05

and eastern parts of the basin and in isolated outcrops throughout the rest of the area. Massive conglomerates, andesitic agglomerates, quartzites, shales, tuffs, and trachytic and andesitic flows make up the Santiago Peak Volcanics. These rocks are more resistant to erosion than the overlying sedimentary rocks.

Drillers' logs indicate that Santiago Peak Volcanics are penetrated by several wells in the basin. These wells also yield water from the overlying sediment of the Poway Group, and so the water-yielding characteristics of these wells may not be representative of water yielding characteristics of the Santiago Peak Volcanics. Elsewhere in San Diego County, well yields from the Santiago Peak Volcanics are generally low, usually less than 2 gal/min.

The La Jolla Group of Eocene age extends from the northern to the southern border of the basin; its expanse is broken only by the alluvium of the stream valleys and occurrences of the Lindavista Formation. The La Jolla Group consists, in ascending order, of three formations: the Del Mar Formation, the Torrey Sandstone, and the Friars Formation. The Del Mar Formation is composed of coarse- and fine-grained sandstone and sandy shales. The formation is generally exposed along the coast and up to 1 mile inland. Maximum thickness in the basin is 200 feet. The Torrey Sandstone extends from Los Penasquitos Canyon to the northern border of the subbasin. The formation is a soft, friable, coarse sandstone that overlies the Del Mar Formation. Thickness ranges from 25 to 200 feet. Friars Formation extends from Carmel Valley Canyon to the northern border of the basin. The formation is composed of sandstone and claystone. Maximum thickness in the basin is 150 feet. Ground water has not been developed in the La Jolla Group in the Soledad basin; however, in the San Dieguito basin to the north, wells have been drilled in this unit, and they typically yield water at a rate of 10 to 20 gal/min (Izbicki, 1983). Of this group, the Torrey Sandstone is more transmissive and yields greater amounts of water to wells than the Del Mar Formation (Izbicki, 1983).

The Poway Group of Eocene age is found in the southern part of the basin and extends from Miramar to the eastern edge of the basin. The Poway Group is an erosion-resistant unit composed mostly of conglomerates, although sands, shales, and caliche are often present. Maximum thickness of the Poway Group in the Soledad basin is about 900 feet.

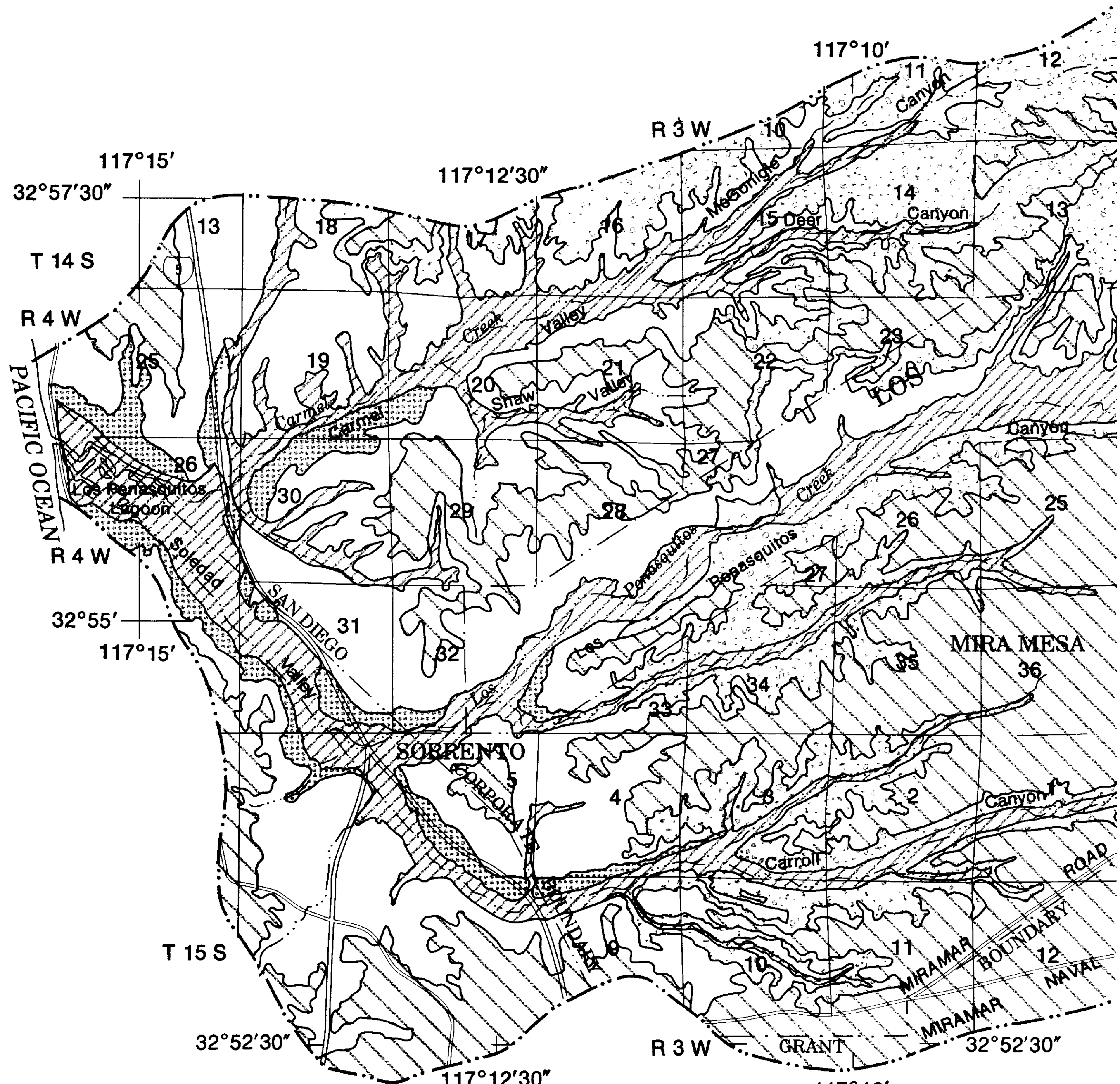
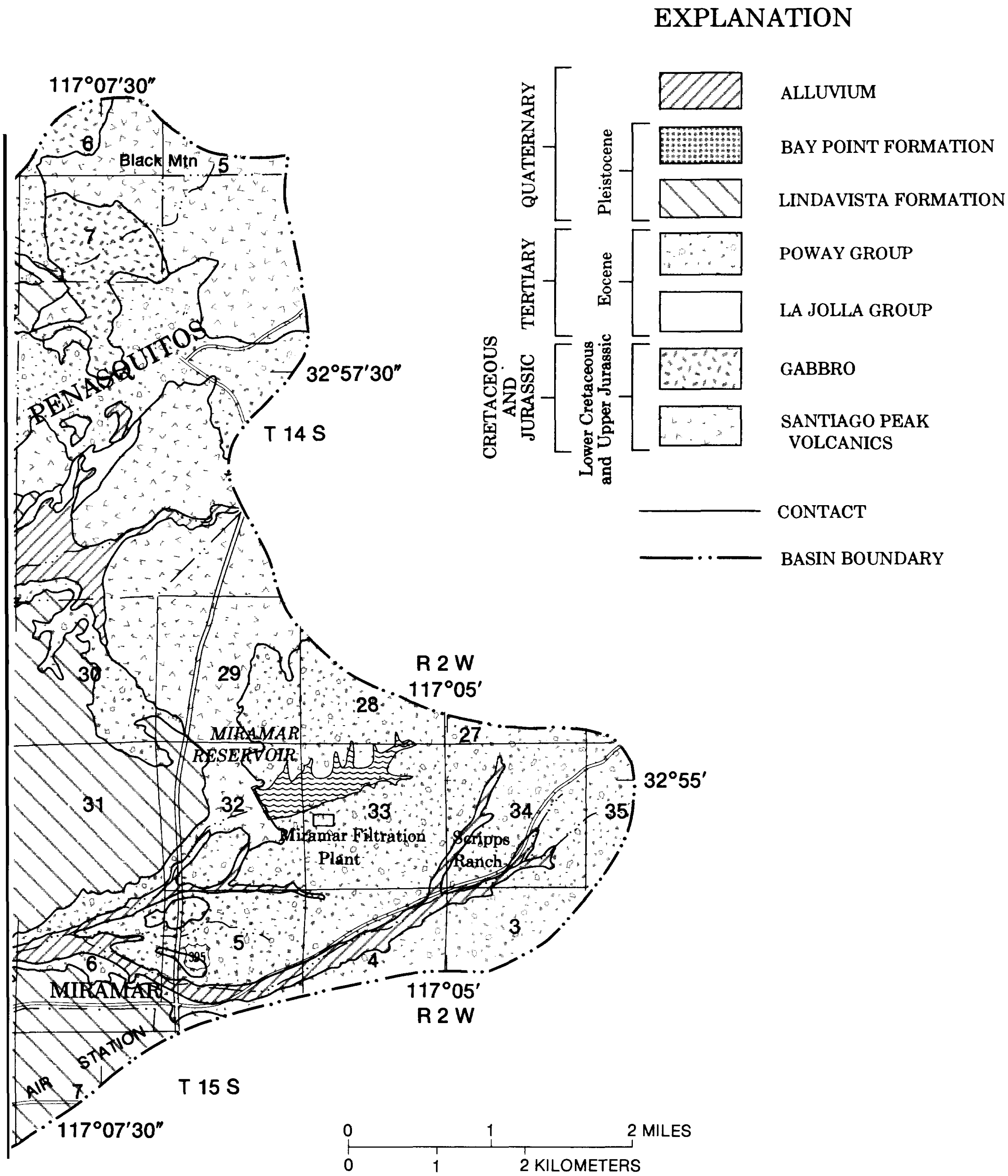


FIGURE 3.—Generalized geology of the Soledad basin (modified from Kennedy, 1975).


EXPLANATION
QUATERNARY
Pleistocene
TERTIARY
Eocene
CRETACEOUS AND JURASSIC
Lower Cretaceous and Upper Jurassic
ALLUVIUM
BAY POINT FORMATION
LINDAVISTA FORMATION
POWAY GROUP
LA JOLLA GROUP
GABBRO
SANTIAGO PEAK VOLCANICS
CONTACT
BASIN BOUNDARY
117°07'30"
Black Mtn
PENASQUITOS
32°57'30"
T 14 S
R 2 W
117°05'
MIRAMAR RESERVOIR
Miramar Filtration Plant
Scripps Ranch
32°55'
MIRAMAR
AIR STATION
T 15 S
0 1 2 MILES
0 1 2 KILOMETERS

Most of the ground water used in the Soledad basin comes from the Poway Group. The ground water probably comes from the coarser conglomerates that make up this group, specifically the Stadium Conglomerate and Pomerado Conglomerate (Kennedy and Peterson, 1975). Well yields range from 10 to 75 gal/min; however, typical yields are 10 to 20 gal/min.

South of Los Penasquitos Canyon, extending from Miramar to the ocean, is the Lindavista Formation of Pleistocene Age (fig. 3). In the eastern part of the study area, the Poway Group Formation is exposed as a broad, gently sloping terrace; in the west, the formation is characterized by narrow terraces separated by steep-walled canyons. The Lindavista Formation consists of an erosion-resistant conglomerate, cemented with iron oxides. These conglomerates form a cap rock for the walls of the stream valleys. The thickness of these deposits usually ranges to 50 feet. This unit is impermeable and generally lies above the water table; therefore, no ground-water development has occurred in this unit in the Soledad basin.

Alluvium, composed of consolidated stream deposits of silt, sand, and cobble-sized particles derived from the surrounding formations, is found in the Soledad and Carmel Valleys and Los Penasquitos and Carroll Canyons (fig. 3). Thickness of the alluvial fill is greatest in Soledad Valley, where depths up to 100 feet have been reported. In the Carmel Valley and Los Penasquitos and Carroll Canyons, depths probably do not exceed 25 feet. In all these valleys, the alluvium thins out rapidly upstream and eventually disappears, exposing the underlying sedimentary rocks. Soledad Valley (fig. 3) probably contains the greatest volume of alluvial fill. This band of alluvium is about 4 miles long and 0.3 mile wide on the average. In total, alluvial fill covers about 770 acres. Maximum thickness of the alluvial fill is greater than 100 feet; however, near the center of the Soledad Valley; thickness is 30 to 40 feet. This probably represents the average thickness in the valley, as the alluvium thins out to the south and thickens downgradient to the west. There are about 1,176 million ft^3 of alluvial fill in the Soledad Valley.

Carroll and Los Penasquitos Canyons and Carmel Valley all contain much thinner bands of alluvium. The width rarely exceeds 0.25 mile. Although these alluvial aquifers are smaller, they probably contain water with lower concentrations of dissolved solids than that of Soledad Valley. Together, these smaller valleys include about 2,340 acres and contain about 1,529 million ft^3 of alluvial fill. No information on well yields in any of the alluvial aquifers was available. Alluvial fill totals about 2,705 million ft^3 in the Soledad basin.

Of these valleys, the only area in which ground water has been developed is Carmel Valley. Ground water is the primary water supply in this area and supplies enough water for domestic as well as agricultural uses. The alluvial aquifer in this valley contains about 142 million ft^3 of fill. If the average specific yield of Soledad basin is assumed to be 0.1 (Johnson, 1967), ground-water storage, based on October 1984 water-level measurements, is estimated to be 260 acre-ft.

Two wells supply water for domestic uses in the upper part of Los Penasquitos Canyon. One well was flowing at the time of the study, and water in the other stands 1 foot below land surface. The canyon is currently an ecological reserve, and any ground-water development in the near future is unlikely.

In summary, most of the ground water used in the Soledad basin is derived from the Poway Group; however, alluvium and Santiago Peak Volcanics also contribute water to some wells in the area.

Soils

Soils are an important consideration when evaluating a site for reclaimed-water use, as they are the first material encountered when water is being recharged into an underlying aquifer. Distribution of soils in the San Diego area is more complex than the geology since factors that make up soil development include vegetation, topography, climate, living organisms, and time, as well as geologic parent material. Important attributes to consider when contemplating reclaimed-water use are soil thickness, permeability, slope, unusual chemical reaction, and depth to water. Eight soil associations (fig. 4) have been identified in the Soledad basin (U.S. Soil Conservation Service, 1973): Redding-Olivenhain, Redding, Diablo-Linne, Salinas-Corralitas, Marina-Chesterton, Las Flores-Huerhuero, Exchequer-San Miguel, and a miscellaneous association of broken land, terrace escarpments, and sloping gullied land (fig. 4).

Redding-Olivenhain and Redding soils have developed over cobbly and gravelly material such as the conglomerates of the Poway Group and the La Jolla Group. These soils cover a large part of the central and southern parts of the basin and lie on dissected terraces at altitudes of 100 to 600 feet. Thickness of these soils ranges from 10 to 60 inches. Degree of slope generally dictates soil thickness; for example, thicker soils are generally found on flatlands and gentle slopes, and thinner soils are found on steep slopes.

Redding soils are well-drained gravelly loams located on 2 to 50 percent slopes. The subsoil of the Redding soils is gravelly, heavy clay loam, and gravelly clay; a layer of cemented hardpan is commonly found below this subsoil. In a typical profile of Redding soils, any one of these layers may be missing. Because of the hardpan, infiltration is slow, less than 0.06 in/h; where the hardpan is absent, infiltration rates range from 0.63 to 2 in/h (U.S. Soil Conservation Service, 1973).

Olivenhain soils resemble Redding soils in texture, which ranges from cobbly loams to cobbly, sandy loams. The subsoil is cobbly clay, cobbly sandy clay, or cobbly clay loam. Although the Redding and Olivenhain soils share a clayey subsoil, the hardpan layer is absent in the Olivenhain soils. Infiltration rates in this soil are 0.63 to 2 in/h in the surface layer and <0.06 in/h in the subsurface (U.S. Soil Conservation Service, 1973).

Diablo-Linne soils have developed from weathered sandstone and shale. These are generally deep soils located on 2 to 50 percent slopes and altitudes of 100 to 600 feet. These soils are located in the center of the basin. They range in texture from clay loams to clays. Diablo soils are clays, 20 to 40 inches thick. Infiltration rates are slow, ranging from 0.06 to 0.2 in/h. Linne soils range from 28 to 40 inches in depth, and infiltration rates range from 0.2 to 0.63 in/h.

Salinas-Corralitas soils develop from material of marine origin. These soils are located on the valley floors (fig. 4). Slopes range from 0 to 15 percent, and altitudes range from 25 to 300 feet. Corralitas soils are thick, loamy sands that have formed from alluvium of marine sandstones. Infiltration rates range from 6.3 to 20 in/h. Salinas soils have developed on sediments washed off soils located on the upland slopes, specifically the Diablo, Linne, Las Flores, Huerhuero, and Olivenhain. Salinas soils are deep clay loams and have a lower infiltration rate of 0.2 to 0.63 in/h (U.S. Soil Conservation Service, 1973). This association contains saline soils; if reclaimed water is applied to these soils, the resulting ground water might contain a greater concentration of dissolved solids than expected.

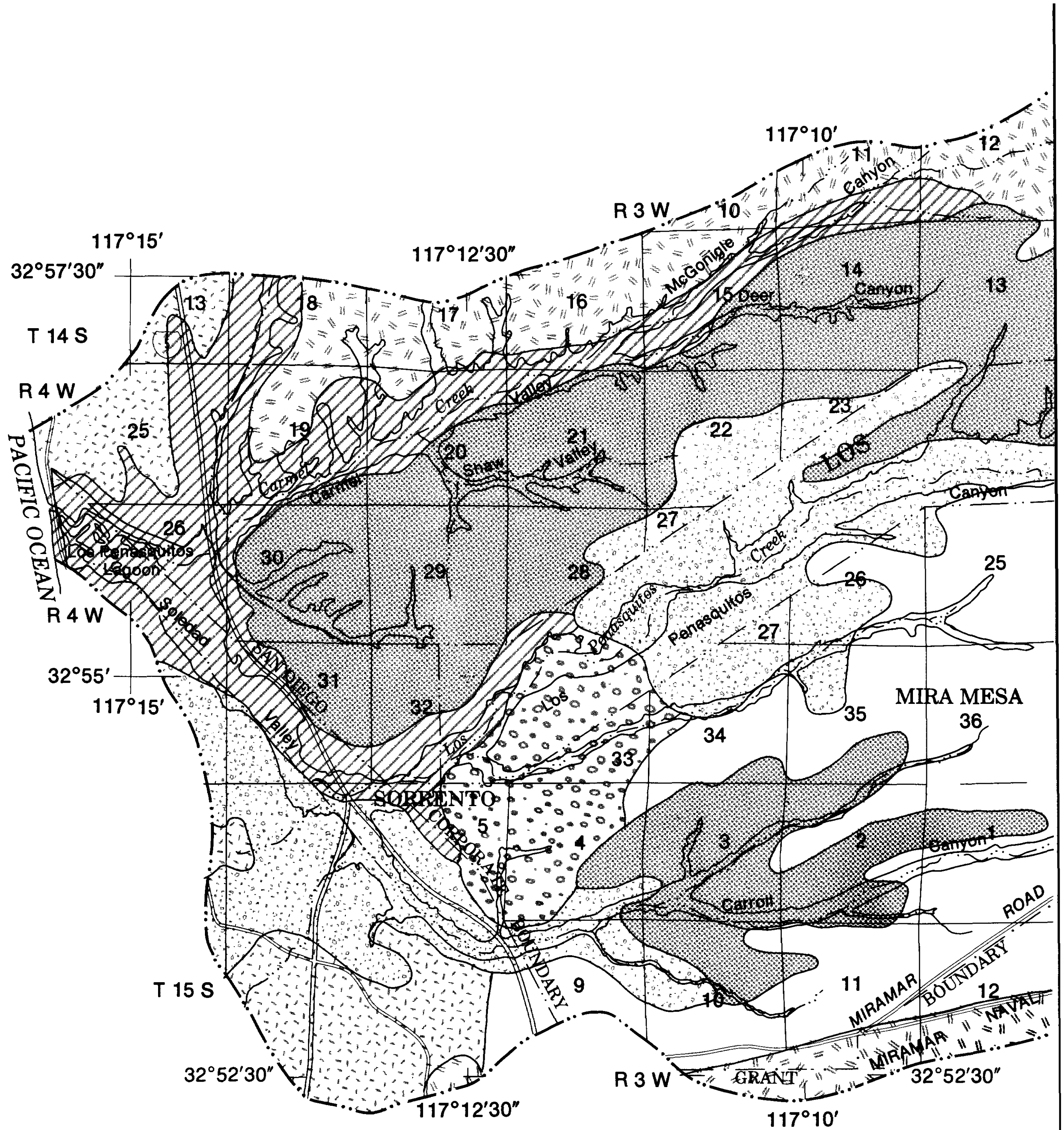
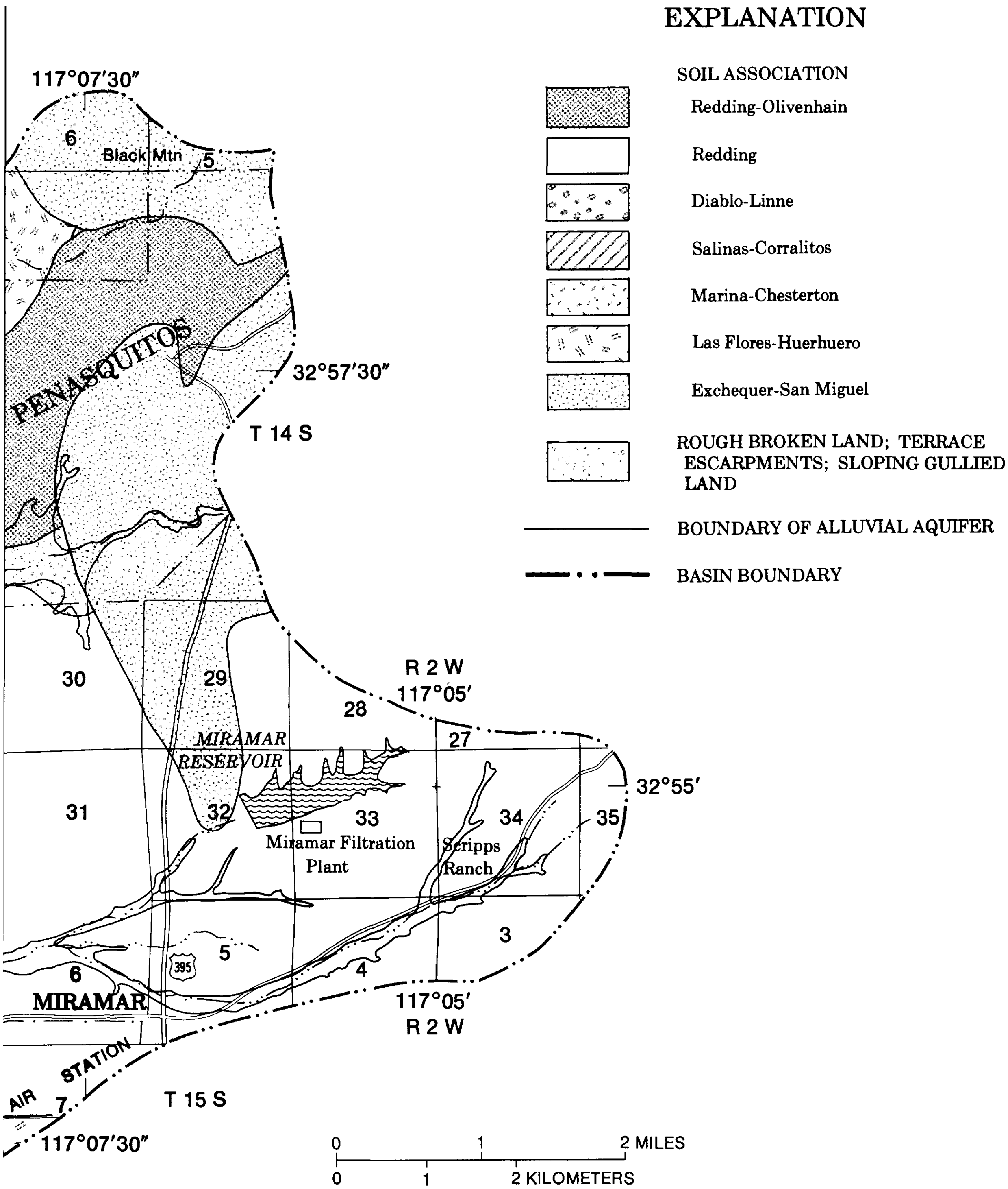


FIGURE 4.—Soil associations of the Soledad basin (modified from U.S. Soil Conservation Service, 1973).


EXPLANATION
SOIL ASSOCIATION
Redding-Olivenhain
Redding
Diablo-Linne
Salinas-Corralitos
Marina-Chesterton
Las Flores-Huerhuero
Exchequer-San Miguel
ROUGH BROKEN LAND; TERRACE ESCARPMENTS; SLOPING GULLIED LAND
BOUNDARY OF ALLUVIAL AQUIFER
BASIN BOUNDARY
117°07'30"
Black Mtn
PENASQUITOS
32°57'30"
T 14 S
R 2 W
117°05'
MIRAMAR RESERVOIR
Miramar Filtration Plant
Scripps Ranch
32°55'
395
MIRAMAR
AIR STATION
T 15 S
117°07'30"
117°05'
R 2 W
0 1 2 MILES
0 1 2 KILOMETERS

Marina-Chesterton soils have developed from iron-rich sand and sandstone. These soils occupy small parts of the north and southwestern parts of the basin. Marina soils are located on old beach ridges on 2 to 30 percent slopes, and subsurface textures are similar, ranging from loam to loamy sand. Infiltration in these soils is rapid, ranging from 6.3 to 20 in/h. Chesterton soils are found on ridge tops on slopes ranging from 2 to 15 percent and are composed of a surface layer of fine sandy loam to loamy sand that is 10 to 30 percent iron. The surface layer is often underlain by a hardpan layer. Infiltration ranges from 2 to 6.3 in/h in the surface layer and is 0.06 in/h in the hardpan.

Las Flores-Huerhuero soils have developed over material weathered from marine sediments. They are located in the uplands along the northern and southern edge of the basin on 2 to 30 percent slopes. These soils consist of a deep surface layer of loam to loamy sands with a clayey subsoil. Infiltration ranges from 0.06 to 2 in/h. Las Flores soils are loamy sands with a sandy clay subsoil that have developed from marine sandstone. Huerhuero soils are loams that have developed from sandy marine sediments.

Exchequer-San Miguel soils have developed from weathered material from Santiago Peak Volcanics. These soils are located in the uplands on slopes ranging from 9 to 70 percent. Rock outcrops are common, covering about 10 percent of the area. The surface layer of the Exchequer-San Miguel soils is silty loam, 8 to 10 inches thick. In the San Miguel soils, a subsoil of clay about 15 inches thick is present. This layer is absent in the Exchequer soils, where the thin surface layer is underlain with hard rock. Infiltration ranges from 0.06 to 2 in/h in the San Miguel soils and 0.63 to 2 in/h in the Exchequer soils.

In summary, areas covered by Exchequer, San Miguel, Las Flores, Huerhuero, Chesterton (where hardpan is present), Salinas, Corralitas, Diablo, Linne, Redding, and Olivenhain are not good sites for ground-water recharge because of low infiltration rates or the saline condition of the soil. Marina are generally good soils for ground-water recharge areas because they are located on gentle slopes, they are deep, and they have infiltration rates ranging from 6.3 to 20 in/h.

Ground Water

Occurrence and movement

Historically, movement of ground water in the small alluvial aquifers has been downgradient to Soledad Valley (fig. 5). Movement of ground water in Soledad Valley also has been downgradient toward the ocean. Marshy conditions exist up to 2 miles inland from the ocean, and water-level measurements made in 1984-85 in the Soledad Valley show that depth to water is about the same as that measured by Ellis and Lee (1919). At this time, depth to water in these valleys ranged from 2 to 9.5 feet.

Ground-water levels measured in 1984-85 in Carmel Valley were generally deeper than those in Soledad Valley, ranging from 7 to 37 feet below land surface. Ground-water flow in Carmel Valley is still downgradient toward Los Penasquitos Lagoon, and water levels ranged from 5 to 36 feet below land surface (fig. 5). In general, water levels were lower in the summer and autumn and higher in the spring.

Recharge to the alluvial aquifers of Los Penasquitos and Carroll Canyons and Soledad Valley is by streamflow, precipitation, ground-water flow from the surrounding formations, and municipal returns. These sources, as well as irrigation return, also are the sources of recharge to the alluvial aquifer in the Carmel Valley.

Streamflow in the Carmel Valley, which is limited to storm runoff and precipitation, is a minor source of recharge water to the aquifer. Irrigation water is derived solely from local water supplies. No additional water is brought into the area. Some of the water used for irrigation makes its way back to the alluvial aquifer, but most is lost through evapotranspiration, leaving only a small percentage for recharge.

Ground-water quality

Carroll Canyon and Soledad Valley.--Historical water-quality data available for well water in Carroll Canyon and Soledad Valley indicate that water quality has degraded between 1963 and 1977. In 1963, water from two wells in Carroll Canyon, 15S/3W-3N1 and 15S/3W-3N2, had dissolved-solids concentrations of 140 and 660 mg/L (milligrams per liter), respectively. At the same time in Soledad Valley, water in well 15S/3W-6H2 had a dissolved-solids concentration of 830 mg/L. By 1977, the two wells in Carroll Canyon had been abandoned and the dissolved-solids concentration of the well water in Soledad Valley was 1,400 mg/L. By 1984, all wells in Soledad Valley and Carroll Canyon had been abandoned.

Los Penasquitos Canyon. -- Historical water-quality data from two wells located in lower Los Penasquitos Canyon are evidence that water quality in the lower part of the canyon is probably unsuitable for human consumption. Concentrations of dissolved solids in 1963 were 2,200 and 2,100 mg/L, and concentrations of chloride and sulfate ranged from 580 to 590 mg/L and 470 to 580 mg/L, respectively. These wells have been abandoned, and no current data are available for this area. Historical water-quality data from a well located in upper Los Penasquitos Canyon, 14S/3W-24J1, indicate that water quality in the upper part of the canyon is of better quality than downstream. Analysis of more current data indicates that the water quality in this area has remained unchanged over the past 30 years. Concentrations of dissolved solids (residue) in the water from well 14S/3W-24J1 ranged from 1,500 mg/L (1985) to 1,600 mg/L (1975). This well water also exceeded basin water-quality objectives for iron and chloride. From 1974 to 1985, iron values ranged from 0.19 to 0.56 mg/L and averaged 0.41 mg/L. Chloride concentrations over the same period ranged from 600 to 730 mg/L and averaged 650 mg/L.

Another well located about 1 mile upstream had a dissolved-solids concentration of 1,200 mg/L in 1985 and chloride concentration of 470 mg/L; both values were slightly lower than in well 14S/3W-24J1, but at or exceeding basin standards. Iron concentration in well water (0.6 mg/L) also exceeded basin objectives.

Carmel Valley.--Historical water-quality data for wells in the Carmel Valley area are available for 1954-63 (California Department of Water Resources, 1967) and 1977 (Michael McCann, California Regional Water Quality Control Board, San Diego Region, written commun., 1985). Well-depth data were unavailable for most of the wells that have water-quality records.

In the samples collected in 1954-63, concentrations of dissolved solids in these wells ranged from 510 to 6,100 mg/L and averaged 2,000 mg/L (fig. 6). Dissolved-solids concentrations in 40 percent of the wells sampled exceeded the established basin objective of 1,200 mg/L. Chemical water types were generally sodium calcium chloride.

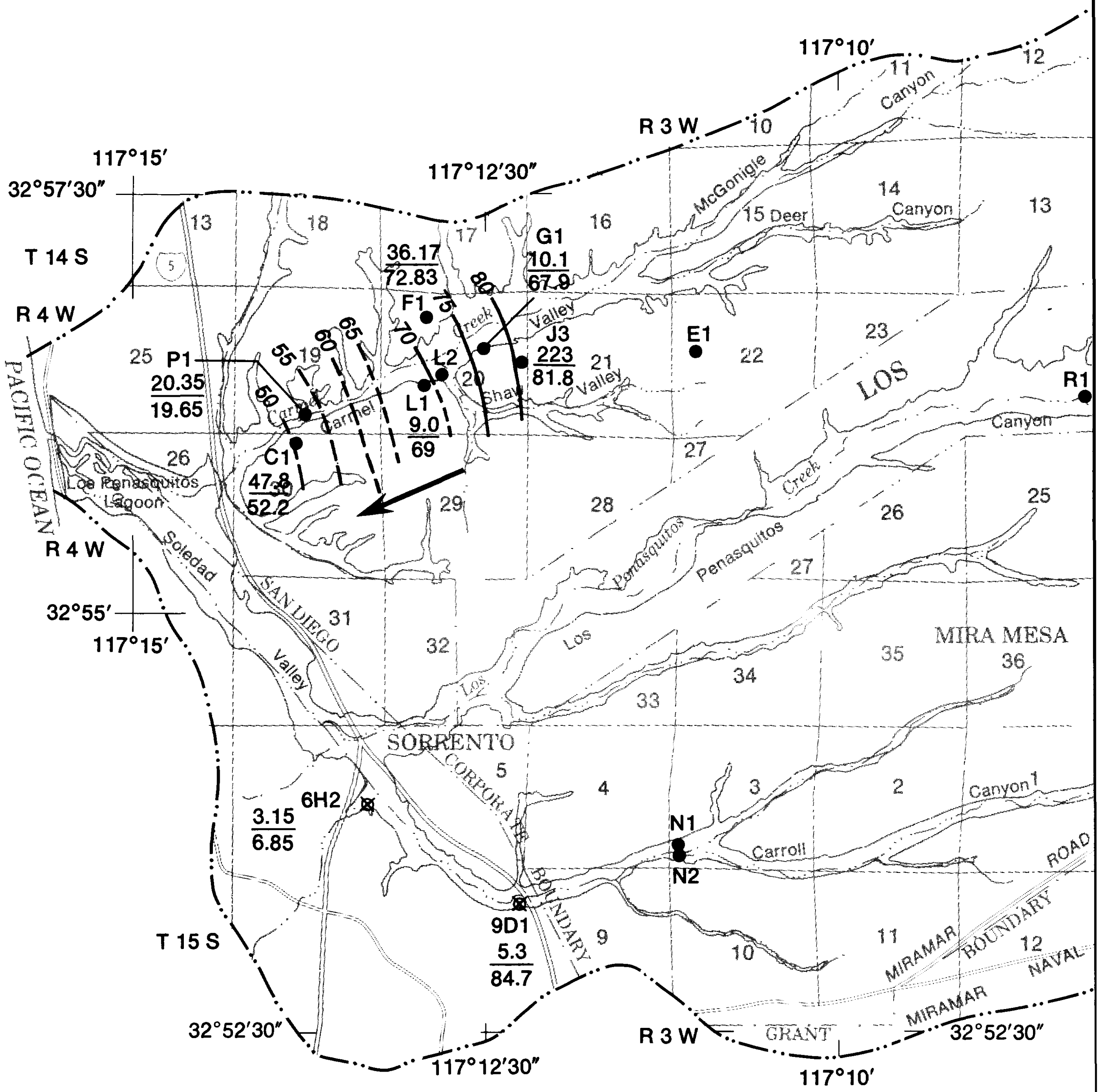
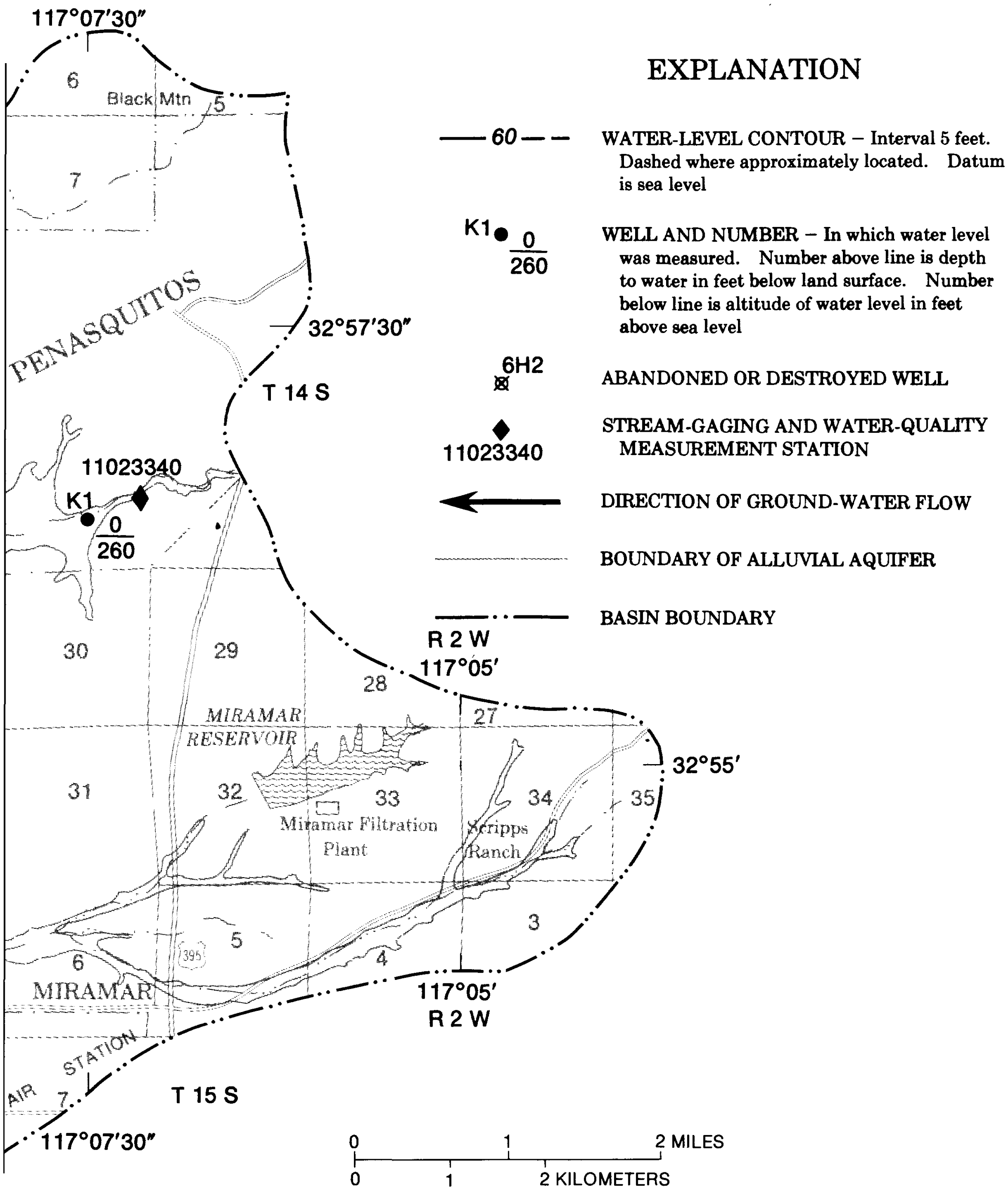


FIGURE 5.—Water-level contours and depth to water in the Soledad basin, spring 1985, and location of stream-gaging and water-quality measurement station.


117°07'30"
Black Mtn
PENASQUITOS
32°57'30"
T 14 S
11023340
K1
0
260
30
29
28
R 2 W
117°05'
27
MIRAMAR RESERVOIR
32°55'
31
32
33
34
35
Miramar Filtration Plant
Scripps Ranch
3
5
6
4
MIRAMAR
395
117°05'
R 2 W
AIR STATION
7
T 15 S
117°07'30"
0 1 2 MILES
0 1 2 KILOMETERS
EXPLANATION
60
WATER-LEVEL CONTOUR – Interval 5 feet. Dashed where approximately located. Datum is sea level
K1
0
260
WELL AND NUMBER – In which water level was measured. Number above line is depth to water in feet below land surface. Number below line is altitude of water level in feet above sea level
6H2
ABANDONED OR DESTROYED WELL
11023340
STREAM-GAGING AND WATER-QUALITY MEASUREMENT STATION
DIRECTION OF GROUND-WATER FLOW
BOUNDARY OF ALLUVIAL AQUIFER
BASIN BOUNDARY

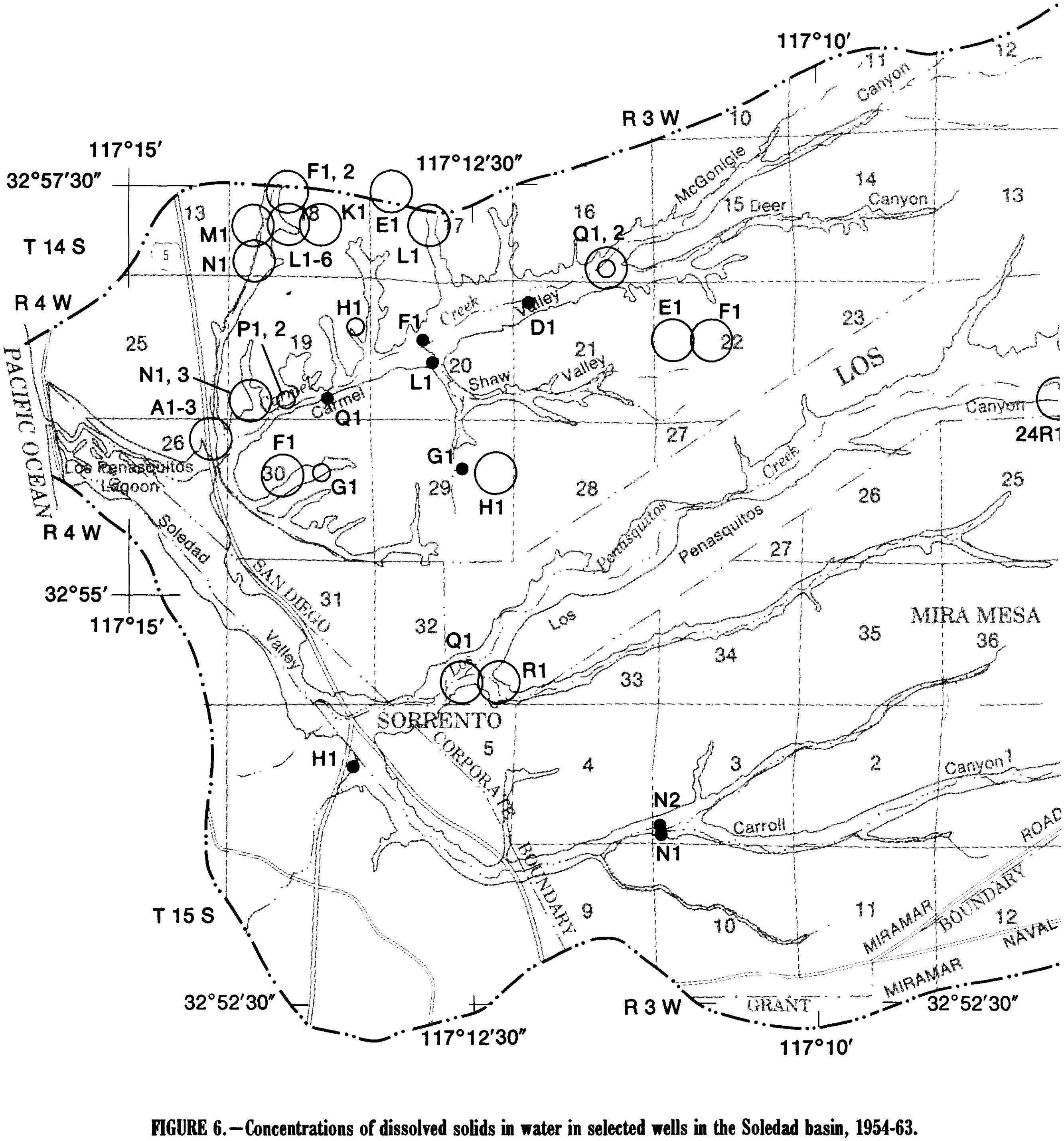
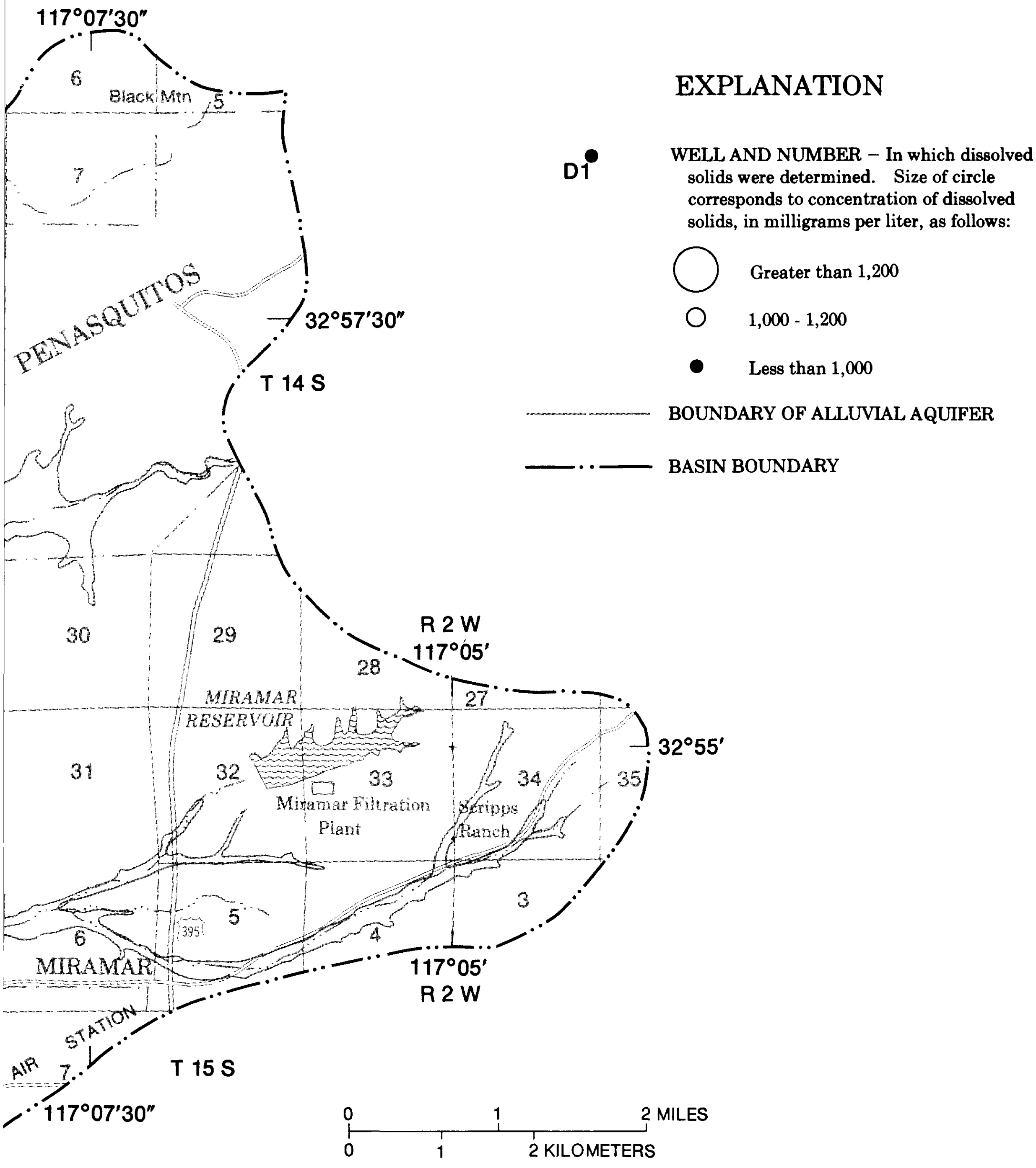


FIGURE 6.—Concentrations of dissolved solids in water in selected wells in the Soledad basin, 1954-63.



117°07'30"
6
Black Mtn
5
7
PENASQUITOS
32°57'30"
T 14 S
30
29
R 2 W
117°05'
28
27
MIRAMAR
RESERVOIR
32°55'
31
32
33
34
35
Miramar Filtration
Plant
Scripps
Ranch
3
5
395
6
4
MIRAMAR
117°05'
R 2 W
AIR STATION
7
T 15 S
117°07'30"
0
1
2 MILES
0
1
2 KILOMETERS
EXPLANATION
D1
WELL AND NUMBER – In which dissolved solids were determined. Size of circle corresponds to concentration of dissolved solids, in milligrams per liter, as follows:
Greater than 1,200
1,000 - 1,200
Less than 1,000
BOUNDARY OF ALLUVIAL AQUIFER
BASIN BOUNDARY

Concentrations of fluoride and boron were below the objectives for the basin. Water from several wells exceeded basin objectives for nitrate concentrations; however, these high concentrations are probably indicative of local conditions, such as agricultural return flow to areas, rather than representative of conditions in the aquifer. One-third of the wells sampled in 1954-63 had water that exceeded the basin objectives for chloride.

In 1977, concentrations of dissolved solids ranged from 890 to 1,760 mg/L and averaged 1,360 mg/L. This apparent lowering of dissolved solids may have resulted from wells with higher dissolved-solids concentrations going out of production, thereby lowering the range and mean. At this time, 60 percent of the wells sampled contained water that exceeded 1,200 mg/L of dissolved solids. Also during this time, several wells sampled exceeded the basin objectives for both chloride and sulfate. Values for these two constituents ranged from 100 to 600 mg/L and from 140 to 580 mg/L, respectively. One well contained water that exceeded basin objectives for fluoride, having a concentration of 1.1 mg/L. In samples collected throughout the 1970's, iron concentrations exceeded basin standards in almost half the wells sampled; at this time values ranged from 0.05 to 2.1 mg/L. Concentrations for all other constituents for which basin objectives had been set were at or below those values.

Most of the wells sampled in 1984-85 contained water in which concentrations of dissolved solids exceeded basin objectives. These concentrations ranged from 1,000 to 2,000 mg/L (fig. 7). Water types were determined mathematically by computing the relative concentration of cations to anions in chemical equivalents. The dominant cation and the dominant anion, those that amount to 50 percent or more of the total, designate the water type. If no one cation or anion amounted to 50 percent of the total, the water type is designated by the most dominant anions or cations which together constitute at least 50 percent (Hem, 1985). The dominant chemical water type of the valley has become more mixed since the early 1960's. On the basis of samples collected in 1984-85, the dominant water types were calcium sodium and chloride sulfate. This addition of sulfate as a dominant anion also has led to an increase of wells with sulfate values above those established for basin objectives. Sulfate concentrations ranged from 280 to 600 mg/L. Chloride concentrations were at or below basin objectives throughout the valley, ranging from 260 to 500 mg/L. Only one well, 14S/3W-20L1S, had been sampled in 1963, 1977, 1984, and 1985 (fig. 7). Analysis of these data show the same trends that were observed. Concentrations of dissolved solids have increased steadily from 790 mg/L in 1963 to 1,070 mg/L in 1985. Concentrations of chloride and sulfate also have increased from 180 and 190 mg/L to 320 and 260 mg/L, respectively. Concentrations of iron also tended to be high; values ranged from 0.29 to 880 mg/L. Water-quality analyses from 1984-85 are shown in tables 7 and 8.

Historical data indicate that the quality of ground water in the Poway group is more mineralized than that of the alluvium in the Carmel Valley area. Water-quality data collected in 1962-63 show that concentrations of dissolved solids in water from wells located in the area bordering the Carmel Valley ranged from 730 to 4,000 mg/L and averaged 2,200 mg/L. Of the wells sampled, 94 percent had concentrations of dissolved solids in excess of 1,200 mg/L; 60 percent exceeded chloride concentrations of 500 mg/L; and one-third exceeded sulfate concentrations of 500 mg/L. As of 1984, most of these wells had been abandoned.

TABLE 7.--*Water quality in wells in the Soledad, Poway, and Moosa basins, 1984-85*

[Values are in milligrams per liter unless otherwise indicated. --, no data. µS/cm, microsiemens per centimeter. °C, degrees Celsius. <, less than]

Well No.	Date of sample	Specific conductance (µS/cm)	pH (standard units)	Temperature (°C)	Hardness, as $CaCO_3$	Hardness, noncarbonate, as $CaCO_3$	Calcium, dissolved, as Ca	Magnesium, dissolved, as Mg	Sodium, dissolved, as Na	Percent sodium	Sodium adsorption ratio
					Soledad basin						
14S/2W-19K1S	3-20-85	882	7.1	26.5	220	31	58	19	110	52	3
14S/3W-20G1S	10-15-84	2,860	7.1	22.5	1,000	790	290	77	250	34	3
	3-20-85	2,700	7.0	22.5	1,000	750	290	72	280	37	4
14S/3W-20L1S	3-20-85	1,640	7.4	19.0	540	320	150	41	150	37	3
14S/3W-24R1S	10-16-84	2,600	7.2	23.5	550	370	130	54	320	56	6
	3-20-85	2,500	7.2	23.0	510	340	120	52	350	60	7
					Poway basin						
14S/1W-7D2S	10-16-84	2,300	7.1	21.0	690	450	120	96	230	42	4
14S/1W-8D1S	10-16-84	1,080	7.0	22.0	240	81	49	29	130	54	4
	3-19-85	972	7.1	20.5	240	88	46	31	140	55	4
14S/1W-8H2S	10-16-84	860	6.6	21.0	200	64	54	17	110	54	3
14S/1W-17B2S	10-16-84	1,170	6.7	23.5	310	110	50	45	120	45	3
	3-19-85	1,180	6.8	21.5	340	140	55	48	120	43	3
14S/1W-21H1S	10-16-84	1,780	6.9	20.5	530	210	140	43	170	41	3
	3-19-85	1,800	7.0	20.5	540	220	140	47	160	39	3
14S/2W-12K2S	10-16-84	2,600	7.0	21.0	810	550	160	100	230	38	4
	3-19-85	2,640	7.2	21.0	940	600	160	130	280	39	4
14S/2W-22C1S	10-16-84	1,500	6.9	21.0	390	190	69	53	140	43	3
	3-19-85	1,470	6.9	21.5	410	200	72	55	150	44	3
14S/2W-25M1S	10-16-84	1,770	7.1	--	470	180	120	42	170	44	4
	3-19-85	1,520	6.9	20.5	470	200	120	40	140	40	3
14S/2W-26J1S	10-16-84	1,600	7.0	19.0	480	230	120	43	130	37	3
	3-19-85	1,500	7.0	19.0	450	230	110	43	120	37	3
					Moosa basin						
11S/3W-1F2S	10-17-84	1,900	7.3	19.0	560	280	120	63	180	41	3
	3-18-85	1,730	7.1	16.0	570	340	130	59	170	39	3
11S/3W-1Q2S	10-17-84	960	7.3	21.0	290	89	76	24	75	36	2
	3-21-85	964	7.5	20.0	320	120	86	25	72	33	2
11S/4W-5J1S	10-17-84	1,240	6.7	19.5	290	130	54	38	140	51	4
	3-21-85	1,290	6.7	17.5	340	180	66	43	140	47	3
11S/4W-5N1S	10-17-84	1,550	6.7	18.5	490	260	110	53	100	30	2
11S/4W-5Q2S	10-17-84	1,790	6.7	20.0	440	270	97	49	190	48	4
	3-18-85	1,820	6.6	15.0	530	310	120	57	180	42	3
11S/4W-6G2S	10-17-84	1,840	7.2	21.5	470	210	99	54	200	48	4
	3-18-85	1,920	7.0	16.5	590	340	130	64	200	42	4
11S/4W-9J2S	10-17-84	790	6.7	19.0	210	64	50	20	79	45	2
11S/4W-10N1S	10-17-84	1,330	6.6	19.0	400	280	95	39	110	37	2
	3-18-85	1,250	6.5	15.5	390	210	92	38	110	38	3

TABLE 7.--*Water quality in wells in the Soledad, Poway, and Moosa basins, 1984-85*--Continued

Well No.	Date of sample	Potassium, dissolved, as K	Alkalinity, field as $CaCO_3$	Sulfate, dissolved, as SO_4	Chloride, dissolved, as Cl	Fluoride, dissolved, as F	Silica, dissolved, as SiO_2	Solids, residue at 180 °C dissolved	Solids, sum of constituents, dissolved	Nitrogen, nitrite dissolved, as N	Nitrogen, NO_2+NO_3 dissolved, as N
Soledad basin											
14S/2W-19K1S	3-20-85	2.9	271	130	470	0.60	39	1,210	1,200	<0.010	<0.10
14S/3W-20F1S	10-15-84	3.3	194	33	170	.50	49	518	530	--	1.6
	3-20-85	1.8	193	87	130	.90	30	537	550	<.010	.22
14S/3W-20G1S	10-15-84	5.1	257	660	500	.70	27	1,990	2,000	<.010	.47
	3-20-85	4.7	272	670	460	.70	28	1,910	2,000	<.010	.21
14S/3W-20L1S	3-20-85	2.7	221	290	260	.60	26	1,070	1,100	<.010	.20
14S/3W-24R1S	10-16-84	2.7	181	180	640	1.0	44	1,500	1,500	<.010	<.10
	3-20-85	2.9	180	180	640	1.0	42	1,490	1,500	<.010	<.10
Poway basin											
14S/1W-7D2S	10-16-84	4.6	247	400	400	0.04	60	1,560	1,500	<0.010	11
14S/1W-8D1S	10-16-84	2.8	161	100	150	.70	60	640	620	<.010	13
	3-19-85	2.5	155	100	160	.80	63	688	640	<.010	10
14S/1W-8H2S	10-16-84	1.9	141	81	140	1.0	28	561	520	.020	.37
14S/1W-17B2S	10-16-84	6.7	205	100	210	.70	73	715	730	<.010	<.10
	3-19-85	6.4	199	100	210	.70	77	732	740	<.010	.11
14S/1W-21H1S	10-16-84	3.6	317	84	370	1.0	49	972	1,100	<.010	.80
	3-19-85	3.9	321	90	380	.90	47	1,070	1,100	<.010	<.10
14S/2W-12K2S	10-16-84	4.0	262	290	570	.50	57	1,620	1,600	.050	4.3
	3-19-85	4.0	335	140	270	.40	46	804	1,200	.010	3.6
14S/2W-22C1S	10-16-84	4.3	203	69	300	.70	57	884	820	<.010	4.9
	3-19-85	4.3	210	71	310	.80	62	870	850	<.010	4.5
14S/2W-25M1S	10-16-84	1.7	295	48	380	.60	46	980	990	<.010	1.4
	3-19-85	1.5	264	36	330	.50	55	910	880	<.010	1.8
14S/2W-26J1S	10-16-84	1.9	251	41	350	.60	45	782	880	<.010	2.7
	3-19-85	1.8	227	39	330	.60	50	898	830	<.010	2.9
Moosa basin											
11S/3W-1F2S	10-17-84	2.2	280	240	330	0.30	36	1,170	1,100	<0.010	0.83
	3-18-85	2.1	227	240	290	.30	35	1,060	1,100	<.010	1.6
11S/3W-1Q2S	10-17-84	5.1	200	37	180	.40	42	525	560	<.010	<.10
	3-21-85	5.0	196	36	170	.40	44	535	560	<.010	<.10
11S/4W-5J1S	10-17-84	3.4	159	160	210	.40	48	752	750	<.010	1.1
	3-21-85	3.7	160	200	210	.40	51	833	810	<.010	.98
11S/4W-5N1S	10-17-84	8.6	229	110	290	.20	46	917	860	<.010	7.8
11S/4W-5Q2S	10-17-84	4.2	176	230	350	.40	46	1,100	1,100	<.010	.12
	3-18-85	3.5	229	280	330	.40	44	1,140	1,200	<.010	.28
11S/4W-6G2S	10-17-84	1.9	257	280	300	.60	39	1,170	1,100	.020	.11
	3-18-85	1.9	249	300	300	.40	37	1,260	1,200	--	.35
11S/4W-9J2S	10-17-84	1.8	143	56	130	.30	49	487	470	<.010	1.0
11S/4W-10N1S	10-17-84	2.6	117	180	250	.40	40	824	790	<.010	3.5
	3-18-85	2.7	178	190	210	.40	43	786	790	<.010	3.8

TABLE 7.--*Water quality in wells in the Soledad, Poway, and Moosa basins, 1984-85*--Continued

Well No.	Date of sample	Nitrogen, ammonia dissolved, as N	Nitrogen, ammonia dissolved, as NH_4	Nitrogen, ammonia + organic total, as NH_4	Phosphorus, ortho, dissolved, as P	Aluminum, dissolved, as Al (µg/L)	Arsenic, dissolved, as As (µg/L)	Boron, dissolved, as B (µg/L)	Cadmium, dissolved (µg/L)	Chromium, dissolved (µg/L)
					Soledad basin					
14S/2W-19K1S	3-20-85	0.020	0.03	0.20	<0.010	10	<1	210	<1	<1
14S/3W-20F1S	10-15-84	--	--	--	--			90		
	3-20-85	.030	.04	.30	<.010	20	2	200	<1	<1
14S/3W-20G1S	10-15-84	.140	.18	<.20	.010			340		
	3-20-85	.110	.14	.60	<.010	10	2	330	<1	<1
14S/3W-20L1S	3-20-85	.290	.37	.50	.020	20	1	250	<1	<1
14S/3W-24R1S	10-16-84	.040	.05	<.20	.020			430		
	3-20-85	.030	.04	.20	<.010	10	<1	420	<1	<1
					Poway basin					
14S/1W-7D2S	10-16-84	0.010	0.01	1.3	0.070			150		
14S/1W-8D1S	10-16-84	<.010	--	<.20	.070			80		
	3-19-85	<.010	--	.30	.060	10	2	90	<1	<1
14S/1W-8H2S	10-16-84	.020	.03	--	.140			200		
14S/1W-17B2S	10-16-84	.020	.03	<.20	.020			170		
	3-19-85	<.010	--	.30	.010	<10	2	170	<1	<1
14S/1W-21H1S	10-16-84	.040	.05	<.20	.010			120		
	3-19-85	.020	.03	.30	<.010	<10	<1	110	<1	<1
14S/2W-12K2S	10-16-84	.030	.04	.80	.010			230		
	3-19-85	<.010	.01	.60	.020			200		
14S/2W-22C1S	10-16-84	.020	.03	.80	.120			190		
	3-19-85	<.010	--	.30	.120	<10	2	180	<1	<1
14S/2W-25M1S	10-16-84	.030	.04	.20	.040			70		
	3-19-85	.010	.01	.30	.030	10	<1	70	<1	<1
14S/2W-26J1S	10-16-84	.040	.05	.60	.020			80		
	3-19-85	.010	.01	.40	.010	10	1	80	<1	<1
					Moosa basin					
11S/3W-1F2S	10-17-84	0.050	0.06	<0.20	0.060			140		
	3-18-85	<.010	--	--	.040	<10	--	130	<1	<1
11S/3W-1Q2S	10-17-84	.020	.03	<.20	.010			60		
	3-21-85	<.010	--	<.20	<.010	<10	<1	60	<1	<1
11S/4W-5J1S	10-17-84	<.010	--	.20	.020			110		
	3-21-85	.010	.01	.30	<.010	<10	1	120	<1	<1
11S/4W-5N1S	10-17-84	.030	.04	1.5	.050			80		
11S/4W-5Q2S	10-17-84	.020	.03	<.20	.050			120		
	3-18-85	<.010	--	.40	.080	30	<1	110	--	--
11S/4W-6G2S	10-17-84	.030	.04	<.20	.040			170		
	3-18-85	--	--	--	--	<10	<1	140	<1	<1
11S/4W-9J2S	10-17-84	.020	.03	<.20	.050			60		
11S/4W-10N1S	10-17-84	.020	.03	.60	.020			100		
	3-18-85	.030	.04	.10	.020	<10	<1	110	<1	<1

TABLE 7.--*Water quality in wells in the Soledad, Poway, and Moosa basins, 1984-85*--Continued

Well No.	Date of sample	Cobalt, dis-solved, as Co (µg/L)	Copper, dis-solved, as Cu (µg/L)	Iron, dis-solved, as Pb (µg/L)	Lead, dis-solved, as Fe (µg/L)	Lith-ium, dis-solved, as Li (µg/L)	Molyb-denum, dis-solved, as Mo (µg/L)	Nickel, dis-solved, as Ni (µg/L)	Sele-nium, dis-solved, as Se (µg/L)	Stron-tium, dis-solved, as Sr (µg/L)	Vana-dium, dis-solved, as V (µg/L)
					Soledad basin						
14S/2W-19K1S	3-20-85	<1	2	<3	<1	64	6	<1	<1	560	9
14S/3W-20F1S	10-15-84			14							
	3-20-85	<1	1	160	<1	41	2	3	<1	160	2
14S/3W-20G1S	10-15-84			290							
	3-20-85	<1	6	570	<1	100	2	<1	1	910	9
14S/3W-20L1S	3-20-85	<1	1	350	<1	57	1	<1	<1	490	3
14S/3W-24R1S	10-16-84			440							
	3-20-85	<1	2	420	<1	50	6	2	<1	620	15
					Poway basin						
14S/1W-7D2S	10-16-84			30							
14S/1W-8D1S	10-16-84			23							
	3-19-85	<1	2	76	<1	30	7	<1	1	220	23
14S/1W-8H2S	10-16-84			140							
14S/1W-17B2S	10-16-84			19							
	3-19-85	<1	190	11	<1	63	10	<1	<1	190	19
14S/1W-21H1S	10-16-84			200							
	3-19-85	<1	4	2,200	<1	150	6	<1	<1	710	18
14S/2W-12K2S	10-16-84			600							
	3-19-85			50							
14S/2W-22C1S	10-16-84			15							
	3-19-85	<1	4	12	<1	77	13	<1	2	260	24
14S/2W-25M1S	10-16-84			42							
	3-19-85	<1	5	80	<1	75	<1	<1	2	560	7
14S/2W-26J1S	10-16-84			10							
	3-19-85	<1	3	13	<1	120	1	<1	5	820	7
					Moosa basin						
11S/3W-1F2S	10-17-84			4							
	3-18-85	<1	2	34	1	23	8	1	<1	540	18
11S/3W-1Q2S	10-17-84			580							
	3-21-85	<1	2	760	<1	61	13	<1	<1	160	6
11S/4W-5J1S	10-17-84			21							
	3-21-85	<1	5	18	3	42	6	3	<1	300	15
11S/4W-5N1S	10-17-84			5							
11S/4W-5Q2S	10-17-84			140							
11S/4W-5Q2S	3-18-85	--	--	35	--	--	--	--	--	--	--
11S/4W-6G2S	10-17-84			37							
	3-18-85	2	3	81	2	24	13	2	<1	540	16
11S/4W-9J2S	10-17-84			11							
11S/4W-10N1S	10-17-84			17							
	3-18-85	<1	10	15	2	70	8	3	2	210	4

TABLE 8.--*Pesticide concentrations in water from selected wells in Soledad, Poway, and Moosa basins*

[Values are in micrograms per liter. <, less than]

Well No.	Basin	Date of sample	Boron, dis-solved, as B	Iron, dis-solved, as Fe	PCB, total	Naphtha-lenes, poly-chlor, total	Chlor-dane, total	DDD, total	DDE, total	DDT, total	Dia-zinon, total
14S/3W-20G1S	Soledad	10-15-84	340	290	<0.1	<0.10	<0.1	<0.010	<0.010	<0.010	<0.01
14S/1W-8D1S	Poway	10-16-84	80	23	<.1	<.10	<.1	<.010	<.010	<.010	<.01
14S/2W-22C1S	Poway	10-16-84	190	15	<.1	<.10	<.1	<.010	<.010	<.010	<.01
		3-19-85	180	12	<.1	<.10	<.1	<.010	<.010	<.010	<.01
11S/4W-10N1S	Moosa	10-17-84	100	17	<.1	<.10	<.1	<.010	<.010	<.010	<.01

Well No.	Basin	Date of sample	Di-eldrin, total	Endo-sulfan, total	Endrin, total	Ethion, total	Hepta-chlor, total	Hepta-chlor epox-ide, total	Lin-dane, total	Mala-thion, total	Meth-oxy-chlor, total
14S/3W-20G1S	Soledad	10-15-84	<0.010	<0.010	<0.010	<0.01	<0.010	<0.010	<0.010	<0.01	<0.01
14S/1W-8D1S	Poway	10-16-84	<.010	<.010	<.010	<.01	<.010	<.010	<.010	<.01	<.01
14S/2W-22C1S	Poway	10-16-84	<.010	<.010	<.010	<.01	<.010	<.010	<.010	<.01	<.01
		3-19-85	<.010	<.010	<.010	<.01	<.010	<.010	<.010	<.01	<.01
11S/4W-10N1S	Moosa	10-17-84	<.010	<.010	<.010	<.01	<.010	<.010	<.010	<.01	<.01

Well No.	Basin	Date of sample	Methyl parathion, total	Methyl trithion, total	Mirex, total	Para-thion, total	Per-thane, total	Toxa-phene, total	Trithion, total
14S/3W-20G1S	Soledad	10-15-84	<0.01	<0.01	<0.01	<0.01	<0.1	<1	<0.01
14S/1W-8D1S	Poway	10-16-84	<.01	<.01	<.01	<.01	<.1	<1	<.01
14S/2W-22C1S	Poway	10-16-84	<.01	<.01	<.01	<.01	<.1	<1	<.01
		3-19-85	<.01	<.01	<.01	<.01	<.1	<1	<.01
11S/4W-10N1S	Moosa	10-17-84	<.01	<.01	<.01	<.01	<.1	<1	<.01

Surface Water

Streamflow characteristics

Los Penasquitos Creek drains the central and southern parts of the Soledad basin; it is currently the only gaged stream in the basin. McGonigle Canyon drains the northern part of the basin, and Carroll Canyon drains the southern and western parts of the basin (fig. 5). All flow from the basin drains into the ocean through Los Penasquitos Lagoon.

Los Penasquitos Creek connects the Poway and Soledad basins (fig. 1). Flow in Los Penasquitos Creek is perennial. Surface runoff in upper McGonigle and Carroll Canyons is confined to peak flow from major storms. In the lower reaches of McGonigle Canyon, agricultural return flow feeds the stream for part of the year. Because Carroll Canyon drains only urban and industrial areas, there is no agricultural return to maintain low flow. Surface-water flow data are summarized in table 9, and the location of the gage (10223340) is shown in figure 5.

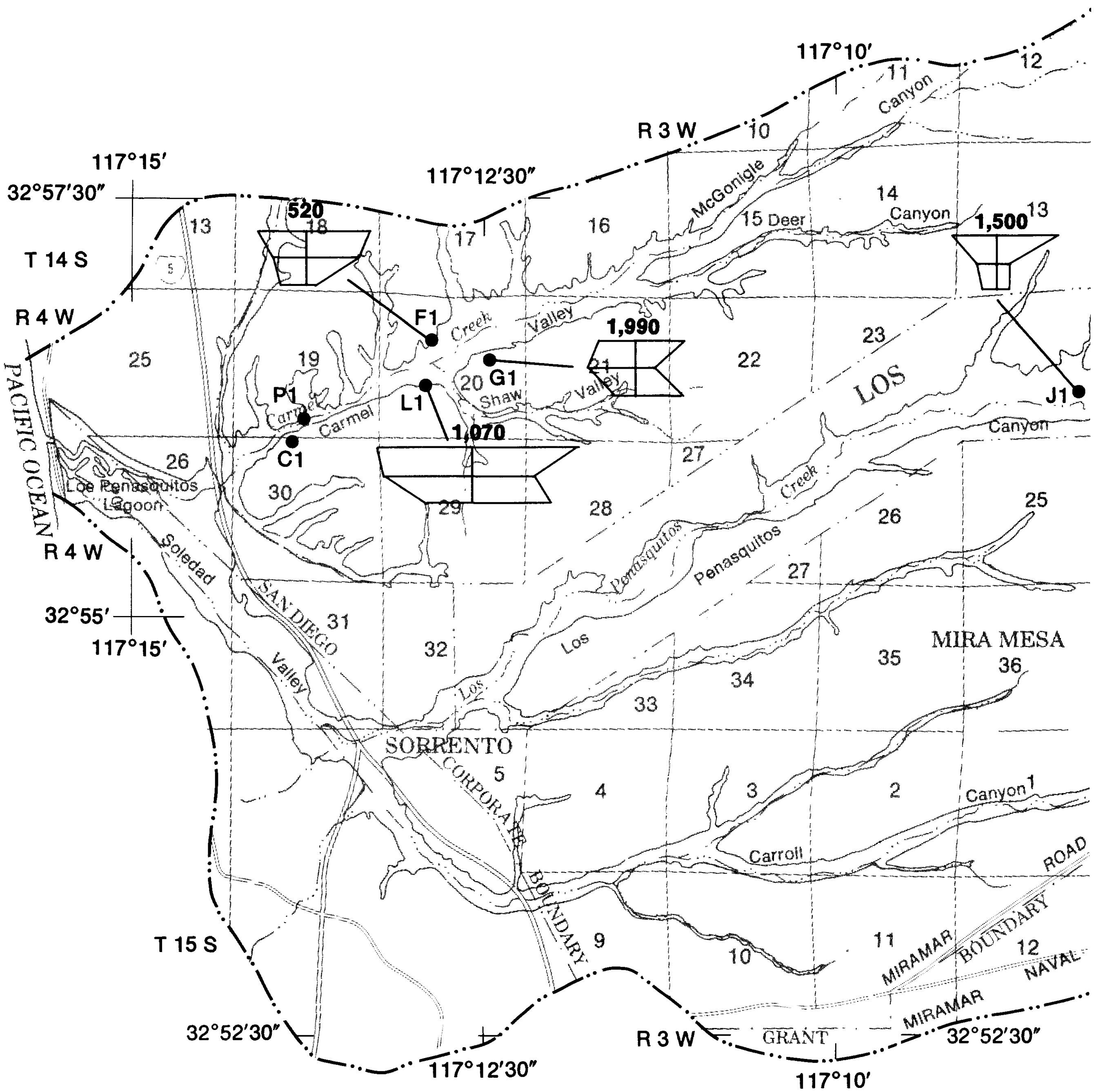


FIGURE 7.—Quality of water in selected wells in the Soledad basin, autumn 1984.

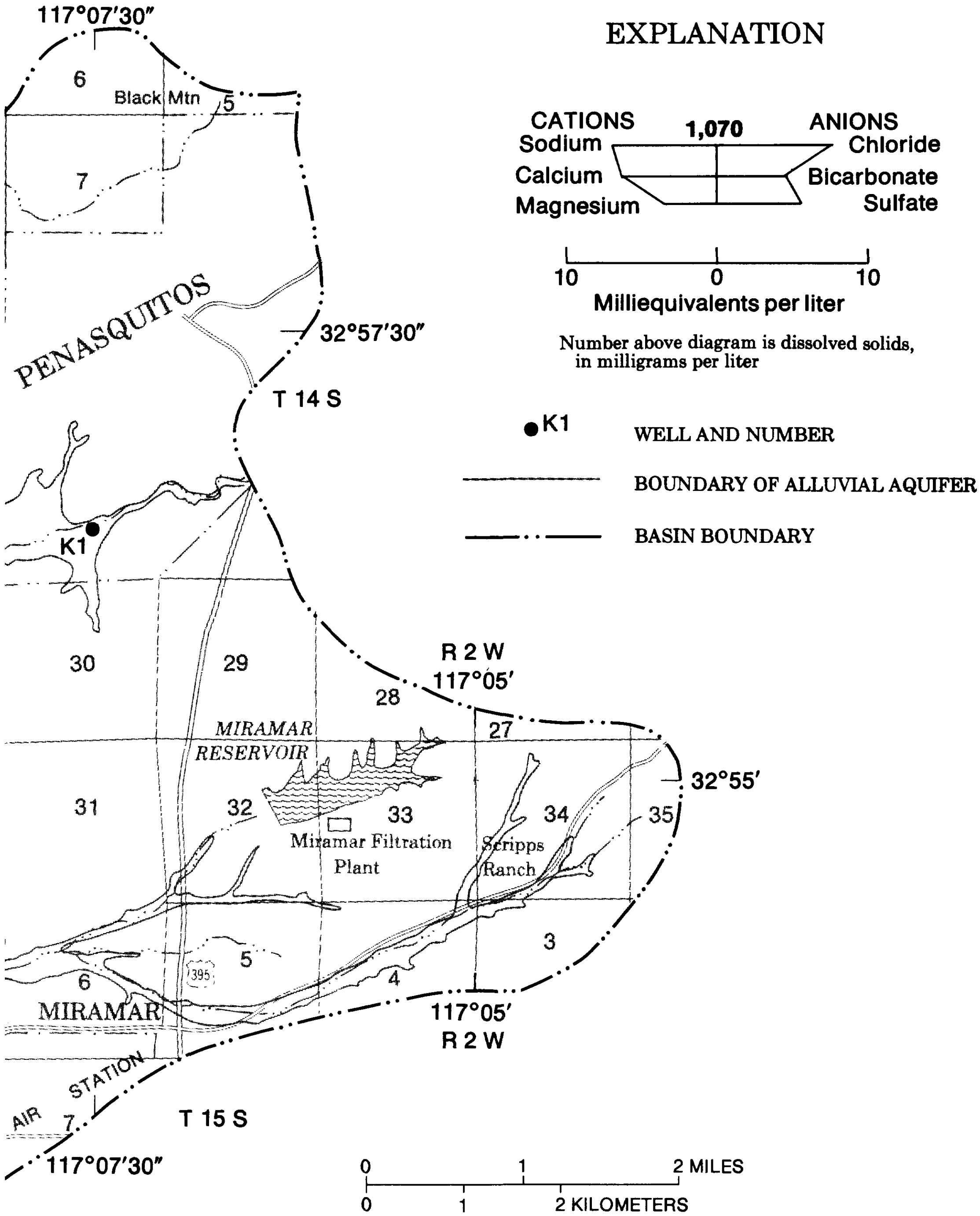

117°07'30"
6
Black Mtn
5
7
PENASQUITOS
32°57'30"
T 14 S
K1
30
29
28
R 2 W
117°05'
27
MIRAMAR RESERVOIR
32°55'
31
32
33
34
35
Miramar Filtration Plant
Scripps Ranch
3
5
395
6
4
MIRAMAR
117°05'
R 2 W
AIR STATION
7
T 15 S
117°07'30"
0 1 2 MILES
0 1 2 KILOMETERS
EXPLANATION
CATIONS
Sodium
Calcium
Magnesium
1,070
ANIONS
Chloride
Bicarbonate
Sulfate
10 0 10
Milliequivalents per liter
Number above diagram is dissolved solids, in milligrams per liter
K1 WELL AND NUMBER
BOUNDARY OF ALLUVIAL AQUIFER
BASIN BOUNDARY

TABLE 9.--*Summary of surface-water flow data for streams in Soledad and Poway basins*

[Drainage area measured in square miles. Annual discharge measured in acre-feet. Maximum discharge for period of record measured in cubic feet per second]

Station name and No.		Period of record	Drainage area	Annual discharge		Median number of days of no flow	Maximum discharge for period of record	
				Average	Median		Instantaneous	Annual
11023250	Poway Creek near Poway...	1979-83	7.92	870	818	222	755	1,833
11023310	Rattlesnake Creek at Poway..................	1970-83	8.13	1,402	1,148	162	1,430	3,484
11023320	Pomerado Creek at Poway Road, near Poway.......	1971-75	4.14	107	99	144	131	195
11023325	Beeler Creek at Pomerado Road, near Poway.......	1977-83	5.46	1,094	1,147	196	1,410	2,101
11023330	Los Penasquitos Creek below Poway Creek, near Poway.............	1971-83	31.2	2,707	916	3.5	4,990	8,564
11023340	Los Penasquitos Creek near Poway.............	1965-83	42.1	3,268	1,528	0	4,750	12,161

Surface-water quality

Water-quality data for Los Penasquitos Creek near Poway, California, are presented in table 10. These data were collected in October 1984 and March 1985 to represent base and storm flows, respectively. Comparison of the quality of water during these two periods shows that the concentration of dissolved solids is much lower during storm flow than during base flow. At both times, basin objectives were exceeded. Chemical water types also varied; during base flow, the water type is sodium chloride; during storm flow, the water type becomes mixed. Concentrations of chloride and sulfate exceeded basin objectives in the fall but not in the spring. Location of the sampling site is shown in figure 5.

Concentrations of trace elements were negligible. During the base-flow sampling period, diazinon, a pesticide commonly used in households, was detected in Los Penasquitos Creek. The pesticide may have entered the creek in urban runoff upstream.

Reclaimed Water

All municipal wastewater from the Soledad basin is transported to the treatment facility for the city of San Diego and discharged to the ocean off Point Loma (fig. 1). At present, there are no plans from the city of San Diego for use of reclaimed water in the basin. However, the city of Poway, located in the upgradient Poway basin, is considering plans for the use of reclaimed water in the Soledad basin.

Reclaimed water from the city of Poway would be transported into the Soledad basin to be used as recharge water for an alluvial aquifer. This anticipated reclaimed water would be less mineralized than the local ground water in the basin it would recharge. The plans call for pumping the ground water out of the aquifer and replacing it with reclaimed water, thereby improving the quality of the ground water. The plans anticipate that this recharged ground water can be used for irrigation. These plans are still in a preliminary stage, and the specific area of the Soledad groundwater basin to be used for this recharge has not been selected yet.

Several of the alluvial aquifers may be good candidates for this program. The Carmel Valley has the greatest demand for irrigation water; however, the alluvial aquifer may contribute water to some wells in the valley used for domestic supplies. At present, ground water in the lower part of Los Penasquitos Canyon, as well as in Soledad Valley, is unused. An irrigation supply could be used for roadside and ornamental vegetation and possibly for industry near and in these areas.

Imported Water

Sources and quantity

Imported water in the Soledad basin is supplied by the city of San Diego. The water is purchased from the San Diego County Water Authority, which purchases it from the Metropolitan Water District. The water purchased from the Metropolitan Water District is a blend of water from the California State Water Project in the northern part of the state and water from the Colorado River. The city of San Diego further blends this water with local surface water from various parts of San Diego County. Local rain also contributes a small percentage of the water supplied to the Soledad basin. The resulting water supply generally is 70 percent imported water and 30 percent local water. This proportion varies, depending on rainfall and water demands in different areas of California.

The municipal water supply for the Soledad basin is stored in Miramar Reservoir and treated at the Miramar filtration plant (fig. 5). Imported water is the sole water supply for most of the basin.

Quality of Imported Water

Water-quality data from the Miramar filtration plant for the period July 1982 to July 1984 are summarized in table 11. In general, the quality of the imported water is considerably less mineralized than that of the local ground water in the Soledad basin. Concentrations of dissolved solids are much lower in the imported water, ranging from 400 to 740 mg/L (Mary H. Middendorf, city of San Diego Utilities Department, written commun., 1985). Chemical water type of the imported water also differs from that of the ground water. Although the chemical water type of the imported water changes periodically, it is generally sodium chloride sulfate.

Water Use

Historically, ground water was an important source of water in the Carmel and Soledad Valleys and Carroll Canyon. Ground water has never been used outside these areas in the Soledad basin, specifically in the southern and eastern parts, where most of the population is located. In 1984-85, ground water was used only in the Carmel Valley, where it was the sole water supply. Imported water was used exclusively throughout the rest of the basin. Surface water has not been developed for use in the basin because flows are intermittent.

The California Regional Water Quality Control Board, San Diego Region (1979), noted existing and potential beneficial uses of surface and ground water for the Soledad basin. During the summer of 1984, the U.S. Geological Survey conducted a field survey of water use in the basin. These uses generally concur with those listed in the 1978 amendments. Specific applications of the various water supplies are discussed in detail under their specific headings.

TABLE 10.--*Water quality of streams in the*

[Values are in milligrams per liter unless otherwise indicated. Latitude numbers. µS/cm, microsiemens per centimeter at 25 °C;

Station name and number	Date of sample	Specific conductance (µS/cm)	pH (standard units)	Temperature (°C)	Hardness, as $CaCO_3$	Hardness, noncarbonate, as $CaCO_3$	Calcium, dissolved, as Ca	Magnesium, dissolved, as Mg	Sodium, dissolved, as Na	Percent sodium	Sodium adsorption ratio
11023340 Los Penasquitos Creek near Poway	10-16-84	3,200	7.8	19.5	810	420	160	100	380	50	6
	3-21-85	1,190	8.0	14.0	330	99	71	37	120	44	3
11023330 Los Penasquitos Creek below Poway Creek, near Poway	3-20-85	2,060	8.2	17.0	590	330	120	70	250	48	5
11023325 Beeler Creek at Pomerado Road	3-21-85	693	7.8	14.5	210	87	48	21	68	41	2
Rattlesnake Creek at Commercial Road 33°15'15"/117°09'10"	3-21-85	1,940	7.7	15.0	520	250	99	66	230	49	5
Moosa Creek below dam 33°12'45"/117°05'02"	10-17-84	1,770	7.6	17.5	460	260	94	54	190	47	4
	3-21-85	1,690	7.7	14.5	480	310	98	58	180	45	4
South Fork Moosa Creek 33°13'15"/117°08'15"	3-21-85	1,350	8.1	14.5	420	180	81	53	130	40	3
Moosa Creek at Champagne Road 33°15'15"/117°09'10"	3-21-85	1,760	8.1	17.5	550	320	120	60	170	40	3

and Longitude are provided for temporary stations that do not have station
°C, degrees Celsius; µg/L, micrograms per liter]

Potassium, dissolved, as K	Alkalinity, field, as $CaCO_3$	Sulfate, dissolved, as SO_4	Chloride, field, dissolved, as Cl	Fluoride, dissolved, as F	Silica, dissolved, as SiO_2	Solids, residue at 180 °C, dissolved	Solids, sum of constituents, dissolved	Nitrogen, nitrite, dissolved, as N	Nitrogen, NO_2+NO_3, dissolved, as N	Nitrogen, ammonia, dissolved as N	Nitrogen, ammonia, dissolved, as NH_4	Nitrogen, ammonia + organic, total, as NH_4	Phosphorus, ortho, dissolved, as P	Boron, dissolved, as B (µg/L)	Iron, dissolved, as Fe (µg/L)
4.2	394	340	690	0.70	40	2,030	2,000	0.010	0.27	0.040	0.05	0.70	0.080	380	100
2.7	231	140	200	.30	22	690	730	<.010	.12	.010	.01	.40	.020	120	17
3.0	261	230	450	.50	21	1,310	1,300	<.010	<.10	.020	.03	.50	.030	200	30
3.1	120	73	110	.30	23	407	420	<.010	.79	.020	.03	.70	.050	100	7
1.8	275	230	370	.60	36	1,250	1,200	.010	3.8	.010	.01	1.2	.020	200	10
5.4	196	280	290	.40	48	1,140	1,100	.020	1.1	.020	.03	.40	.070	120	86
2.4	177	340	260	.40	49	1,120	1,100	<.010	.79	.020	.03	.30	.020	110	52
2.4	240	150	220	.30	37	828	820	<.010	<.10	.010	.01	.40	<.010	80	16
1.7	230	260	300	.4	35	1,120	1,100	.02	.21	.02	.03	.4	<.01	130	17

TABLE 11.--*Summary of water-quality data from Miramar filtration plant, monthly samples, July 1982 to July 1984*

[From Mary H. Middendorf, city of San Diego Utilities Department, written commun., 1985. Values are in milligrams per liter unless otherwise indicated. Number of samples is 24]

Property or constituent	Mean	Median	Minimum	Maximum
pH (units)....	8.2	8.2	7.8	8.4
Hardness......	260	260	180	320
Noncarbonated hardness....	150	150	85	200
Calcium.......	65	66	42	82
Magnesium.....	24	24	17	31
Sodium........	82	80	62	110
Potassium.....	5.0	5.0	3.8	6.4
Sulfate.......	210	210	110	300
Chloride......	79	77	66	97
Fluoride......	.261	.28	.026	.4
Dissolved solids......	569	570	396	744
Iron..........	.02	.02	.02	.08

As population and acreage of developed lands increase, water demand also will increase. Projections from 1980 to 2000 for the entire Los Penasquitos basin estimate an increase of about 100 percent in the demand for water (California Regional Water Quality Control Board, San Diego Region, 1975). Of this demand, agricultural water supply is expected to decrease by about 85 percent while other water uses, specifically domestic, commercial, and industrial, are expected to increase by about 90 percent. These projections are for the entire Los Penasquitos basin, which includes the Soledad, Poway, Scripps, Miramar, and Tecolote basins. Because of similarities among these basins, the trends and percentage of changes probably are extrapolated accurately to the Soledad basin.

Ground Water

As of 1985, ground water was used only in and around the Carmel Valley. In this area, ground water is the sole water supply and is used for agriculture, industry, and domestic purposes. Most of the water in the Carmel Valley, however, is not well suited for irrigation supplies. According to the U.S. Salinity Laboratory's (1954) system of classification of water as to its suitability for irrigation, most of the water in wells sampled in the Carmel Valley are rated medium on sodium hazard and very high on salinity hazard.

Irrigation water probably accounts for the largest water use in this area. Total irrigation-water demand was about 10,120 acre-ft/yr in the Carmel Valley in 1980 (California Region Water Quality Control Board, San Diego Region, 1975). Irrigation water probably accounts for the largest water use in this area. Population in the Carmel Valley area is low; the amount of water used for domestic and industrial purposes probably does not exceed 100 acre-ft/yr.

As long as the Carmel Valley remains largely agricultural, ground water can probably supply the area's water needs. However, if the quality of the ground water continues to deteriorate, the ground water could become unusable for both agricultural and domestic purposes. If urban expansion extends into the area, imported water could be brought in to supplement that part of the water supply.

Surface Water

Surface water in the Soledad basin is intermittent and, therefore, not a dependable supply. Consequently, surface water generally is not used as a water-supply source. The beneficial uses associated with surface water are noncontact recreation, agriculture, and fish and wildlife habitat. Surface water in the Soledad basin also has the potential for industrial use.

Imported Water

In the Soledad basin, imported water is used for indoor and outdoor municipal purposes as well as for industry. Per-capita water production in the basin is 0.18 acre-ft/yr (California Regional Water Quality Control Board, San Diego Region, 1975). To supply the population of the basin (65,390 in 1980) (table 1), an additional water supply of about 11,770 acre-ft/yr is needed. This estimate does not include the amount of water needed for irrigation or for industry, which varies widely depending on the requirements of the particular industry; therefore, the total demand is actually greater.

POWAY BASIN

Location

The Poway basin adjoins the eastern border of the Soledad basin (fig. 1) and covers about 41 mi^2. The city of Poway lies in the center of the Poway basin (fig. 1). Rolling hills separate Poway basin from the Soledad basin, and steep hillsides form the eastern edge of the basin. To the northwest of Poway, high-density housing is becoming the dominant land use; however, most of the Poway area in 1985 was urban-rural: low-density residential, light industry, and agriculture. Poway, Beeler, and Rattlesnake Creeks are the main drainages in the area (fig. 8).

Population

The population of the Poway basin, which was 33,520 in 1980 (San Diego Association of Governments, written commun., 1985), is expected to increase about 140 percent by the year 2000. The greatest increase is expected in the 1980's. Table 12 shows projected populations from 1980 to 2000.

Currently, the main population center is the city of Poway (fig. 1). From 1980 to 2000, the population of the city is expected to increase 46 percent. The largest increase in population is expected in the areas north and west of Poway. The rugged terrain to the east will probably curtail growth in that direction.

Land Use

The Poway basin contains about 22,200 acres. The 1980 census indicates that about 25 percent of the total acreage was developed in 1980 (San Diego Association of Governments, 1984). Of this, 80 percent was residential development and 20 percent was nonresidential. Agriculture occupies the largest amount of land developed for nonresidential uses (fig. 8).

Projections to 2000 show sharp increases in the acreage of developed land. Acreage of residential development is expected to increase more than 90 percent, and acreage of nonresidential development is expected to increase almost 120 percent. Table 13 shows projections of acreage under specific land uses from 1980 to 2000.

Undeveloped land occupies the greatest acreage in the Poway area. In the eastern part of the basin, the undeveloped land is rugged, steeply sloping terrain, but in the western part, the undeveloped land is generally gently rolling terrain. The western part of the study area is expected to undergo the greatest development, and the eastern part is expected to undergo little development.

Residential and agricultural land uses are dominant in the Poway basin. Residential lands are concentrated near the center of the basin in and around the city of Poway. Agricultural lands are located in the western and northern parts of the basin. Commercial and recreational lands and schools occupy a small percentage of land in the basin (fig. 8).

Water-Quality Objectives

The establishment of and rationale for water-quality objectives have been described in the discussion of the Soledad basin. The same criteria for the establishment of water-quality objectives apply in the Poway basin. Water-quality objectives for surface and ground water in the Poway basin are found in tables 14 and 15, respectively. In addition to the objectives presented in table 14, the domestic use of ground water warrants the application of requirements of the State of California (1977) (tables 3 and 4).

Hydrologic System

Geologic Units and their Water-Bearing Characteristics

The six geologic units exposed in the Poway basin are, in ascending order, the Santiago Peak Volcanics, the Lusardi Formation of the Rosario Group of Late Cretaceous age, granitic rocks of the southern California batholith, the Friars Formation of the La Jolla Group, the Poway Group, and alluvium (fig. 9).

The Santiago Peak Volcanics are the oldest rocks in the basin (fig. 9). They are most commonly found in the western part of the study area; however, isolated outcrops also occur in the eastern part of the basin. These volcanics, which have been described in detail in the discussion of the Soledad basin, are extremely resistant to erosion, and they form the elevated ridge between the Poway and Soledad subunits. The volcanics yield small quantities of water to wells from cracks and fissures, but in the Poway basin no wells have been drilled into them.

The occurrence of the Lusardi Formation is limited to several small outcrops in the eastern part of the basin (fig. 9). These rocks are cobble and boulder conglomerates occasionally containing lenses of sandstone (Kennedy and Peterson, 1975).

Granitic rocks of the southern California batholith are exposed in or underlie the north and east parts of the basin (fig. 9). These rocks are quartz diorite, gabbro, and tonalites. Tonalites can be deeply weathered, and wells drilled in weathered tonalites can produce high yields; wells drilled in the more resistant diorites and gabbros generally have low yields.

The Friars Formation of the La Jolla Group, a nonmarine lagoonal sandstone and claystone, is exposed along the southern side of Poway Valley and Los Penasquitos Canyon (fig. 9). The formation is also found adjacent to the east and west sides of the alluvium around Beeler Creek and around the outcrop of the Poway Group in the northern part of the basin. This formation also underlies sedimentary deposits throughout the area. The maximum thickness in the basin is about 150 feet. Because this formation is located in areas that are unpopulated, it has not been developed as a source of ground water in the Poway basin. The La Jolla Group typically yields small quantities of water to wells elsewhere in San Diego County (Izbicki, 1983; 1985).

The Poway Group forms the south wall of the Poway Valley and extends throughout the southern part of the basin (fig. 9). Isolated occurrences also are located north of Poway Creek and west of Rattlesnake Creek. This group is composed of the Stadium Conglomerate, the Mission Valley Formation, and the Pomerado Conglomerate (Kennedy and Peterson, 1975). The Stadium and Pomerado Conglomerates are lithologically similar. Both consist of a cobble conglomerate that has a coarse-grained sandstone matrix, and lenses of sandstone compose as much as 50 percent of the units. The Stadium Conglomerate is the lowermost formation and the Pomerado Conglomerate is the uppermost formation in the Poway Group. The Mission Valley Formation lies between the two. This formation is composed of marine, lagoonal, and nonmarine sandstone. The sandstone is soft and locally contains carbonate-cemented beds (Kennedy and Peterson, 1975). Drillers' logs indicate that the Poway Group is a source of water to wells in the Poway basin. Well depth in this unit ranges from 100 to 200 feet. These wells probably derive water from the coarser parts of the Stadium and Pomerado Conglomerates. Well yields range from 2 to 30 gal/min in the Poway Group.

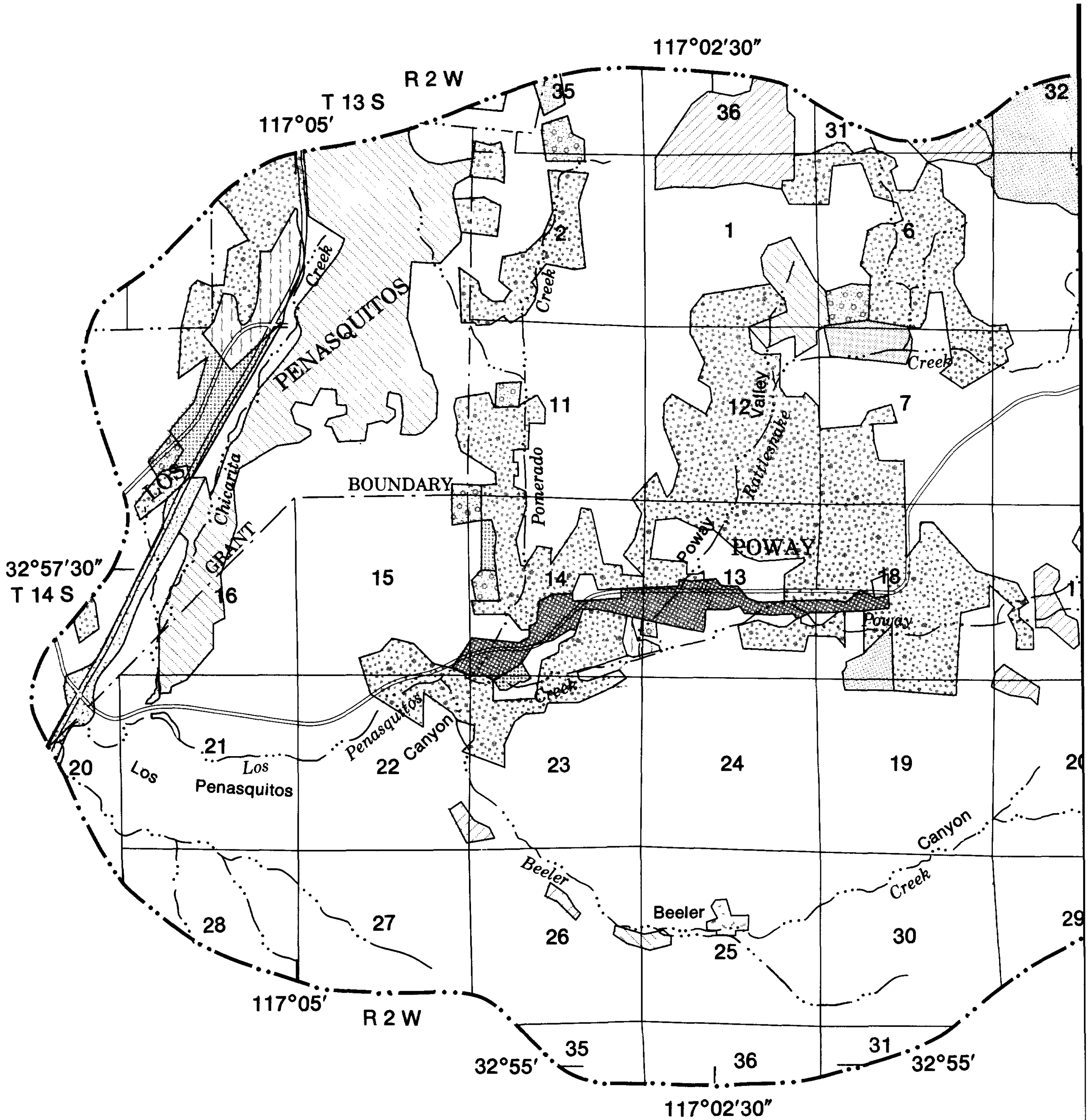
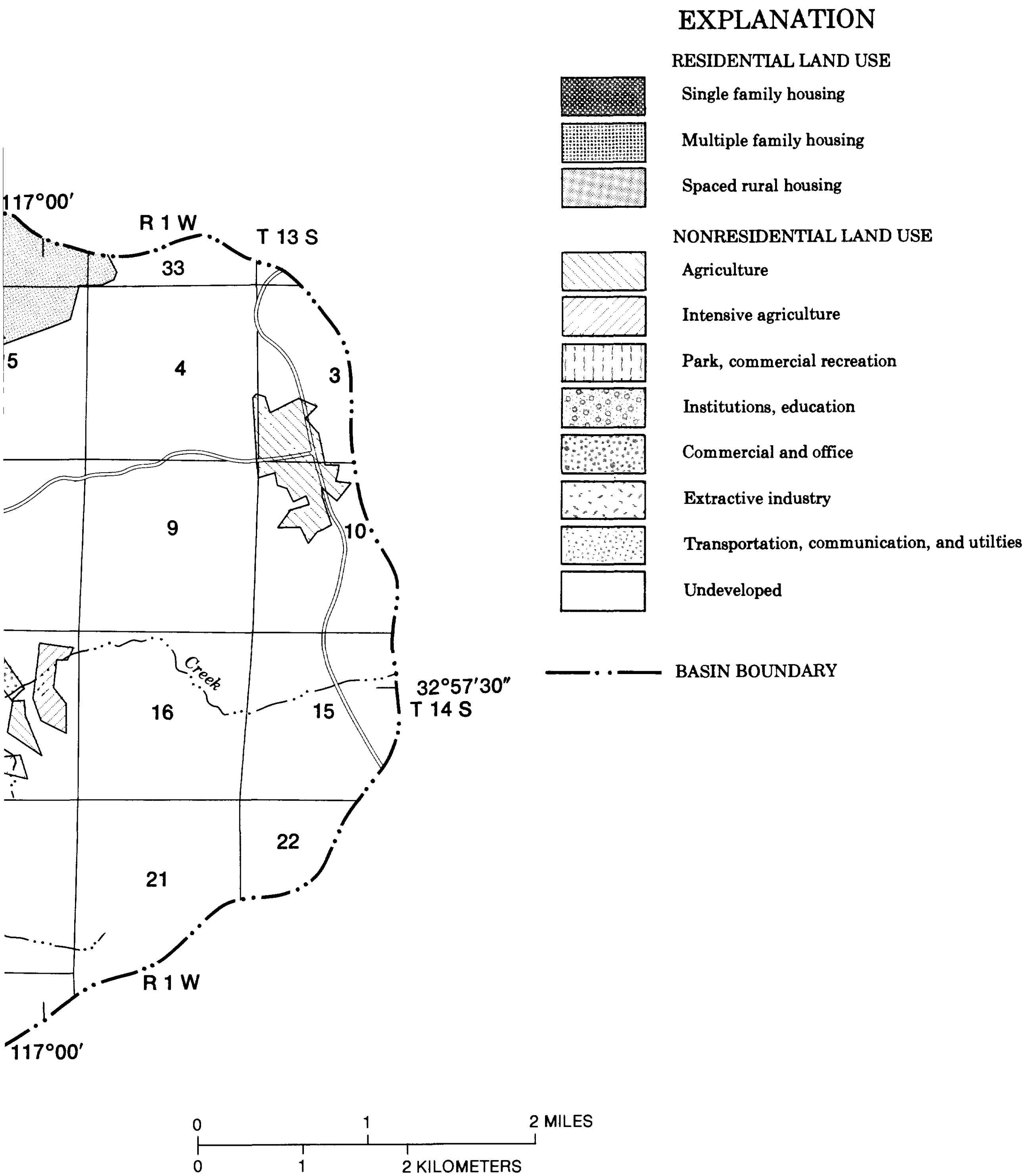


FIGURE 8.—Generalized land use in the Poway basin (modified from San Diego Association of Governments, 1980).


EXPLANATION
RESIDENTIAL LAND USE
Single family housing
Multiple family housing
Spaced rural housing
NONRESIDENTIAL LAND USE
Agriculture
Intensive agriculture
Park, commercial recreation
Institutions, education
Commercial and office
Extractive industry
Transportation, communication, and utilties
Undeveloped
BASIN BOUNDARY
117°00′
R 1 W
T 13 S
33
5
4
3
9
10
Creek
16
15
32°57′30″
T 14 S
22
21
R 1 W
117°00′
0
1
2 MILES
0
1
2 KILOMETERS

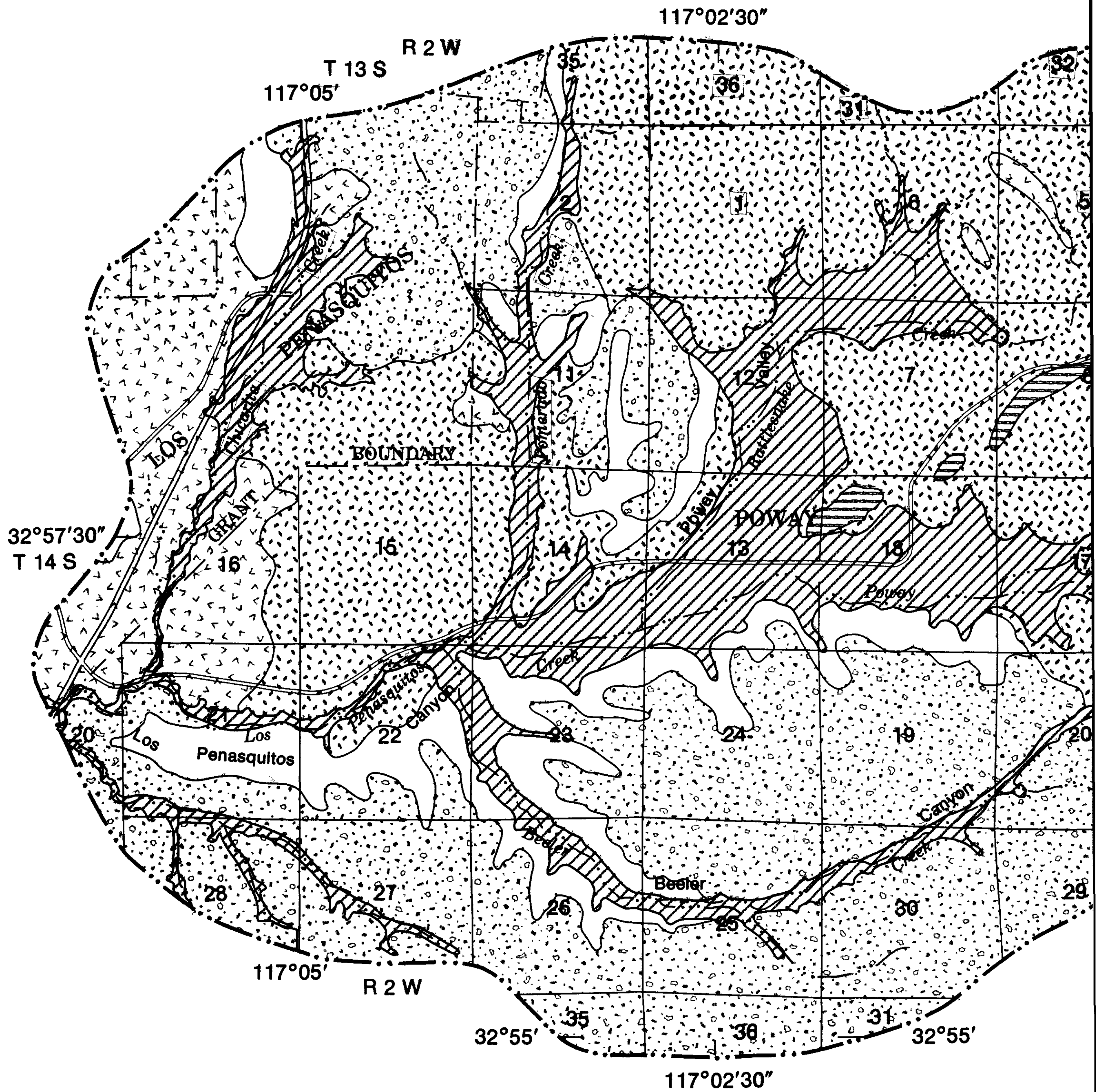


FIGURE 9.—Generalized geology of the Poway basin (modified from Kennedy, 1975).

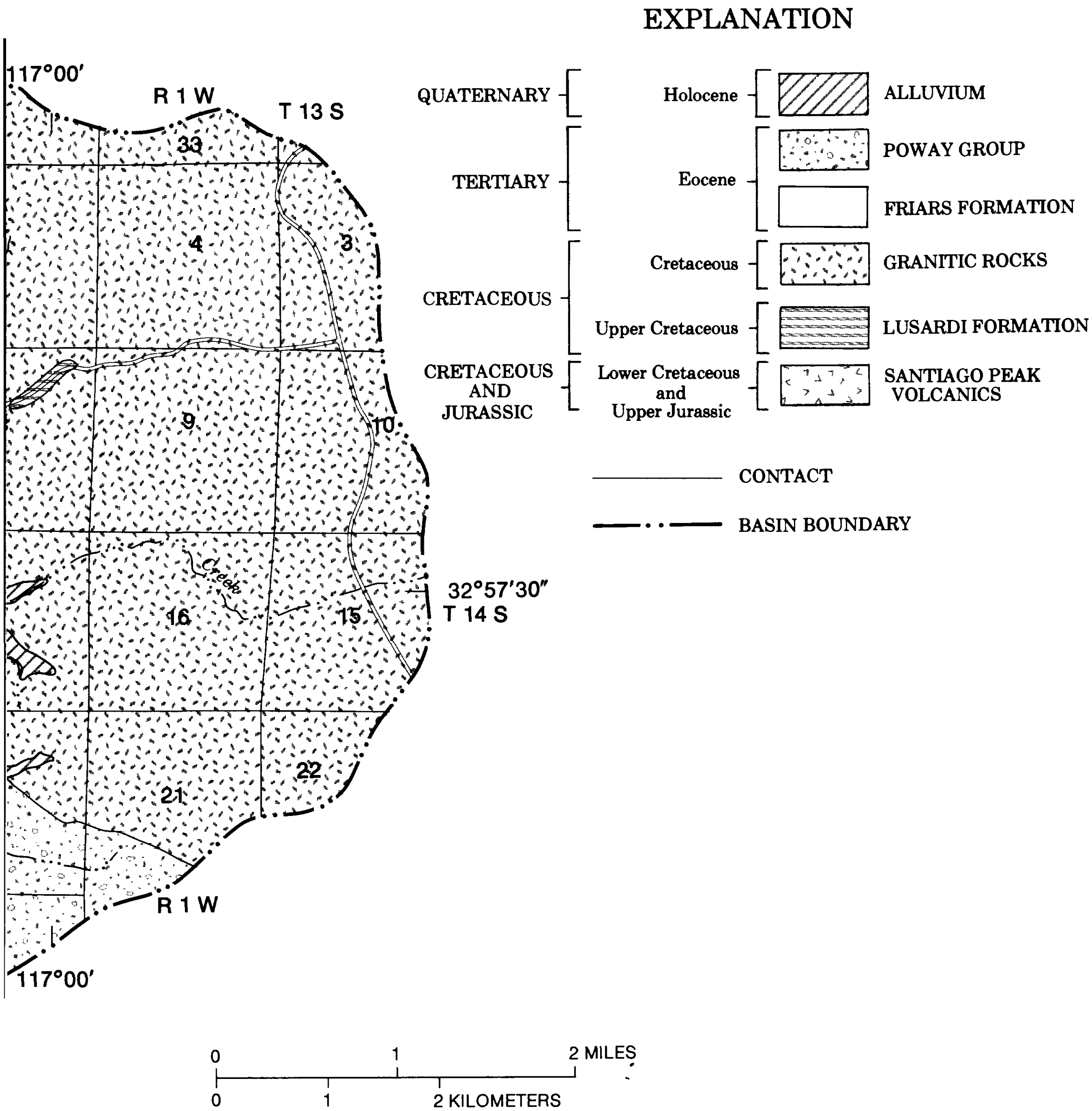

EXPLANATION
QUATERNARY
Holocene
ALLUVIUM
TERTIARY
Eocene
POWAY GROUP
FRIARS FORMATION
CRETACEOUS
Cretaceous
GRANITIC ROCKS
Upper Cretaceous
LUSARDI FORMATION
CRETACEOUS AND JURASSIC
Lower Cretaceous and Upper Jurassic
SANTIAGO PEAK VOLCANICS
CONTACT
BASIN BOUNDARY
117°00′
R 1 W
T 13 S
33
4
3
9
10
Creek
16
15
32°57′30″
T 14 S
21
22
R 1 W
117°00′
0
1
2 MILES
0
1
2 KILOMETERS

TABLE 12.--*Population projections for the Poway basin*

[From San Diego Association of Governments, written commun., 1985]

Year	Population
1980	34,000
1990	54,000
1995	66,000
2000	81,000

TABLE 13.--*Land-use acreage and projections for the Poway basin*

[From San Diego Association of Governments, written commun., 1985. Values are in acres]

Year	Total	Developed	Residential	Non residential	Undeveloped: Developable	Undeveloped: Undevelopable
1980	22,200	4,440	3,650	790	7,400	10,380
1990	22,200	6,000	5,000	1,000	5,000	10,380
2000	22,200	9,000	7,000	2,000	3,000	10,380

Alluvium covers about 4.7 mi^2 in the Poway basin (fig. 9). This alluvium is composed of unconsolidated stream deposits of silt, sand, and cobble-sized particles derived from surrounding formations (Kennedy and Peterson, 1975). The largest deposit of alluvium is located in the center of the basin along the Poway Valley. This alluvium-covered area is about 4 miles long and ranges in width from 0.5 to 1 mile. Three other minor occurrences of alluvium are found in the basin, one extending along Beeler Creek south of the main valley, one extending along Pomerado Creek and one along Chicarita Creek to the north of the valley. Thickness of alluvium in the Poway valley varies. The maximum thickness averages about 40 feet and probably does not exceed 75 feet. The thickness of alluvial fill in the minor valleys probably does not exceed 10 feet. Where the deposits are thick enough, wells obtain water from the alluvium. Ground-water yields are low in the alluvial aquifer; some wells yield enough water for domestic uses, but not enough for irrigation.

TABLE 14.--*Water-quality objectives for inland surface water in the Poway basin*

[From California Regional Water Quality Control Board, San Diego Region (1979). Concentrations not to be exceeded more than 10 percent during any one year period. Values given in milligrams per liter unless otherwise indicated. JTU, Jackson turbidity unit]

Property or constituent	Objective
Color (units)	20
Odor (units)	None
Turbidity (JTU)	20
Percent sodium	60
Sulfate	250
Chloride	250
Fluoride	1.0
Dissolved solids	500
Nitrogen and phosphorus	([1])
Boron	.5
Iron	.3
Manganese	.05
Methylene blue active substance	.5

[1]Phosphorus concentrations not to exceed 0.1 mg/L in flowing water and 0.025 mg/L in standing bodies of water. Values for nitrogen compounds have not been established; however, natural ratios of nitrogen to phosphorus are to be determined by surveillance and upheld. Where data are lacking, a ratio of N>P = 10:1 shall be used (California Regional Water Quality Control Board, San Diego Region, 1979).

TABLE 15.--*Water-quality objectives for ground water in the Poway basin*

[From California Regional Water Quality Control Board, San Diego Region (1979). Concentrations not to be exceeded more than 10 percent during any one year period. Values given in milligrams per liter unless otherwise indicated. JTU, Jackson turbidity unit]

Property or constituent	Objective
Color (units)	15
Odor (units)	None
Turbidity (JTU)	5
Percent sodium	60
Sulfate	300
Chloride	300
Fluoride	1.0
Dissolved solids	750
Nitrogen and phosphorus	10
Boron	.5
Iron	.3
Manganese	.05
Methylene blue active substance	.5

In summary, the major sources of ground water in the Poway basin are granitic rocks, the Poway Group, and alluvium.

Soils

Seven soil associations are present in the Poway basin (fig. 10): Redding-Olivenhain, Exchequer-San Miguel, Ramona-Placentia, Friant-Escondido, Cieneba-Fallbrook, Fallbrook-Vista, and Diablo-Altamont (U.S. Soil Conservation Service, 1973).

The Redding-Olivenhain and Exchequer San Miguel associations (fig. 10) overlie the conglomerate of the Poway Group and Santiago Peak Volcanics, respectively. These soils (described previously in the "Soils" section of the discussion of Soledad basin) tend to be thin, commonly containing a clay or hardpan layer that makes infiltration slow. Redding-Olivenhain and Exchequer-San Miguel are generally not good soils for reclaimed-water recharge areas.

Ramona-Placentia soils are located on the floor of the Poway Valley (fig. 10). These soils are sandy loams that have formed from granitic alluvium. Slopes are from 0 to 9 percent, and soils are from 28 to 80 inches deep. The surface layer of the Ramona soils ranges from sandy loam to coarse sandy loam, and it is underlain by a subsoil that ranges from sandy-clay loam to clay loam. Infiltration ranges from 2 to 6.3 in/h. Placentia soils have a surface layer of sandy loam and a subsoil that ranges from clay to clay loam in texture. Infiltration is 2 to 6.3 in/h in the surface soil and 0.06 in/h in the subsoil.

Friant-Escondido soils (fig. 10), which are found on the east side of the Poway basin, have developed from metasedimentary rock. These thin sandy loams, which are often eroded, occupy upland slopes. Friant soils range from very fine sandy loams to sandy loams. These soils are usually thin, 3 to 15 inches, and are located on steep slopes, 9 to 70 percent. Infiltration is moderate, 2 to 6.3 in/h. Escondido soils are generally thicker than Friant soils, ranging in depth from 20 to 40 inches. These soils have a surface layer that ranges from fine sandy loam to silt loam in texture and is underlain by a subsurface layer of similar texture. Infiltration ranges from 0.63 to 2 in/h.

Cieneba-Fallbrook soils (fig. 10) develop from material weathered from granitic rocks. These soils are found in the hills between 200 and 3,000 feet and are usually thin, ranging from 10 to 24 inches in thickness. This association is rocky, and rock outcrops are common over some of the area. Cieneba soils are located on slopes ranging from 9 to 75 percent.

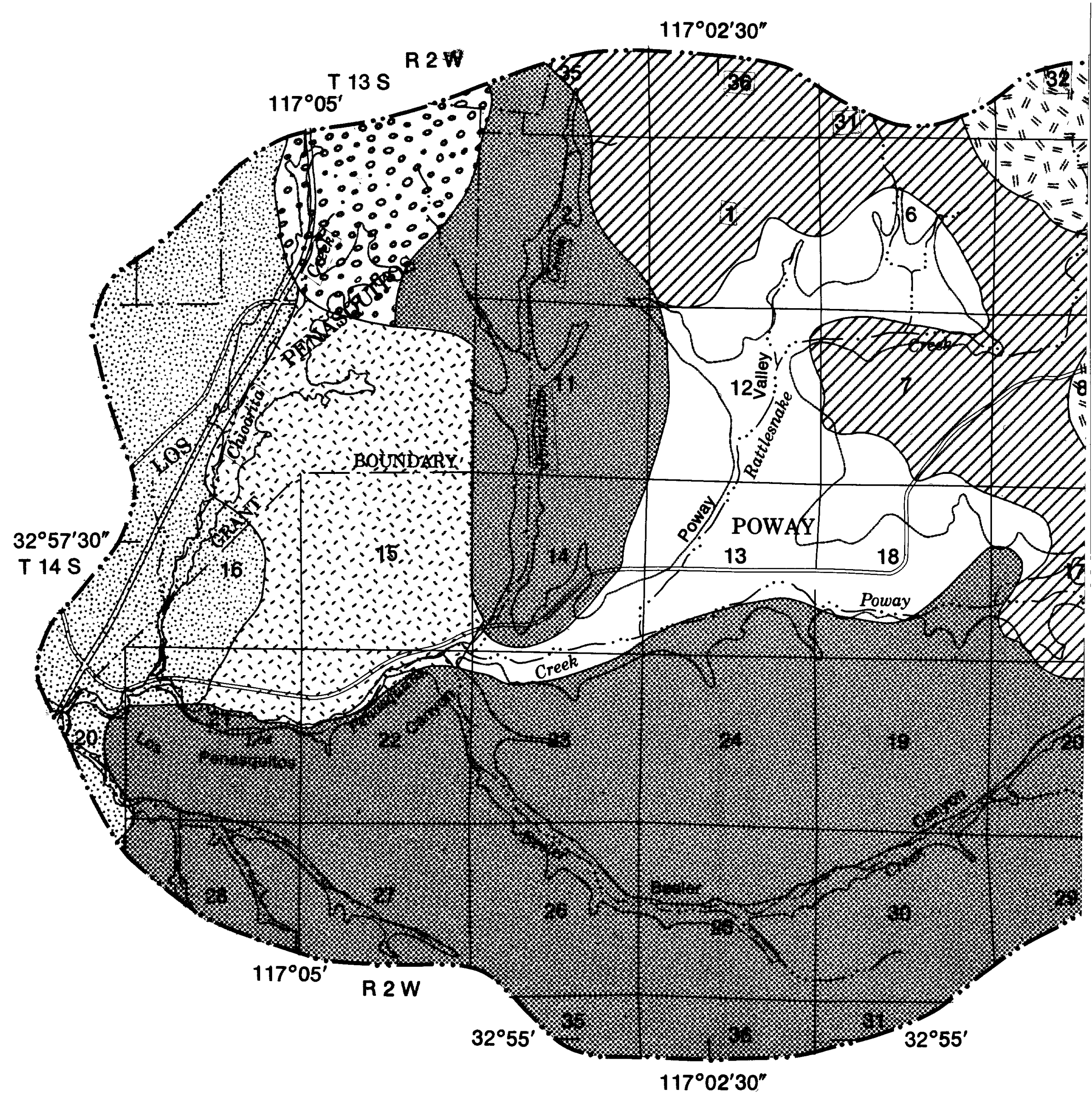
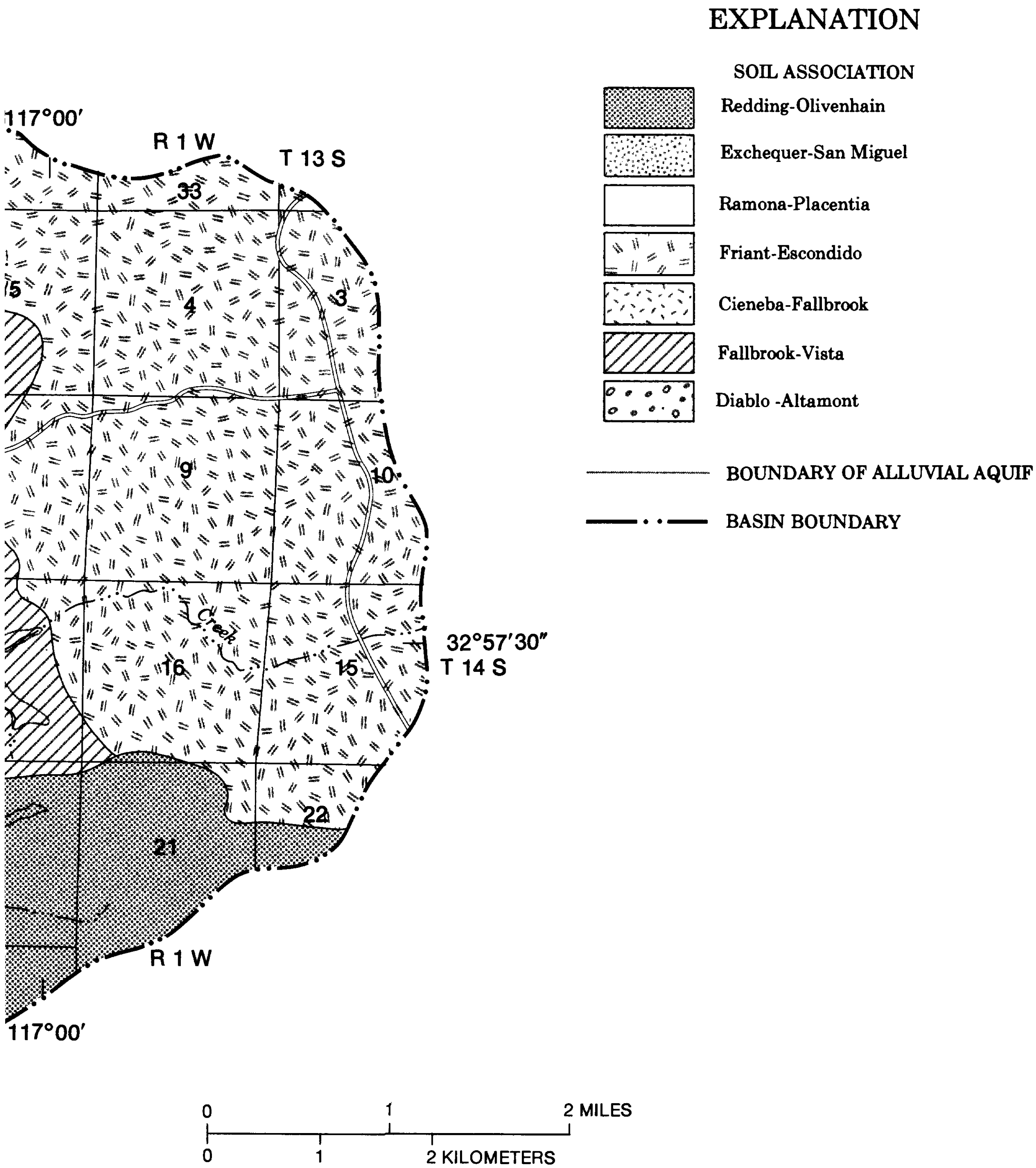


FIGURE 10.—Soil associations of the Poway basin (modified from U.S. Soil Conservation Service, 1973).



117°00′
R 1 W
T 13 S
33
5
4
3
9
10
Creek
16
15
32°57′30″
T 14 S
22
21
R 1 W
117°00′
EXPLANATION
SOIL ASSOCIATION
Redding-Olivenhain
Exchequer-San Miguel
Ramona-Placentia
Friant-Escondido
Cieneba-Fallbrook
Fallbrook-Vista
Diablo -Altamont
BOUNDARY OF ALLUVIAL AQUIF
BASIN BOUNDARY
0
1
2 MILES
0
1
2 KILOMETERS

These soils have a surface layer ranging from coarse sandy loam to sandy loam, underlain by decomposed granite. Infiltration rates are 6.3 to 20 in/h. The surface layer of the Fallbrook soils is similar to that of the Cieneba; these soils, however, are underlain by a subsoil that has a sandy-clay loam texture, which makes infiltration rates slower than those of the Cieneba soils. The infiltration in these soils ranges from 0.63 to 2.0 in/h.

Fallbrook-Vista soils (fig. 10) also have developed from weathered granitic rocks and are found at altitudes of 200 to 3,000 feet. These soils are located in the north central part of the basin. Rock outcrops also are common in this association. These soils tend to be thicker than the Cieneba-Fallbrook, ranging from 20 to 57 inches. Infiltration ranges from 2 to 6.3 in/h. Fallbrook soils have been described previously. Vista soils have a surface layer of coarse sandy loams and a subsurface layer of sandy loam.

Diablo-Altamont soils (fig. 10) are found in the uplands in the northwestern part of the basin on 2 to 30 percent slopes. These soils are clays, generally 20 to 37 inches thick, that have formed over calcareous sandstone and shale. Consequently, infiltration is slow, 0.06 to 0.2 in/h. Diablo soils have a surface layer that is sandy loam to clay loam in texture. Altamont soils have a surface layer that is 35 to 50 percent clay and a subsoil that ranges from clay to clay loam in texture.

In summary, because of slow infiltration rates or thin soil profile, the Redding, Olivenhain, Placentia, Friant, Escondido, Cieneba, and Fallbrook soils may be less suitable for reclaimed-water recharge sites than the Diablo, Altamont, Vista, and Ramona soils which tend to be thick and have faster infiltration rates.

Ground Water

Occurrence and movement

Historically, the movement of ground water has been downgradient along Los Penasquitos Creek (fig. 11) into lower Los Penasquitos Canyon in the Soledad basin (fig. 5). The alluvial fill in the Poway basin is blocked by an outcrop of basaltic rock in the lower reaches of the Poway Valley. This rock acts as a dam, which has, in the past, produced a spring (Ellis and Lee, 1919). Above this rock, in the western part of the Poway valley, the water table is near land surface (Ellis and Lee, 1919).

Ground-water reconnaissance work was done in the Poway Valley by the U.S. Geological Survey in 1969. At that time, water levels were measured at about 70 sites. Movement of water was downgradient to the west, towards the Soledad basin (fig. 11). Since then, the number of wells in use has continued to decline. Although depth to ground water in the valley area during 1969 (fig. 11) ranged from 4 to 70 feet and during 1984-85 (fig. 12) ranged from 7 to 88 feet, comparison of this data shows that overall in the basin, water levels have increased in many wells. Figures 11 and 12 show altitude of water surface below land surface in 1969 and 1984, respectively. If the average specific yield of the basin is assumed to be 0.1 (Johnson, 1967), in October 1984 there were about 2,330 acre-ft of ground water in storage.

Recharge

Most of the recharge to the alluvial aquifer comes from Poway Creek, but applied-water return, precipitation, and ground-water flow from surrounding sedimentary rock also contribute water to recharge the aquifer.

Applied water includes septic-tank discharges, municipal outside use, and irrigated agriculture. The use of septic tanks is limited in the Poway basin and therefore only contributes minor amounts of recharge water to the alluvial aquifer. Currently, no reclaimed water is discharged into the ground water (Michael McCann, California Regional Water Quality Control Board, San Diego Region, written commun., 1985). Evapotranspiration accounts for most of the water for irrigation and municipal outside use, so that only a small percentage is available for percolation to the aquifer.

Measurements made during 1984-85 indicate that water levels experience seasonal fluctuations (table 16). Most of the water levels are higher in the spring, when water use is low and recharge is high due to precipitation and increased streamflow; water levels are lower in the summer, when water use is high and recharge is low.

Ground-Water Quality

In general, water from the alluvial aquifer is more mineralized than water from the Poway Group or granitic rock. Analysis of water-quality data collected between 1958 and 1965 shows that ground water from the alluvial aquifer had higher dissolved-solids concentrations than the ground water obtained from granitic rock (fig. 13). Concentrations of sulfate, chloride, and nitrogen also exceeded basin objectives much of the time in water from the alluvial aquifer.

Granitic rock.--Concentrations of dissolved solids from water samples collected in the early 1960's ranged from 610 to 820 mg/L. Chemical water types, determined mathematically by computing the relative concentration of cations to anions in chemical equivalents (Hem, 1985), were generally mixed. Only one well had concentrations of chloride that exceeded basin objectives. Concentrations of all other constituents were below established basin objectives.

Data collected in 1984-85 indicate that water quality of the granitic rock has not deteriorated. Water types remain generally mixed including sodium chloride bicarbonate, sodium-calcium, or sodium-magnesium chloride. Chloride concentrations exceeded basin standards in several wells sampled. Concentrations ranged from 140 to 570 mg/L. Dissolved-solids concentrations ranged from 520 to 1,600 mg/L, and 50 percent of the wells sampled exceeded basin objectives. In well 14S/1W-8D1, concentrations of nitrogen (nitrite plus nitrate as N) were as great as 13 mg/L, which exceeded the basin objective of 10 mg/L. Concentrations of all other constituents were at or below established basin objectives.

Poway Group.--No historical water-quality data were available for the ground water of the Poway Group in the Poway basin.

Chemical water type of water samples collected from wells that yield water from the Poway Group is sodium calcium or calcium sodium chloride. Concentrations of chloride range from 330 to 380 mg/L, exceeding the basin water-quality objective of 300 mg/L. Dissolved-solids concentrations ranged from 830 to 990 mg/L, also exceeding the basin water-quality objective of 750 mg/L. All other constituents were below concentrations established for basin objectives.

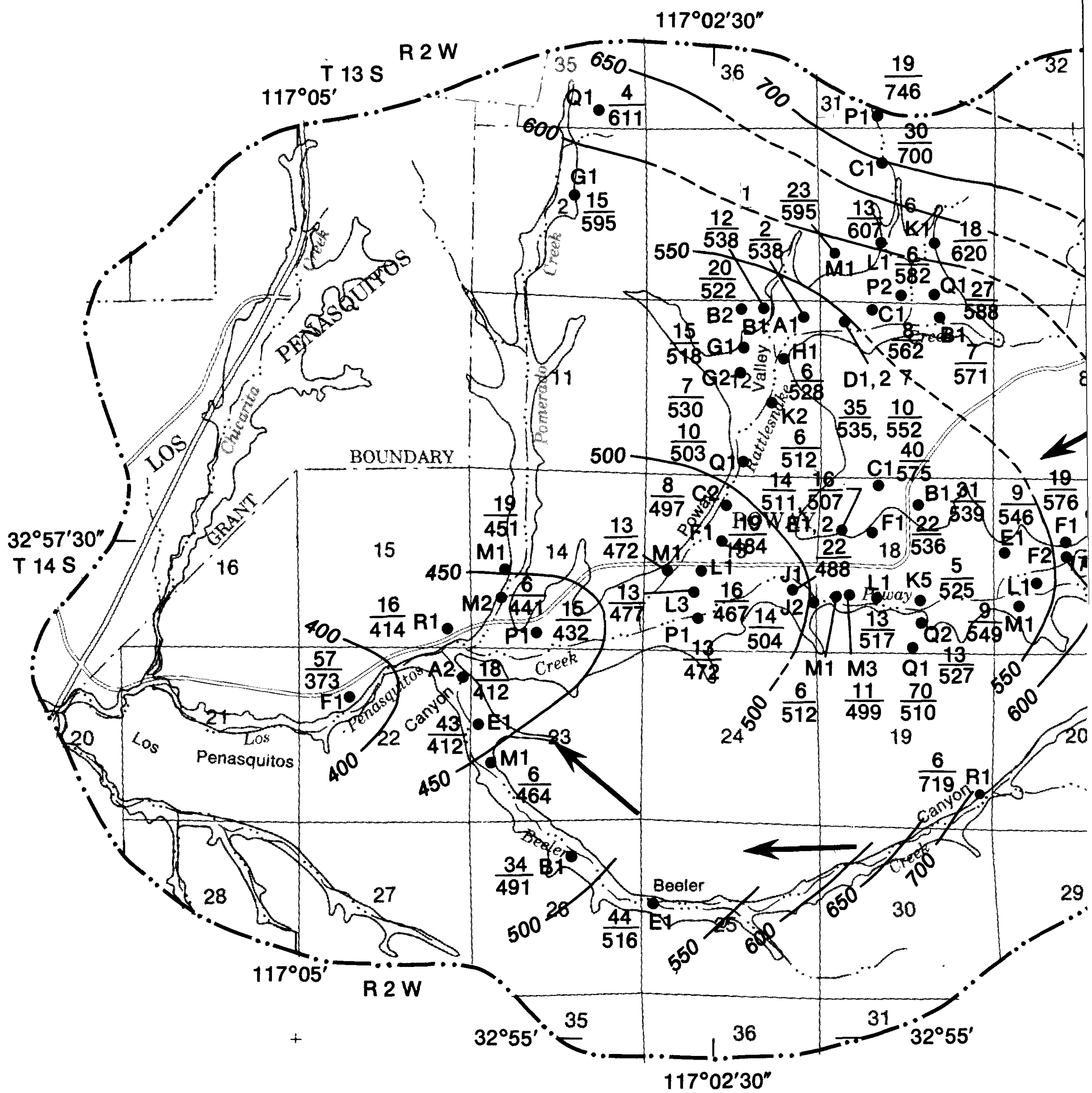
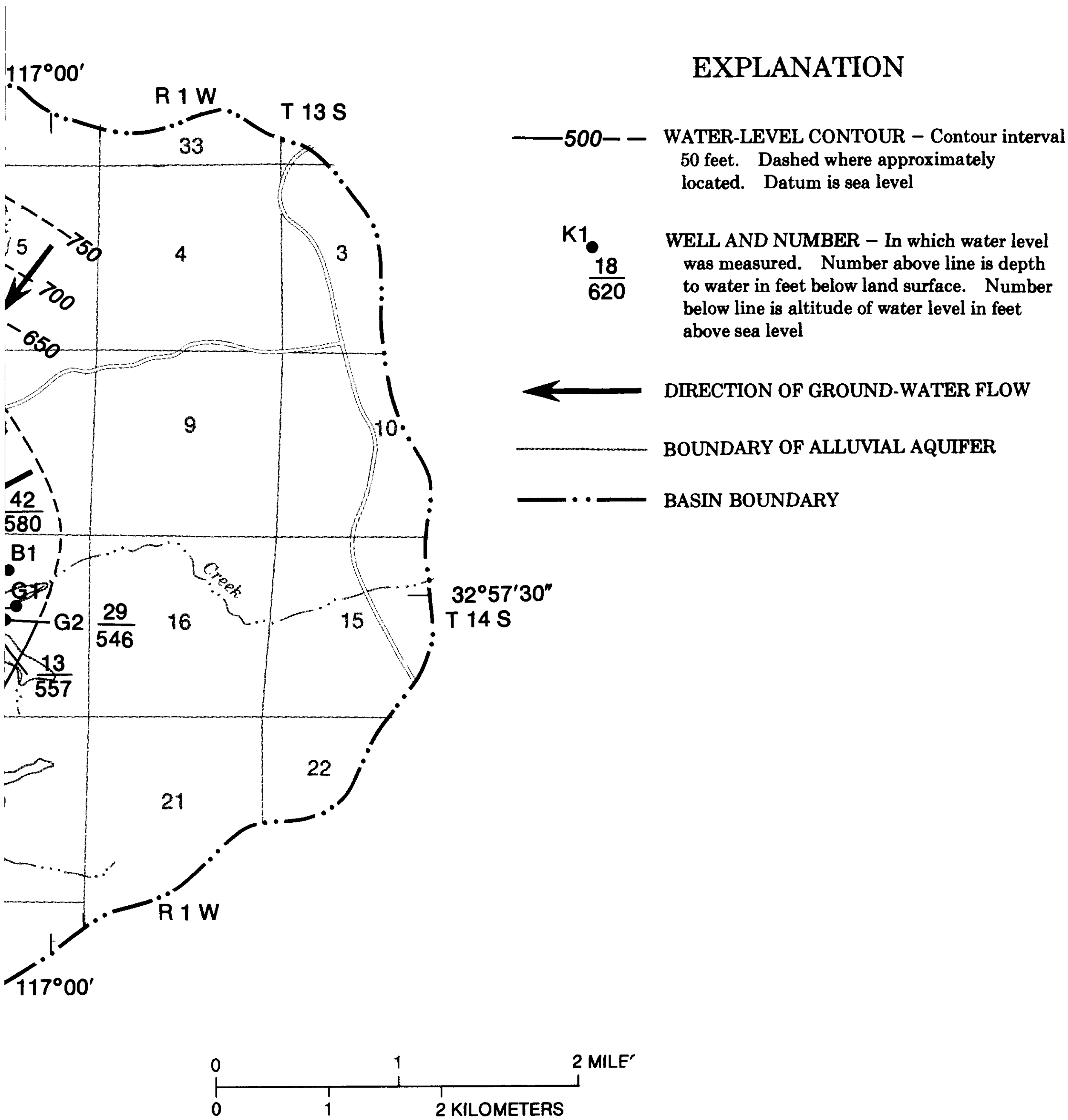


FIGURE 11.—Water-level contours and depth to water in the Poway basin, autumn 1969.


117°00'
R 1 W
T 13 S
33
4
3
5
750
700
650
9
10
42
580
B1
G1
G2
29
546
16
15
Creek
13
557
32°57'30"
T 14 S
22
21
R 1 W
117°00'
0
1
2 MILES
0
1
2 KILOMETERS
EXPLANATION
500
WATER-LEVEL CONTOUR – Contour interval 50 feet. Dashed where approximately located. Datum is sea level
K1
18
620
WELL AND NUMBER – In which water level was measured. Number above line is depth to water in feet below land surface. Number below line is altitude of water level in feet above sea level
DIRECTION OF GROUND-WATER FLOW
BOUNDARY OF ALLUVIAL AQUIFER
BASIN BOUNDARY

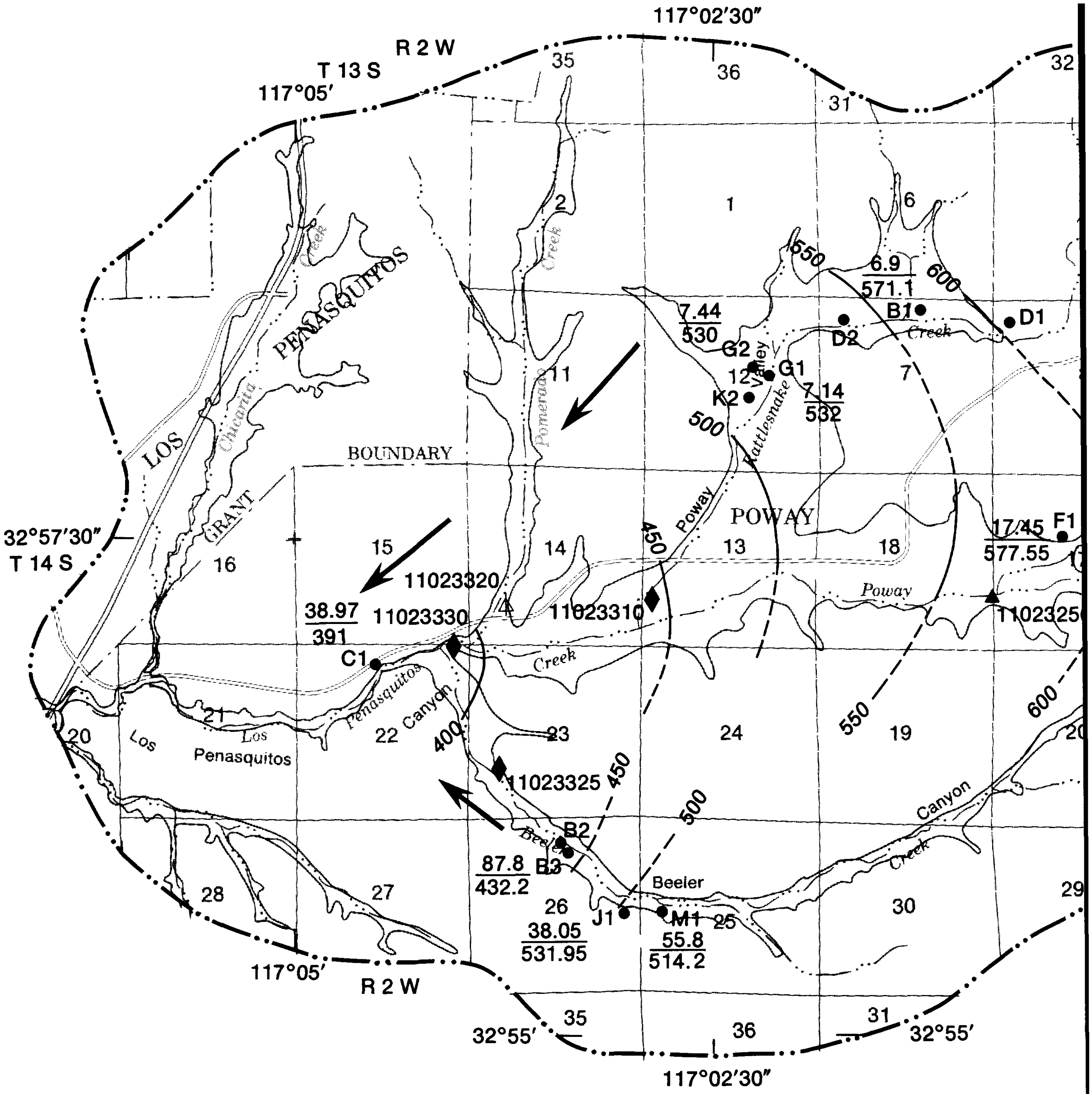
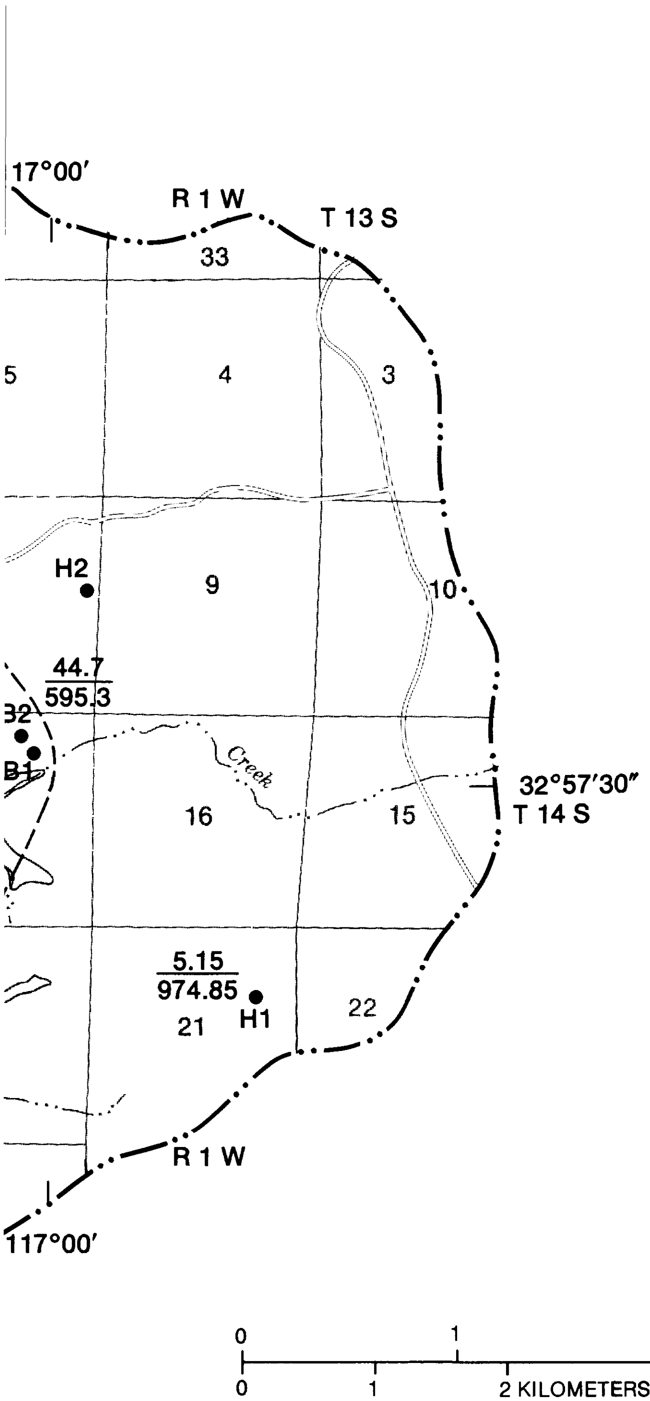


FIGURE 12.—Water-level contours and depth to water in the Poway basin, spring 1985, and location of stream-gaging and water-quality measurement stations.



EXPLANATION

——*500*— — WATER-LEVEL CONTOUR – Interval 50 feet. Dashed where approximately located. Datum is sea level

B1● 6.9 / 571.1 WELL AND NUMBER – In which water level was measured. Number above line is depth to water in feet below land surface. Number below line is altitude of water level in feet above sea level

▲ 11023250 STREAM-GAGING STATION

11023320 DISCONTINUED STREAM-GAGING STATION

◆ 11023330 STREAM-GAGING AND WATER-QUALITY MEASUREMENT STATION

DIRECTION OF GROUND-WATER FLOW

BOUNDARY OF ALLUVIAL AQUIFER

BASIN BOUNDARY

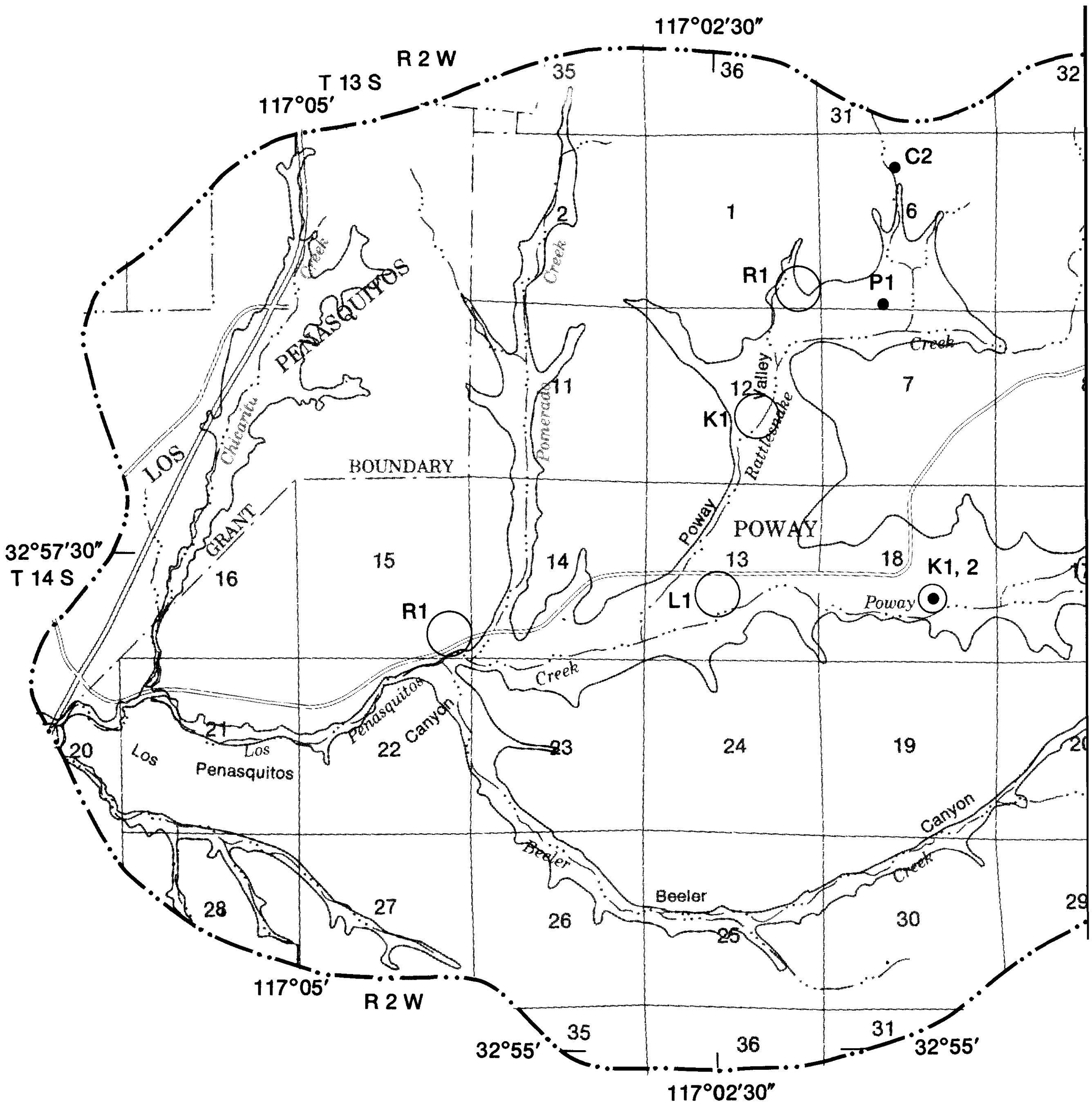
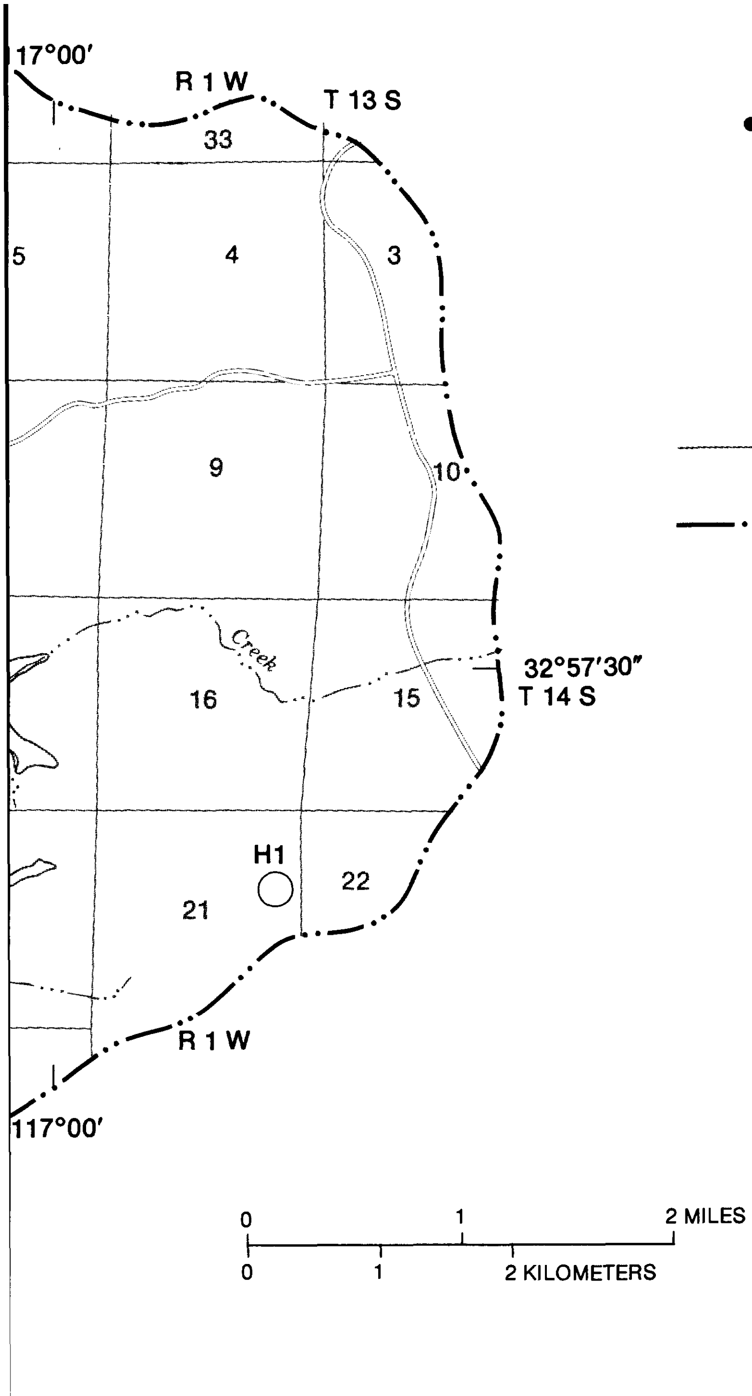


FIGURE 13.—Concentrations of dissolved solids in water in selected wells in the Poway basin, 1958-64.



EXPLANATION

● C2 WELL AND NUMBER – In which dissolved solids were determined. Size of circle corresponds to concentration of dissolved solids, in milligrams per liter, as follow:

- ◯ Greater than 1,000
- ○ 150 – 1,000
- ● Less than 150

——— BOUNDARY OF ALLUVIAL AQUIFER

—— · · —— BASIN BOUNDARY

TABLE 16.--*Ground-water-level measurements for the Soledad, Poway, and Moosa basins*

Well No.	Site identification	Depth of well (feet)	Date	Water level (feet below land surface)
		Soledad basin		
15S/3W-9D1S	325317117121801	--	3-20-85	5.3
15S/3W-6H1S	325356117131101	--	3-20-85	3.15
14S/3W-30C1S	325604117134801	--	10-15-84	47.6
			5-10-84	47.8
14S/3W-24R1S	325618117081901	--	3-20-85	([1])
			10-16-84	([1])
14S/3W-22E1S	325625117105501	--	3-20-85	7.05
14S/3W-20L2S	325627117125101	200	10-15-84	6.53
			5-8-84	10.1
14S/3W-20L1S	325625117125601	200	3-20-85	5.35
			10-15-84	6.51
			5-8-84	9.0
14S/3W-20H1S	325629117122101	260	10-15-84	223.05
			5-10-84	223.21
14S/3W-20F1S	325635117125501	100	3-20-85	34.72
			5-8-84	36.17
14S/3W-19P1S	325610117134701	--	5-10-84	20.35
14S/2W-19K1S	325623117062601	6.0	3-20-85	0
		Poway basin		
14S/2W-26J1S	325538117025801	189	3-19-85	38.05
			10-16-84	39.3
			5-8-84	38.49
14S/2W-26B2S	325557117032501	215	5-8-84	39.81
14S/2W-26B3S	325557117032502	--	3-19-85	87.8
14S/2W-25M1S	325538117025001	--	3-19-85	55.80
			10-16-84	54.34
			5-8-84	65.8
14S/2W-22C1S	325646117043701	350	3-19-85	38.97
			10-16-84	40.0
			5-9-84	39.03
14S/2W-12G3S	325819117021801	50.0	3-19-85	7.44
			5-8-84	8.3
14S/2W-12G1S	325824117020901	--	3-19-85	7.14
			5-9-84	7.55
14S/2W-7B1S	325845117011801	51.0	3-19-85	6.9
			10-16-84	7.98
			7-12-84	5.65
14S/1W-21H3S	325635116585501	30.0	3-18-85	5.15

See footnote at end of table.

TABLE 16.--*Ground-water-level measurements for the Soledad, Poway, and Moosa basins*--Continued

Well No.	Site identification	Depth of well (feet)	Date	Water level (feet below land surface)
		Poway basin--Continued		
14S/1W-17F1S	325730117002101	--	3-19-85	17.45
			10-16-84	17.31
14S/1W-17B2S	325737117001901	350	3-19-85	44.70
14S/1W-17B2S	325737117001901	350	10-16-84	88.28
			7-12-84	55.57
14S/1W-17B1S	325736117001801	78.0	7-12-84	47.89
14S/1W-8H1S	325815116595001	593	10-16-84	266.8
14S/1W-7D3S	325836117014501	110	5-7-84	12.93
		Moosa basin		
11S/2W-17L1S	331255117064701	--	10-17-84	11.7
			5-9-84	11.43
11S/2W-10N1S	331345117050101	--	3-18-85	5.95
			10-17-84	5.88
			7-12-84	6.08
11S/2W-6G2S	331504117074401	--	3-18-85	5.82
			10-17-84	6.30
			5-9-84	6.11
11S/2W-6G1S	331502117075101	50.0	5-9-84	18.10
11S/2W-5Q2S	331435117063401	--	3-18-85	7.85
			10-17-84	12.38
			7-18-84	10.00
11S/2W-5Q1S	331438117063501	24.0	3-18-85	7.05
			7-11-84	7.87
11S/2W-5N1S	331427117070001	106	3-21-85	44.2
			3-18-85	44.5
			10-17-84	44.92
11S/2W-5K2S	331449117062301	--	3-18-85	8.50
			10-17-84	15.85
			5-9-84	12.35
11S/2W-3D1S	331521117044901	302	5-9-84	48.30
11S/2W-1Q2S	331434117084101	--	3-20-85	([1])
			7-11-84	16.26
11S/2W-1Q1S	331438117085001	76.0	7-11-84	15.4
11S/2W-1F3S	331500117090701	--	3-21-85	36.47
11S/2W-1F2S	331510117090501	30.0	3-19-85	9.78
			10-17-84	10.87
			7-11-14	11.3
11S/2W-1F1S	331508117085801	--	10-17-84	10.17
			7-11-84	15.27

[1]Flowing well.

Alluvial aquifer. -- Water-quality data collected in the early 1960's indicate that water in the alluvial aquifer was of marginal quality. These wells exceeded established basin objectives for dissolved solids and chloride. Dissolved-solids concentrations ranged from 1,200 to 3,300 mg/L, and chloride concentrations ranged from 380 to 1,200 mg/L. Sulfate and nitrate each were present in concentrations exceeding basin objectives in separate well water.

Analysis of a 1984 sample from well 14S/2W-22C1S, which obtained water from the alluvial aquifer, as well as from granitic rock, is evidence that water quality of the alluvial aquifer has not improved. The dissolved-solids concentration of 1,500 mg/L for water from this well exceeded basin objectives. Nitrogen, sulfate, and chloride concentrations also exceeded basin objectives.

In general, water from the alluvial aquifer probably does not meet basin objectives for dissolved solids, chloride, and sulfate. Results from the 1984-85 water-quality sampling period are shown in tables 7 and 8 and figure 14.

Surface Water

Streamflow characteristics

Streamflow data are summarized in table 9, and locations of stream gages are shown in figure 12. Recorded streamflow into the Poway basin is from Poway Creek, Rattlesnake Creek, Beeler Creek, and Pomerado Creek. All outflow from the basin is through Los Penasquitos Creek, which flows through the center of the basin.

The largest creek is Los Penasquitos Creek, which drains a total of 31.2 mi^2 of urban, agricultural, and undeveloped land in the Poway basin. Flow in Poway, Beeler, and Los Penasquitos Creeks is partly regulated by reservoirs. Pomerado and Rattlesnake Creeks are unregulated streams. Flow in the basin is limited to fall to early spring, when there is precipitation.

Surface-water quality

Water-quality data from Beeler, Rattlesnake, and Los Penasquitos Creeks are shown in table 10. These data were collected in March 1985 and, as these creeks are intermittent, represent typical flow conditions.

With the exception of Beeler Creek, the dissolved solids ranged from 830 to 1,300 mg/L. The chemical water types are sodium calcium or sodium magnesium chloride. Basin standards were exceeded for dissolved solids and chloride in both Los Penasquitos and Rattlesnake Creeks.

Comparison of these data shows the quality of water in Beeler Creek to be much different from that of the other creeks in the basin. Concentrations of dissolved solids are lower, and the water contains higher proportions of calcium and bicarbonate. Beeler Creek drains the southern part of the basin and is separated from the Poway Valley by a range of low hills. Poway Conglomerates make up the dominant geologic material in this drainage basin, whereas granitic rock and alluvium are the dominant geologic material in the drainage of Rattlesnake and Los Penasquitos Creeks. The Beeler Creek drainage basin is also largely undeveloped compared to other basins that drain the Poway Valley. These two factors may contribute to the anomalous water quality of Beeler Creek.

Concentrations of trace elements were negligible, and pesticides were not detected in the stream water.

Reclaimed Water

All municipal wastewater from the Poway basin goes into the city of San Diego wastewater-treatment facilities. This reclaimed water is discharged into the ocean off Point Loma. Reclaimed water from the central part of the basin, the area served by the city of Poway, averaged 3.5 Mgal/d, totalling 3,900 acre-ft, in 1984 (Robert Foerster, city of Poway, written commun., 1985).

Before the basin attained its present population, a wastewater-treatment facility near the western edge of the basin in Los Penasquitos Canyon served the entire area. The treatment facility is not in use because it is not equipped to treat water to secondary-treatment standards (State of California, 1977) and because it no longer has the capacity to serve the present needs of the basin.

Imported Water

Sources and quantity

All the municipal water supply in the Poway basin is imported. Both the city of Poway and the city of San Diego supply water to this basin. The city of San Diego supplies the western part of the basin with water from Miramar reservoir. This water is discussed in the Soledad basin section of this report. The water is a blend of Colorado River water, California State Water Project (SWP) water, and surface water from San Diego County. The water supplied by the city of Poway, which is stored in Lake Poway, consists entirely of Colorado River and SWP water. Both agencies purchase the imported water from San Diego County Water Authority, which purchases it from the Metropolitan Water District.

Imported-water quality

The chemical character of the two water supplies is similar because both come from almost the same sources. The quality of water supplied by the city of San Diego is summarized in table 11 (Mary H. Middendorf, city of San Diego Water Utilities Department, written commun., 1985). Water-quality data for the city of Poway are shown in tables 17 and 18 (Robert Foerster, city of Poway, written commun., 1985). Chemical water types are somewhat more mixed in the water supplied by the city of Poway than that supplied by the city of San Diego. Chemical water types in the water supplied by the city of San Diego are generally sodium chloride sulfate, but in the water supplied by the city of Poway, sodium calcium sulfate chloride is the dominant chemical water type. Concentrations of trace elements are negligible.

Water Use

The usable water supply in the Poway basin is composed of imported and local ground water. Imported water is used exclusively in the municipal water supply served in the area. The use of ground water is limited to individual well owners, generally for domestic supply. Wells also occasionally supply water for irrigation use. Surface water has not been developed for use because flows are intermittent.

The California Regional Water Quality Control Board, San Diego Region (1975; 1979) noted existing and potential beneficial uses of surface and ground water for the Poway basin. During summer 1984, the U.S. Geological Survey conducted a field survey of water use in the subarea. These uses generally concur with those listed in the 1978 amendments.

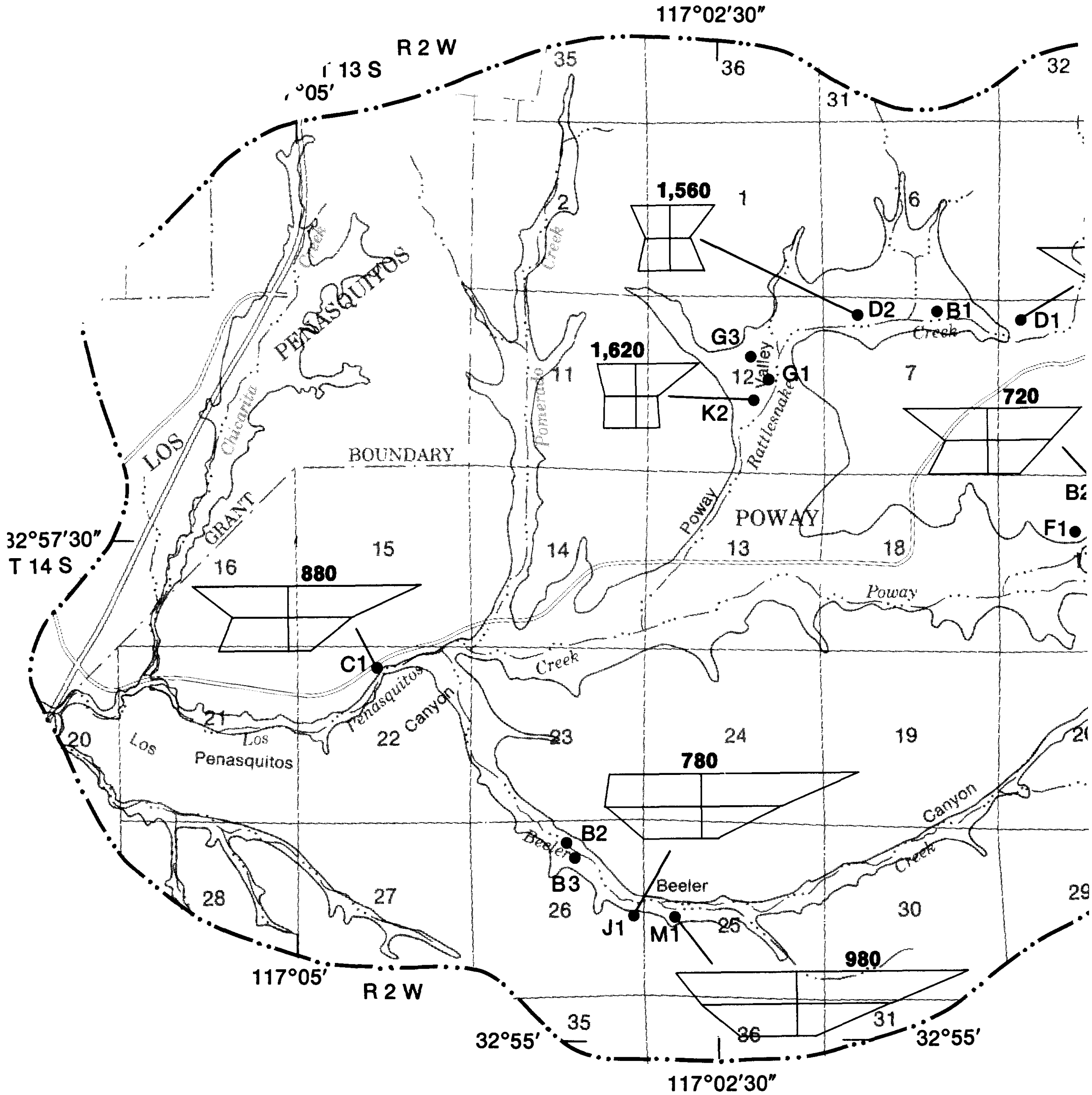


FIGURE 14.—Quality of water in selected wells in the Poway basin, autumn 1984.

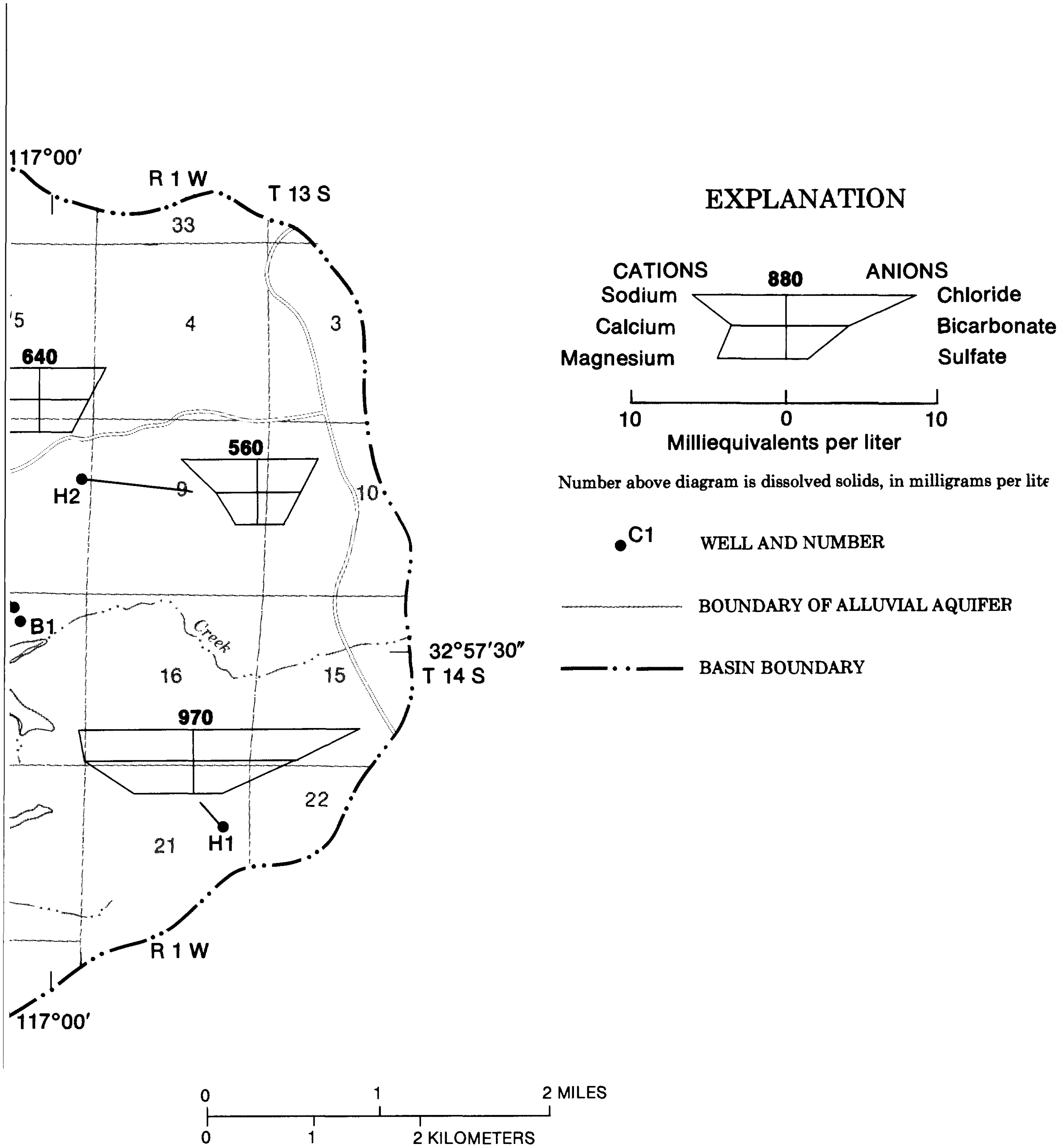

117°00′
R 1 W
T 13 S
33
'5
4
3
640
560
H2
9
10
B1
Creek
32°57′30″
T 14 S
16
15
970
22
21
H1
R 1 W
117°00′
0
1
2 MILES
0
1
2 KILOMETERS
EXPLANATION
CATIONS
880
ANIONS
Sodium
Chloride
Calcium
Bicarbonate
Magnesium
Sulfate
10
0
10
Milliequivalents per liter
Number above diagram is dissolved solids, in milligrams per lite
C1
WELL AND NUMBER
BOUNDARY OF ALLUVIAL AQUIFER
BASIN BOUNDARY

TABLE 17.--*Summary of major-ion concentrations in the city of Poway municipal water supply, 1983-84*

[From Robert Foerster, city of Poway, written commun., 1985. Values are in milligrams per liter unless otherwise indicated]

Property or constituent	Mean	Median	Minimum	Maximum
pH (units)...	8.1	8.1	8.1	8.0
Hardness.....	290	290	290	290
Calcium......	75	75	78	73
Magnesium....	25	25	26	24
Sodium.......	92	92	96	89
Sulfate......	210	210	220	190
Fluoride.....	.4	.4	.4	.3
Dissolved solids.....	584	584	600	568
Chloride.....	87	87	105	70

Specific applications of the various water supplies are discussed in detail under their various headings in this report.

As population and acreage of developed lands increase, water demand also will increase. Projections from 1980 to 2000 for the entire Los Penasquitos hydrographic subunit, which includes the Poway basin, are described in the "Water Use" section of the discussion of the Soledad basin. These trends and percentage increases probably also apply to the Poway basin. In summary, the amount of water needed will increase by about 100 percent by the year 2000. Agricultural water demand is expected to decrease, while commercial, industrial, and domestic demands are expected to increase.

TABLE 18.--*Concentrations of trace elements in the city of Poway municipal water supply*

[From Robert Foerster, city of Poway, written commun., 1985. Values are in milligrams per liter]

Property or constituent	Concentration
Antimony..................	<0.005
Arsenic...................	<.005
Beryllium.................	<.02
Cadmium...................	<.001
Chromium..................	<.01
Copper....................	<.02
Iron......................	<.01
Manganese.................	<.01
Lead......................	<.005
Mercury...................	<.0002
Nickel....................	<.01
Selenium..................	.006
Silver....................	<.01
Tellurium.................	<.005
Zinc......................	<.01

Water demand based on population and land use data is presented in table 19. The methods of estimation have been described in the Soledad section. Uses such as commercial and industrial have not been included, and therefore total water demand is actually greater than 13,750 acre-ft/yr.

Ground Water

Ground water in the Poway basin is used for agricultural, industrial, and domestic purposes. Wells are located throughout the area but are most heavily

TABLE 19.--*Estimated and projected water demand in the Poway basin*

[Municipal projections based on an estimated 0.31 acre-feet per year per-capita water production for the city of Poway. Agricultural projections unavailable; figure for the year 2000 is based on an estimated 85 percent decrease in the demand for irrigation water in the Los Penasquitos hydrographic unit. Information from California Regional Water Quality Control Board, San Diego Region (1975)]

Year	Municipal	Agricultural	Total
1980	10,400	3,400	13,800
1990	16,600	--	--
2000	25,000	500	25,500

used on the edges of the basin, where municipally supplied water is unavailable or inconvenient. The primary use for ground water is for domestic purposes; agricultural uses are secondary. According to the U.S. Salinity Laboratory (1954) system of classification of irrigation suitability of water, most of the well water sampled in the Poway basin was rated low for sodium hazard but high for salinity hazard. Therefore, the ground water may be of marginal quality for irrigation use.

New development in the Poway basin probably depends on imported water supplies.

Surface Water

Because surface water in the Poway basin is intermittent and undependable, it generally is unused as a source of water supply. The beneficial uses associated with surface water include contact and noncontact recreation, agriculture, and habitat for fish and wildlife.

Reclaimed Water

The city of Poway is considering building a new wastewater-treatment plant that would have the capacity to serve the entire service area (Alan Archibald, city of Poway, oral commun., 1985). Adequately treated wastewater from this plant could be used for irrigation in an area downstream from the treatment plant. The new plant might be built at the site of the old plant 4 miles from the city. If this site is used, the reclaimed water might be used somewhere in the Soledad basin because the treatment plant would be immediately upstream from the Soledad basin boundary. These plans are still in a preliminary stage, and sites for the treatment facility as well as the basin to be used for ground-water recharge have not been selected yet. However, the recharge basin probably would be downstream from the treatment plant, and the city of Poway is considering Los Penasquitos Canyon.

Imported Water

Imported water is used for irrigation, industry, and domestic purposes in the Poway basin. The city of Poway supplies water to most of the basin. The city's service area covers the entire Poway Valley. In 1984, the volume of water supplied to the basin was 12,350 acre-ft, an increase nearly double the volume of the 1983 supply, which was 6,430 acre-ft. Water supplied to the basin has increased by 160 percent since 1970. Water demand will increase proportionately with the expected increase in population.

MOOSA BASIN

Location

The Moosa basin, about 100 mi^2 in area, is the farthest north of the three study areas (fig. 1). Development is agricultural and low-density residential. The basin is characterized by steep, rocky, rugged hills. Avocado and citrus groves occupy most of the arable slopes. Three golf courses, each surrounded by small housing developments, take up most of the flatland areas. Moosa Creek is the major natural drainage in the area.

Population

The population and land-use forecasts for the Moosa area are based on a San Diego Association of Governments report (written commun., 1985) in which the Moosa area is not specifically defined but rather included as part of the greater Valley Center census tract. Land use patterns on the 1980 land-use maps appear evenly distributed throughout the Valley Center area, indicating that the population estimate for 1980 (table 20) is fairly accurate. However, because rugged terrain limits building space in the Moosa area, population projections to 2000 may not be accurate. The actual population in the Moosa basin probably will be proportionately lower than the projected population for the rest of the area.

TABLE 20.--*Population projections for the Moosa basin*

[From San Diego Association of Governments, written commun., 1985]

Year	Population
1980	2,215
1990	4,000
2000	5,000

Population in the Moosa area is expected to increase rapidly between 1980 and 2000. The growth rates are expected to peak during the 1980's and decline slightly in the 1990's.

The population for the Valley Center area is expected to increase by 140 percent between 1980 and 2000. A 70-percent increase is expected for the 1980's, and a 40-percent increase is expected during the 1990's. This growth is reflected in an anticipated 420-percent increase in the amount of land developed for residential use in the area. This increase probably will be somewhat lower for the Moosa basin because of the limited space in the Moosa area compared to the rest of the Valley Center area.

Land Use

Undeveloped land makes up the largest percentage of the Moosa area. Rugged terrain has precluded intensive urban development. Of the 17,900 acres that make up the area, about 16,500 acres are currently undeveloped (table 21). Land in the Moosa area is used mostly for agriculture, urban housing, and golf courses (fig. 15).

There are no population centers in the Moosa area. The population is spread out along the flatlands adjoining Moosa Canyon and South Fork Moosa Canyon and in a fairly flat upland valley in the southern part of the study area.

TABLE 21.--*Land-use acreage and projections for the Moosa basin*

[From San Diego Association of Governments, written commun., 1985. Values are in acres]

Year	Total	Developed	Residential	Non residential	Undeveloped: Developable	Undeveloped: Undevelopable
1980	17,900	1,400	1,120	290	6,600	9,920
1990	17,900	3,000	2,000	400	5,000	9,920
2000	17,900	6,000	6,000	400	2,000	9,920

Orchards account for most of the agricultural land. The orchard trees, mostly citrus and avocado, are adaptable to the steep hillsides and therefore occupy lands that would otherwise be unused. Field crops are restricted to the flatlands and occupy a much smaller percentage of the total agricultural lands.

The amount of developed land in the Valley Center area is expected to increase by 340 percent between 1980 and 2000 (table 21). The largest increase is expected in residential housing. As in the population extrapolations, the land-use figures may actually be somewhat lower, although the trends will probably be similar.

Water-Quality Objectives

The establishment of and rationale for water-quality objectives has been described previously. The same criteria for the establishment of water-quality objectives apply to the water of the Moosa basin. Tables 22 and 23 present the water-quality objectives for surface and ground water in the Moosa basin. In addition to the objectives listed in table 23, the domestic use of ground water warrants the application of requirements of the State of California (1977) (tables 3 and 4).

Hydrologic System

Geologic Units and their Water-Bearing Characteristics

The Moosa basin is underlain dominantly by the Woodson Mountain Granodiorite of Cretaceous age and lesser amounts of metavolcanic and volcanic rocks. These basement rocks are overlain by alluvial deposits found in the major stream valleys (fig. 16).

In the Moosa basin, alluvial deposits are found on the floors of Moosa and South Fork Moosa Canyons (fig. 16). Alluvial deposits cover about 2 mi^2 in the basin. Older and younger alluvium occur alongside each other throughout most of the basin. The younger alluvium, which is generally a thin layer of boulders, gravel, sand, silt, and clay, is located adjacent to the streams and usually is above the water table. Gravels, sand, silts, and clays make up older alluvium, which usually underlies or lies adjacent to the younger alluvium. The older alluvium generally extends below the water table and composes the alluvial aquifer.

Little information is available on ground water in the Moosa basin. Crystalline rocks are the most important source of ground water. Ground water is derived from the joints, fractures, and weathered zones of the granodiorite. Well yields vary greatly in this unit, ranging from 4 to 250 gal/min.

The alluvial aquifer contributes some water to wells in the Moosa basin. Alluvial fill extends along Moosa Canyon from the western edge of the basin about 5 miles east in a band less than 0.25 mile wide. Along South Fork Moosa Canyon alluvial fill extends to the southern edge of the basin about 3.5 miles south in a band also less than 0.25 mile wide.

Soils

More than 10 soil groups are found in the Moosa basin (U.S. Soil Conservation Service, 1973). The Cieneba-Fallbrook, Fallbrook-Vista, and Acid Igneous Rock are dominant; in fact, they cover such a large area that they could be considered exclusively representative of the area.

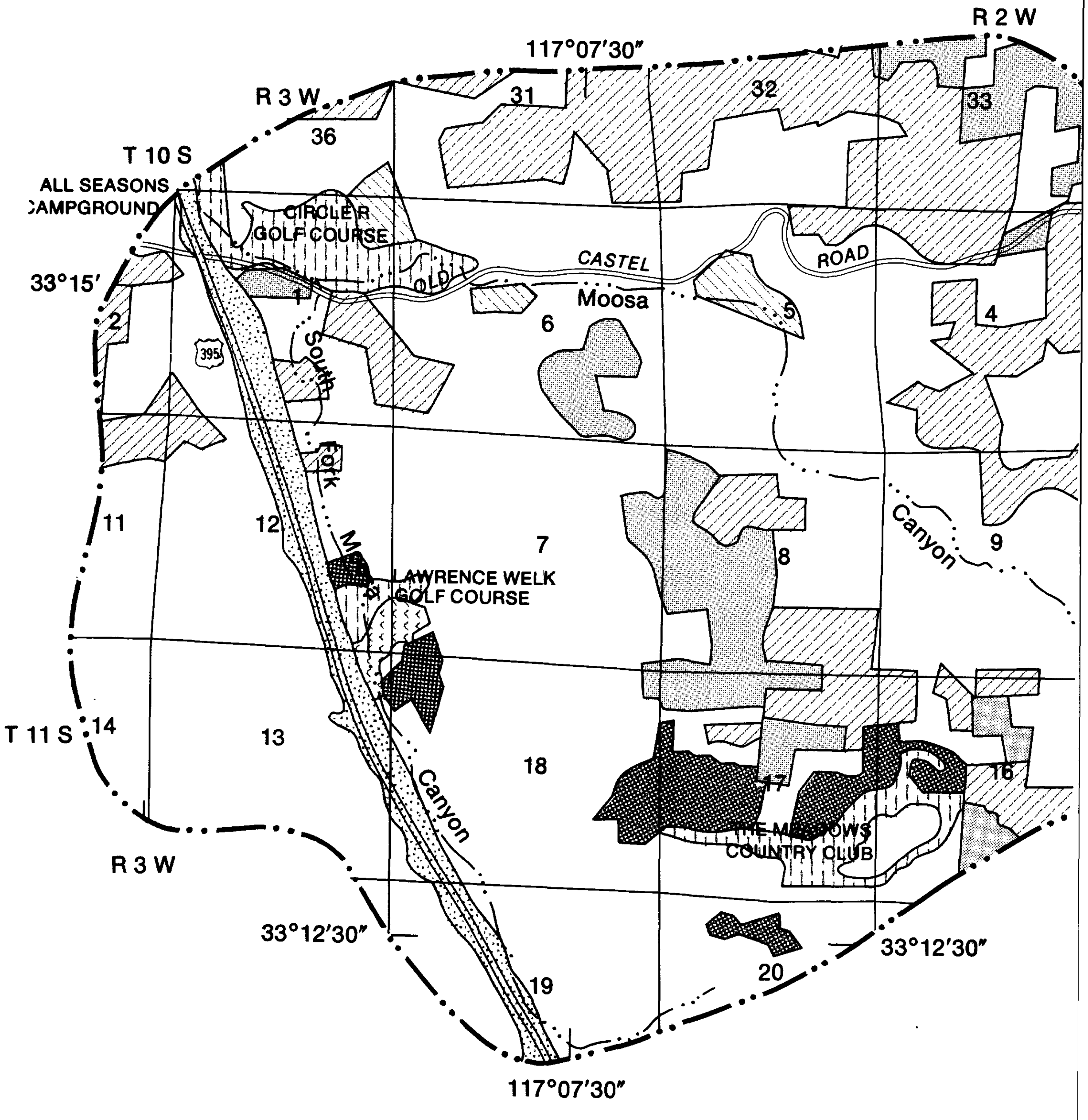
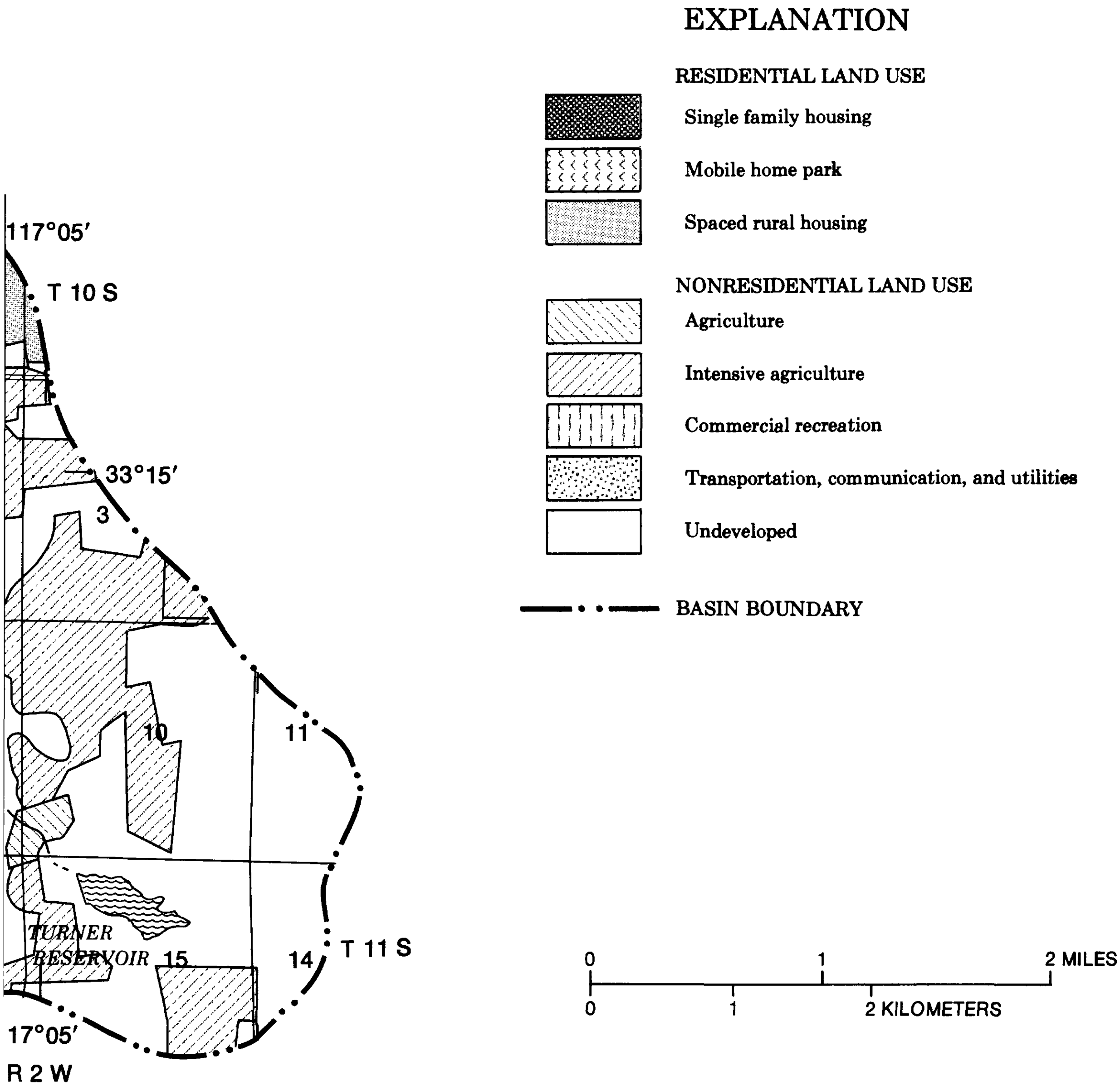


FIGURE 15.—Generalized land use in the Moosa basin (modified from San Diego Association of Governments, 1980).


EXPLANATION
RESIDENTIAL LAND USE
Single family housing
Mobile home park
Spaced rural housing
NONRESIDENTIAL LAND USE
Agriculture
Intensive agriculture
Commercial recreation
Transportation, communication, and utilities
Undeveloped
BASIN BOUNDARY
117°05′
T 10 S
33°15′
3
10
11
TURNER
RESERVOIR
15
14
T 11 S
17°05′
R 2 W
0
1
2 MILES
0
1
2 KILOMETERS

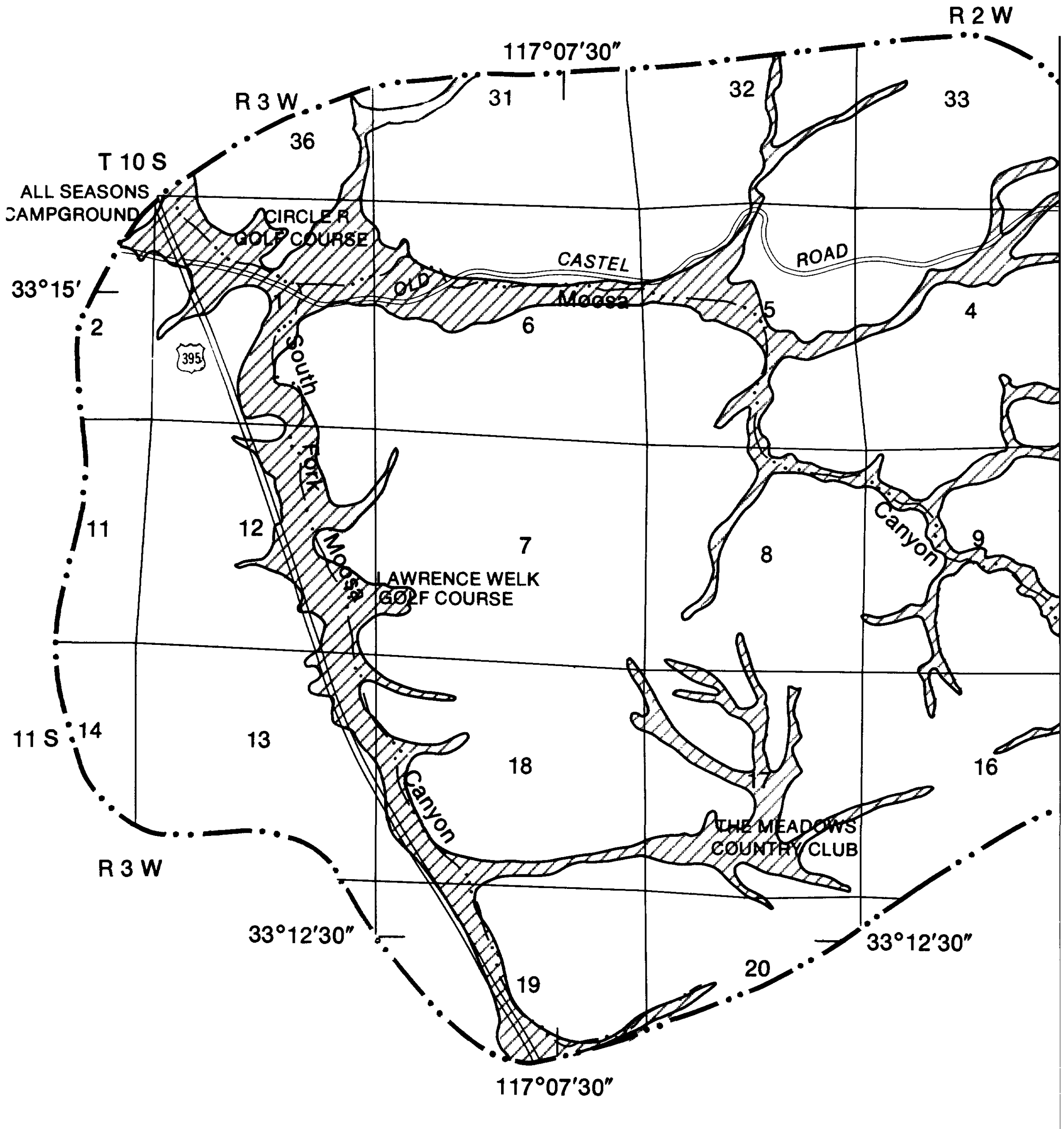


FIGURE 16.—Generalized geology of the Moosa basin (modified from Moyle, 1971).

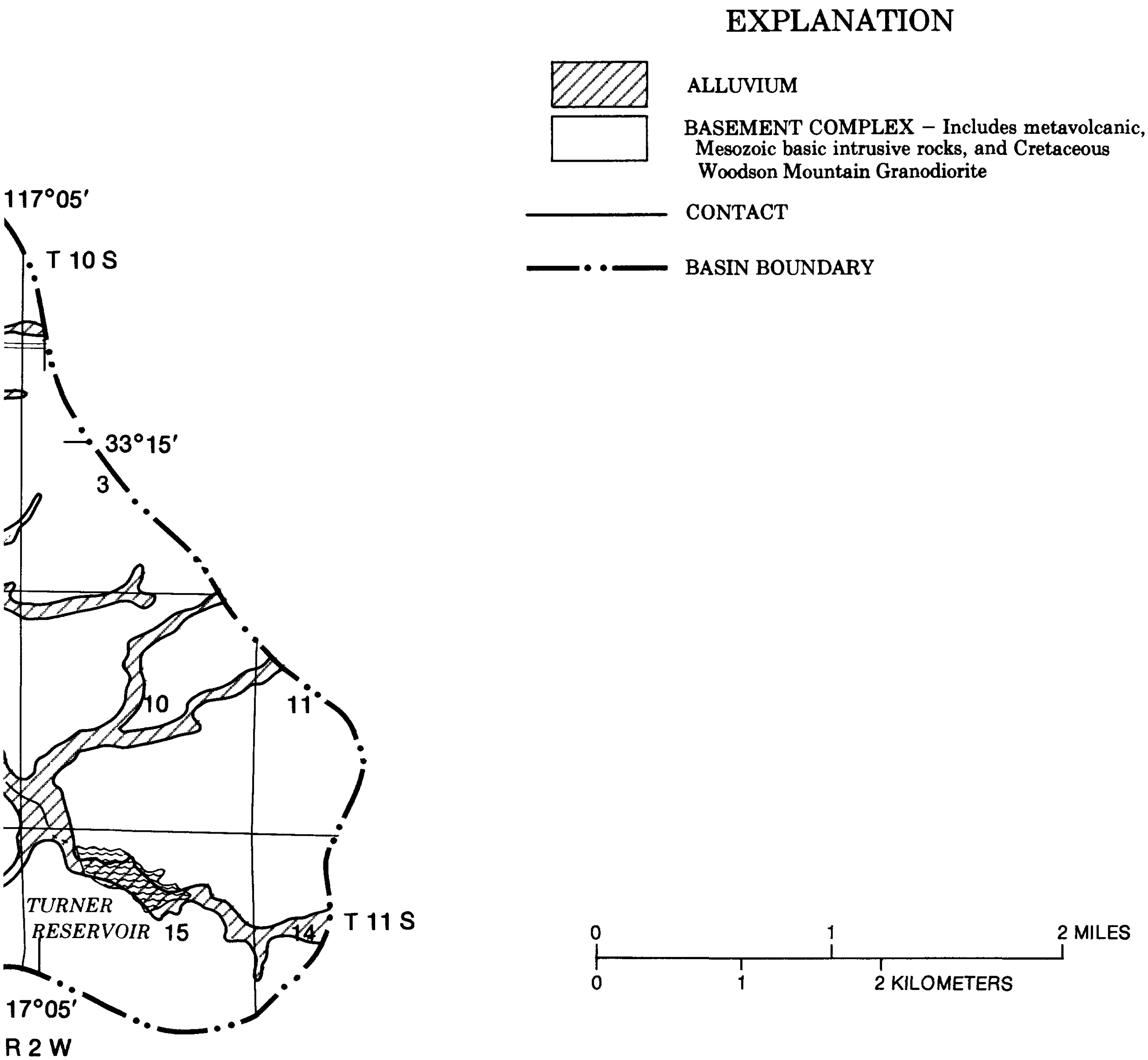

EXPLANATION
ALLUVIUM
BASEMENT COMPLEX – Includes metavolcanic, Mesozoic basic intrusive rocks, and Cretaceous Woodson Mountain Granodiorite
CONTACT
BASIN BOUNDARY
117°05′
T 10 S
33°15′
3
10
11
TURNER RESERVOIR
15
14
T 11 S
17°05′
R 2 W
0
1
2 MILES
0
1
2 KILOMETERS

TABLE 22.--*Water-quality objectives for inland surface water in the Moosa basin*

[From California Regional Water Quality Control Board, San Diego Region (1979). Concentrations not to be exceeded more than 10 percent during any one year period. Values given in milligrams per liter unless otherwise indicated. JTU, Jackson turbidity unit]

Property or constituent	Objective
Color (units)	20
Odor (units)	None
Turbidity (JTU)	20
Percent sodium	60
Sulfate	250
Chloride	250
Fluoride	1.0
Dissolved solids	500
Nitrogen and phosphorus	([1])
Boron	.5
Iron	.3
Manganese	.05
Methylene blue active substance	.5

[1]Phosphorus concentrations not to exceed 0.1 mg/L in flowing water and 0.025 mg/L in standing bodies of water. Values for nitrogen compounds have not been established; however, natural ratios of nitrogen to phosphorus are to be determined by surveillance and upheld. Where data are lacking a ratio of N>P = 10:1 shall be used (California Regional Water Quality Control Board, San Diego Region, 1979).

Other soils located in the basin are Escondido, Greenfield, Los Posas, Ramona, Placentia, Tunjunga, Visalia, and miscellaneous associations of river wash and gullied lands. Because these soils cover such a small part of the basin, the present discussion is limited to the three dominant soils in the area. Visalia soils are also included in the discussion because they cover the valley floors. Figure 17 shows areal distribution of dominant soils in the Moosa basin.

TABLE 23.--*Water-quality objectives for ground water in the Moosa basin*

[From California Regional Water Quality Control Board, San Diego Region (1979). Concentrations not to be exceeded more than 10 percent during any one year period. Values given in milligrams per liter unless otherwise indicated. JTU, Jackson turbidity unit]

Property or constituent	Objective
Color (units)	15
Odor (units)	None
Turbidity (JTU)	5
Percent sodium	60
Sulfate	400
Chloride	300
Fluoride	1.0
Dissolved solids	800
Nitrogen and phosphorus	10
Boron	.5
Iron	.3
Manganese	.05
Methylene blue active substance	.5

Cieneba-Fallbrook soils have developed from material weathered from granodiorite (fig. 17). These soils cover most of the basin and have been previously described in the discussion of Poway basin. These soils are thin, usually rocky, and have a slow infiltration rate that may make them unsuitable as reclaimed-water use sites.

Fallbrook-Vista soils are found in the northern and southern parts of the basin (fig. 17). These soils also have been described in detail in the discussion of Poway basin. Briefly, Fallbrook-Vista soils are similar to the Cieneba-Fallbrook soils; they are located at the same altitudes and have the same geologic parent material.

Fallbrook-Vista soils, however, are thicker, generally 20 to 57 inches, and have faster infiltration rates, 2 to 6.3 in/h. These differences make Fallbrook-Vista soils more suitable than Cieneba-Fallbrook soils as reclaimed-water use sites.

Visalia soils in the Moosa basin are located on 2 to 5 percent slopes in the canyon bottoms. These soils are sandy loams that form granitic alluvium. The soils are up to 40 inches deep, and the infiltration rate ranges from 2 to 6.3 in/h. Because Visalia and Vista soils are thick and have relatively rapid infiltration rates, they are good soils for reclaimed-water recharge sites.

In summary, because of slow infiltration rates or thin soil profile, the Cieneba-Fallbrook soils may be less suitable for reclaimed-water recharge sites than the Fallbrook-Vista or Visalia soils.

Ground Water

Occurrence and movement

Thickness of alluvial deposits varies greatly. The greatest depths are found in the downstream section of Moosa Canyon. Drillers' logs indicate that the depth of alluvial material in Moosa Canyon is less than 50 feet, and in South Fork Moosa Canyon the depth probably is less than 20 feet. There are about 941 million ft^3 of alluvial fill in the Moosa area. Information on well yields in the alluvial aquifer in the Moosa basin is sparse. However, well yields are probably less than 100 gal/min.

Recharge to the alluvial aquifer originates primarily outside the basin as flow in upper Moosa Canyon. Streamflow, imported water for irrigation and municipal use, ground-water flow from the surrounding aquifer, and precipitation also contribute to the recharge. Ground-water discharge leaves the basin as streamflow through lower Moosa Canyon (fig. 18).

Recharge studies done by the U.S. Geological Survey in July 1984 (table 24) along Moosa Creek show that in places both Moosa and South Fork Moosa Creek lose water to the alluvial aquifer. These sections are located downstream, where the slope of the creekbed has flattened out and the channel bottom is mostly sandy (fig. 19).

Springs, as well as flowing wells, have been reported in Moosa and South Fork Moosa Canyons. Two wells, one in Moosa Canyon and one in South Fork Moosa Canyon, are reported to flow throughout the year. Both wells are located near the stream channels and both tap non-alluvial material, indicating that water from the surrounding rock also recharges alluvial aquifer. Ground water also comes to the surface in the lowest part of the basin near All Seasons Campground (fig. 18).

Seasonal water-level fluctuations in the Moosa basin are minimal. Measurements from June and October 1984 and March 1985 show that water-levels tend to be higher in the spring, during and immediately following the wet period, and lower in the autumn, at the end of the dry period (table 16). Water levels range from flowing to 15 feet below land surface throughout the year. If the average specific yield of Moosa basin is assumed to be 0.1 (Johnson, 1967), ground-water storage, based on October 1984 water-level measurements, is about 17,000 acre-ft. Previous studies indicate that the alluvial aquifer in the lower part of Moosa Canyon in the Moosa basin is at maximum capacity (California Regional Water Quality Control Board, San Diego Region, 1984).

Little historical information is available on water levels in the Moosa basin. Water-level measurements are available for several wells from 1954-66. Water levels during this period ranged from 14 to 40 feet below land surface (fig. 18). Comparison with data collected in 1984-85 (fig. 19) indicates that water levels may have risen slightly since the 1960's.

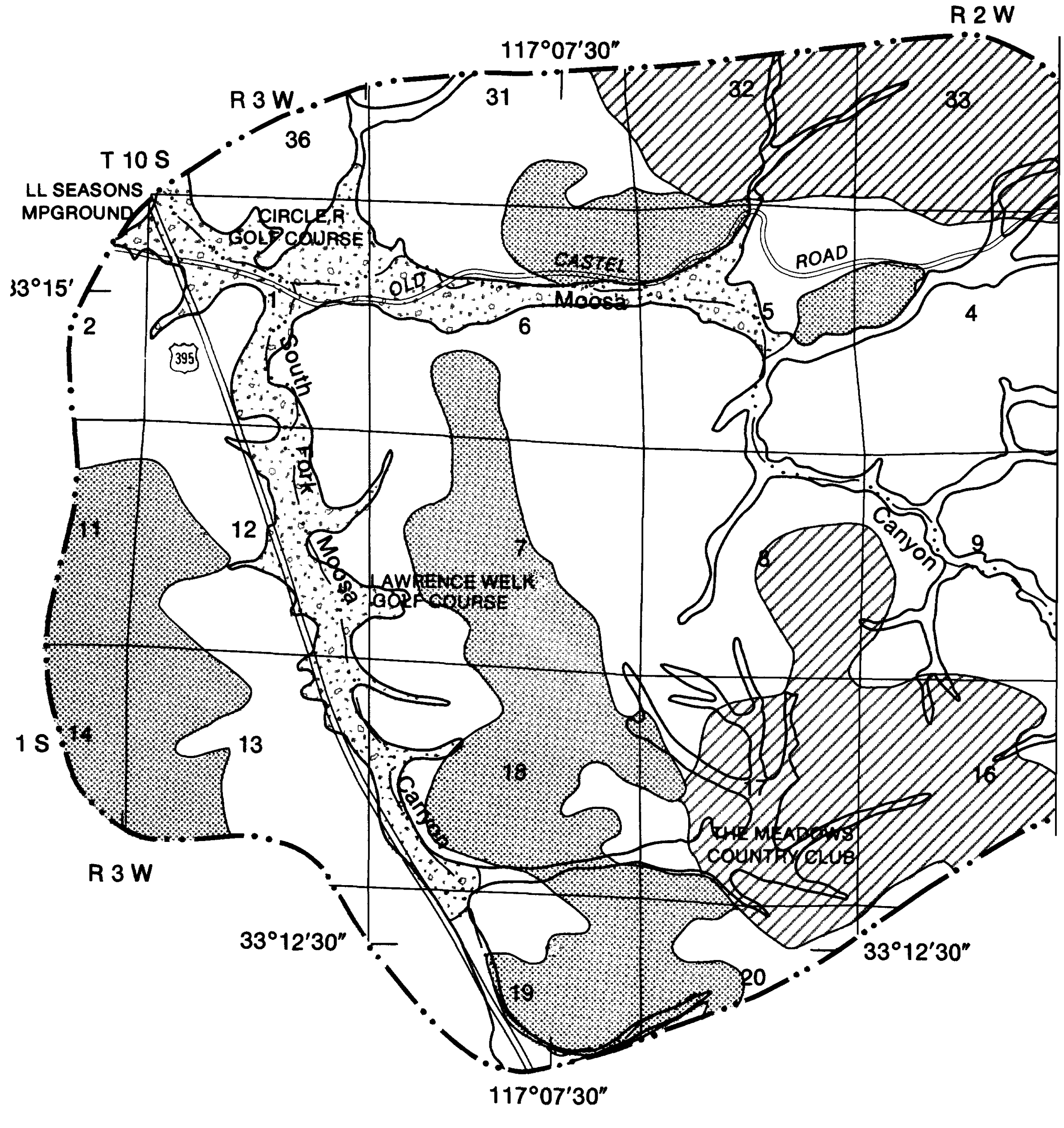
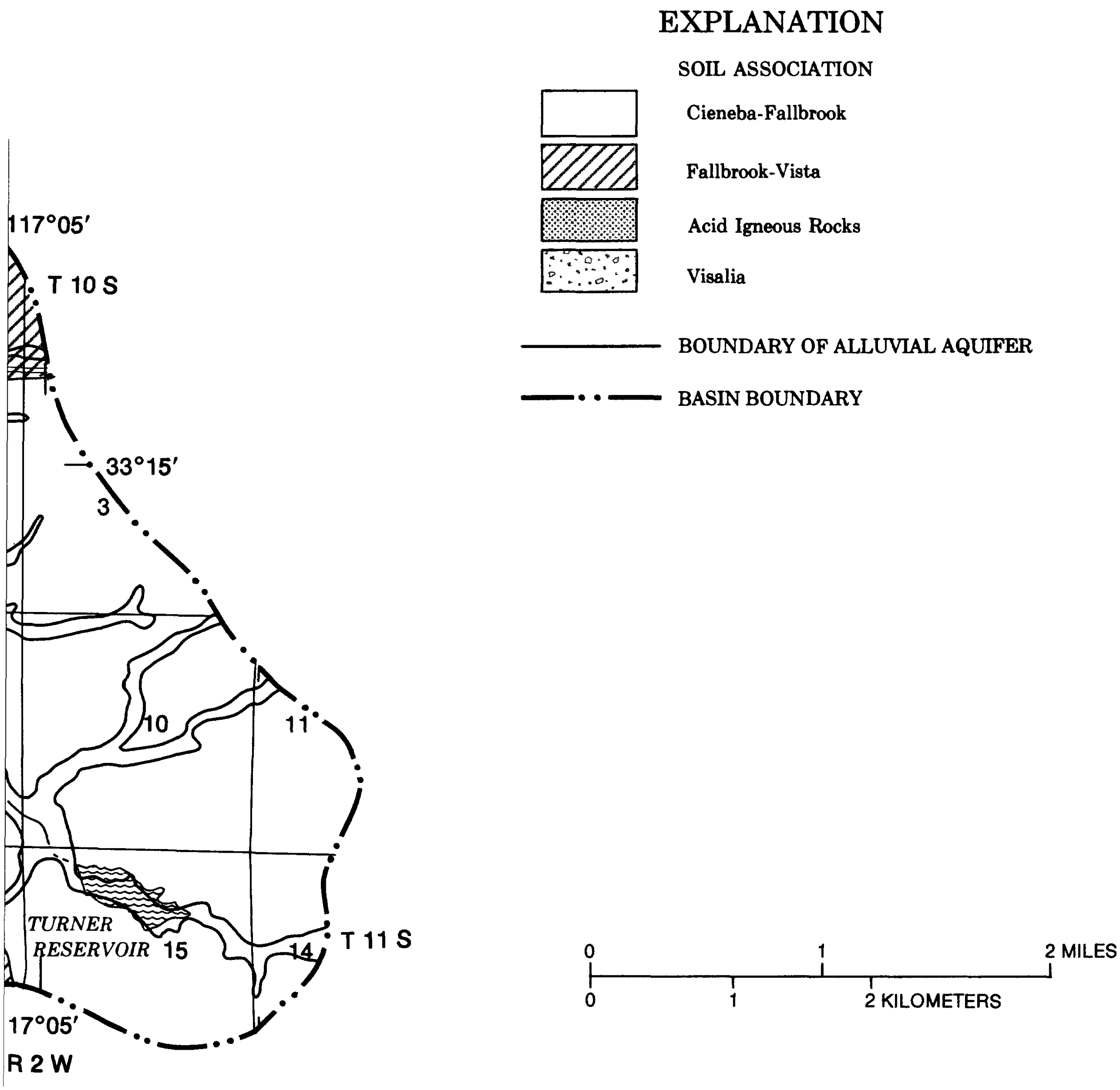


FIGURE 17.—Soil associations of the Moosa basin (modified from U.S. Soil Conservation Service, 1973).


EXPLANATION
SOIL ASSOCIATION
Cieneba-Fallbrook
Fallbrook-Vista
Acid Igneous Rocks
Visalia
BOUNDARY OF ALLUVIAL AQUIFER
BASIN BOUNDARY
117°05′
T 10 S
33°15′
3
10
11
TURNER RESERVOIR
15
14
T 11 S
17°05′
R 2 W
0
1
2 MILES
0
1
2 KILOMETERS

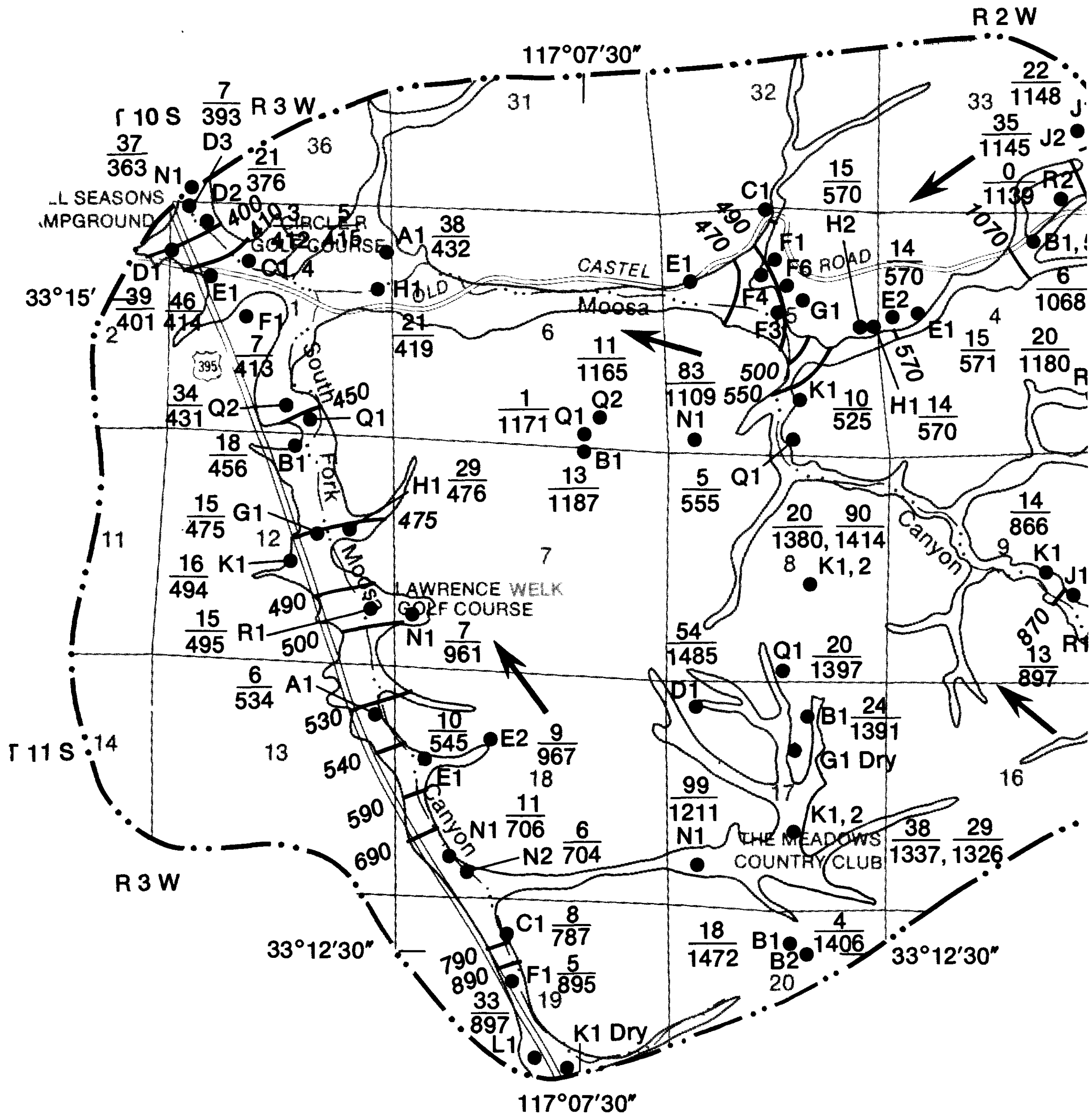
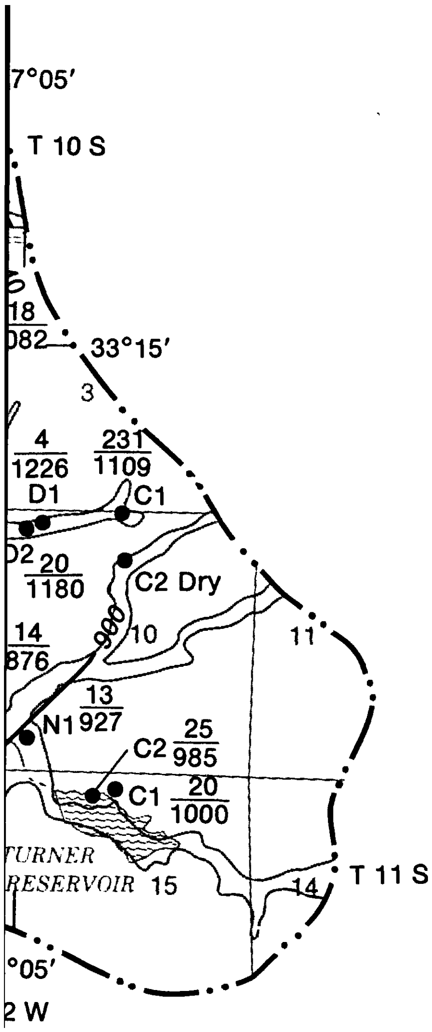


FIGURE 18.—Water-level contours and depth to water in the Moosa basin, spring 1966 (modified from Moyle, 1971).



EXPLANATION

—— *500* —— WATER-LEVEL CONTOUR – Interval variable, in feet. Datum is sea level

● E1 15/571 WELL AND NUMBER – In which water level was measured. Number above line is depth to water in feet below land surface. Number below line is altitude of water level in feet above sea level

DIRECTION OF GROUND-WATER FLOW

BOUNDARY OF ALLUVIAL AQUIFER

BASIN BOUNDARY

0 1 2 MILES

0 1 2 KILOMETERS

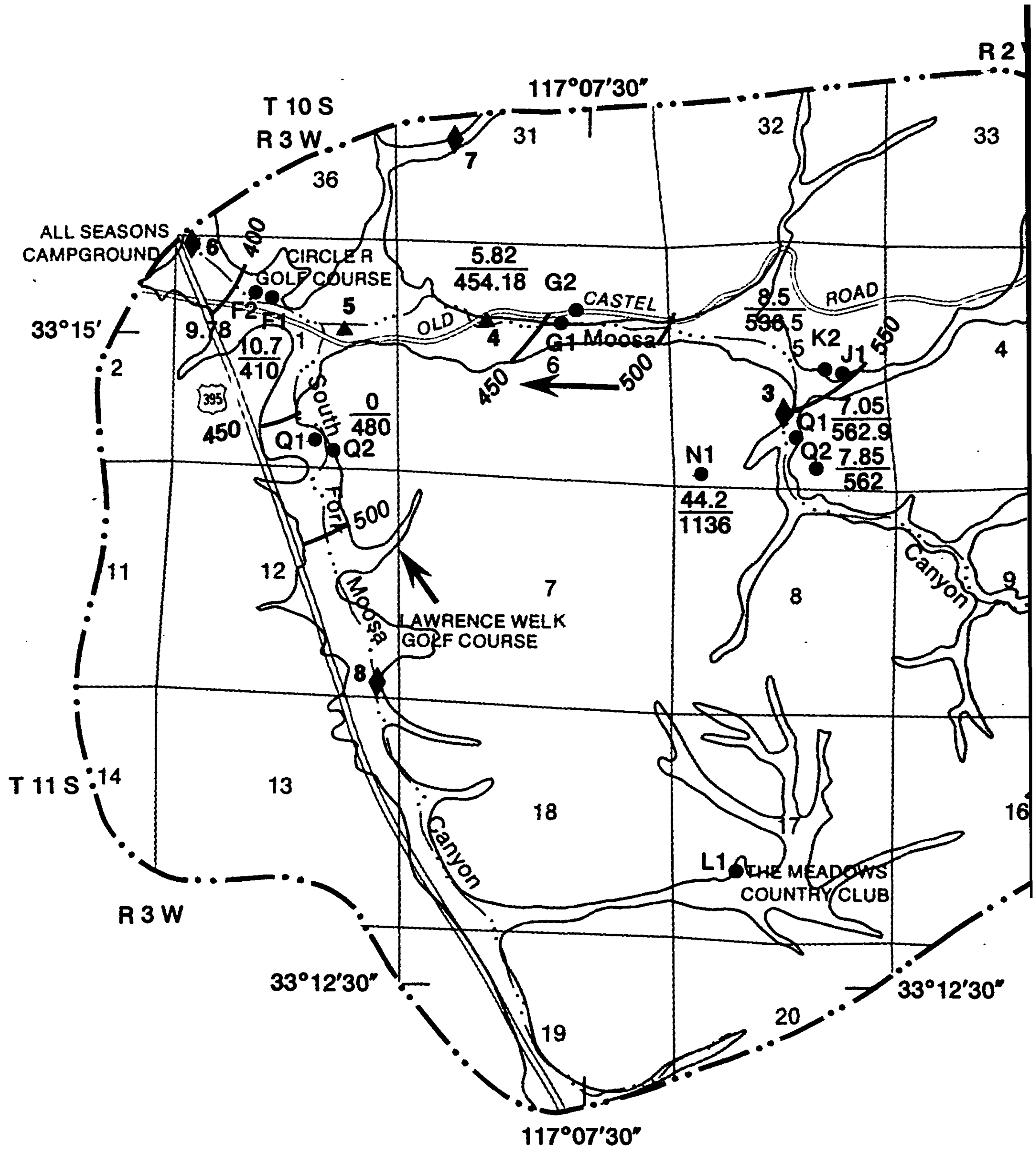
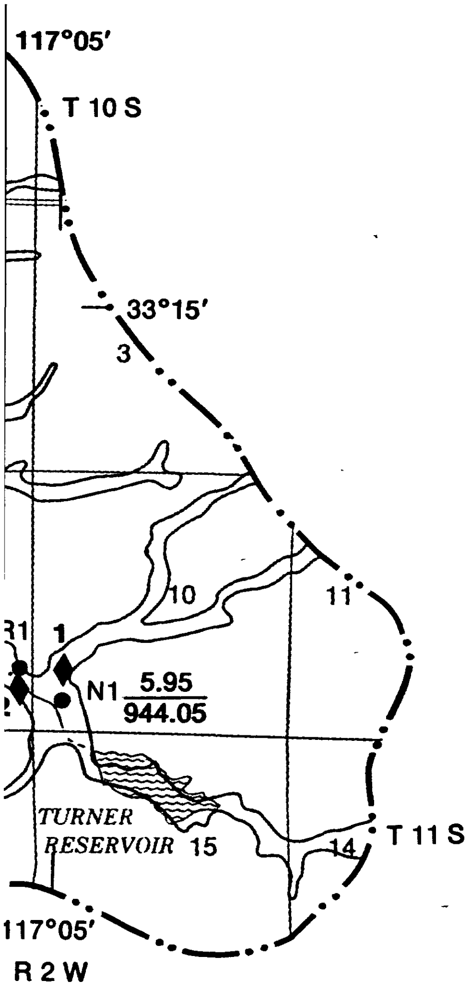


FIGURE 19.—Water-level contours and depth to water in the Moosa basin, spring 1985, and location of stream-gaging and water-quality measurement stations.



EXPLANATION

—— 500 —— WATER-LEVEL CONTOUR – **Interval 50 feet.** Datum is sea level

N1 ● 44.2 / 1136 WELL AND NUMBER – **In which water level was measured. Number above line is depth to water in feet below land surface. Number below line is altitude of water level in feet above sea level**

▲4 STREAM-GAGING STATION

♦1 STREAM-GAGING AND WATER-QUALITY **MEASUREMENT** STATION – **Number corresponds to stations listed on table 24**

← **DIRECTION OF GROUND-WATER FLOW**

—— **BOUNDARY OF ALLUVIAL AQUIFER**

—— • • —— **BASIN BOUNDARY**

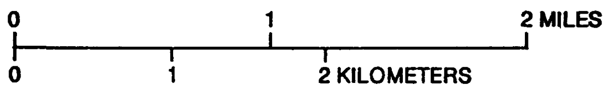


TABLE 24.--*Miscellaneous flow data for streams in Moosa basin, near Valley Center, California*

[ft^3/s, cubic feet per second]

Site no.	Station name	Date of sample	Time (hours)	Discharge (ft^3/s)
1	Tributary at well 11S/2W-9R1..................	7-11-84	1035	0.02
2	Moosa Creek below confluence below dam.........	7-11-84	1115	.09
		3-21-84	1445	.35
3	Moosa Creek 1,000 feet upstream of Old Castle Road................................	7-10-84	1150	.08
4	Moosa Creek at Old Castle Road................	7-10-84	1000	.04
5	Moosa Creek at Circle "R" Golf Course..........	7-10-84	1220	.10
6	Moosa Creek at Champagne Road.................	7-10-84	1350	.12
		3-21-85	1330	1.8
7	North Fork tributary at Ridge Creek Road.......	7-11-84	1150	.12
8	South Fork Moosa Creek above mobile home park..	7-10-84	1305	.10
		3-21-85	1215	.25

Ground-water quality

Most of the ground water used in the Moosa basin comes from the granodiorite. In most of San Diego County, water from this unit has a chemical water type of sodium to calcium bicarbonate and dissolved-solids concentrations ranging from 250 to 1,500 mg/L (California Department of Water Resources, 1967). The California Department of Water Resources (1967) attributed the presence of higher concentrations of dissolved solids to human activities.

Water samples collected in October 1984 and March 1985 indicate slightly different trends. Dissolved-solids concentrations ranged from 490 to 1,200 mg/L (fig. 20). Sodium is the dominant cation, and calcium is second in dominance; the dominant anion, however, is chloride rather than bicarbonate (fig. 20). In general, little difference was detected between the October and March samplings.

Higher concentrations of dissolved solids were found in water samples from wells in which water was derived in whole or in part from the alluvial aquifer. In these wells, dissolved solids ranged from 1,100 to 1,200 mg/L. Chemical water types, determined mathematically by computing the relative concentration of cations to anions in chemical equivalents, were similar to the water types found in the hard rock, dominantly sodium calcium chloride sulfate.

Chemical character of ground water derived from both the alluvial aquifer and the granodiorite is similar. In both cases, the ground water is typically sodium calcium chloride and hard to very hard; concentrations exceed established objectives for one or more constituents. The largest difference in the water derived from the two units is the concentration of dissolved solids, as was discussed previously. In general, the chemical quality of the ground water in the Moosa basin does not meet objectives established for the basin. Chloride and dissolved solids exceeded established objectives in most of the wells sampled.

Sulfate exceeded criteria in 30 percent of the wells sampled and iron in one well. Data from the October and March samplings are summarized in tables 7 and 8.

Historical ground-water data are limited in the Moosa basin. Records were available for one well in the basin. The sample was collected in August 1954. The chemical water type at that time was sodium chloride bicarbonate, and dissolved solids concentration was 600 mg/L. All constituents for which analysis was done were below established objectives.

Surface Water

Streamflow characteristics

There are no stream-gaging stations in the Moosa basin. Streamflow data were collected during the sampling periods in October 1984 and March 1985. These flow data are presented in table 24, and location of flow and quality measuring sites are shown in figure 19.

Streamflow into the Moosa basin is from Moosa Canyon and South Fork Moosa Canyon. All surface-water flow leaves the basin through Moosa Canyon in the northwest corner of the basin.

Streamflow in upper Moosa Canyon is intermittent; flows occur mostly in conjunction with storm runoff, although agricultural return and ground water feed lower Moosa so that it flows most of the year.

Surface-water quality

Water-quality data from Moosa and South Fork Moosa Creeks are presented in table 10. These data were collected in October 1984 and March 1985 in order to represent base and storm flows, respectively.

Dissolved-solids concentrations in the surface water in the Moosa area, ranging from 1,300 to 1,700 mg/L, exceed basin objectives. In general, South Fork Moosa Creek has lower dissolved-solids concentrations than Moosa Creek. Lower concentrations of dissolved solids also occur during storm flow. There were no other major changes between the fall and spring samples. Based on the calculations of the data collected in 1984-85, the chemical water type of Moosa Creek and South Fork Moosa Creek is sodium calcium chloride bicarbonate.

Concentrations of dissolved solids and chloride exceeded basin objectives. Upper Moosa Creek had sulfate values that exceeded established objectives in both the autumn and spring samples; however, lower Moosa and South Fork Moosa Creeks had much lower sulfate concentrations. No other constituents met or exceeded basin objectives. Concentrations of trace elements were negligible, and no pesticides were detected in any of the stations sampled.

Reclaimed Water

Reclaimed-water quantity

A wastewater-treatment facility is located in the northwestern corner of the Moosa basin. This facility, owned and operated by the Valley Center Municipal Water District, serves most of the basin and can treat 0.5 Mgal/d. The plant currently maintains three percolation ponds, which are located just outside the basin in the Bonsall hydrologic subbasin. The total volume of the ponds is 60 acre-ft. These ponds are the only means of wastewater disposal. Adequately treated water from this facility is a potential source of reclaimed water.

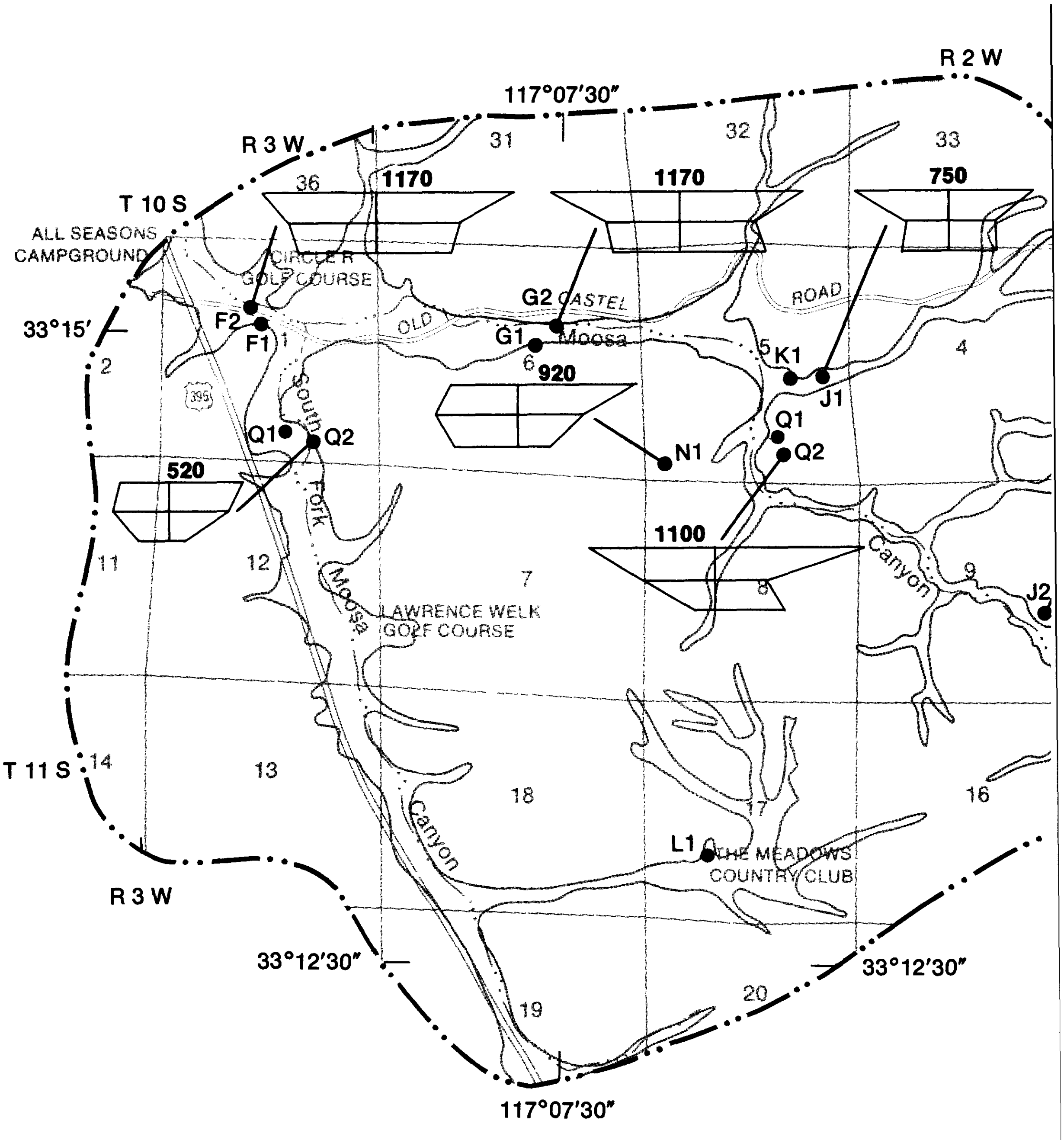
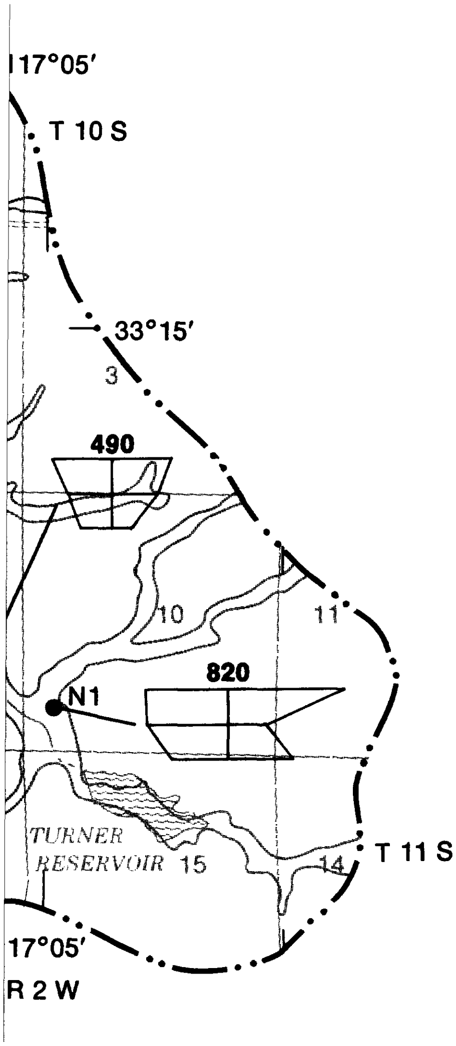
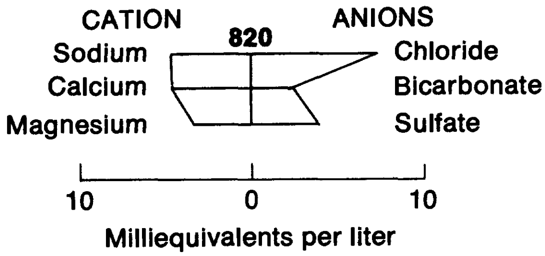


FIGURE 20.—Quality of water in selected wells in the Moosa basin, autumn 1984.



EXPLANATION

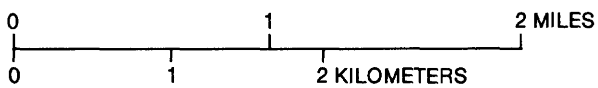


Number above diagram is dissolved solids, in milligrams per liter

● N1 WELL AND NUMBER

BOUNDARY OF ALLUVIAL AQUIFER

BASIN BOUNDARY



This secondary treatment and disposal facility has been in operation for about 10 years (California Regional Water Quality Control Board, San Diego Region, 1984). Expansion of the facility is planned from its current capacity of 0.5 Mgal/d to 1.0 Mgal/d. The handling of wastes from the community of Valley Center, which is located outside the basin, is the main reason for the expansion.

Reclaimed-water quality

Comparison of ground-water samples collected from wells at Circle "R" and Lawrence Welk golf courses (fig. 20) with secondarily treated water indicates that the reclaimed water is less mineralized than the local ground water (table 25). Concentrations of most constituents, other than bacteriological, were lower in the reclaimed water. The primary exceptions to this were nitrogen and phosphorus. The range of nitrogen concentrations exceeded objectives established for ground water in the basin. Daily maximum allowable concentrations for various constituents have been established by the California Regional Water Quality Control Board (1984) (table 26). Water containing concentrations greater than those listed would not be used in percolation ponds or irrigation supplies. Use of reclaimed water may improve the quality of ground water in this area (California Regional Water Quality Control Board, San Diego Region, 1984).

TABLE 25.--*Water-quality analysis of ground water from selected wells and of reclaimed water from the Moosa Canyon plant*

[From California Regional Water Quality Control Board (1984), and Ken Simon, Valley Center Municipal Water District, written commun., 1985. Values are in milligrams per liter]

Property or constituent	Well 11N/3W-1F2 (autumn 1984)	Lawrence Welk Golf Course well	Moosa Canyon plant reclaimed water
Sodium........	180	--	--
Sulfate.......	240	120	240
Chloride......	330	245	140
Fluoride......	.30	.22	.4
Dissolved solids......	1,100	1,100	820
Nitrate.......	.83	.05	9.5
Kjeldahl, nitrogen total.......	--	.03	--
Phosphorus....	--	.01	4.9
Boron.........	.14	.23	.8

Imported Water

Sources and quantity

The imported water used in the Moosa basin is supplied by the Valley Center Municipal Water District. The water is

TABLE 26.--*Maximum allowable concentrations of constituents for reclaimed water used in percolation ponds or irrigation*

[From California Regional Water Quality Control Board, San Diego Region (1984). Values are in milligrams per liter unless otherwise indicated]

Property or constituent	Monthly average	Daily maximum
pH (units)..........	([1])	([1])
Biochemical oxygen demand.....	20	30
Percent sodium......	--	60
Sulfate.............	--	250
Chloride............	--	200
Fluoride............	--	.5
Dissolved solids....	--	1,000
Suspended solids....	20	30
Boron...............	--	.5

[1]Values must be greater than 6.0 and less than 9.0 at all times.

a blend of Colorado River water and filtered California State Water Project (SWP) water. A typical ratio of the blend is 80 percent Colorado River water and 20 percent SWP water (Ken Simon, Valley Center Municipal Water District, oral commun., 1985). The water stored for use in the Moosa basin is contained in large tanks located on the hills throughout the area and in Turner Reservoir.

Imported-water quality

The quality of the imported water is similar to that of the imported water used in the Soledad and Poway basins and is generally better than that of the local ground water. Water-quality data for Colorado River water and California State Water Project water are presented in table 27.

Water Use

Ground water is used for irrigation supplies in the Moosa and South Fork Moosa Canyon areas. This irrigation water is mainly applied to golf courses and pasture lands. Domestic wells supply water to wells mainly in the Moosa Canyon area. Imported water fills the rest of the basin's domestic and agricultural needs. Surface water in the basin is intermittent and therefore not a dependable water supply.

The California Regional Water Quality Control Board, San Diego Region, (1975) noted existing and potential beneficial uses of surface and ground water for the Bonsall hydrographic subunit, of which the Moosa basin is a small part. Specific applications of various water supplies are discussed in detail under the water-supply headings in this report.

Projections in water demand are available for the Bonsall hydrographic subunit (California Regional Water Quality Control Board, San Diego Region, 1975). Although the volumes of water are considerably lower for the Moosa basin, the trends are assumed to be the same. However, the rugged terrain could retard development, so that projections for the Moosa basin are probably less than those anticipated for the rest of the hydrographic subarea. Overall water demand for agricultural, as well as domestic, commercial, and industrial uses are expected to increase.

TABLE 27.--*Quality of imported water used in the Moosa Basin*

[From Ken Simon, Valley Center Municipal Water District, written commun., 1985. Sampling was done in September 1985 grab sample. Values are in milligrams per liter unless otherwise noted. Specific conductance is in microsiemens per centimeter at 25 °C. Temperature is in degrees Celsius. NTU, Nephelometric turbidity units]

Property or constituent	Colorado River water	California water project
Specific conductance	58	647
pH (units)	8.5	8.1
Temperature	25	23
Turbidity (NTU)	1.7	.16
Hardness	280	180
Calcium	72	47
Magnesium	25	16.5
Sodium	91	60
Potassium	4	2.6
Bicarbonate	152	121
Carbonate	2	0
Alkalinity	129	99
Carbon dioxide	.8	1.6
Sulfate	240	140
Chloride	71	56
Fluoride	.31	.19
Silica	8.5	9
Dissolved solids	590	390
Nitrate	.7	.25
Boron	.07	.11

Estimated water demand, based on population and land-use data, is presented in table 28. The methods of estimation are described in the Soledad section. As municipal and agricultural needs make up most of the basin's water demands, the two together probably represent the total water demand for the basin.

Ground Water

Ground water in the Moosa basin is currently used for both agricultural and domestic purposes. The largest agricultural use of ground water is for irrigation of golf courses. According to the U.S. Salinity Laboratory (1954) system of classification of water as to its suitability for irrigation, the ground water of the Moosa basin is marginal for irrigation supplies because of high salinity hazard. With the expected use of reclaimed water for irrigation supplies in these areas, the primary use of ground water may become domestic.

TABLE 28.--*Estimated and projected water demand in the Moosa basin, in acre-feet per year*

[Projections for agricultural water demand may actually decrease by the use of reclaimed water for irrigation water on two golf courses, as planned by the Valley Center Water District. Municipal projections based on estimated 0.22 acre-feet per year per-capita water production for the city of Escondido. Information from California Regional Water Quality Control Board, San Diego Region (1975)]

Year	Municipal	Agricultural	Total
1980	487	4,960	5,447
1990	800	4,960	6,800
2000	1,200	4,960	6,100

Surface Water

Surface water in the Moosa basin is mostly intermittent and therefore not a dependable water supply; consequently, it is generally not used as a water-supply source. The beneficial uses associated with surface water are contact and noncontact recreation, agriculture, and habitat for fish and wildlife. These uses have been designated for the entire Bonsall hydrographic subunit, of which the Moosa basin is a small part. No other uses of surface water are projected for the basin.

Reclaimed Water

Current plans for reclaimed-water use are oriented toward providing water suitable for irrigation supplies. When the new wastewater-treatment plant is fully operational, reclaimed water from the plant, as well as ground water extracted downstream from the percolation ponds, may be used to irrigate Circle "R" and Lawrence Welk golf courses located in the downstream part of the Moosa basin.

Imported Water

Most of the agricultural water used for irrigation on the upland part of the basin and municipal water used in the same areas is imported water. The irrigation water is mainly used on citrus and avocado orchards and turf grass.

SUMMARY AND CONCLUSIONS

Reclaimed-water is being considered as a supplemental water supply in the Soledad, Poway, and Moosa basins, San Diego County. This report examines the geology, soils, hydrology, and cultural factors in each of the basins as they apply to use of reclaimed water.

Imported water is currently the major water-supply source in the basins. Ground-water supplies are used to a limited extent for both agricultural and domestic needs. Surface-water flows are intermittent and therefore have not been developed for use in the basins. All three of the basins have the potential for use of reclaimed water; however, only the Moosa basin currently has such a plan.

The population of the Soledad basin, which in 1980 was 65,390, is expected to increase by 140 percent by the year 2000. Imported water meets most of the basin's water demands. Ground water is used for domestic and agricultural supplies in the northern part of the basin. In this area, the alluvial aquifer contains about 260 acre-ft of ground water in storage. Concentrations of dissolved solids in ground water ranged from 1,000 to 2,000 mg/L throughout the basin. Concentrations of dissolved solids, chloride, sulfate, and iron commonly exceeded established basin objectives. As of 1985, plans under consideration for the use of reclaimed water were oriented toward improving the quality of the ground water. One likely plan included pumping the highly mineralized water out of an aquifer and replacing it with reclaimed water that contains lower concentrations of dissolved solids. The only anticipated use of this recharged ground water is for irrigation.

The population of the Poway basin was 3,350 in 1980 and is expected to increase by 140 percent by the year 2000. With this increase, the water demand also will increase. Imported water currently supplies most of the basin's water demands. Ground water is used to a limited extent throughout the eastern part of the basin for domestic and agricultural needs. The alluvial aquifer in the Poway basin contains about 23,300 acre-ft of ground water in storage. The quality of water from the alluvial aquifer is generally more mineralized than that found in other water-bearing formations. Concentrations of dissolved solids ranged from 500 to 1,600 mg/L throughout the basin. Concentrations of dissolved solids and chloride commonly exceeded basin objectives. As of 1985, there were no plans to use reclaimed water in the Poway basin.

The population of the Moosa basin was 2,215 in 1980 and is expected to increase by more than 100 percent by the year 2000. As of 1985, most of the basin's water demands were filled with imported water. Ground water was used for domestic and agricultural purposes by individual well owners. The alluvial aquifer in the Moosa basin contains about 16,000 acre-ft of ground water in storage. Dissolved solids in ground water ranged from 470 to 1,200 mg/L throughout the basin. Concentrations of dissolved solids and chloride commonly exceeded basin objectives. One plan for use of reclaimed water was to supply irrigation water on two golf courses in the lower Moosa and South Fork Moosa Canyons. The reclaimed water was expected to be less mineralized than the local ground water; after percolation into the aquifer, such water may improve the quality of the ground water.

If, as expected, the population in the Soledad, Poway, and Moosa basins increases by more than 100 percent between 1980 and 2000, water demands will increase accordingly. As of 1985, imported water, chiefly from the Colorado River, met most water needs of the three basins. None of the basins have dependable surface-water supplies to help meet expected needs. Ground-water supplies in all the basins also are insufficient to meet expected needs, because the supplies are small and water quality does not meet basin objectives. Ground water in the basins generally exceeds established objectives for concentrations of dissolved solids, chloride, and sulfate. In the Soledad basin, iron concentrations in most water samples exceed basin objectives.

As of 1985, reclaimed water was under consideration to supplement irrigation supplies on two golf courses in the Moosa basin. The applied reclaimed water was expected to be less mineralized than the local ground water used for irrigation supplies. Infiltration of reclaimed water into the basin may improve the water quality of the alluvial aquifer in the lower part of the basin.

No wastewater-treatment facilities exist in the Soledad or Poway basins. The city of Poway is considering construction of a wastewater-treatment plant in Los Penasquitos Canyon at the western edge of the basin. Reclaimed water produced from this plant may be used to recharge and improve the quality of the ground water in an aquifer downstream and to create an irrigation-water supply. Recharge with reclaimed water could improve the ground-water quality in any of the alluvial aquifers in the Soledad basin. The alluvial aquifers in the Soledad basin are near full saturation, however, so that ground water would have to be removed by pumping before reclaimed water could infiltrate, dilute, and replenish existing ground-water supplies. The lower Moosa Canyon, the lower part of Los Penasquitos Canyon in Poway basin, and Soledad Valley also are near storage capacity and could benefit from the recharge of less mineralized reclaimed water.

The use of reclaimed water under consideration for the Moosa and the Soledad basins would supplement the water supply used for irrigation. Although this action would alleviate part of the total demand, it would not alleviate the water demand for domestic uses, which make up the largest part of the total water demand. To meet the expected shortages of the total water supply, other plans may need to be explored.

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