GROUND-WATER HYDROLOGY AND QUALITY IN THE LOMPOC AREA, SANTA BARBARA COUNTY, CALIFORNIA, 1987-88

By Daniel J. Bright, Christina L. Stamos, Peter Martin, *and* David B. Nash

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U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 91-4172

Prepared in cooperation with the

SANTA YNEZ RIVER WATER CONSERVATION DISTRICT

Sacramento, California
1992

U.S. DEPARTMENT OF THE INTERIOR
MANUEL LUJAN, JR., *Secretary*

U.S. GEOLOGICAL SURVEY
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CONTENTS

PLATE

FIGURES

TABLES

Conversion Factors and Vertical Datum

Conversion Factors

Multiply	By	To obtain
acre	0.4047	hectare
acre-foot (acre-ft)	0.001233	cubic hectometer
acre-foot per day (acre-ft/d)	0.001233	cubic hectometer per day
acre-foot per day per mile [(acre-ft/d)/mi]	0.000766	cubic hectometer per day per kilometer
acre-foot per year (acre-ft/yr)	0.001233	cubic hectometer per year
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
gallon per minute (gal/min)	0.06308	liter per second
gallon per day per square foot [$(gal/d)/ft^2$]	0.04073	cubic meter per day per square meter
inch (in.)	25.40	millimeter
inch per year (in/yr)	25.40	millimeter per year
mile (mi)	1.609	kilometer

Vertical Datum

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

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ABSTRACT

The principal water-bearing units in the Lompoc area are the river-channel deposits and younger alluvium that compose the upper aquifer and the Paso Robles Formation and Careaga Sand that compose the lower aquifer. The upper aquifer consists of three water-bearing zones: (1) the shallow zone, (2) the middle zone, and (3) the main zone. The main zone of the upper aquifer has been the primary source of water in the Lompoc plain. The lower aquifer has been the primary source of water in the Lompoc upland and Lompoc terrace.

Ground-water movement in the shallow and main zones of the upper aquifer during spring 1988 generally was from east to west. In both zones, ground water moved westward from the Santa Ynez River toward a water-level depression in the eastern plain. Ground-water movement in the lower aquifer during spring 1988 generally was toward the western plain from the surrounding upland and terrace areas.

Water-level measurements indicate that water flowed to the main zone from overlying and underlying water-bearing deposits throughout 1988 in the eastern plain. Ground water moved freely between the upper and lower aquifers in this area. In the central and western plain, water flowed to the main zone from overlying and underlying deposits only during the irrigation season. Downward flow to the main zone in these areas, however, was limited because of the presence of silt and clay deposits in the shallow zone.

The dissolved-solids concentrations in ground water varied markedly throughout the Lompoc plain. In general, the dissolved-solids concentrations in the shallow, middle, and main zones increased from the eastern plain to the western plain. In areas adjacent to the Santa Ynez River that have had little, if any, history of agricultural activity, dissolved-solids concentrations in the shallow zone were about 1,000 milligrams per liter. However, in areas that have been irrigated, dissolved-solids concentrations commonly were greater than 3,000 milligrams per liter. Dissolved-solids concentrations of ground water in the shallow zone were more than twice those in the main zone and several times higher than in the lower aquifer. Dissolved-solids concentrations of water in the shallow zone were greater than 8,000 milligrams per liter near the coast.

In the northeastern plain, high dissolved-solids concentrations (2,900 milligrams per liter) of water in the middle zone were attributed to leakage from the overlying shallow zone. This water of high dissolved-solids concentration was diluted by recharge of water from the southern edge of the plain as it moved downgradient toward the western plain. Downward leakage through silt and clay deposits in the shallow zone was limited in areal extent, as indicated by the presence of water of low dissolved-solids concentration (650 milligrams per liter) in the middle zone beneath the western plain.

Data collected from this and other studies indicate that ground-water quality has deteriorated steadily in many areas of the Lompoc plain from the 1950's to 1988. Concentrations of dissolved solids in the main zone have increased throughout the Lompoc plain. Pumping for irrigation and for municipal use in the eastern plain has intercepted a large percentage of the recharge from the Santa Ynez River since the 1950's. The cone of depression caused by this pumping has induced downward movement of water of high dissolved solids concentration from the shallow zone into the main zone. Unlike the middle zone, in which the dissolved-solids concentrations decreased in the western plain, dissolved-solids concentrations of water in the main zone remained high throughout the plain. High concentrations of dissolved solids in the upper aquifer along the coast during 1987-88 were attributed to downward leakage of seawater from the overlying estuary.

In general, ground water in the lower aquifer had significantly lower dissolved-solids concentrations than water in the upper aquifer during 1987-88. The lower aquifer beneath the Lompoc plain contained water of slightly higher dissolved-solids concentration than water in the aquifer beneath the Lompoc upland; the major source of recharge to the lower aquifer beneath the Lompoc upland was direct infiltration of precipitation. Water-quality samples from wells at the base of the canyons that drain the foothills of the Santa Ynez Mountains suggest that recharge of runoff from the foothills probably contributed significant quantities of dissolved solids to the lower aquifer beneath the Lompoc plain. Also, the direct contact between the shallow zone and the lower aquifer at the southern edge of the plain probably allowed irrigation-return flow to percolate into the lower aquifer.

INTRODUCTION

Ground water historically has been the main source of water supply in the Lompoc area of the Santa Ynez River basin (fig. 1). Construction of the missile facilities at Vandenberg Air Force Base (VAFB) in the 1960's and increased population growth in the 1980's have significantly increased the demand for water in the Lompoc area for domestic and municipal uses. In addition, there continues to be a large demand for ground water for irrigation on the Lompoc plain, which is the principal agricultural area in the Santa Ynez River basin.

Ground water in the Lompoc area in 1983, especially in the Lompoc plain, was only marginally acceptable for most uses. Dissolved-solids concentration of ground water in the western Lompoc plain has increased from an average of 1,260 mg/L (milligrams per liter) in the mid-1930's (Wilson, 1959, p. 103) to more than 3,000 mg/L by 1983 (Berenbrock, 1988). Dissolved-solids concentration of ground water from the surrounding Lompoc upland and terrace areas, however, has not changed appreciably in the last 50 years (Ahlroth and others, 1977). Several studies have documented the deterioration of ground-water quality in the Lompoc plain (Wilson, 1959; Evenson, 1966; Miller, 1976; Berenbrock, 1988). These studies suggested that recharge by irrigation-return flow may have been the principal cause of the deterioration. If ground-water quality continues to deteriorate, the ground water will become unusable for most purposes, including irrigation, without some treatment. Because the demand for ground water in the Lompoc area has continued to increase, the Santa Ynez River Water Conservation District entered into a cooperative program with the U.S. Geological Survey in 1986 to study ground-water-quality conditions in the Lompoc area.

PURPOSE AND SCOPE

A two phase approach was used to study ground-water-quality conditions in the Lompoc area. The purpose of this report on the first phase of the study is to describe the ground-water hydrology and quality of the Lompoc area of the Santa Ynez River basin. The planned second phase of the study is the application of a ground-water-flow model for the Lompoc area and a solute-transport model for the Lompoc plain. Both models will be useful for evaluating the potential effectiveness of ground-water management plans prior to their implementation. This report:

1. Describes the geohydrologic framework of the Lompoc area, with particular emphasis on the geologic structure of the unconsolidated Tertiary deposits.

2. Summarizes and evaluates estimates of recharge and discharge from previous studies.

3. Describes vertical variation in water quality and the degree of hydraulic connection between aquifers in the Lompoc plain.

4. Evaluates possible sources for ground-water quality degradation in the Lompoc plain.

DESCRIPTION OF THE AREA

The Lompoc area is on the west coast of Santa Barbara County (fig. 1). The study area is in the Lompoc hydrologic subunit of the Santa Ynez hydrologic unit (California Department of Water Resources, 1964) and includes the Lompoc plain, the Lompoc terrace, and the Lompoc upland. The Lompoc plain, terrace, and upland are bordered on the north by the Purisima Hills, on the east by the Santa Rita Hills, on the south by the foothills of the Santa Ynez Mountains, and on the west by the Pacific Ocean. For this report, the Lompoc plain is subdivided into nine areas (fig. 2) to aid in the description of water-quality conditions.

The Lompoc area has a typical coastal climate of warm, dry summers and cool, wet winters. Coastal fog is common in the valley throughout the year. Practically all the precipitation occurs from November through April. The average annual precipitation at Lompoc during 1951-88 was 14.2 in., ranging from a minimum of 6.42 in. in 1956 to a maximum of 32.66 in. in 1983 (U.S. Department of Commerce, Weather Bureau, 1954-76 and 1958; National Oceanic and Atmospheric Administration, 1976-88).

The area is drained by the Santa Ynez River and its tributaries. Perennial surface flow in the river has occurred only in the northern plain and coastal area where it has been maintained by sewage effluent and by ground-water discharge, and irrigation runoff, respectively. Several small streams, some with perennial flow, enter the Lompoc plain from the south. Ephemeral streams drain the north side of the basin and the Lompoc terrace area.

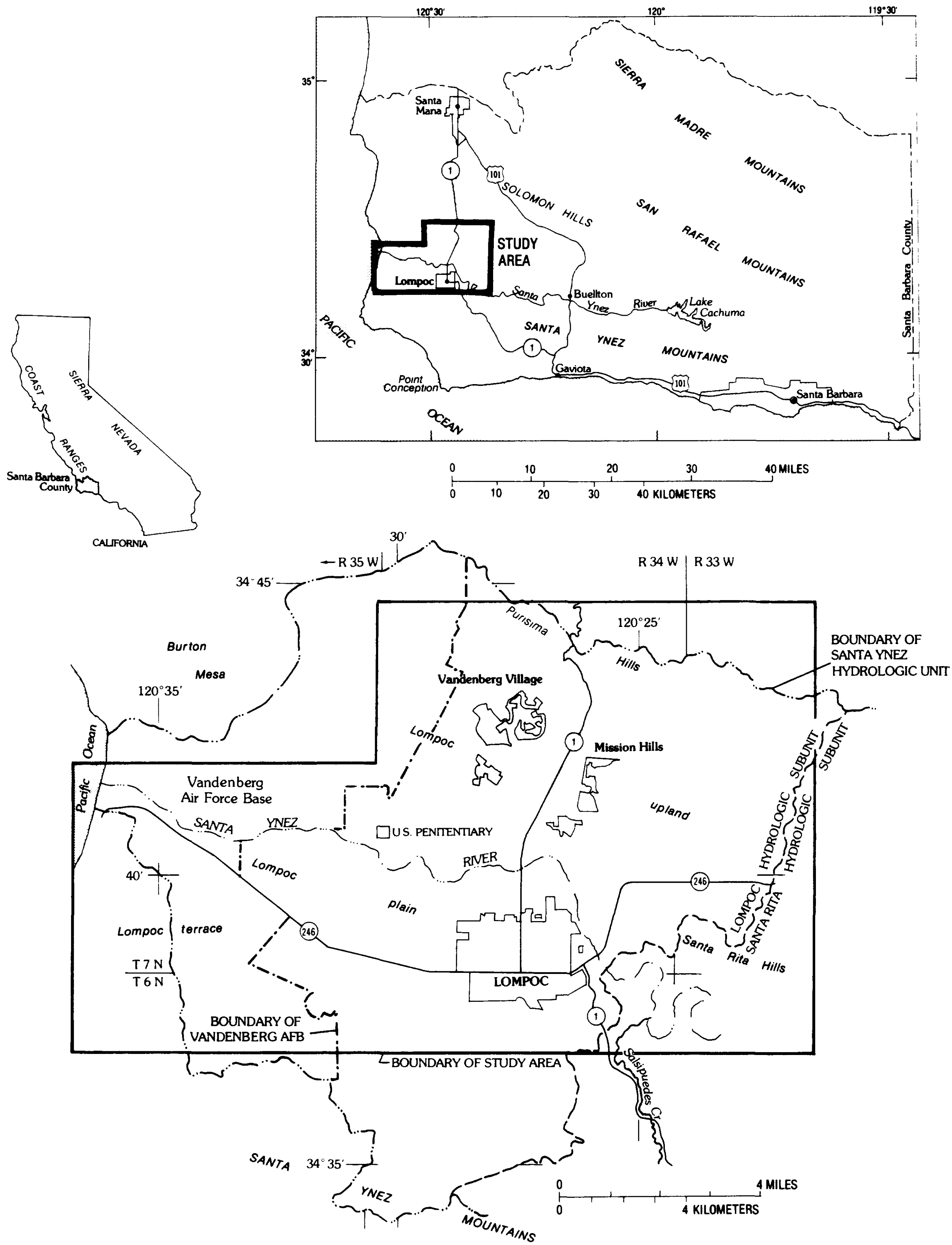


Figure 1. Location of study area.

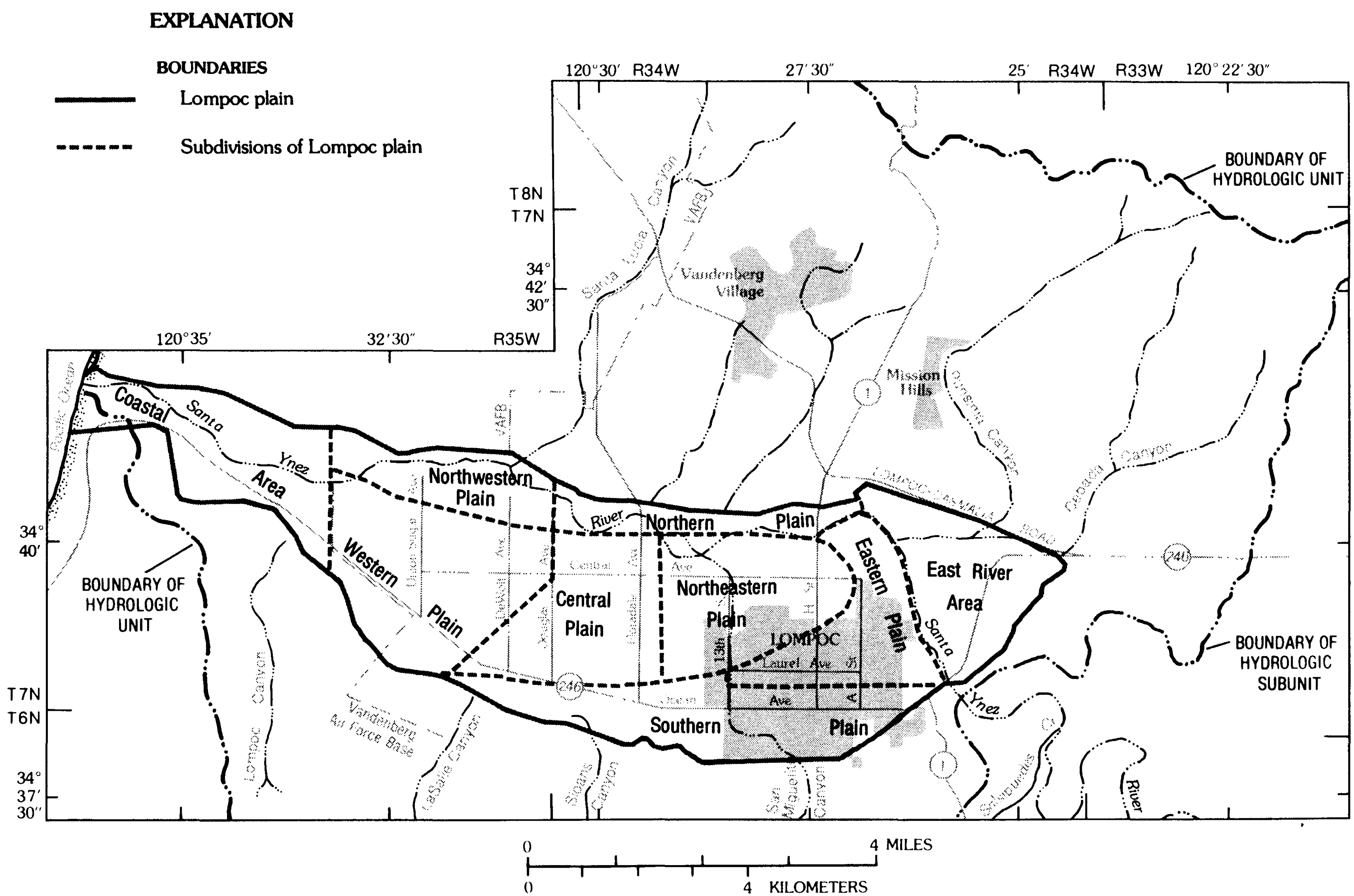


Figure 2. Subdivisions of the Lompoc plain.

Land in the study area has been used primarily for agriculture. Historically, the uplands were used for dry farming or pastureland and the flatlands for irrigated farming. Figure 3 shows the distribution and percentages for land-use categories in 1985 (California Department of Water Resources, 1987). The land-use categories include urban/suburban, irrigated agriculture, nonirrigated agriculture, and native vegetation. The main urban areas include the city of Lompoc in the eastern plain and the communities of Vandenberg Village and Mission Hills in the Lompoc upland. The western quarter of the area is occupied by Vandenberg Air Force Base (VAFB).

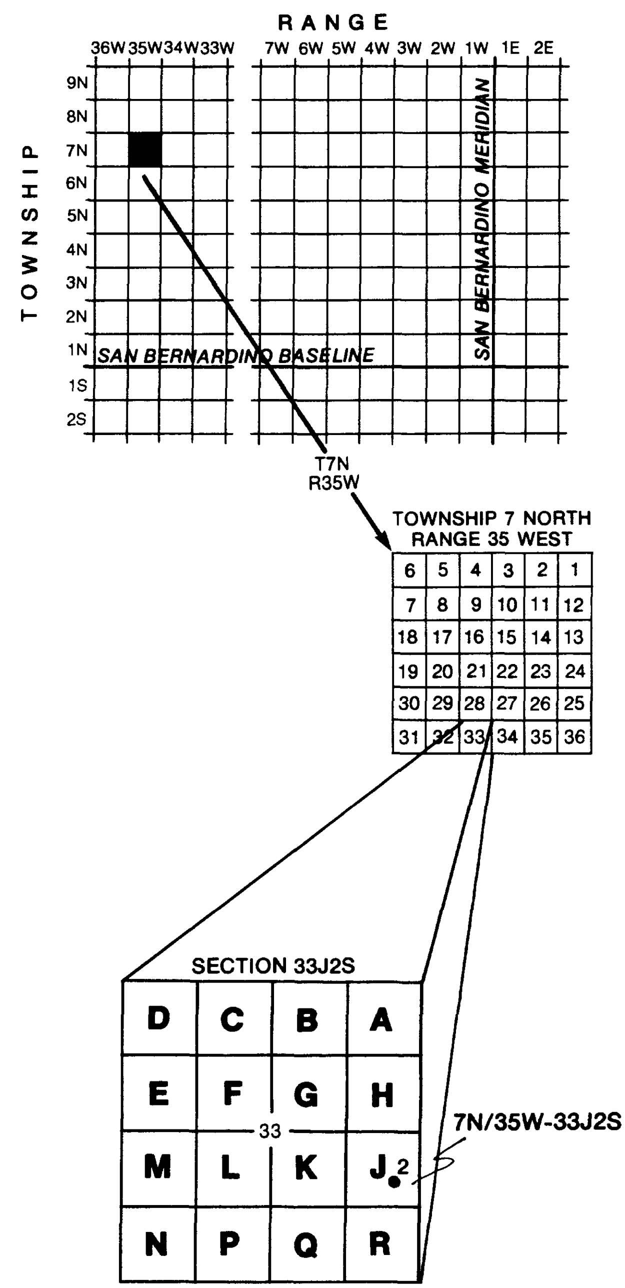
ACKNOWLEDGMENTS

Individuals within each of the following agencies kindly provided hydrologic data for this investigation and are gratefully acknowledged: Gary Keefe, Virgil Godsey, Richard Wise, and Dale Ducharme of the city of Lompoc; Jon Ahlroth of the Santa Barbara County Water Agency; Christopher Reeves of the U.S. Bureau of Reclamation; Thomas Hom, Richard Nichols, Donald Griggs, and Bert Johnson of Vandenberg Air Force Base; David Aguayo of the Federal Correctional Institution; Roger Brett of Park Water Co.; John Lewis and Kathy Schlottmann of Mission Hills Community Services District; Virginia Wilkinson of the Santa Ynez River Water Conservation District; and Thomas Stetson of Stetson Engineers Inc. The cooperation extended by Steve Jordan of Jordan Brothers Ranch, and by Robert Witt and Jon Anderson of Robert Witt Ranch, in allowing access to data-collection sites on private land is greatly appreciated. The authors also express their gratitude to the following colleagues in the U.S. Geological Survey: Theresa Presser and Mark Hubner of the Branch of Regional Research, Western Region, and Irving Friedman of the Branch of Isotope Geology, Central Region, for their assistance with oxygen-18 and deuterium isotope analyses.

WELL-NUMBERING SYSTEM

Wells are numbered according to their location in the rectangular system for subdivision of public lands. For example, in well number 7N/35W-33J2, the number and letter preceding the slash indicate the township (T. 7 N.); the number and letter following the slash indicate the range (R. 35 W.); the number following the hyphen indicates the section (sec. 33); the letter (J) following the section number indicates the 40-acre subdivision. Wells are sequentially numbered in the order they are inventoried (number 2). The final letter (S) [for San Bernardino] indicates the base line and meridian. The area covered by this report lies entirely in the northwest quadrant of the San Bernardino base line and meridian. The final (S) is deleted in illustrations and tables. The letters (LYS) following the sequence number indicates a lysimeter.

To find wells and lysimeters on maps in this report, use the diagram below in conjunction with township and range designations at map margins.



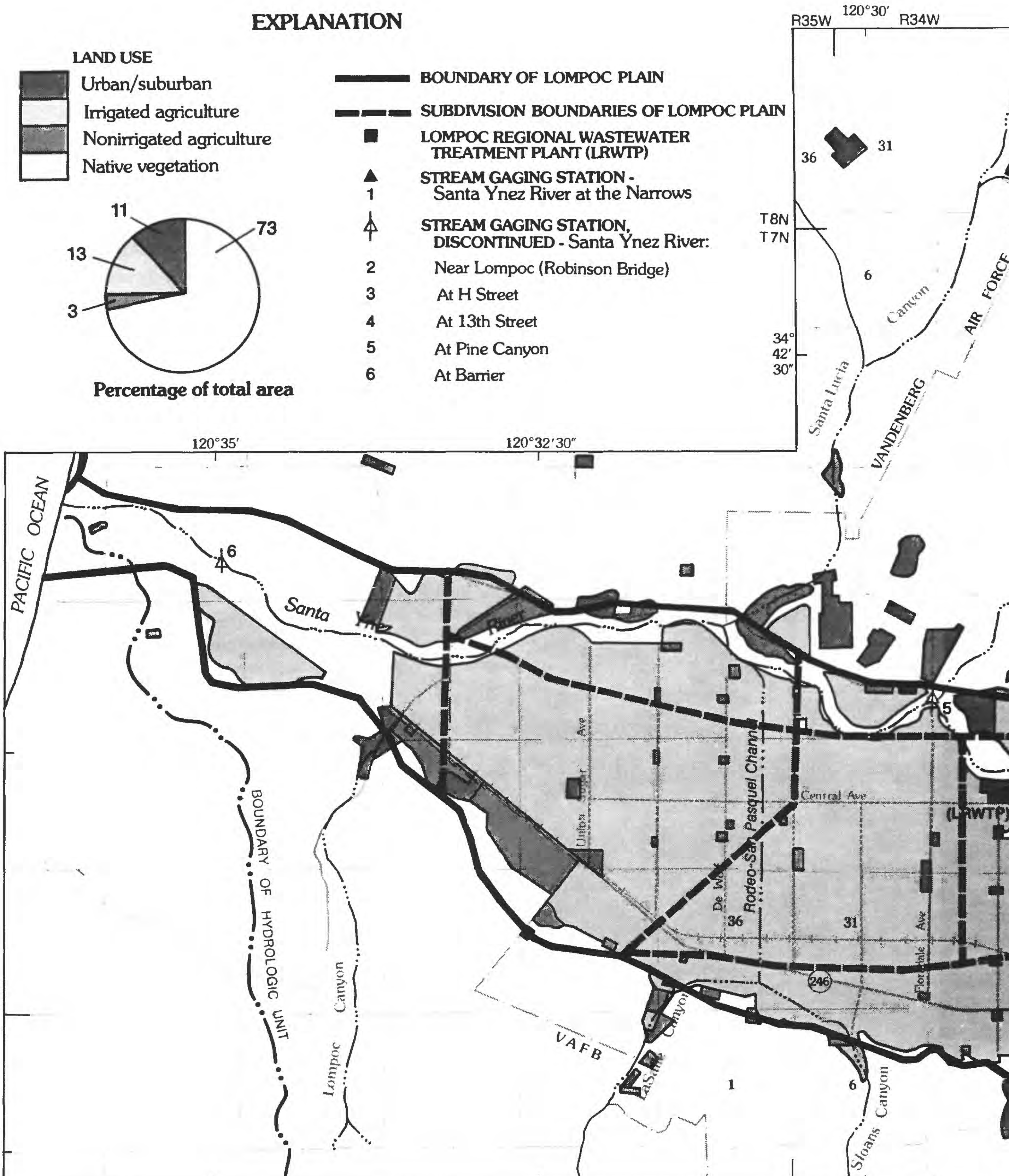
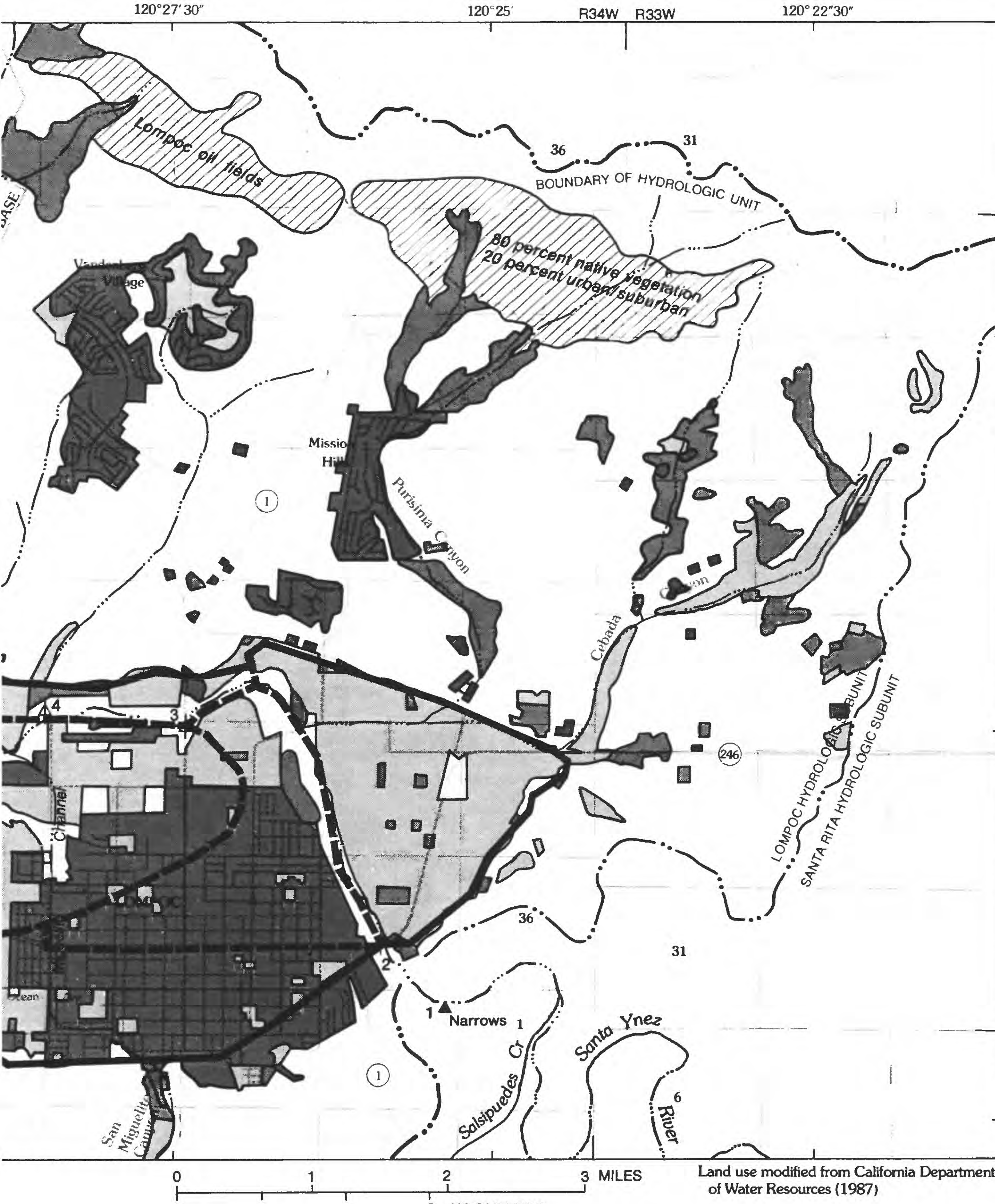


Figure 3. Land use and location of gaging stations and wastewater-treatment plant, 1985.



Land use modified from California Department of Water Resources (1987)

GEOLOGY

The geology of the Lompoc plain and surrounding areas was discussed in detail in reports by Dibblee (1950), Woodring and Bramlette (1950), Upson and Thomasson (1951), and Miller (1976). The geologic analysis presented in this report summarizes these reports, with an emphasis on the lithology of the consolidated rocks and unconsolidated deposits and on the structure of the basin that underlies the Lompoc area.

LITHOLOGIC UNITS

For this report, the lithologic units mapped by Dibblee (1950) in the Lompoc area were placed in two general categories: (1) consolidated rocks, which underlie the ground-water basin and crop out in the surrounding hills; and (2) unconsolidated deposits, which form the ground-water basin. The outcrop pattern of these units and their stratigraphic and structural relations are shown on plate 1.

The consolidated rocks, predominantly marine in origin, are nearly impermeable--except for slightly permeable sandstone and in fracture zones. In comparison with the unconsolidated deposits, the consolidated rocks have not been an important source of ground water, and for the purposes of this report they are considered the lower boundary of the ground-water basin.

The unconsolidated deposits generally are highly porous, and the coarser deposits transmit water readily. These deposits have been divided into eight units on the basis of lithologic character and occurrence and water-bearing properties. The principal lithologic units and their water-bearing properties are summarized in table 1.

STRUCTURAL FEATURES

The geologic structure of the Lompoc area is dominated by a series of anticlinal and synclinal folds (pl. 1). These structures determined the areas in which the unconsolidated deposits could accumulate and thus the thickness of the ground-water basin.

The Santa Ynez Mountains bound the Lompoc area on the south. These mountains are offset by a large fault (pl. 1) that extends from the Lompoc terrace eastward to Lake Cachuma (fig. 1; Sylvester and Darrow, 1979). This fault is referred to as the Santa Ynez River fault (Sylvester and Darrow, 1979) in this report, but it also has been called the Lompoc-Solvang fault in earlier studies (Hall, 1978). In the Lompoc terrace, the fault separates the Careaga Sand from older consolidated deposits on the south (pl. 1). East of La Salle Canyon, the exact location of the fault in the Lompoc area is unknown (A.G. Sylvester, University of California, Santa Barbara, oral commun., 1989).

The greatest thickness of unconsolidated deposits (more than 1,500 ft) in the Lompoc area occurs in the trough created by the Santa Rita syncline immediately north of the Santa Rita Hills (pl. 1). The Santa Rita syncline extends eastward through the Santa Rita Valley toward Buellton (fig. 1) and also is believed to swing to the west-southwest beneath the Lompoc plain, where the axis of the syncline plunges gently eastward. The plunge of the Santa Rita syncline has caused Tertiary consolidated rocks to be uplifted and exposed at the western end of the Lompoc plain. The Tertiary deposits underlying the Lompoc plain dip to the east, becoming progressively younger from the western to eastern ends of the plain. The Orcutt Sand, terrace deposits, and younger alluvium, which are relatively undisturbed by folding, unconformably overlie the Tertiary deposits.

A west-to-northwest-trending anticline lies beneath the southern part of the Lompoc upland and the northeast part of the Lompoc plain. This anticline uplifts the Careaga Sand to near land surface in the southwestern part of the Lompoc upland near the Santa Ynez River (pl. 1). For the purposes of this report, this anticline is referred to as the Burton Mesa anticline. The Burton Mesa anticline probably is the eastward extension of the anticlinal upwarp exposed over a large part of the Burton Mesa (pl. 1), as mapped by Dibblee (1950, pl. 1, p. 52).

North of the Burton Mesa anticline, a series of northwestward-trending folds form the synclinal trough beneath the Lompoc upland (pl. 1, geologic map and sections *C-C′* and *D-D′*), The unconsolidated deposits reach a maximum thickness of about 1,500 ft north of Mission Hills in the northern end of the synclinal trough.

The Lompoc upland is bounded on the north by an anticline that forms the Purisima Hills and locally is called the Purisima anticline (pl. 1). Consolidated non-water-bearing rocks are exposed in the central part of the anticline.

Table 1. Principal lithologic units and their water-bearing properties

[Modified from Upson and Thomasson, 1951, p. 28-29. Thickness: Actual thickness of unit measured perpendicular to its dip. Water-bearing properties: Hydraulic-conductivity values from U.S. Geological Survey data files, San Diego, California; VAFB, Vandenberg Air Force Base. ft, foot; (gal/d)/ft^2, gallon per day per square foot; gal/min, gallon per minute; in., inch]

Geologic age		Formation and map symbol	Thickness, in feet	General lithologic character and occurrence	Water-bearing properties
Quaternary	Holocene	River-channel deposits (Qrc)	30-40	Coarse to fine sand with some gravel zones. Occurs in present channel of the Santa Ynez River. Fluvial origin.	Permeable; hydraulic conductivity of surface samples ranges from 400 to 1,500 (gal/d)/ft^2 (Upson and Thomasson, 1951). Not tapped by wells in Lompoc plain. Part of shallow zone of upper aquifer.
		-Unconformity-			
		Alluvium--upper member (Qalu)	0-150	Fine sand, silt, and clay. Underlies the Lompoc plain, tributary streams, and southern streams. Grades areally into a fine to medium sand and silt in the eastern Lompoc plain, west of Santa Ynez River. Medium to coarse sand zones, typically less than 10 ft thick, are common. Gravel zones occur locally in areas adjacent to and east of the Santa Ynez River and near the mouth of streams entering the southern Lompoc plain. Fluvial origin.	Slightly to moderately permeable. Hydraulic conductivity ranges from 2 to 40 (gal/d)/ft^2 in western and central Lompoc plain. Sand zones are tapped by some domestic wells in Lompoc plain. Upper member acts as leaky confining layer over much of lower member. The uppermost deposits of the upper member form shallow zone of upper aquifer. Basal part of upper member is termed middle zone of upper aquifer.
		Alluvium--lower member (Qall)	0-90	Gravel, medium to very coarse sand forms the lower part of this member, usually 20-60 ft thick. Grades vertically upward into a fine to coarse sand with some gravel in most areas. Upper part of this member is finer grained and consists mainly of fine sand, silt, and clay in the northeastern, central, and western Lompoc plain. Gravel deposits in lower member underlie the upper member in the northern two-thirds of the Lompoc plain; restricted to the Santa Ynez River channel near the Narrows (fig. 3) and in the western half of the coastal area. Base of gravels 170-180 ft below land surface throughout most of areal extent. Fluvial origin.	Permeable. Hydraulic conductivity of lower gravels ranges from 1,800 to 3,000 (gal/d)ft^2. Lower member is confined over its entire areal extent, except in northwestern and eastern Lompoc plain. It is principal source of water in Lompoc plain for agricultural and municipal use and yields 2,000 gal/min or more to many wells. The lower member is termed main zone of upper aquifer.
		-Unconformity-			
	Pleistocene	Terrace deposits (Qt)	0-50±	Gravel and sand, and silt and clay zones common. Underlies alluvium in most of the southern Lompoc plain. Crops out along the southeastern and northern margins of Lompoc plain. Fluvial origin.	Moderately permeable. Generally above zone of saturation, except in the deposits underlying southern Lompoc plain. Deposits in this area yield several hundred gallons per minute of water to wells. Forms part of lower aquifer in southern Lompoc plain.
		-Unconformity-			
		Orcutt Sand (Qo)	0-300±	Coarse sand, silt, and clay. Zones of silt, clay, and gravel are common. Underlies most of the Lompoc upland and terrace and locally extends beneath the alluvium in southern and southern part of western Lompoc plain. Mainly nonmarine.	Moderately permeable. Generally above zone of saturation, except in the deposits underlying southern and southern part of western Lompoc plain, where it is tapped by wells. Locally contains perched ground water in Lompoc upland. Forms part of lower aquifer in Lompoc plain.
		-Unconformity-			

Table 1. Principal lithologic units and their water-bearing properties--*Continued*

Geologic age		Formation and map symbol	Thickness, in feet	General lithologic character and occurrence	Water-bearing properties
Quaternary --?--	Pliocene to Pleistocene	Paso Robles Formation (QTpr)	0-350±	Fine to coarse sand, silt, and clay. Zones of silt, clay, and gravel are common in upper part. Lower part is finer grained and consists mainly of silt, clay, some zones of coarse sand, and coarse gravel. Lower parts commonly less than 100 ft thick. Crops out in northern part of Lompoc upland. Underlies Orcutt Sand in Lompoc upland and the alluvium in east river area of Lompoc plain. Fluvial origin.	Moderately permeable. Hydraulic conductivity of lower Paso Robles Formation in the Los Osos basin near San Luis Obispo is about 50 (gal/d)/ft^2 (E.B. Yates, U.S. Geological Survey, written commun., 1989). Hydraulic conductivity of combined Paso Robles Formation and Careaga Sand (Graciosa Member) is about 660 (gal/d)/ft^2 in the Lompoc upland. Partly saturated in Lompoc upland, and saturated in Lompoc plain. Municipal wells at Mission Hills and irrigation wells in Cebada Canyon derive much of their water from this formation. Municipal wells at Vandenberg Village derive some of their water from this formation. Forms part of the lower aquifer in Lompoc plain and upland.
Tertiary	Pliocene	Careaga Sand--Graciosa Coarse-Grained Member (Tcg)	0-450±	Medium to coarse sand. Upper part is finer grained and consists of fine to medium sand, lower part is coarser grained and consists of medium to coarse sand and gravel. Some silt and clay zones occur and have a characteristic gray color. Locally fossiliferous in lower part. Crops out in northern part of Lompoc upland, and southern margin of Lompoc plain (near Floradale Avenue). Underlies Paso Robles Formation in Lompoc upland, the alluvium throughout most of the Lompoc plain, and parts of the alluvium and Orcutt Sand in Lompoc terrace. A fossiliferous shell zone, commonly less than 20 ft thick, marks base of the member. This zone is present in Lompoc upland and plain and absent in Lompoc terrace. Marine origin.	Moderately permeable to permeable. Hydraulic conductivity ranges from 40 to 530 (gal/d)/ft^2. Saturated beneath Lompoc plain and most of Lompoc upland and terrace. Municipal wells at Vandenberg Village and VAFB wells in northern Lompoc plain derive much of their water from this member. Municipal wells at Mission Hills and irrigation wells in Cebada Canyon derive some of their water from this member. Not tapped by irrigation wells in Lompoc plain. Sanding problems have occurred in wells with perforation widths greater than 0.040 in. Forms part of the lower aquifer in Lompoc plain, upland, and terrace.
		Careaga Sand--Cebada Fine-Grained Member (Tcc)	0-350±	Fine sand, typically massive and well sorted. Grades into very fine sand and silt in lower part. Crops out in northern part of Lompoc upland and southern margin of Lompoc plain (near Floradale Avenue). Underlies Graciosa Member throughout the study area, as well as alluvium and Orcutt Sand in Lompoc terrace. Locally fossiliferous. Contact between this member and underlying formations is gradational except in Lompoc terrace, where base is marked by a fossiliferous gravel zone. Marine origin.	Slightly to moderately permeable. Hydraulic conductivity ranges from less than 1.0 to 20 (gal/d)/ft^2 beneath Lompoc plain. Saturated beneath Lompoc upland and terrace. VAFB wells in Lompoc terrace derive much of their water from the gravel zone at the base of this member. Not tapped by wells in Lompoc upland or plain. Sanding problems have occurred in wells with perforation widths greater than 0.030 in. Forms part of the lower aquifer in Lompoc plain, upland, and terrace.
	Miocene to Pliocene	Undifferentiated Tertiary rocks (Tu). Includes Foxen, Sisquoc, and Monterey Formations	Several thousand	Predominantly consolidated mudstone and shale. Both Foxen and Sisquoc Formations are unsilicified. Foxen Formation is a massive mudstone. Sisquoc Formation is massive (upper) to laminated (lower) diatomaceous mudstone. Monterey Formation is silicified and consists of banded chert, shale, and diatomite. Underlies Careaga Sand throughout its areal extent, as well as lower member of the alluvium, terrace deposits, and Orcutt Sand in western Lompoc plain, and both members of the alluvium in parts of southern Lompoc plain. Marine origin.	Impermeable to moderately permeable. Saturated beneath Lompoc plain and most of Lompoc upland and terrace. Partly saturated in canyons south of Lompoc plain, where a few wells derive their water from fracture zones. Well yields range from a few gallons per minute (domestic) to a few hundred gallons per minute (industrial).

GROUND-WATER HYDROLOGY

DEFINITION OF THE AQUIFER SYSTEM

The principal water-bearing units in the Lompoc area are the river-channel deposits and alluvium of Holocene age, the Paso Robles Formation of Pliocene and Pleistocene (?) age, and the Careaga Sand of Pliocene age. The terrace deposits and Orcutt Sand of Pleistocene age are highly permeable but are unsaturated throughout most of the Lompoc upland and terrace. For the purpose of this report, all these units were grouped into two aquifers: (1) the upper aquifer and (2) the lower aquifer.

UPPER AQUIFER

The upper aquifer includes the river-channel deposits and the alluvium and is limited approximately to the area of the Lompoc plain. On the basis of geologic and electric logs of selected wells (pl. 1), the upper aquifer was subdivided into three zones: (1) the shallow zone, (2) the middle zone, and (3) the main zone (fig. 4).

The shallow zone includes the river-channel deposits and the shallow deposits of the upper member of the alluvium. The river-channel deposits consist of sand and gravel and are 30 to 40 ft thick. These deposits occur beneath the present channel of the Santa Ynez River (fig. 4). The shallow deposits of the alluvium consist predominantly of fine sand, silt, and clay of low permeability in the western, central, and northeastern plain (fig. 4). These low-permeability deposits confine or partly confine the underlying deposits. Beneath the eastern plain, the shallow deposits grade into a fine to medium sand with occasional gravel and clay layers. The average thickness of the shallow zone is 50 ft.

Beneath most of the Lompoc plain, the base of the upper member of the alluvium contains fine sand, silt, and clay deposits interbedded with lenses of permeable sand and gravel. These sand and gravel lenses range from 5 to 40 ft in thickness. The base of the upper member of alluvium is referred to as the middle zone in this report. Previous investigators (Upson and Thomasson 1951, p. 12; Miller, 1976, p. 21) considered these lenses to be part of the shallow zone. However, the lenses beneath the western plain contained ground water of better quality (lower dissolved-solids concentration) than either the overlying shallow zone or the underlying main zone in 1988, indicating that the lenses should be classified as a separate zone.

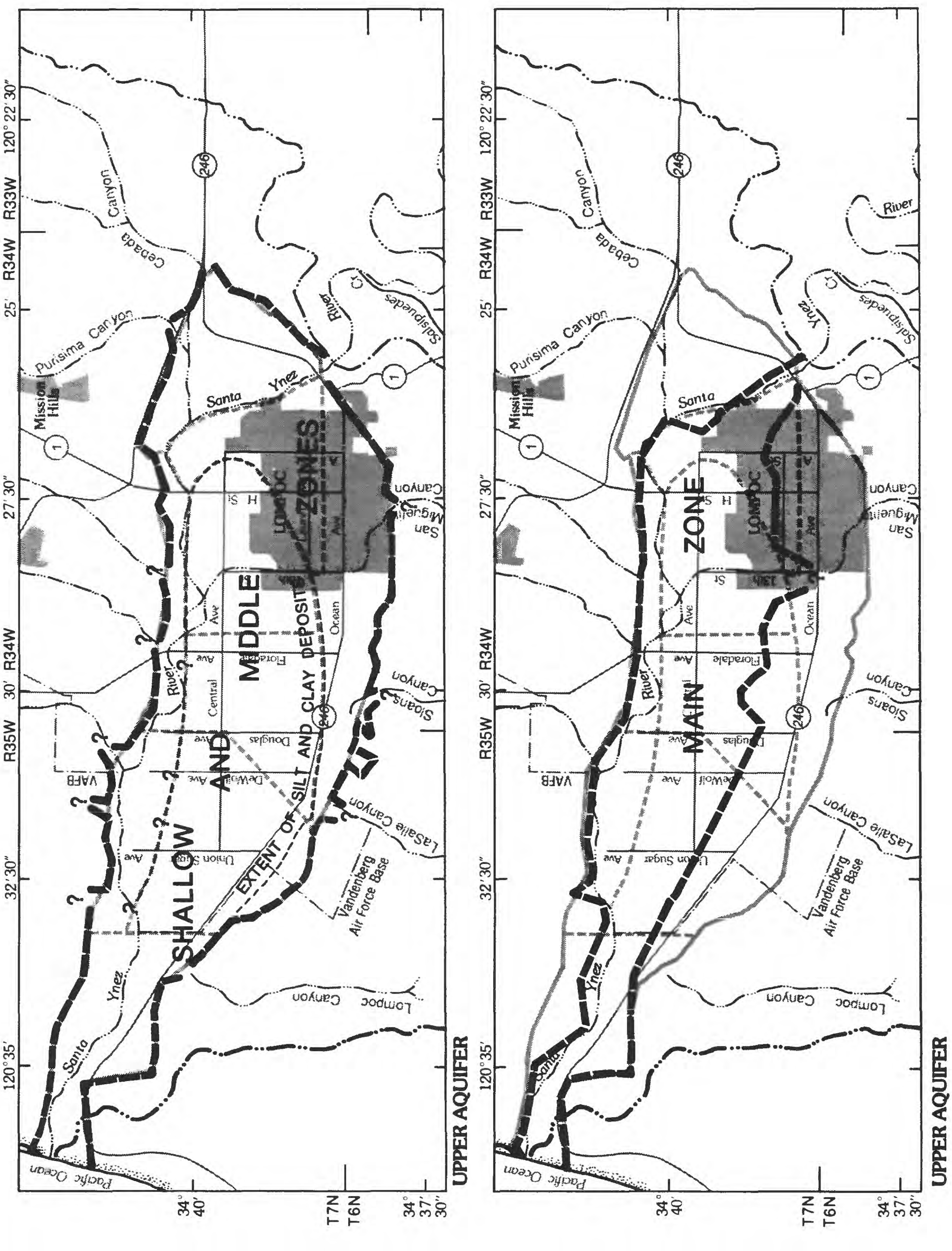
The main zone includes the lower member of the alluvium and consists largely of medium to coarse sand and gravel. Most of the production wells in the Lompoc plain were perforated in this zone. Throughout most of the plain the sands and gravels of the main zone are separated from the middle zone by lenses of silt and clay. These lenses of low-permeability silt and clay confine or partly confine the sand and gravel deposits in the main zone. In the eastern plain and northwestern plain, the silt and clay layers are less continuous or absent; as a result, ground water moved freely between the shallow, middle, and main zones in 1988. In the southern plain, the sand and gravel deposits in the main zone are absent, and the fine deposits in the shallow and middle zones also are less continuous or absent (Upson and Thomasson, 1951, p. 146). Thus, ground water moved freely between the shallow and middle zones of the upper aquifer and the lower aquifer beneath the southern plain in 1988.

LOWER AQUIFER

The lower aquifer includes the terrace deposits, Orcutt Sand, Paso Robles Formation, and the Careaga Sand. This aquifer is present beneath the Lompoc upland, beneath the upper aquifer throughout the eastern two-thirds of the Lompoc plain, and beneath the Lompoc terrace (fig. 4). The lower aquifer is the primary aquifer in the Lompoc upland and Lompoc terrace. Beneath the Lompoc plain, the lower aquifer has not been used as a source of water, except by VAFB on the north side of the plain.

The terrace deposits consist of gravel and sand with occasional silt and clay layers. The Orcutt Sand consists of coarse sand, silt, and clay. Both of these units are highly permeable, but they are generally unsaturated, except in the southern plain and southern part of the western plain. Beneath the Lompoc upland, the Orcutt Sand locally contains perched ground water. Water levels in wells that tapped these perched zones in 1972 generally were more than 100 ft higher than levels in the underlying Paso Robles Formation and Careaga Sand (Miller, 1976, p. 24).

The Paso Robles Formation consists of fine to coarse sand, silt, and clay. This unit forms a major part of the lower aquifer beneath the Lompoc upland and beneath the east river area of the Lompoc plain. In the remaining parts of the study area, the formation is either unsaturated or not present.



UPPER AQUIFER
SHALLOW AND MIDDLE ZONES
EXTENT OF SILT AND CLAY DEPOSIT
MAIN ZONE
Pacific Ocean
Santa Ynez River
Lompoc
Vandenberg Air Force Base
Mission Hills
Purisima Canyon
Cebada Canyon
Lompoc Canyon
LaSalle Canyon
Sloans Canyon
San Miguelito Canyon
Salsipuedes Cr
VAFB
120°35′
32′30″
30′
27′30″
25′
120°22′30″
R35W
R34W
R33W
34°40′
34°37′30″
T7N
T6N

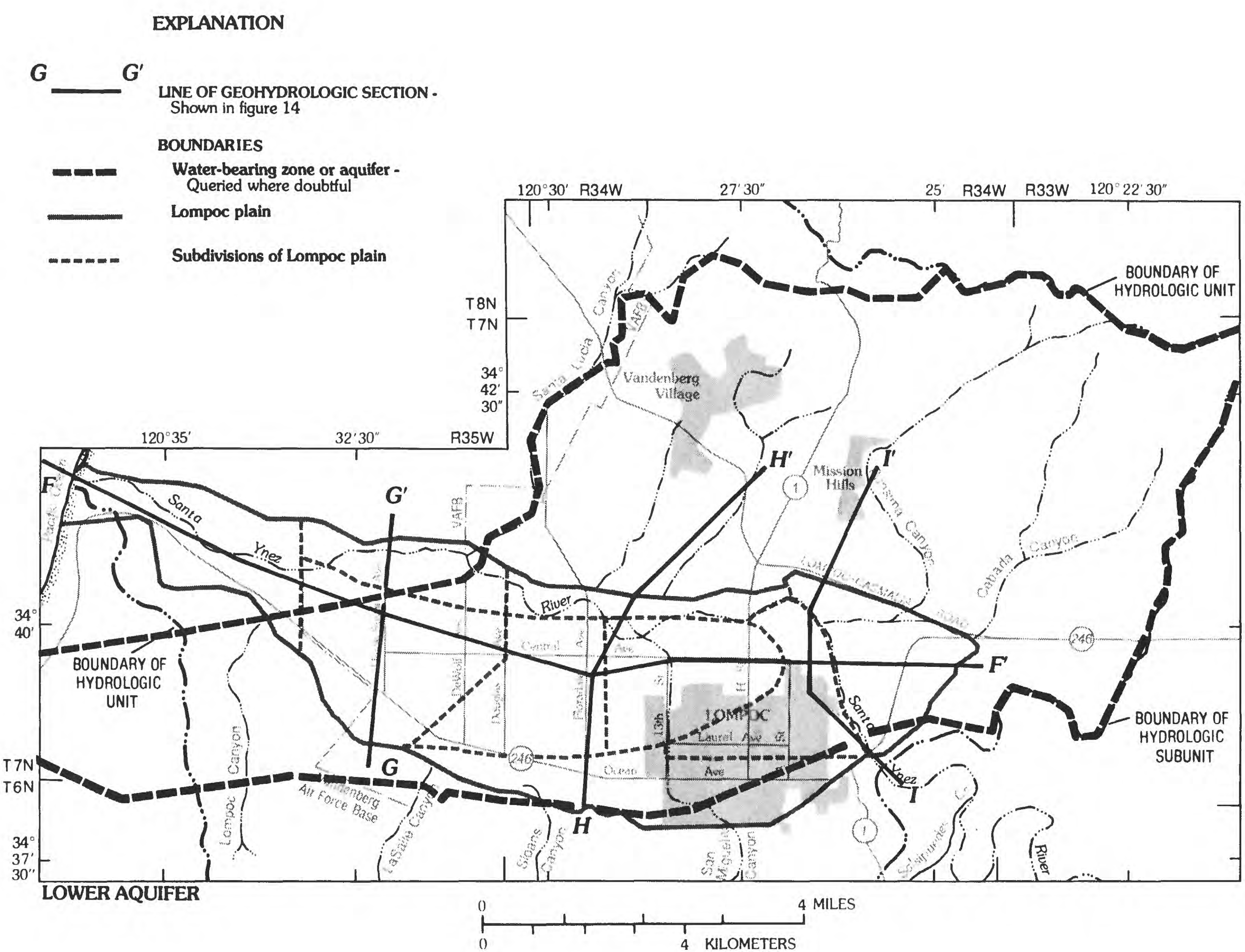


Figure 4. Areal extent of upper and lower aquifers, and location of geohydrologic sections shown in figure 14.

The Careaga Sand consists of two members: the (upper) Graciosa Coarse-Grained Member, which is composed of coarse sand and gravel, and the (lower) Cebada Fine-Grained Member, composed of fine sand. Both members are present beneath the Lompoc upland and most of the Lompoc plain. Beneath the Lompoc terrace, however, the Graciosa Member generally is absent or was unsaturated. Where present, the Graciosa Member of the Careaga Sand was the main producer of ground water in the lower aquifer.

RECHARGE

The primary sources of recharge to the Lompoc area have included (1) seepage loss from the Santa Ynez River and from streams entering the southern plain and coastal area, (2) infiltration of rainfall, (3) infiltration of excess irrigation water, (4) underflow from river-channel deposits, and (5) infiltration of sewage effluent. The interaction of each recharge and discharge component within the Lompoc area is shown in figure 5. Estimates of average annual recharge from earlier studies by Upson and Thomasson (1951), Wilson (1959), Evenson (1966), Miller (1976), and Ahlroth and others (1977) are summarized in table 2.

Previous estimates of average annual recharge to the Lompoc area for selected periods (table 2) varied considerably because of different climatic conditions. Precipitation during 1957-62, 1972, and 1975-76 (table 2) was close to the long-term average (1910-87) of 14.6 in/yr (U.S. Department of Agriculture, 1910-30; U.S. Department of Commerce, 1958, 1954-76; National Oceanic and Atmospheric Administration, 1976-88) and was considered to represent near-normal climatic conditions. Extremely wet conditions existed during 1935-44 when Upson and Thomasson studied the Lompoc area, and extremely dry conditions existed during 1947-51 when Wilson studied the area. Evenson (1966, p. 24) concluded that the increase of estimated average annual recharge during the near-normal period 1957-62 over the earlier wet period (1935-44) was due largely to lower ground-water levels and steeper ground-water gradients than existed during the more recent study. This condition resulted in more available aquifer storage space, which allowed a greater amount of surface and subsurface inflow into the basin. Estimated average annual recharge to the Lompoc area during the dry period 1947-51 (7,600 acre-ft) was less than 30 percent of the average of the estimates for the near-normal periods (26,800 acre-ft).

Estimates of average annual recharge to the Lompoc area differ mainly in the estimated recharge from seepage loss along the Santa Ynez River and streams entering the southern plain, seepage loss of sewage effluent, and irrigation-return flow (table 2). Evenson (1966) estimated that seepage from the Santa Ynez River during 1957-62 averaged about 7,600 acre-ft annually. This estimate includes 3,000 acre-ft of seepage loss in the reach from the gaging station at 13th Street to the gaging station at Barrier (fig. 3) (Evenson, 1966, p. 13). The remaining estimates of recharge from this source (for 1935-44, 1972, and 1975-76) were based on seepage losses in a shorter reach along the river from the Narrows to near the gaging station at Pine Canyon (fig. 3). The estimate of 7,600 acre-ft by Evenson (1966) was therefore adjusted downward in this report (to 4,600 acre-ft) to correspond to the shorter reach used in the other studies.

Recharge estimates of seepage loss from streams entering the southern Lompoc plain for 1935-44, 1947-51, and 1957-62 were based on discharge measurements in Salsipuedes Creek (fig. 1). Upson and Thomasson (1951) accounted for differences in average annual precipitation between Salsipuedes Creek and the streams south of the Lompoc plain by decreasing their estimates of seepage loss by about 30 percent. In this report, estimates of seepage loss from streams entering the southern Lompoc plain by Wilson (1959) and Evenson (1966) were adjusted to correspond to this decrease in precipitation (table 2). Estimates by Miller (1976) and Ahlroth and others (1977) were based on channel-geometry studies on the streams south of the Lompoc plain.

Estimates of recharge from sewage effluent discharged to the Santa Ynez River from the Lompoc Regional Wastewater Treatment Plant were about three times higher for 1972 and 1975-76 than 1957-62 (table 2). This increase in sewage-effluent recharge over the preceding period corresponded to the increase in municipal pumpage by the city of Lompoc beginning in the 1960's (fig. 6).

Estimates of recharge from irrigation-return flow for 1935-44 and 1947-51 (table 2) were considerably lower than estimates for 1957-62, 1972, and 1975-76.

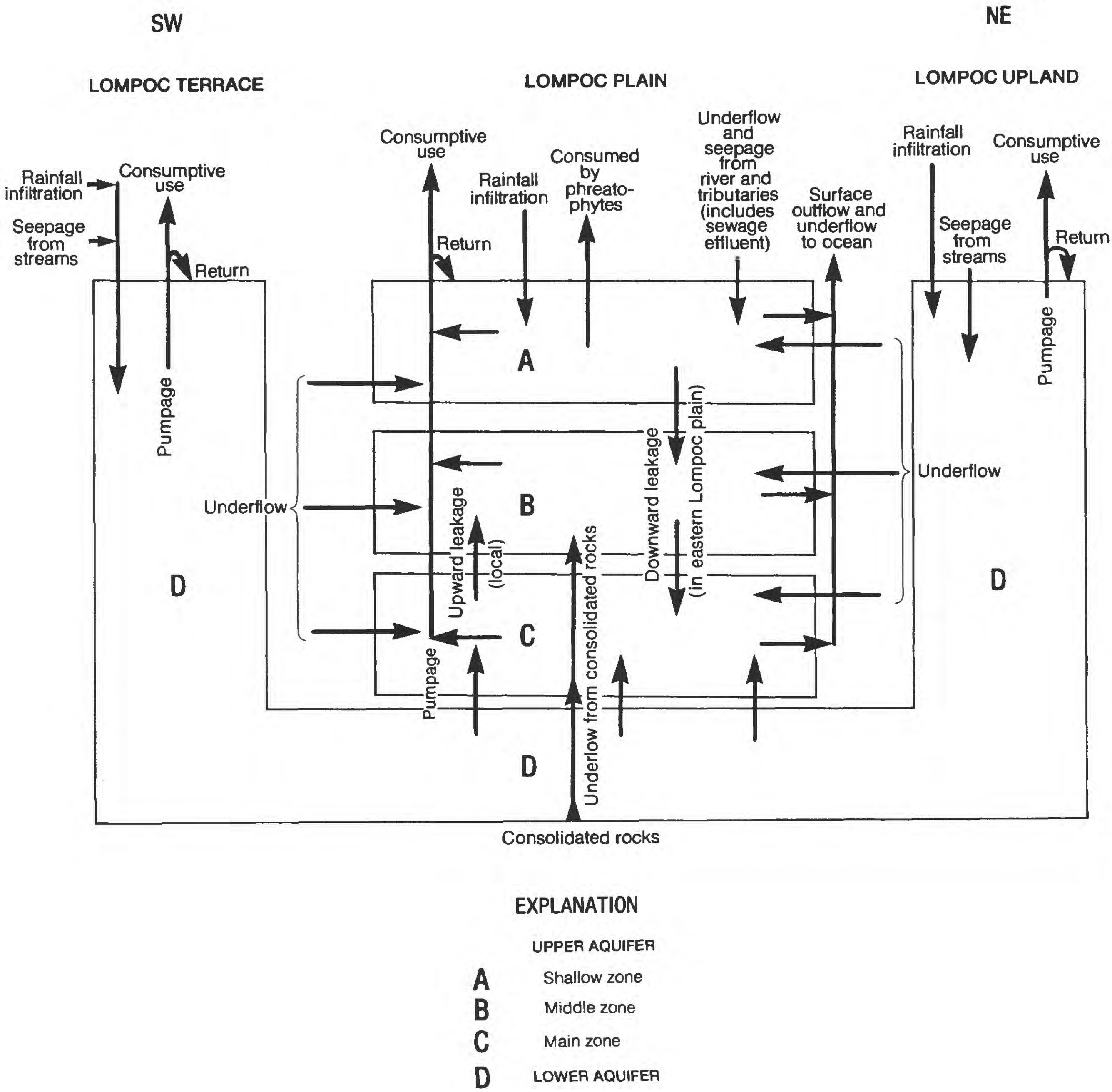


Figure 5. Sources of ground-water recharge and discharge in the study area. (Modified from Miller, 1976, fig. 11.)

The increase in estimated return flow for the last three periods reflected an increase in irrigation pumpage (fig. 6) and a decrease in irrigation-efficiency values. Upson and Thomasson (1951) and Wilson (1959) assumed an irrigation-efficiency value of 85 percent (that is, about 15 percent of the applied irrigation water returned to the water table). Evenson (1966) and Ahlroth and others (1977) based their estimates of recharge on lower irrigation-efficiency values; they assumed that about 45 and 44 percent, respectively, of the applied irrigation water returned to the water table. Recharge from irrigation-return flow in 1972 was not estimated by Miller (1976). In order to obtain an estimate of average annual recharge in

Table 2. Estimates of average annual recharge in the Lompoc area for selected periods

[Recharge values are in acre-foot. in., inch; --, no data]

Recharge source	1935-44 (Upson and Thomasson, 1951)	1947-51 (Wilson, 1959)	1957-62 (Evenson, 1966)	1972 (Miller, 1976)	1975-76 (Ahlroth and others, 1977)
Seepage loss					
Along the Santa Ynez River	2,500	500	7,600 [1]4,600	3,000	4,000
Sewage effluent discharged to Santa Ynez River	0	800	700	[2]2,300	2,000
Streams entering the southern plain and coastal area.[3]	5,400	700 [1]500	7,000 [1]5,000	1,200	3,600
Rainfall infiltration					
Lompoc plain	4,800	0	3,500	4,000	4,600
Lompoc upland	[4]4,600	900	2,600	2,600	2,000
Underflow from river-channel deposits					
Santa Ynez River at the Narrows	600	1,500	1,500	--	1,700
Southern Lompoc plain	--	--	--	200	1,700
Irrigation-return flow	1,500	3,200	9,700	[5]7,200	[6]7,800
Average annual recharge	19,400	7,600	32,600	20,500	27,400
Average annual precipitation during indicated period (in.)	19.3	7.9	13.5	[7]12.5	[8]14.3

[1]Modified recharge estimates for this report. These values are not included in the calculation of average annual recharge.
[2]Equals total amount of wastewater effluent discharged to the Santa Ynez River.
[3]Does not include estimates of recharge from streams entering the northern Lompoc plain (for example, Purisima and Cebada Canyons).
[4]Calculated for this report using infiltration estimates supplied by Santa Barbara County Water Agency.
[5]Calculated for this report. This value is included in the calculation of average annual recharge.
[6]Equals difference between applied irrigation water and agricultural consumptive use (Ahlroth and others, 1977).
[7]Average annual precipitation for 1968-72 (U.S. Department of Commerce, Weather Bureau, 1954-76).
[8]Average annual precipitation for 1972-76 (U.S. Department of Commerce, Weather Bureau, 1954-76; National Oceanic and Atmospheric Administration, 1976-88).

1972, recharge from irrigation-return flow for that period was calculated by multiplying a return-flow value of 44 percent (Miller, 1976, p. 32) by the value of irrigation pumpage for 1972 (16,200 acre-ft; fig. 6). This calculation gives a value of about 7,200 acre-ft (table 2).

Ground-water recharge from the Santa Ynez River has occurred primarily along the reach from the Narrows to H Street (fig. 3). A lesser, but significant quantity of recharge also has occurred from H Street to at least the gaging station at Pine Canyon (Miller, 1976), and possibly as far west as Union Sugar

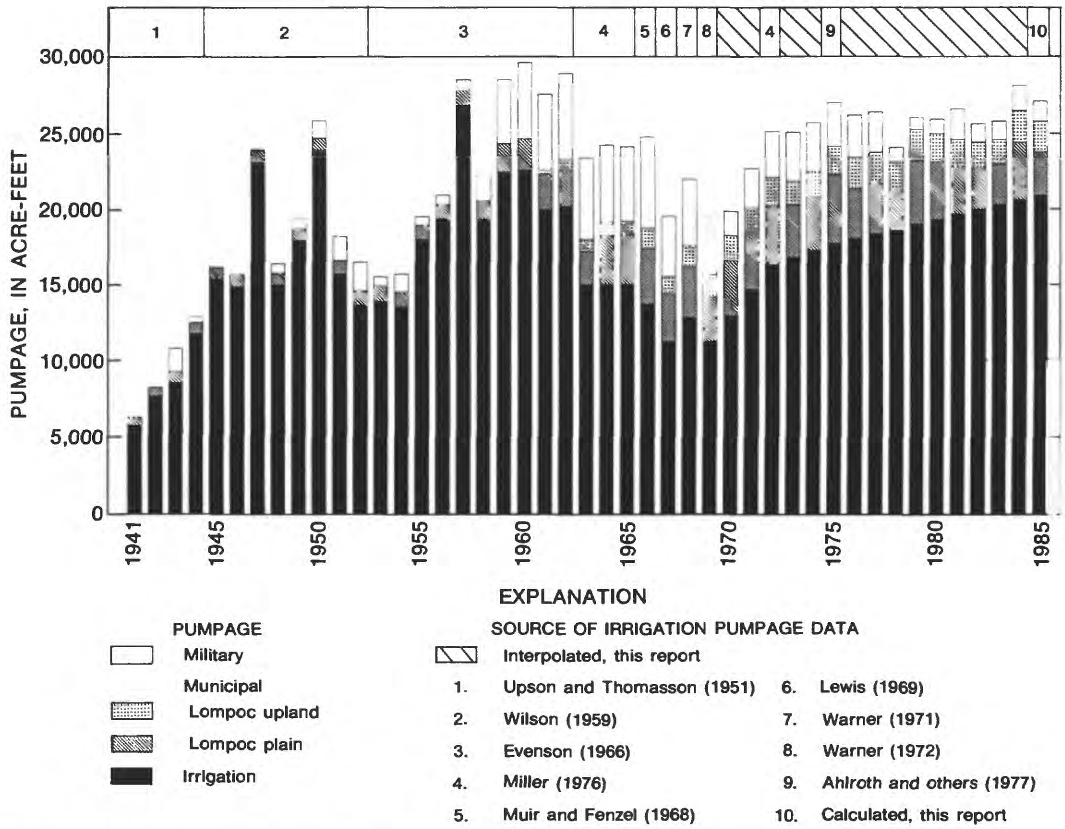


Figure 6. Components of annual pumpage in the Lompoc area, 1941-85.

Avenue (fig. 3). Streamflow has been maintained west of the Lompoc Regional Wastewater Treatment Plant (LRWTP) by sewage effluent that has been discharged continuously (fig. 3) since 1916 (Gary Keefe, city of Lompoc, oral commun., 1990). Successive measurements of streamflow were made along the reach from LRWTP to about 2.6 mi downstream on June 16, 1988. Streamflow measurements and losses are presented in table 3. All losses in streamflow were considered to be the result of seepage loss. The measurements indicate that the rate of seepage loss decreased with increased distance downstream from LRWTP. The annual recharge contributed by seepage loss over this reach was estimated by multiplying the total loss of streamflow (14.78 acre-ft/d) by the average number of days of streamflow per year (365); which gives a value of about 5,400 acre-ft/yr. This method of estimating the annual recharge rate has two main deficiencies: (1) loss of streamflow due to evapotranspiration is not accounted for, and (2) the variation in seepage-loss rate caused by changes in the amount of streamflow is neglected. The presence of lush vegetation downgradient of LRWTP in 1988 suggests that at least some of the sewage effluent was evapotranspired. Consequently, the estimate of annual recharge given above should be considered a maximum estimate; the actual value probably was considerably less.

The regimen of flow in the Santa Ynez River has been altered in the Lompoc area since the completion of Bradbury Dam (fig. 1) on the river in 1953. The dam, which created Lake Cachuma, is about 30 mi upstream from the Lompoc plain. Bradbury Dam was designed to divert nearly 30,000 acre-ft of water from the Santa Ynez River drainage basin to the Santa Barbara coastal area (Miller, 1976, p. 17). The relative duration of measured streamflow for the gaging stations at the Narrows and at Robinson Bridge (site 2) (fig. 3) for periods before (November 1, 1906 to January 1, 1953) and after (January 1, 1953 to September 30, 1987) the construction of Bradbury Dam is shown in figure 7. Historical discharge records at the Narrows and Robinson Bridge were

Table 3. Measurements of streamflow and sewage effluent along the Santa Ynez River in the Lompoc area, June 16, 1988

[Streamflow: Controlled release of sewage effluent from city of Lompoc Regional Wastewater Treatment Plant to Santa Ynez River on June 16, 1988. ft^3/s, cubic foot per second; acre-ft/d, acre-foot per day; mi, mile; (acre-ft/d)/mi, acre-foot per day per mile; ft, foot. na, not applicable]

Streamflow measurement site	Streamflow (ft^3/s)	Streamflow (acre-ft/d)	Loss of streamflow between stations (acre-ft/d)	Flow distance between stations (mi)	Rate of loss of streamflow between stations [(acre-ft/d)/mi]
Outflow drain at Lompoc Regional Wastewater Treatment Plant	9.09	18.03	na	na	na
1,200 ft east of Floradale Avenue	7.36	14.60	3.43	0.45	7.62
Floradale Avenue	5.82	11.54	3.06	.47	6.51
600 ft east of De Wolf Avenue	1.64	3.25	8.29	1.69	4.91
Total			14.78	2.61	[1]5.66

[1]Equals total loss of streamflow between stations divided by total flow distance between stations.

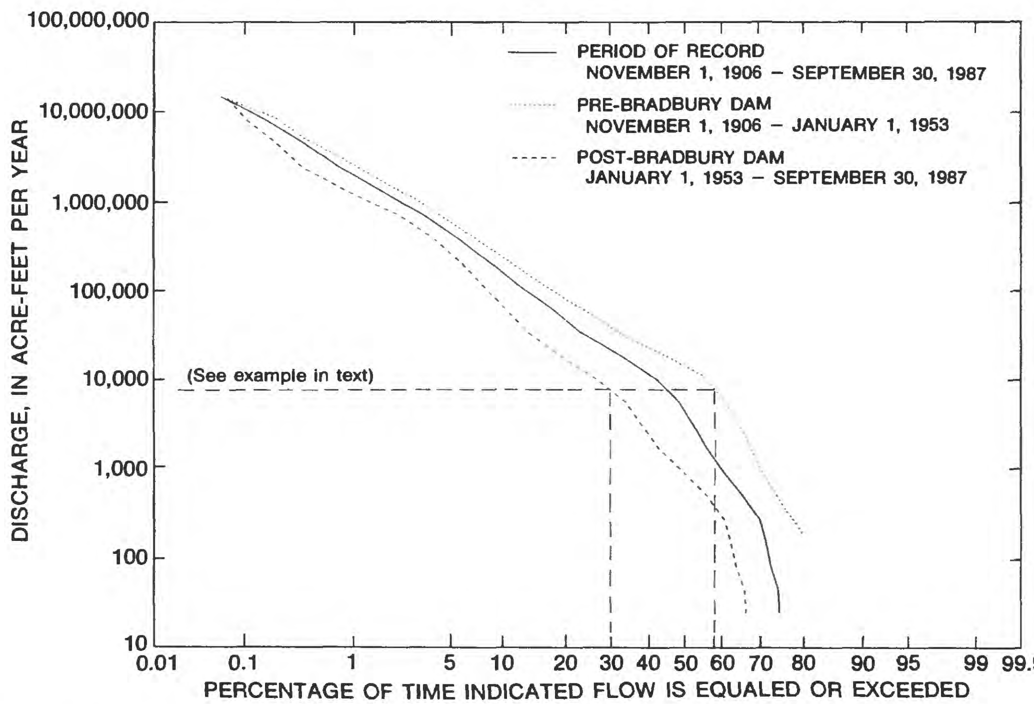


Figure 7. Flow-duration curves for the Santa Ynez River in the Lompoc area (based on gaging-station records at the Narrows and at Robinson Bridge).

combined in order to extend the period of record of the flow-duration curves. Figure 7 shows that streamflow in the Santa Ynez River has diminished in the Lompoc area since the completion of Bradbury Dam, especially at lower flows. For example, a measured discharge of 10 ft^3/s or 7,240 acre-ft/yr was equaled or exceeded 58 percent of the time prior to the construction of Bradbury Dam. After the construction of the dam, a streamflow of 10 ft^3/s was equaled or exceeded 30 percent of the time.

DISCHARGE

The primary components of ground-water discharge from the aquifers in the Lompoc area include (1) agricultural, municipal, and military pumpage, (2) transpiration by phreatophytes along the Santa Ynez River, (3) underflow from the upper aquifer to the ocean, and (4) seepage to the Santa Ynez River in the coastal area. Table 4 summarizes estimates of discharge from earlier studies.

The main component of ground-water discharge in the Lompoc area has been ground-water pumpage. Ground water has been used primarily for irrigation, municipal, and military purposes. The annual distribution of the various pumpages from the ground-water basin for 1941-85 is shown graphically in figure 6. Ground-water pumpage reached a maximum of 29,600 acre-ft/yr in 1960 and has remained relatively constant since that time, except for a slight decrease in the middle and late 1960's. Most irrigation-pumpage estimates were compiled from the reports listed in figure 6. Irrigation pumpage was estimated for 1985 using a consumptive-use factor for each irrigated crop (Ahlroth and others, 1977; California Department of Water Resources, 1987). Municipal and military pumpages values were for metered wells. Lompoc plain municipal-pumpage values were for the city of Lompoc. Lompoc upland municipal-pumpage values were for Park Water Company (1961-85) and Mission Hills Community Service District (1975-85). For years in which pumpage data are lacking, estimates were made by interpolating between calculated values.

Most of the ground-water pumpage in the Lompoc area historically has been used for irrigation (fig. 6). Irrigation wells have been located throughout the Lompoc plain, with the exception of the area occupied by the city of Lompoc. Figure 6 also shows that municipal and military pumpages increased significantly in the late 1950's and early 1960's. Although municipal pumpage has remained relatively constant since the 1960's, military pumpage in the Lompoc area has decreased in recent years as a result of increased percentage of pumping by VAFB from San Antonio Creek valley north of the Santa Ynez River drainage.

Estimates of transpiration by phreatophytes along the Santa Ynez River are given in table 4. Upson and Thomasson (1951) also included transpiration by phreatophytes in the western plain and evaporation from the Santa Ynez River and from bare areas in the channel. The transpiration estimate of 3,200 acre-ft by Miller (1976) was based on periodic surveys of phreatophytes along the Santa Ynez River by the U.S. Bureau of Reclamation (1964-75). These studies concluded that transpiration by phreatophytes along the river ranged from approximately 2,800 to 3,200 acre-ft/yr for 1962-73.

Table 4. Estimates of average annual discharge in the Lompoc area for selected periods

[Discharge values are in acre-feet. --, no data]

Discharge source	1935-44 (Upson and Thomasson, 1951)	1947-51 (Wilson, 1959)	1957-62 (Evenson, 1966)	1972 (Miller, 1976)	1975-76 (Ahlroth and others, 1977)
Ground-water pumpage	[1]10,000	[1]21,400	[2]27,400	[2]25,000	[2]26,000
Transpiration by phreatophytes	5,100	3,000	6,000	[3]3,200	3,200
Underflow to ocean	400	300	150	150	250
Seepage to the Santa Ynez River	1,500	100	--	100	--
Average annual total discharge . .	17,000	24,800	33,550	28,450	29,450

[1]Pumpage for Lompoc plain only.
[2]Pumpage for Lompoc plain, terrace, and upland (Mission Hills not included).
[3]Estimate based on vegetation data for 1964-75.

GROUND-WATER LEVELS AND MOVEMENT

Ground-water levels in the Lompoc area during 1987-88 were determined from measurements of static water levels in 63 monitor wells (table 5). Many of the water-level measurements were made by the U.S. Geological Survey at selected sites in the Lompoc plain. Additional water-level measurements were collected from monitor-well networks operated by the U.S. Bureau of Reclamation, by Santa Barbara County, and by the city of Lompoc. At most sites, nest of wells were perforated at different depths to enable the determination of the vertical distribution of hydraulic head. Those sites are referred to in this report as cluster sites. The location of the monitor wells and cluster sites is shown in figure 8. Well-construction data for all monitor wells and cluster sites are given in table 7 (at back of report).

Water-level measurements made during this study indicate that hydraulic head varied significantly with depth in the Lompoc plain. Figure 9 shows potentiometric contours for the shallow and main zones of the upper aquifer and for the lower aquifer. These contours were based on summer 1987 and spring 1988 water-level measurements. Potentiometric contours for the middle zone of the upper aquifer are not included in figure 9 because of insufficient data.

Ground-water movement in the shallow and main zones of the upper aquifer in spring 1988 generally was from east to west. In the eastern plain, ground water moved freely between zones in the upper aquifer, and flow directions in the main and shallow zones were similar. In both zones, ground water moved westward from the Santa Ynez River toward a water-level depression around the municipal supply wells for the city of Lompoc. These wells obtained most of their water from the main zone. Thus, much of the ground water that recharged the upper aquifer in the eastern plain, from seepage along the Santa Ynez River and underflow through river-channel deposits at the Narrows, was intercepted by these municipal supply wells. In 1975-76, average annual pumpage for the city of Lompoc (fig. 6) was approximately 70 percent of the estimated annual recharge from these sources (table 2).

In the central plain, ground-water movement in the shallow and main zones was slightly different. Ground-water movement in the shallow zone during spring 1988 generally was northwestward. Ground-water movement in the main zone during this period generally was westward. The northwestward movement of ground water in the shallow zone in this area probably was caused by recharge along La Salle and Sloans Canyons at the edge of the southern plain (fig. 9). The southern plain has been described in earlier studies as having free interchange of water between the shallow and middle zones of the upper aquifer and the lower aquifer (Upson and Thomasson, 1951, p. 135). In the central plain, however, silt and clay deposits underlying the middle zone limited downward movement of ground water to the main zone.

In the northern parts of the central plain and western plain, ground-water movement through the shallow zone generally was toward the west and parallel with the Santa Ynez River during spring 1988. In this area, flow in the river was maintained primarily by sewage effluent discharged from the Lompoc Regional Wastewater Treatment Plant. Although streamflow data for summer 1988 (table 3) indicate that seepage of water from the river has occurred downgradient of the LRWTP, water levels and dissolved-solids concentrations in the shallow zone suggest that recharge from the river did not move toward the south and into the shallow zone. Silt and clay deposits in the shallow and middle zones are present to the south and beneath the river in this area, respectively. These deposits probably restrict seepage of water from the river to the permeable channel deposits adjacent to the main course of the river. However, water levels and dissolved-solids concentrations in the shallow and main zones of the northwestern plain indicate that recharge from the river moved freely from the shallow zone and into the main zone (fig. 9). This area has been described in earlier studies as having free interchange of water between all zones in the upper aquifer (Upson and Thomasson, 1951, p. 146).

Table 5. Static water levels for selected monitor wells, summer 1987 and spring 1988

[Static water levels correspond to potentiometric contours in figure 9. Measured zone or aquifer was determined on the basis of well perforations and water quality. State well No.: See well-numbering system in text. Altitude of water level is in feet above sea level. Monitoring agency: COL, city of Lompoc; SB, Santa Barbara County; USBR, U.S. Bureau of Reclamation; USGS, U.S. Geological Survey. --, no data]

State well No.		Date	Altitude of water level	Monitoring agency
Upper Aquifer--*Shallow Zone*				
7N/34W-	22L2	3-28-88	57.8	USBR
	27K4	4-11-88	49.41	USGS
	27P6	4-14-88	37.19	USGS
	29F2	4-13-88	36.54	USGS
	29N4	4-12-88	39.44	USGS
	30L3	3-24-88	35.38	SB
	31C3	3-24-88	44.28	SB
	33E5	4-12-88	44.08	USGS
	35F2[1]	3-23-88	82.78	SB
7N/35W-	13N2	4-15-88	36.27	USGS
	17Q6	5-02-88	10.33	USGS
	23B2	4-15-88	11.58	USGS
	23Q2	4-12-88	23.90	COL
	25F7	3-24-88	34.61	SB
	26L1	4-12-88	30.09	USGS
Upper Aquifer--*Main Zone*				
7N/34W-	27K7	4-12-88	50.08	COL
	27N5	3- -88	38.36	COL
	27P5	3- -88	39.86	COL
	27Q2	3- -88	43.67	COL
	28M2	4-14-88	42.12	COL
	29F1	4-13-88	33.24	COL
	29N6	4-12-88	31.41	COL
	34A4	3- -88	56.00	COL
	34B1	3- -88	44.23	COL
	34F6	3- -88	45.89	COL
	35K9	3-23-88	79.23	SB
7N/35W-	17K21	4-12-88	6.67	COL
	17M1	3-24-88	6.44	SB
	21G2	5-02-88	8.59	USGS
	22J1	3-24-88	13.53	SB
	23E2	4-03-88	18.72	SB
	23Q4	4-13-88	16.32	USGS
	24J4	3-24-88	20.40	SB
	24K5	3-25-88	27.03	SB
	25F5	3-24-88	18.61	SB
	26F4	4-03-88	[2]14.95	SB

State well No.		Date	Altitude of water level	Monitoring agency
Lower Aquifer				
6N/34W-	4G4	3-28-88	44.9	SB
	6C1	3-24-88	36.15	SB
7N/33W-	16G2	8-06-87	152.67	USGS
	17M1	8-06-87	94.15	USGS
	19D1	3-23-88	75.02	SB
	20G3	8-04-87	81.85	USGS
	21G2	8-04-87	119.91	USGS
	28D1	8-06-87	77.50	USGS
	28D3	3-23-88	73.52	SB
7N/34W-	9H5	3-25-88	24.14	SB
	12E1	3-24-88	64.87	SB
	14F3	3-24-88	51.53	SB
	14L1	3-24-88	41.20	SB
	15D1	3-25-88	49.00	SB
	15P1	3-24-88	52.22	SB
	20P3	11-06-87	[3]43.06	USGS
	22J6	3-22-88	[2]55.52	SB
	24N1	3-22-88	58.07	SB
	26H3	3-23-88	[2]57.22	SB
	26Q5	3-28-88	52.8	USBR
	27K6	4-12-88	50.73	COL
	29N7	4-12-88	32.64	USGS
7N/35W-	26L4	4-12-88	18.08	USGS
	27P1	5-02-88	34.16	USGS
	31J1	5-02-88	108.65	USGS
	33J2	--	[4]43	USGS
	33J3	5-02-88	86.78	USGS

[1]Upper perforations in river-channel deposits. Aquifer opposite lower perforations uncertain.

[2]Water level questionable due to unknown perforated interval.

[3]Water level questionable due to date of measurement.

[4]Average static water-level altitude, May 1983-November 1987.

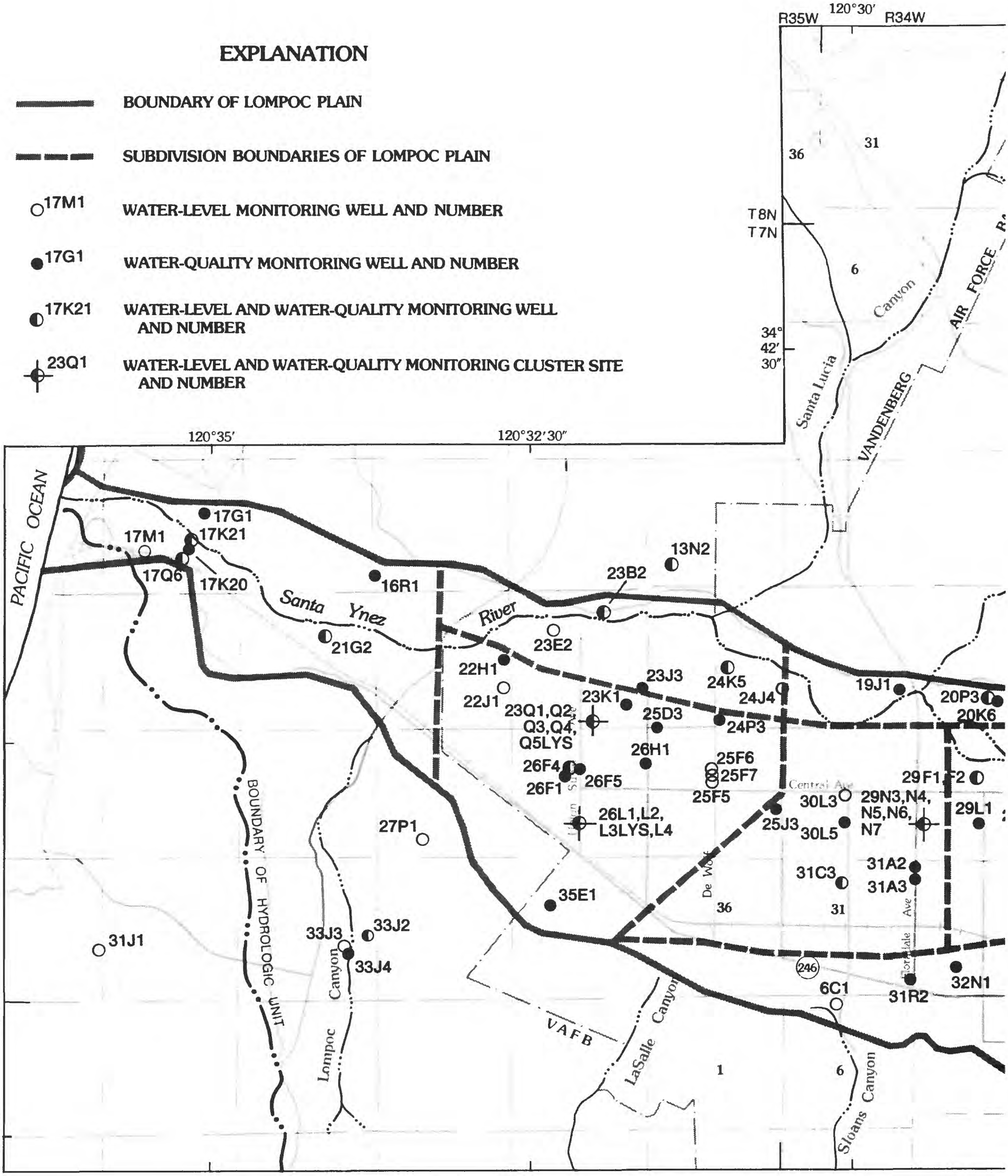
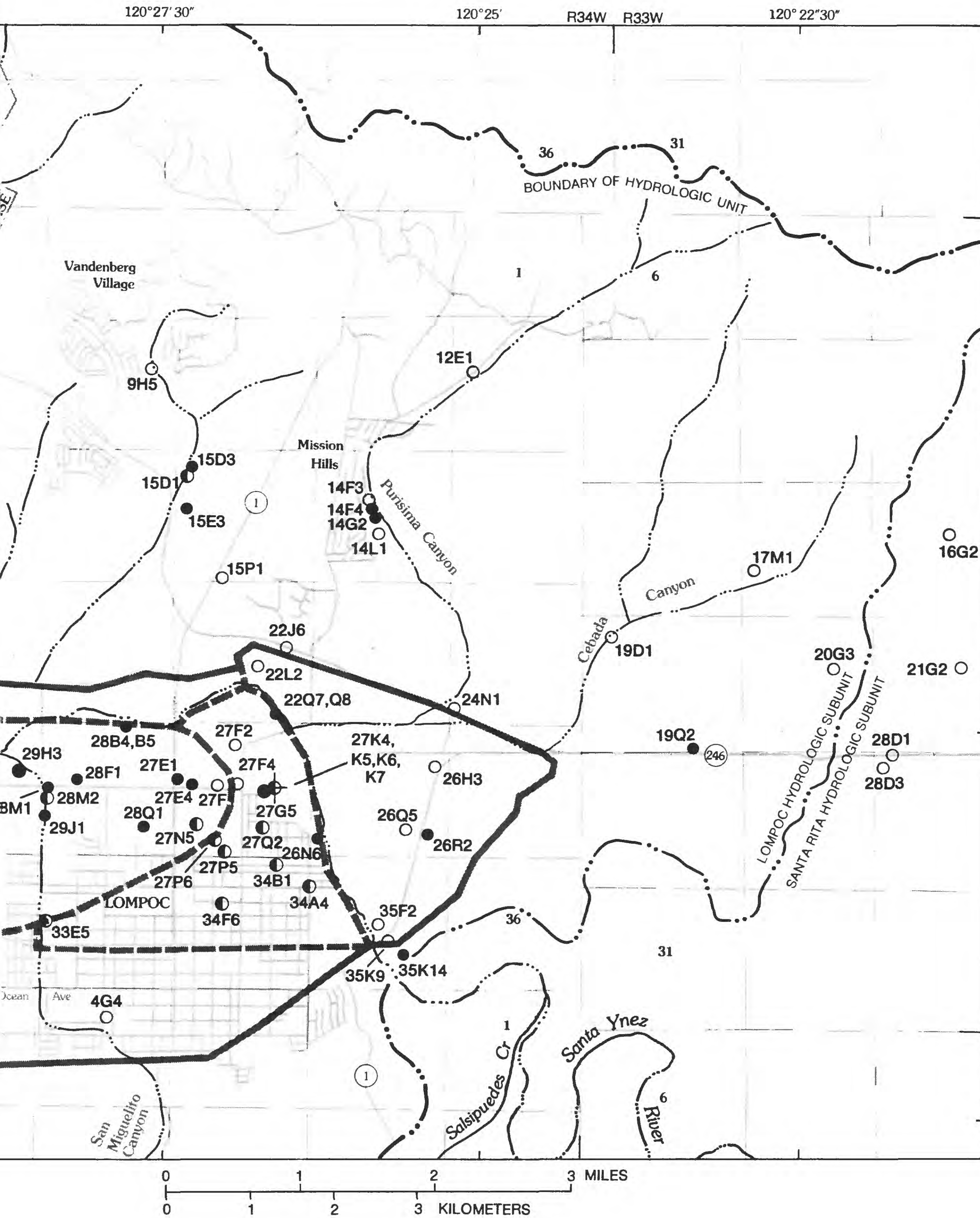


Figure 8. Location of monitor wells and cluster sites.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36
31
BOUNDARY OF HYDROLOGIC UNIT
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6
12E1
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Mission Hills
15D3
15D1
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14F3
14F4
14G2
14L1
Purisima Canyon
15P1
17M1
16G2
Canyon
Cebada
19D1
22J6
22L2
22Q7,Q8
24N1
20G3
21G2
27F2
28B4,B5
27K4, K5,K6, K7
19Q2
246
28D1
28D3
29H3
28F1
27E1
27F4
26H3
28M2
8M1
27E4
27F
27G5
28Q1
29J1
26Q5
27N5
27Q2
26R2
26N6
27P5
27P6
34B1
34A4
LOMPOC HYDROLOGIC SUBUNIT
SANTA RITA HYDROLOGIC SUBUNIT
LOMPOC
34F6
35F2
33E5
36
31
35K9
35K14
Ocean
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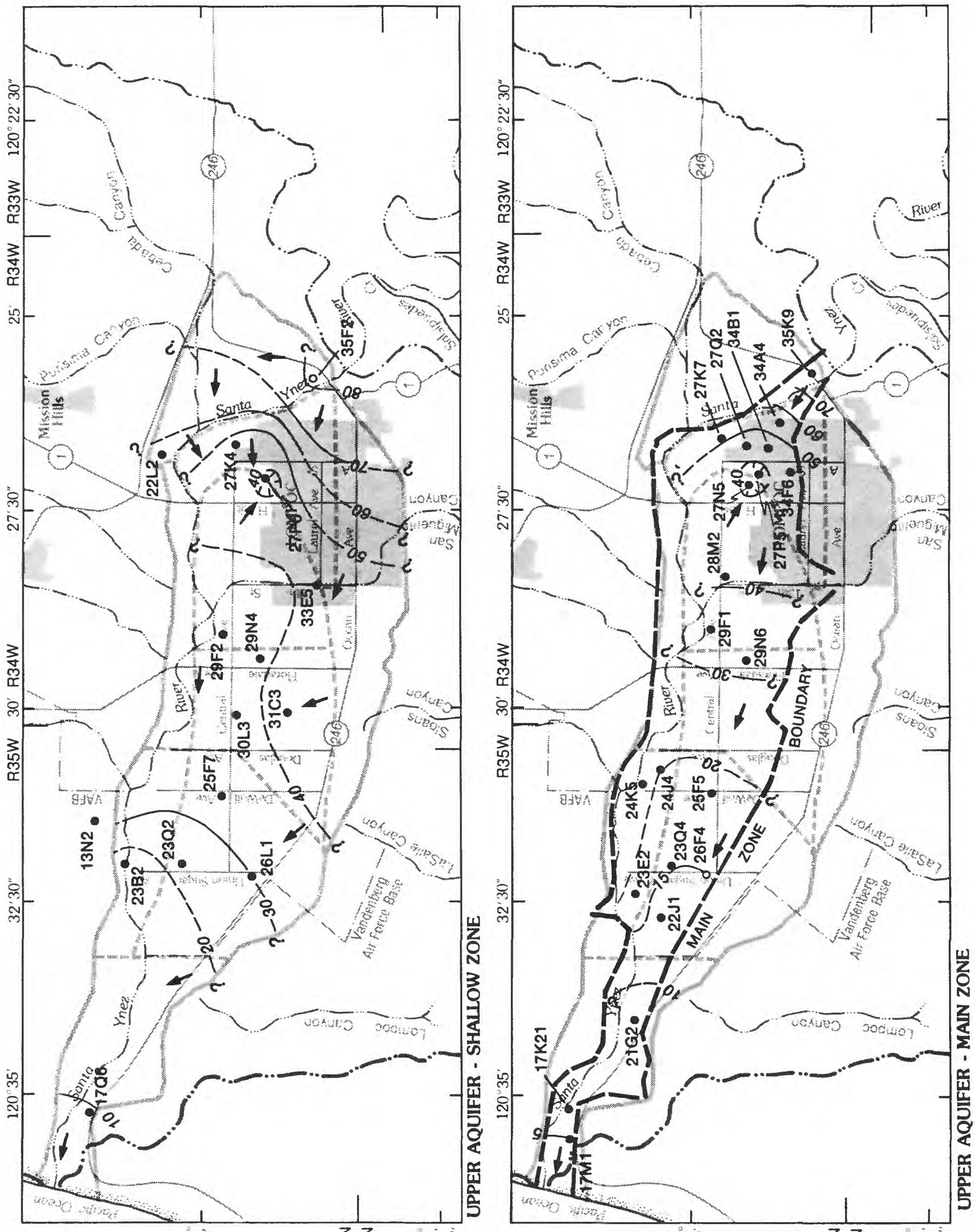
3 KILOMETERS


UPPER AQUIFER - SHALLOW ZONE
UPPER AQUIFER - MAIN ZONE
MAIN ZONE BOUNDARY
Mission Hills
Purisima Canyon
Santa Ynez River
Vandenberg Air Force Base
Pacific Ocean
VAFB
Lompoc Canyon
LaSalle Canyon
Sloans Canyon
San Miguelito Canyon
Cañada Salsipuedes
R35W
R34W
R33W
T7N
T6N
120°35'
32'30"
30'
27'30"
25'
22'30"
120°22'30"
34°40'
34°37'30"

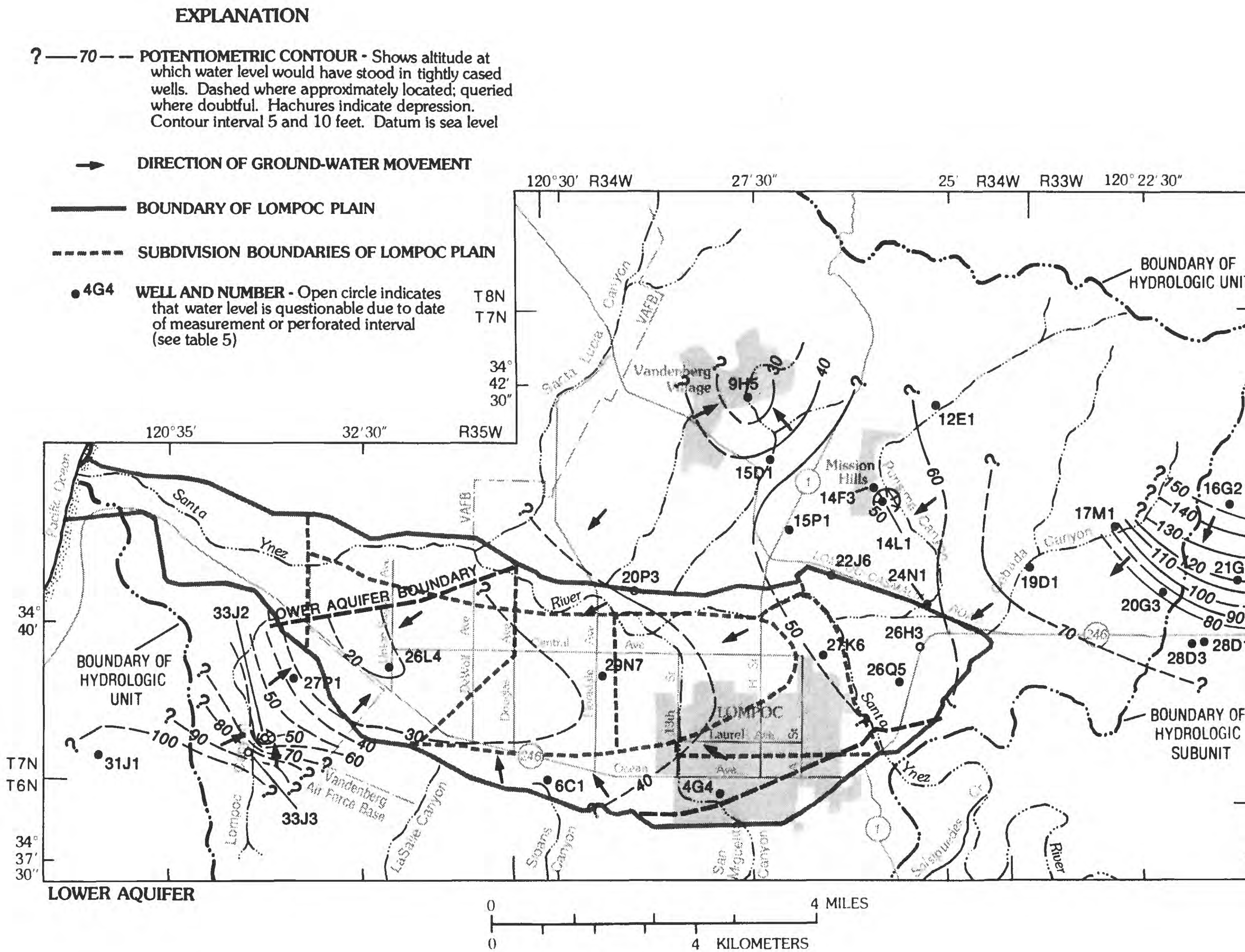


Figure 9. Potentiometric surfaces of shallow and main zones of upper aquifer, spring 1988, and of lower aquifer, summer 1987 and spring 1988. (See table 5 for water-level data.)

During spring 1988, ground water moved from the Lompoc upland and terrace areas toward the Lompoc plain through the lower aquifer. Most of the water-level measurements in the lower aquifer were made in spring 1988; however, water-level measurements along the eastern boundary of the Lompoc area were made in August 1987. In the Lompoc upland, the 1988 water-level measurements indicate two distinct cones of depression caused by municipal pumping. One of the depressions was in Vandenberg Village, and the other was in Mission Hills. The depression in Mission Hills was centered around two municipal supply wells. A municipal well in the center of the depression in Vandenberg Village has supplied only a small percentage of the total annual pumpage since 1979. Long-term hydrographs (see fig. 11*C*) confirm that the altitude of the potentiometric surface of the lower aquifer declined in this area during 1958-88. Comparison of a water-level contour map prepared by Miller (1976, p. 25) with the map presented in this report for 1988 data (fig. 9) indicates that the contours are almost identical near Vandenberg Village. This depression reflects a long-term condition that may be the result of ground-water pumping at the golf course located at the northern edge of Vandenberg Village.

East of Cebada Canyon in the eastern part of the study area, ground water in the lower aquifer generally moved southwestward during August 1987. This movement approximately paralleled the eastern surface-water divide of the basin. Consequently, this surface-drainage divide also acted as a ground-water divide, and it defined the eastern extent of the ground-water basin.

Ground-water movement in the lower aquifer was generally northeastward in spring 1988 in the Lompoc terrace. Water-level measurements indicate a relatively small depression caused by pumping in Lompoc Canyon.

In the lower aquifer, ground water that was not intercepted by production wells in the Lompoc upland and terrace areas flowed toward the western plain. A subsurface ridge of consolidated rocks forms the boundary of the lower aquifer beneath the plain in this area (fig. 9). This ridge creates a ground-water barrier that forced ground water from the lower aquifer to flow into the overlying middle and main zones of the upper aquifer.

Hydraulic head in the lower aquifer was higher than head in the main zone of the upper aquifer in all areas during spring 1988. Thus, water flowed from the lower aquifer to the main zone.

SEASONAL CHANGES

Cluster sites were constructed in four selected agricultural fields in the Lompoc plain to monitor seasonal changes in water levels. The location of the sites is shown in figure 8. One site was adjacent to an irrigated field in the eastern plain. This field was naturally drained and was in an area where the upper aquifer received recharge from the Santa Ynez River (Miller, 1976). Two additional sites, also naturally drained, were in irrigated fields in the central plain and in the northern part of the western plain. A fourth site was located adjacent to an irrigated field in the southern part of the western plain; this site was artificially drained by an unlined canal. At each of the sites, three or more monitor wells were installed at different depths, and bimonthly water-level measurements were made in 1987. Weekly water-level measurements were made in 1988 at all sites, except the southern site in the western Lompoc plain. Continuous water-level recorders were installed in one well at both the central plain site and the northern site in the western plain (table 8, at back of report). Water levels during 1987-88 at each of the sites are shown in figure 10.

In the eastern plain, hydrographs (fig. 10*A*) for the cluster wells indicate similar water-level fluctuations in the shallow, middle, and main zones of the upper aquifer, which suggest that ground water moved freely between the zones, as described by Upson and Thomasson (1951). In addition, hydrographs at this site indicate that water-level fluctuations in the lower aquifer generally were similar to fluctuations in the upper aquifer during 1988 (fig. 10*A*). Water-level altitudes in the well tapping the main zone were consistently lower than in the wells tapping the shallow and middle zones and in the well tapping the underlying lower aquifer. Therefore, the main zone received leakage from both overlying and underlying water-bearing deposits.

Water levels in wells at the cluster site in the central plain (fig. 10*B*) varied seasonally during 1987-88. During the irrigation season, about April through September, water levels in wells tapping the middle and main zones of the upper aquifer and in the lower aquifer declined significantly. Most of the irrigation wells in the Lompoc plain were perforated in both the middle and main zones. During 1988, pumpage from the lower aquifer beneath the Lompoc plain was limited to VAFB and U.S. Penitentiary (USP) supply wells in the northern plain (fig. 1). The water-level fluctuations in wells tapping the lower aquifer at the central plain site were similar to

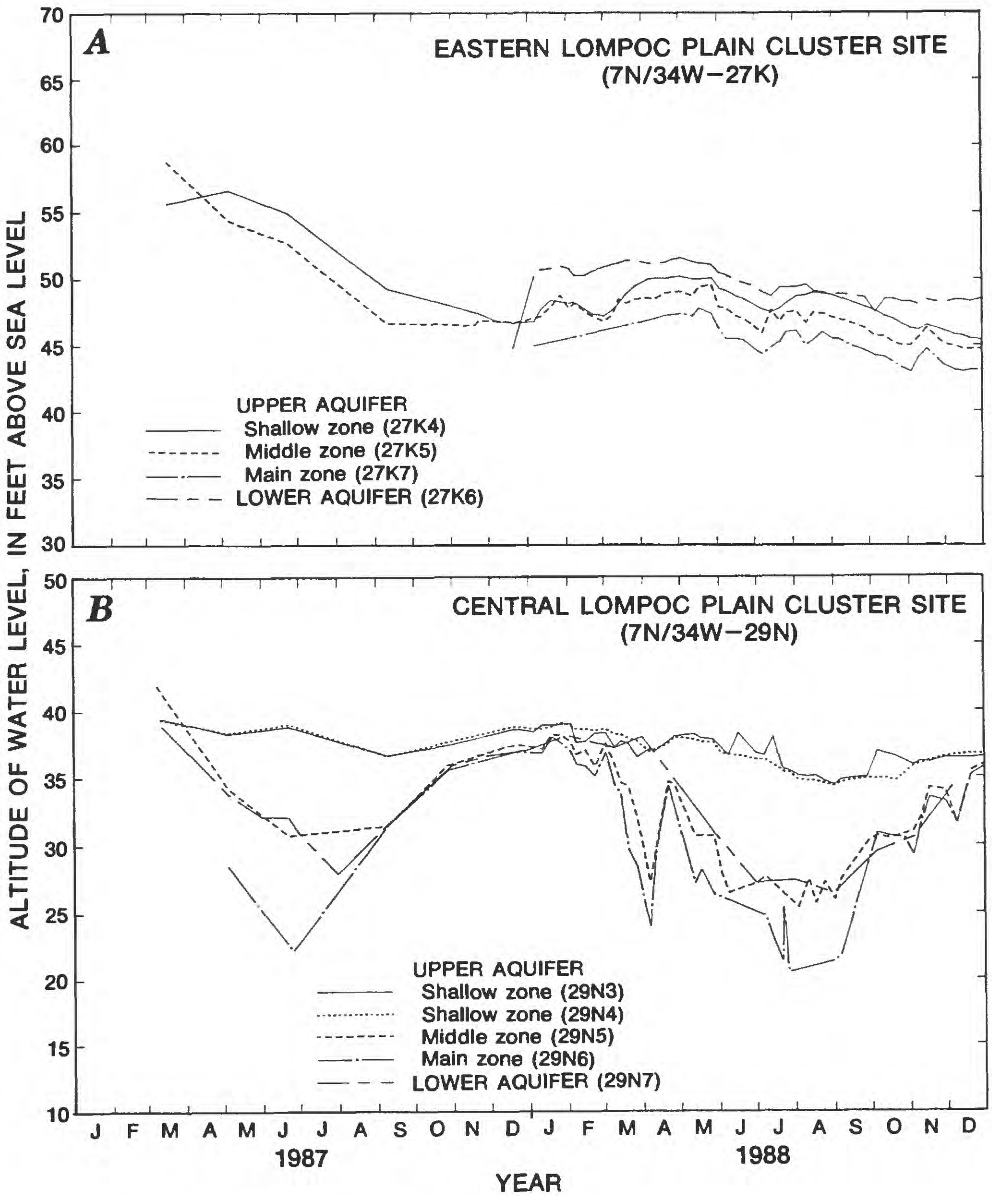


Figure 10. Altitude of water levels for selected cluster sites, 1987-88.

the seasonal water-level changes in both the middle and main zones. Water-level declines in the well perforated in the lower aquifer at this site probably were caused by a combination of seasonal irrigation pumpage from the main zone and pumping by VAFB and USP from the lower aquifer to the north. Water-level data in the central plain indicate that hydraulic head in the lower aquifer was higher than in the main zone during the irrigation seasons of 1987-88.

In the central plain, water levels in wells perforated in the shallow zone did not fluctuate significantly during the irrigation season, and the fluctuations were not similar to water-level changes in wells perforated in underlying zones. Slight increases in hydraulic head in the shallow zone probably were due to infiltration of irrigation water. The large hydraulic-head differences that occurred between the shallow zone and underlying zones during the irrigation season are due, in part, to thick deposits of silt and clay in the shallow zone. Downward leakage of ground water from the shallow zone to the middle zone was limited by these fine deposits. During the non-irrigation season, October through March, water-level altitudes in all wells tapping the upper and lower aquifers were nearly equal in the central plain.

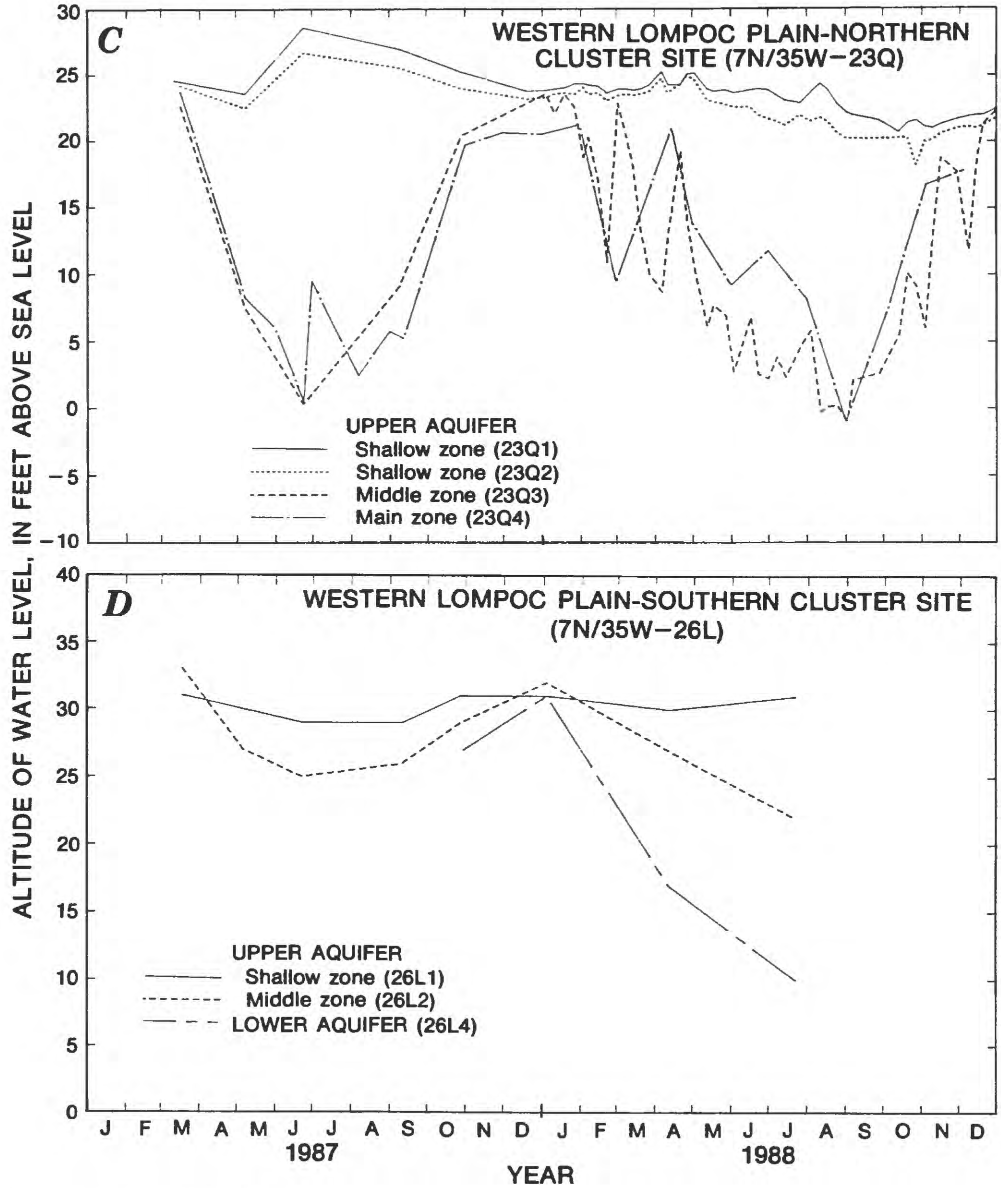


Figure 10. Continued.

The greatest water-level declines were recorded in wells at the northern site in the western plain (fig. 10*C*). At this site, water levels declined more than 20 ft in wells perforated in the middle and main zones of the upper aquifer during the irrigation season in both 1987 and 1988. This suggests that ground water in the middle and main zones was confined to a greater degree in this area. The confined conditions at this site were due partly to an increase in the thickness and proportion of silt and clay deposits in the shallow zone (Miller, 1976, p. 14). Also, consolidated rocks directly underlie the main zone in this area, and upward leakage to the main zone probably was small. This likely resulted in larger drawdowns in the middle and main zones during the irrigation season than elsewhere in the Lompoc plain.

At the southern site in the western plain, the main zone in the upper aquifer is absent (fig. 4). The lower aquifer lies directly below the middle zone in this area but is separated from it by deposits of silt and clay (see fig. 14, section *G-G'*, in "Distribution of Stable Isotopes and Dissolved Solids"). Downward leakage of ground water between these two zones therefore was limited. Irrigation water was pumped from the middle zone in this area and from the main zone north of this site. Hydraulic head in the lower aquifer declined significantly during the 1988 irrigation season (fig. 10*D*). Because the water level in the well perforated in the lower aquifer was much lower than the water level in the well perforated in the middle zone during the irrigation season of 1988, it was believed that pumpage from the main zone north of the site significantly lowered the hydraulic head in the lower aquifer. Historically, this part of the plain was a marshland; however, pumping of ground water from the main zone has lowered water levels below land surface in the former marshland. Also, water-level fluctuations in the well perforated in the shallow zone at this site were not similar to fluctuations in the wells perforated in the middle zone and lower aquifer. Throughout the nonirrigation season, hydraulic heads in all zones were nearly equal at this cluster site.

LONG-TERM CHANGES

Long-term water-level hydrographs for several wells that tap the upper aquifer in the Lompoc plain, and the lower aquifer in the Lompoc upland and Lompoc terrace, are shown in figure 11. These hydrographs show the highest static water-level altitude measured annually at each site. Long-term water-level records were not available for wells perforated in the lower aquifer beneath the Lompoc plain. The hydrographs show water levels in "paired" wells in the eastern (fig. 11*A*) and western (fig. 11*B*) plains. The paired wells are in close proximity to each other and allow comparison of hydraulic heads in the shallow and main zones of the upper aquifer. Short-term fluctuations in these hydrographs reflect response to seasonal pumping and recharge.

In the eastern plain, the paired wells (fig. 11*A*) are a short distance north of the city of Lompoc in an area considered to have free interchange of ground water between the shallow and main zones (Upson and Thomasson, 1951, p. 135). Water-level measurements from shallow-zone wells were scarce in this area; however, measurements made in well 7N/34W-27F2 during 1941-51 were almost identical to water levels measured in wells penetrating the main zone (fig. 11*A*). Hydraulic head in the main zone generally declined during 1947-52 and again in 1959-60. The decline in water levels during 1947-52 reflected the drier-than-average conditions and increased irrigation pumpage that prevailed during that period. Water-level declines in 1959-60 corresponded to an increase in municipal pumpage by the city of Lompoc. Pumpage more than doubled from 1958 to 1961 (fig. 6). On the basis of spring water-level measurements, which are the highest water levels during most years, hydraulic head in the main zone declined approximately 10 to 15 ft during 1930-87 in the eastern plain.

Long-term hydrographs of paired wells in the western plain (fig. 11*B*) indicate a decline of about 10 ft in hydraulic head in the main zone during 1940-88. Downward movement of ground water in this area was prevented or greatly retarded by fine deposits in the shallow zone (Upson and Thomasson, 1951, p. 135). Water-level fluctuations in well 7N/35W-25F6, which is perforated in the shallow zone, only generally corresponded with the water-level fluctuations in well 7N/35W-25F5, which is perforated in the main zone. This indicates that changes in the potentiometric surface of the shallow zone occurred independently of the main zone. Hydraulic head in the shallow zone was higher than that in the heavily pumped main zone in the western plain.

Hydrographs of several wells perforated in the lower aquifer indicate that water levels in the Lompoc upland and Lompoc terrace have declined (fig. 11*C*, 11*D*). Hydrographs for wells in the Lompoc upland show a steady 15- to 20-foot decline in water levels from the early 1960's to 1988. Well 7N/34W-12E1 is north of Mission Hills. Wells 7N/34W-14F3 and 7N/34W-15D1 are near the communities of Mission Hills and Vandenberg Village, respectively. Ground-water pumpage from the Lompoc upland increased considerably during 1962-66 and slightly during 1966-88 (fig. 6). In 1975-76, average annual pumpage from the Lompoc upland was about 1,900 acre-ft (Park Water Company, Mission Hills Community Services District, written commun., 1988; fig. 6); thus, pumpage was approximately equal to the estimated annual recharge from rainfall infiltration on the upland during the same period (table 2).

In monitor wells 7N/35W-27P1 and 7N/35W-31J1 in the northeastern and southwestern Lompoc terrace, slight, but steady, declines in water level occurred from the early 1960's to 1988. Springtime water levels in production well 7N/35W-33J2S in Lompoc Canyon (fig. 11*D*), however, have declined 15 to 20 ft since 1958. This production well derives most of its water from the lower member (very fine sand and silt) of the Careaga Sand.

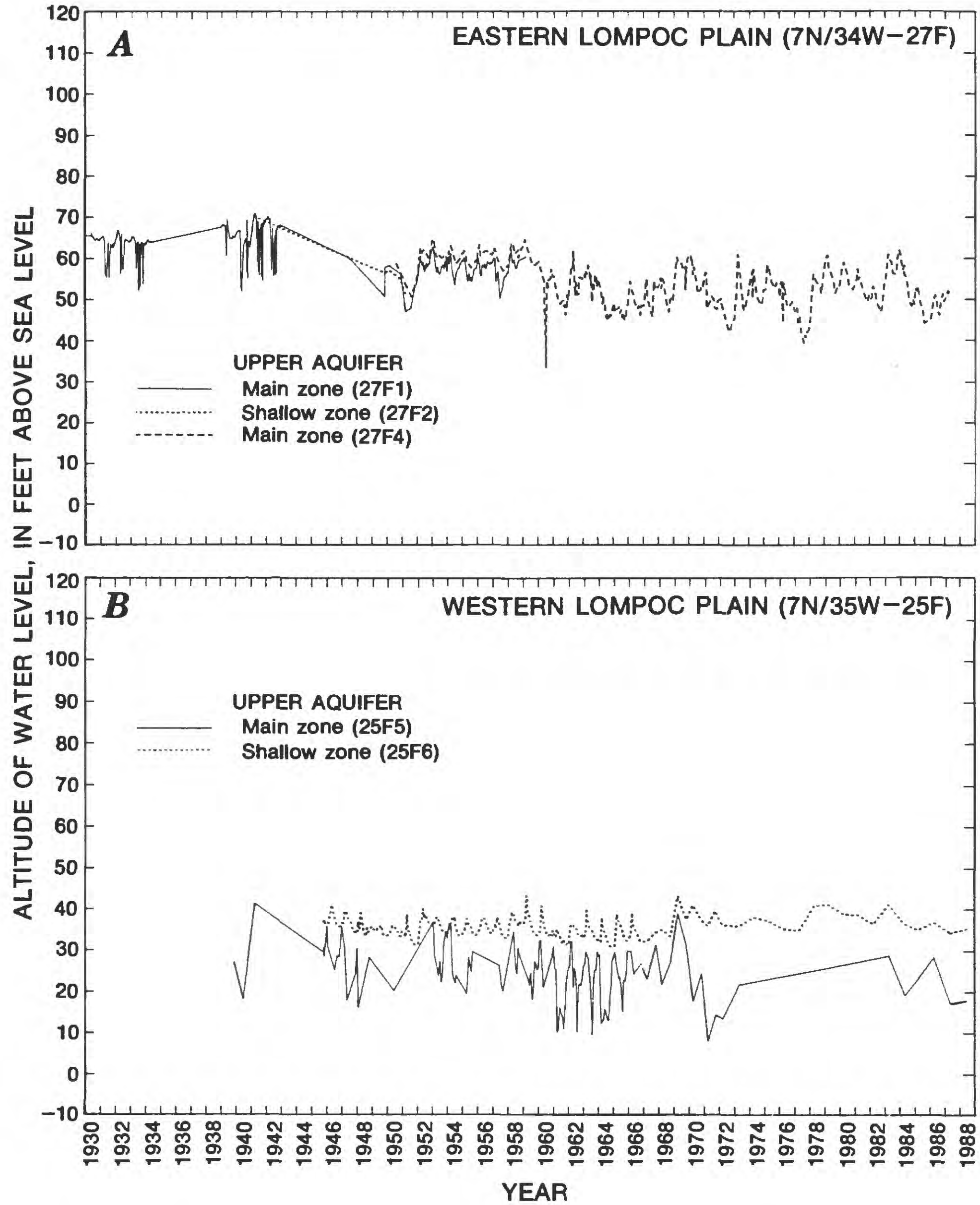


Figure 11. Altitude of water levels for selected wells in the upper (shallow and main zones) and lower aquifers, 1930-88. (See figure 8 for well locations.)

GROUND-WATER QUALITY

Water for agricultural, domestic, and most industrial needs in the Lompoc area has been obtained from wells in the basin. Previous studies (Evenson, 1966; Miller, 1976; Berenbrock, 1988) concluded that, on the basis of chemical composition, the quality of ground water in some areas of the basin has been degraded to levels that fail to meet water-quality standards recommended by the U.S. Environmental Protection Agency (EPA) (1977, 1979) and by the California Department of Public Health, Sanitary Engineering Section (1977). These previous reports presented results from ground-water-quality investigations that were done primarily to define the chemical character of the ground water within the Lompoc plain and areal variations in quality. However, little emphasis was placed on describing the vertical

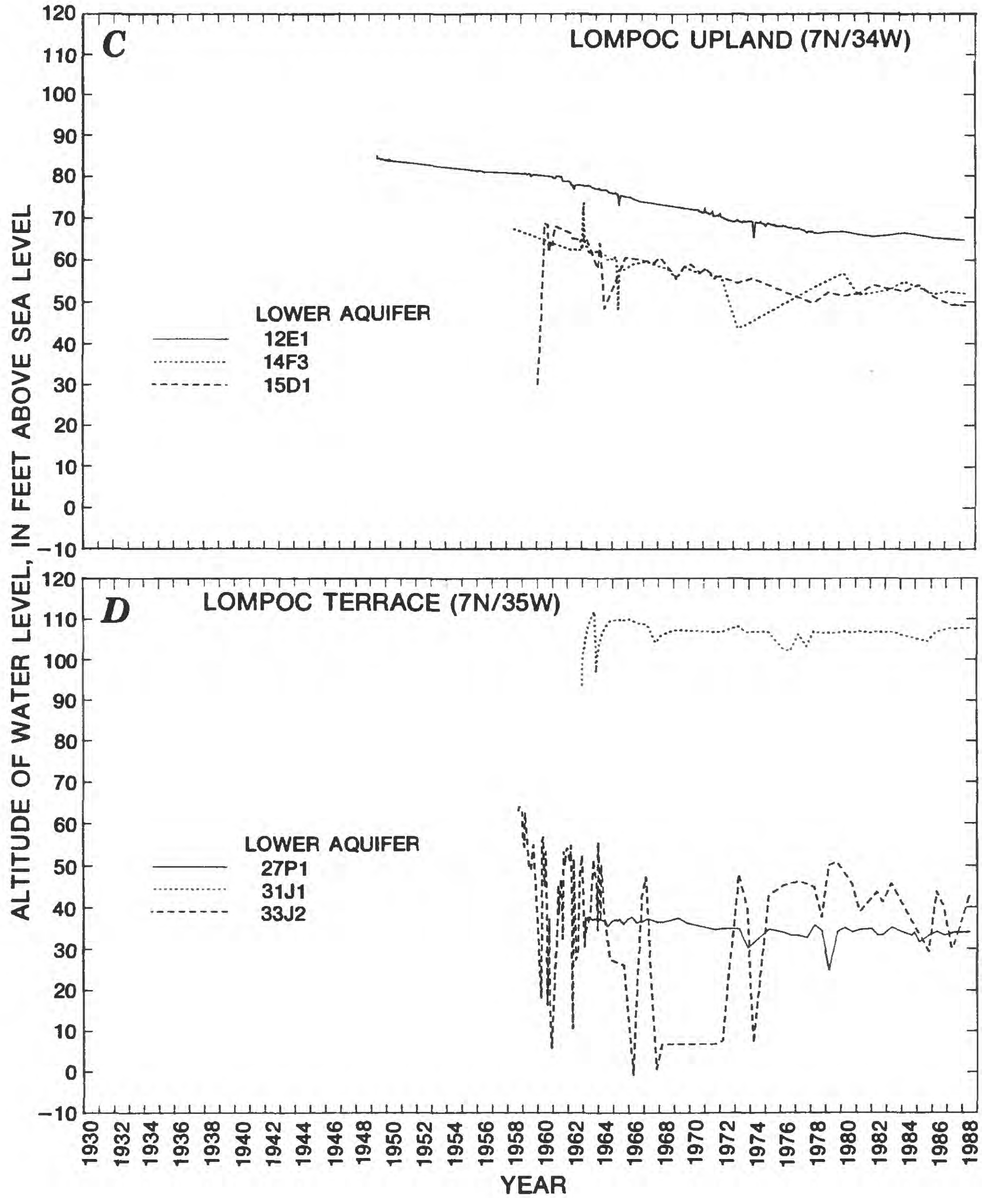


Figure 11. Continued.

variation in ground-water quality. In this report, the areal and vertical variations in ground-water quality will be described and subsequently used to determine the ground-water interaction between water-bearing zones and aquifers.

To determine the areal and vertical variations in ground-water quality in the Lompoc area, samples were collected from 79 monitor wells and two suction-cup lysimeters during the study period of March 1987 to December 1988. Thirty-two of these monitor wells were drilled by the U.S. Geological Survey in selected study plots throughout the Lompoc plain. The wells at each plot were constructed to monitor water quality in the different aquifers in the ground-water system. Figure 8 shows the location of the wells and lysimeters that were sampled for major ions and nutrients. Selected samples from these sites also were analyzed for the stable isotopes deuterium and oxygen-18. These analyses are summarized in table 6. The complete results of the water-quality analyses for the study period are given in table 9 (at back of report).

Table 6. Summary of dissolved solids, nitrogen, and stable isotopes in samples from selected wells, lysimeters, and surface-water sites, March 1987-December 1988

[Measured zone or aquifer was determined on the basis of well perforations and water quality. State well No.: See well-numbering system in text. Delta oxygen-18: Number in parentheses corresponds to designation in figure 13 for both delta deuterium and delta oxygen-18. Sampled zone or aquifer was determined on the basis of well perforations and water quality. Surface-water sites: Date of analyses is shown in parentheses after site name. °C, degrees Celsius; mg/L, milligrams per liter; per mil, parts per thousand; <, actual value is less than value shown; --, no data; na, not applicable]

State well No.	Solids, sum of constituents, dissolved, average (mg/L)	Nitrogen, nitrite plus nitrate dissolved, average (mg/L as N)	April 1988	
			Delta deuterium (per mil)	Delta oxygen-18 (per mil)
Upper Aquifer--*Shallow Zone*				
7N/34W- 22Q8	[1]892	[1]1.1	--	--
27K4	943	1.6	-33.0	-4.85(7)
27P6	876	<.10	-33.0	-5.35(12)
28B5	[1]779	[1]<.10	--	--
29F2	1,392	.17	-33.5	-5.05(16)
29N3	3,428	25	-31.0	-4.65(18)
29N4	3,165	<.10	-31.5	-4.80(19)
31R2	[1,2]1,909	--	--	--
32N1[3]	[1,2]2,083	--	--	--
33E5	3,277	.29	-33.0	-4.90(23)
35K14	[1]1,430	[1]7.30	--	--
7N/35W- 13N2[4]	[1]542	--	-36.0	-5.75(25)
16R1	[1]1,770	[1]<.10	--	--
17G1	3,325	<.10	--	--
17Q6	8,010	<.10	--	--
23B2	871	<.10	-34.5	-5.20(28)
23Q1	5,716	60	-34.0	-4.75(29)
23Q2	5,374	51	-31.0	-4.65(30)
23Q5LYS	4,790	113	--	--
26L1	3,318	37	-32.5	-5.00(33)
26L3LYS	3,275	52	--	--
Upper Aquifer--*Middle Zone*				
7N/34W- 26R2	[1]1,990	[1]24	-33.5	-4.95(5)
27E4	2,273	<.10	-36.5	-5.30(6)
27K5	983	<.10	-31.5	-4.70(8)
27N6	[1]1,460	[1]<.10	--	--
28M1	2,900	12	-33.5	-4.95(13)
28Q1	1,470	.24	--	--
29H3	1,475	<.10	-29.5	-4.60(17)
29L1[3]	[1,2]1,739	--	--	--
29N5	1,744	.24	-37.5	-5.55(20)
7N/35W- 23Q3	1,280	.68	-35.0	-5.55(31)
26L2	646	.35	-33.0	-5.50(34)

Footnotes at end of table.

Table 6. Summary of dissolved solids, nitrogen, and stable isotopes in samples from selected wells, lysimeters, and surface-water sites, March 1987-December 1988–*Continued*

State well No.	Solids, sum of constituents, dissolved, average (mg/L)	Nitrogen, nitrite plus nitrate dissolved, average (mg/L as N)	April 1988 Delta deuterium (per mil)	April 1988 Delta oxygen-18 (per mil)
Upper Aquifer--*Main Zone*				
7N/34W- 19J1[4]	[1]787	[1]0.23	--	--
22Q7	[1]1,120	[1].55	--	--
26N6	[1]854	[1]<.10	--	--
27G5	[1]1,080	[1]<.10	--	--
27K7	[1]1,030	[1].40	-34.0	-4.60(10)
27N5	[1]1,749	[2].16	-36.0	-5.30(11)
27P5	1,445	<.10	--	--
27Q2	[1]1,004	[1]<.10	--	--
28B4	[1]1,030	[1].31	--	--
28M2	1,660	<.10	-35.0	-5.10(14)
29F1	[1]1,308	[1]<.10	-32.5	-4.85(15)
29J1[4]	[1]1,740	[1]<.10	--	--
29N6	2,012	<.11	-36.0	-5.35(21)
30L5[4]	[1]1,950	[1]<.10	--	--
34A4	[1]978	[1]<.10	-33.0	-4.70(24)
34B1	[1]948	[1]<.10	--	--
34F6	[1]1,354	[1]<.10	--	--
7N/35W- 17K20	3,180	<.10	--	--
17K21	4,383	<.23	-32.5	-5.20(26)
21G2	1,975	<.10	--	--
22H1	[1]2,530	[1]<.10	-32.0	-4.85(27)
23K1	[1]1,880	[1]<.10	--	--
23Q4	2,239	<.18	-35.0	-5.55(32)
24K5	[1]1,020	[1]<.10	--	--
24P3[4]	[1]1,730	[1]<.10	--	--
25D3[4]	[1]1,870	[1]<.10	--	--
25J3[3]	[1,2]1,320	--	--	--
26F5	1,923	<.10	--	--
26H1[4]	[1]1,700	[1]<.10	--	--
Lower Aquifer				
7N/33W- 19Q2	[1]479	[1]0.33	--	--
7N/34W- 14F4	[1]512	[1].83	[5]-38.5	[5]-5.60(1)
14G2	[1]428	[1].59	--	--
15D3	--	--	-36.0	-5.70(2)
15E3	[1]503	[1].36	-37.0	-5.75(3)
20K6	714	.13	[5]-37.5	[5]-5.60(4)
20P3	[1]562	[1]<.10	--	--
27K6	655	<.10	-41.0	-6.35(9)
29N7	1,019	<.12	-38.0	-5.75(22)

Footnotes at end of table.

Table 6. Summary of dissolved solids, nitrogen, and stable isotopes in samples from selected wells, lysimeters, and surface-water sites, March 1987-December 1988--*Continued*

State well No.	Solids, sum of constituents, dissolved, average (mg/L)	Nitrogen, nitrite plus nitrate dissolved, average (mg/L as N)	April 1988	
			Delta deuterium (per mil)	Delta oxygen-18 (per mil)
Lower aquifer--*Continued*				
7N/35W- 26L4	818	0.14	-36.0	-5.65(35)
33J2	418	2.4	-34.5	-5.45(36)
33J4	674	.21	--	--
35E1	[1]368	[1]10	-35.5	-5.65(37)
Surface-water sites				
Santa Ynez River[6] (2/29/88) . .	[1,7]410	--	-29.9	-4.95
Santa Ynez River[6] (6/87)	[1,7]1,280	--	-34.5	-5.65
Lompoc Regional Wastewater Treatment Plant[8] (6/88)	[9]1,050	--	-39.0	-5.20
Lake Cachuma[10] (6/88)	--	--	-29.0	-2.60

[1]Value represents a single sample.
[2]Dissolved-solids concentration computed from specific conductance.
[3]Sampled July 1989.
[4]Sampled pre-1987.
[5]Sampled June 1987.
[6]Sampled at Narrows gaging station (11133000).
[7]Solids residue on evaporation at 180 °C.
[8]Sampled at effluent discharge point to Santa Ynez River.
[9]Solids residue on evaporation at 180 °C. Data from operator, Lompoc Regional Wastewater Treatment Plant (written commun., 1988).
[10]Sampled at outlet works.

AREAL VARIATION IN GROUND-WATER QUALITY

The quality of ground water in the Lompoc area varied areally within individual water-bearing deposits. The distribution of dissolved solids and the chemical quality of samples from selected wells during 1987-88 are shown in figure 12 for the upper aquifer (shallow, middle, and main zones) and for the lower aquifer. Where complete chemical analyses were not available, the dissolved-solids concentrations were estimated by multiplying the specific conductance by a factor of 0.83 for the shallow zone, 0.74 for the middle zone, and 0.66 for the main zone and for the lower aquifer. These factors were determined using linear-regression techniques for samples collected by the U.S. Geological Survey in the Lompoc area.

Representative chemical analyses of ground water throughout the Lompoc area are shown pictorially in figure 12 using a method suggested by Stiff (1951). The water-quality diagrams show the general quality of the water and areal differences in chemical character of the water. Analyses with similarly shaped diagrams represent ground water of similar chemical characteristics with regard to the major ions. Changes in the width of the diagrams are approximate indications of the differences in the concentrations of dissolved constituents.

UPPER AQUIFER

Shallow Zone

Average dissolved-solids concentration during 1987-88 in the shallow zone of the upper aquifer ranged from 871 mg/L in the northwestern plain to 8,010 mg/L in the coastal area (fig. 12, table 6). In the eastern plain, in areas where there has been little, if any, history of agricultural activity, the shallow zone had dissolved-solids concentrations less than 1,000 mg/L. However, in some areas of the plain that have been irrigated, dissolved-solids concentrations were greater than 5,000 mg/L. The dissolved-solids concentrations in the shallow zone in irrigated areas commonly were more than twice those in the main zone, and several times higher than those in the lower aquifer.

In the coastal area, average dissolved-solids concentration in the shallow zone increased dramatically--to as great as 8,010 mg/L--with sodium and chloride as the major ions. Chloride to sulfate ratios were highest for samples from wells near the coast and were at least three times higher than those inland (table 9). As discussed by Hem (1985, p. 205), the ratios of selected ions may be used as indicators of seawater intrusion. Accordingly, the high sodium and chloride concentrations in the shallow zone, along with chloride to sulfate ratios, suggest that seawater has been the source of the ground-water degradation near the coast.

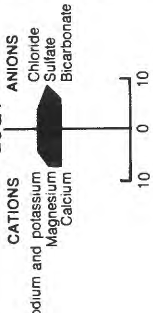
Beneath the irrigated fields, ground water from the shallow zone was characterized by high concentrations of sulfate, boron, and nitrate during 1987-88. Concentrations of sulfate generally exceeded 1,000 mg/L, and in samples from some wells were as high as 2,900 mg/L. Nitrate-nitrogen concentrations ranged from about 11 to 81 mg/L in samples from wells in the central and western plain and were as high as 130 mg/L from lysimeter 7N/35W-23Q5LYS in the unsaturated zone beneath an irrigated field in the western plain (table 9). However, the nitrate-nitrogen concentrations in samples from wells in the eastern part of the plain generally were less than 1 mg/L. Boron concentrations exceeded the recommended level of 750 μg/L for sensitive plants (Ayers and Westcott, 1976, p. 7) throughout the plain; in the western plain, boron concentrations exceeded 3,000 μg/L.

EXPLANATION FOR FIGURE 12

BOUNDARY OF LOMPOC PLAIN

SUBDIVISION BOUNDARIES OF LOMPOC PLAIN

— — 500 —?— LINE OF EQUAL DISSOLVED SOLIDS CONCENTRATION, IN MILLIGRAMS PER LITER - Dashed where approximately located; queried where doubtful. Interval variable



STIFF DIAGRAM AND WELL NUMBER - Constituents in milliequivalents per liter. Differences in configuration reflect differences in chemical character. The area of the diagram is an indication of dissolved-solids concentration. The larger the diagram, the greater the dissolved-solids concentration (Stiff, 1951)

WELL AND NUMBER - For wells without Stiff diagram, number shown at well. S indicates concentration calculated from specific conductance. P indicates pre-1987 data. J indicates data collected July 1989

22Q8 Upper aquifer

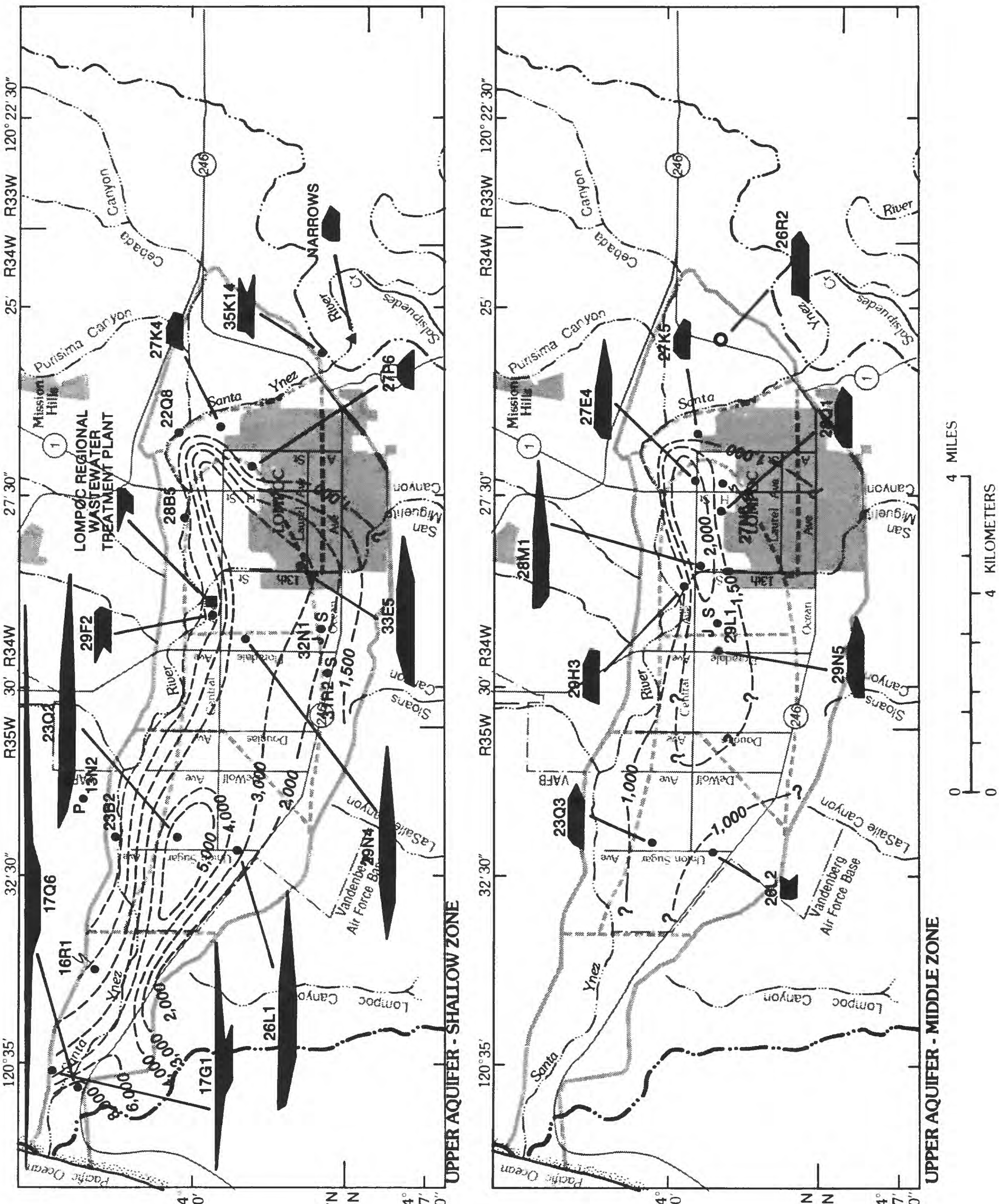
Lower aquifer

19Q2 Graciosa Coarse-Grained Member of Careaga Sand

33J2 Cebada Fine-Grained Member of Careaga Sand

20K6 Uncertain perforated interval

STREAM-GAGING STATION


UPPER AQUIFER - SHALLOW ZONE
UPPER AQUIFER - MIDDLE ZONE
LOMPOC REGIONAL WASTEWATER TREATMENT PLANT
NARROWS
Mission Hills
Purisima Canyon
Cebada Canyon
Salsipuedes Cr
Santa Ynez River
San Miguelito Canyon
Sloans Canyon
LaSalle Canyon
Lompoc Canyon
Pacific Ocean
Vandenberg Air Force Base
VAFB
LOMPOC
17G1
16R1
17Q6
23Q2
13N2
23B2
26L1
29N4
29F2
28B5
22Q8
27K4
35K14
27D6
33E5
32N1
26R2
27K5
27E4
28M1
29H3
29L1
29N5
23Q3
26L2
28Q1
2,000
3,000
4,000
5,000
6,000
8,000
1,500
1,000
120°35′
32′30″
30′
27′30″
25′
120°22′30″
R35W
R34W
R33W
T7N
T6N
34°40′
34°37′30″
0 4 MILES
0 4 KILOMETERS

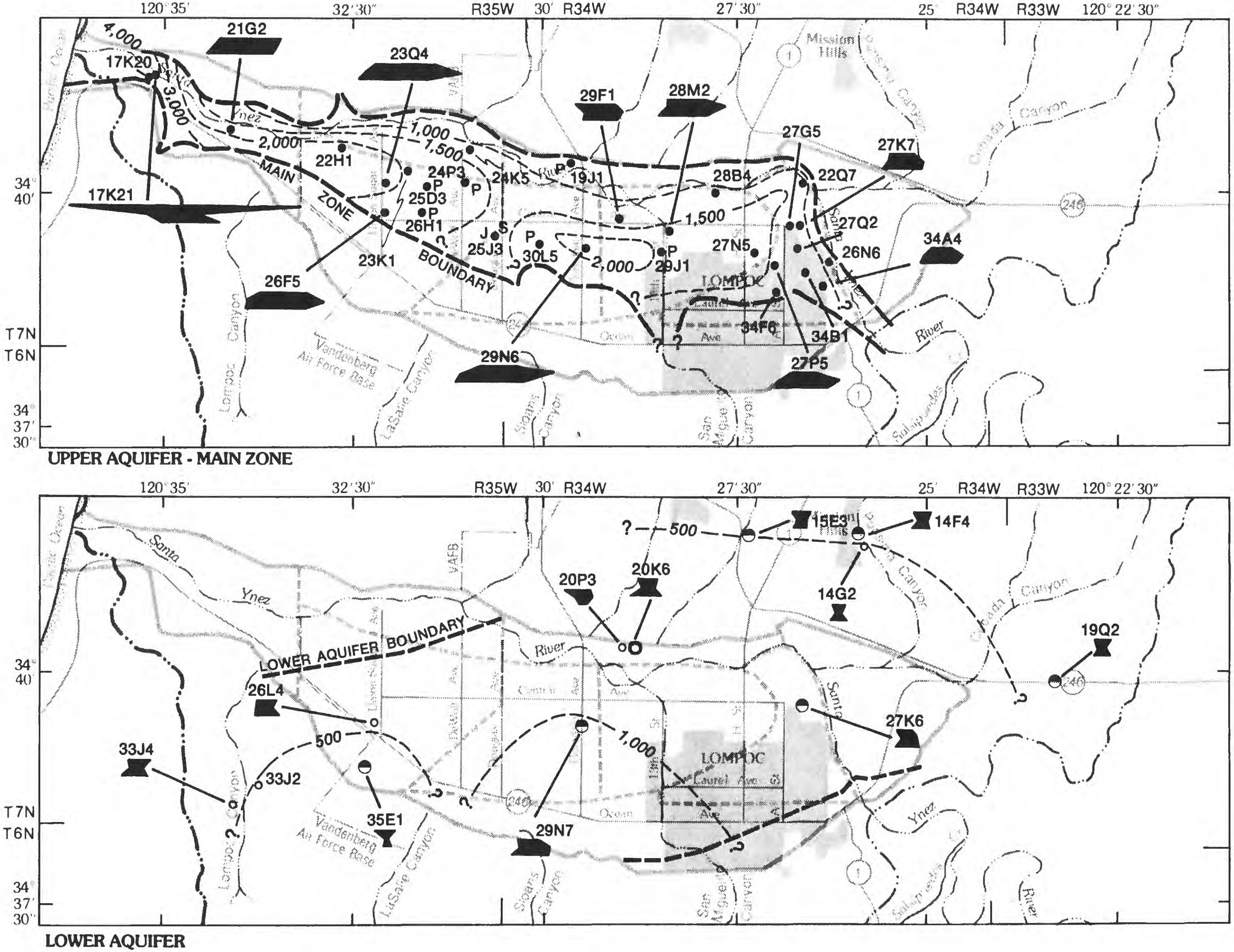


Figure 12. Distribution of dissolved solids in water samples from the Santa Ynez River (SYR) and from wells perforated in the upper (shallow, middle, and main zones) and lower aquifers, March 1987-December 1988. (See table 6 for dissolved-solids concentrations.) (See page 35 for explanation.)

Middle Zone

In some respects, the distribution of dissolved solids in the middle zone was similar to that in the shallow zone during 1987-88. The middle zone contained ground water with an average dissolved-solids concentration less than 1,000 mg/L adjacent to the Santa Ynez River in the eastern plain. Beneath the irrigated or formerly irrigated fields in the northeastern plain (fig. 12, table 6), average dissolved-solids concentration was greater than 2,000 mg/L. Unlike the shallow zone, however, the middle zone did not contain ground water of high dissolved-solids concentration beneath the irrigated fields in the western plain. For example, the average dissolved-solids concentration in a sample from well 7N/35W-26L2 in the western plain was only 646 mg/L. The source of the water of low dissolved-solids concentration in this area probably was underflow from the terrace deposits and Orcutt Sand, which are contiguous to the middle zone on the southern edge of the plain.

The source of the high dissolved-solids concentrations in the middle zone in the northeastern plain was downward leakage from the shallow zone. In the eastern plain, the silt and clay layers of the shallow zone are less extensive than in the western plain and water moved freely between the zones. As the ground water of high dissolved-solids concentration in the northeastern plain moved downgradient beneath the western plain, it was diluted by the water that contained low concentrations of dissolved solids from the southern edge of the plain. The presence of water of low dissolved-solids concentration in the middle zone indicates that little, if any, of the water of high dissolved-solids concentration from the shallow zone recharged the underlying middle zone in the western plain. The lack of leakage from the shallow zone to the middle zone was the result of extensive silt and clay layers in the shallow zone that restrict downward leakage in the western plain.

Main Zone

The average dissolved-solids concentration in the main zone ranged from about 718 mg/L in the eastern plain near the Santa Ynez River to more than 4,500 mg/L in the coastal area during 1987-88 (fig. 12, table 6). Throughout most of the plain, dissolved-solids concentration ranged from 1,500 to 2,000 mg/L. Sulfate was usually the dominant anion, and calcium and magnesium were usually the dominant cations. As in the shallow and middle zones, dissolved-solids concentrations increased west and south of the Santa Ynez River in the northeastern plain. However, unlike the middle zone (in which dissolved solids decreased in the western plain), dissolved-solids concentrations in the main zone were high throughout the plain--exceeding concentrations in the overlying middle zone throughout the western plain.

Nitrate-nitrogen concentrations in the main zone generally were less than 1 mg/L (table 6). The lack of nitrate-nitrogen in the main zone suggests that leakage of water with high dissolved-solids concentration from the shallow zone occurred only in the eastern plain, where nitrate-nitrogen concentrations in the shallow zone also were minimal. As stated earlier, the presence of water of low dissolved-solids concentration in the middle zone beneath the western plain during 1987-88 also indicates insignificant downward migration of water from the shallow zone.

West of Union Sugar Avenue in the western plain, the average dissolved-solids concentration in the main zone generally exceeded 2,000 mg/L. The increase in dissolved solids was due almost entirely to increases in sodium and chloride concentrations. Evenson (1964) suggested that upward migration of ground water through fractures within the underlying consolidated rocks was responsible for the increase in dissolved solids in this part of the basin (see fig. 14 in "Distribution of Stable Isotopes and Dissolved Solids"). In the coastal area, where dissolved-solids concentrations exceeded 4,500 mg/L, the predominant ions were sodium and chloride. As in the shallow zone, the high concentrations of sodium and chloride, along with high chloride to sulfate ratios, suggest that seawater has been the source of the ground-water degradation.

LOWER AQUIFER

In general, ground water in the lower aquifer has significantly lower dissolved-solids concentrations than water in the upper aquifer. Beneath the Lompoc upland, ground water in the lower aquifer contained dissolved-solids concentrations of approximately 500 mg/L during 1987-88. The primary source of recharge to the lower aquifer in the uplands has been the direct infiltration of precipitation, which accounts for the relatively low dissolved-solids concentrations. The water-quality diagrams in figure 12 also illustrate the relatively low percentage of sulfate in the lower aquifer in comparison with the upper aquifer. The low sulfate concentrations and the odor of hydrogen sulfide that was evident when many of the wells in the lower aquifer were pumped suggest that sulfate reduction may have been occurring within this aquifer (Hem, 1985, p. 117).

Average dissolved-solids concentration in sparse samples from the lower aquifer beneath the Lompoc plain was 655 mg/L in the eastern plain, 818 mg/L in the southern part of the western plain, and 1,019 mg/L in the central plain. Water-level data (fig. 10) indicate that ground-water flow was upward from the lower aquifer to the main zone beneath the Lompoc plain. Therefore, it is unlikely that downward migration of ground water from the main zone was the source of the increased dissolved-solids concentrations toward the central plain. Potentiometric contours for the lower aquifer (fig. 9) indicate that ground-water movement beneath the southern, western, and central parts of the plain was from the southern edge of the plain to the north. This suggests that runoff from the Santa Ynez Mountains has been a major source of recharge to the lower aquifer beneath the plain.

Streams that drain the Santa Ynez Mountains frequently had dissolved-solids concentrations in excess of 1,000 mg/L (table 10, at back of report). This supports the suggestion that the infiltration of streamflow from the mountains to the south was a probable source of the higher dissolved-solids concentrations in the lower aquifer beneath the plain. In addition, the shallow zone directly overlies the lower aquifer along the southern edge of the plain (see fig. 14 in "Distribution of Stable Isotopes and Dissolved Solids"). Thus, downward migration of ground water of high dissolved-solids concentration from the shallow zone in this area also may have been a source of the higher dissolved-solids concentrations in the ground water of the lower aquifer beneath the plain.

Dissolved-solids concentrations in samples from the lower aquifer beneath the Lompoc terrace ranged from 368 mg/L near the eastern edge of the terrace to 674 mg/L near Lompoc Canyon. The sample from well 7N/35W-35E1 had the lowest dissolved-solids concentration; this well was perforated in the Orcutt Sand, which forms part of the lower aquifer (table 1). Infiltration of precipitation probably was the source of the water of low dissolved-solids concentration. Well 7N/35W-33J4 yielded the sample with the highest dissolved-solids concentration; it was perforated in the Careaga Sand. The higher dissolved-solids concentration from the Lompoc Canyon area suggests that this water probably was a mixture formed by infiltration of precipitation and infiltration of runoff from the Santa Ynez Mountains to the south.

VERTICAL VARIATION IN GROUND-WATER QUALITY

Comparison of dissolved-solids and stable-isotope concentrations along selected geohydrologic cross sections of the Lompoc area help to explain the vertical variations in chemical quality. Used alone, dissolved-solids or stable-isotope concentrations may not provide a unique explanation of the observed vertical variation in chemical quality. However, when the two are used together, along with hydrologic data presented in earlier sections of this report, the variation in chemical quality can be reasonably explained. A brief description of stable-isotope chemistry is included in the following paragraphs.

STABLE-ISOTOPE CHEMISTRY

The ratios of isotopes of oxygen (oxygen-18 [^{18}O] : oxygen-16 [^{16}O]) and hydrogen (deuterium, D[^{2}H] : hydrogen [^{1}H]) in ground water are indicators of its hydrologic history. The isotope ratios are expressed in delta notations (δ) as per mil (parts per thousand [‰]) differences relative to a standard known as standard mean ocean water:

$$\delta^{18}O = \frac{(^{18}O/^{16}O)\text{sample} - (^{18}O/^{16}0)\text{standard}}{(^{18}O/^{16}O)\text{standard}} \times 1{,}000, \text{ and} \quad (1)$$

$$\delta D = \frac{(^{2}H/^{1}H)\text{sample} - (^{2}H/^{1}H)\text{standard}}{(^{2}H/^{1}H)\text{standard}} \times 1{,}000. \quad (2)$$

Craig (1961) found that a linear relation existed between δD and $\delta^{18}O$ in meteoric waters throughout the world. This relation is referred to as the global meteoric water line (see fig. 13).

The isotopic composition of seawater is nearly constant, but it undergoes isotopic fractionation during transfer from the ocean surface to the vapor phase. Further fractionation occurs as water vapor condenses from the atmosphere, leaving the remaining vapor relatively depleted in the heavier isotopes (oxygen-18 and deuterium). Thus, the last rain that falls from a vapor mass as it moves inland will be isotopically

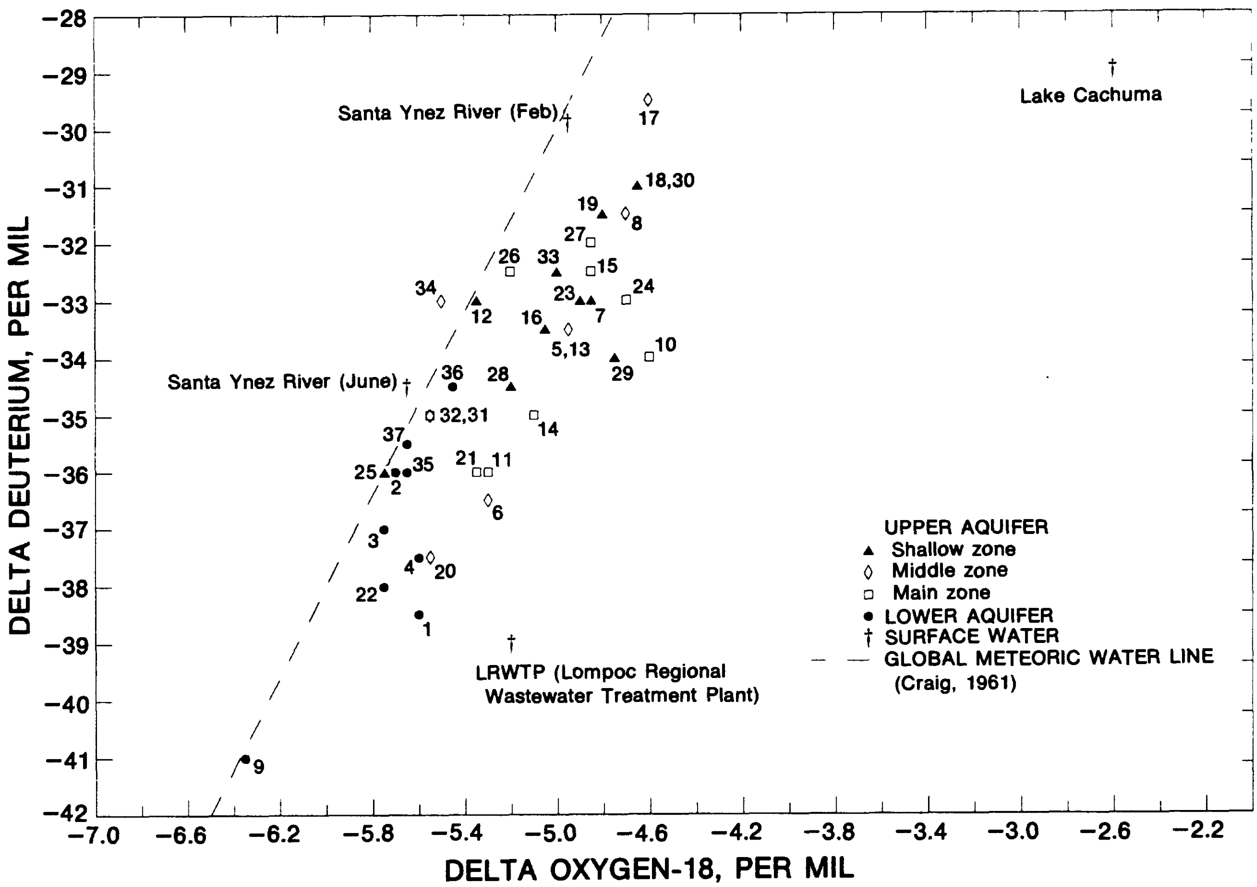


Figure 13. Relation between delta deuterium and delta oxygen-18 values for samples from selected wells and surface-water sites. (Sample-identification numbers at data points correspond to numbers in delta oxygen-18 column in table 6.)

lighter than the first rain that falls. Isotopic fractionation is dependent on air temperature as well as distance from the ocean. The net result is that precipitation from a given storm becomes isotopically lighter as the storm moves inland, and precipitation that forms at lower temperatures is also lighter than precipitation that forms at higher temperatures (Fournier and Thompson, 1980, p. 3).

Evaporation also causes isotopic fractionation. When water is evaporated, the lighter isotopes of oxygen and hydrogen are preferentially partitioned into the vapor phase, causing the remaining water to be isotopically heavier. Further change to the isotopic composition does not occur at the low temperatures of most ground-water systems after the recharge water has migrated below the depth at which evaporation occurs. Therefore, any subsequent changes in the isotopic composition of ground water along a flow line generally reflect only the mixing within the aquifer system or concentration by evaporation in a discharge area.

DISTRIBUTION OF STABLE ISOTOPES AND DISSOLVED SOLIDS

Results of water analyses for oxygen and hydrogen isotopes are plotted graphically in figure 13. Generalized geohydrologic sections showing the distribution of dissolved-solids concentration and $\delta^{18}O$ values are shown in figure 14. As shown in both figures, samples from the upper aquifer were enriched in oxygen-18 (values are less negative) in comparison with samples from the lower aquifer. The isotopic data for samples from the upper aquifer are shifted slightly to the right of the global meteoric water line (fig. 13), indicating some evaporation of the recharge water prior to infiltration into water-bearing deposits. Most of the samples from the upper aquifer were from wells in or near irrigated fields (fig. 14).

Dissolved-solids concentrations in samples from the shallow zone of the upper aquifer increased from less than 1,000 mg/L in the eastern plain near the Santa Ynez River to more than 5,000 mg/L in the western plain (fig. 14, section *F-F'*). Although the dissolved-solids concentrations increased dramatically, the $\delta^{18}O$ values remained about the same throughout most of the plain. This suggests that the high concentrations of dissolved solids in the ground water of the shallow zone were a result of mixing as opposed to evaporation. Therefore, the higher concentrations of dissolved solids in the western plain must have been the result of accumulation of salts from upgradient irrigated fields, and (or) the dissolution of soluble salts in the shallow zone. If recycling and evaporation were the cause of the high dissolved-solids concentration, the $\delta^{18}O$ values of the water of high dissolved-solids concentration would have been significantly heavier (less negative) than the $\delta^{18}O$ values of the water of low dissolved-solids concentration.

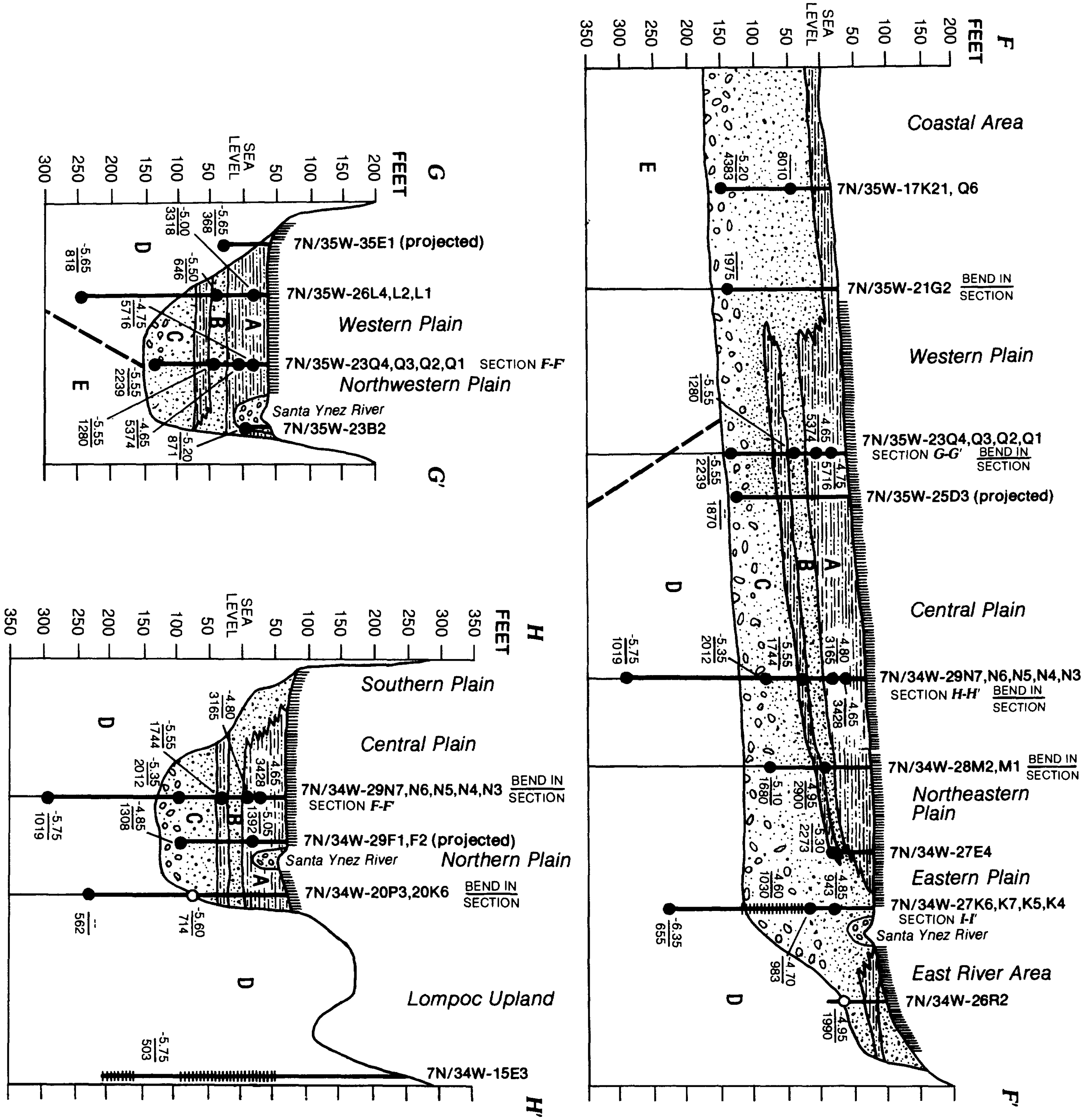
Ground water of high dissolved-solids concentration from the shallow zone leaked to the middle zone beneath the northeastern plain as indicated by high dissolved-solids concentrations in samples from wells 7N/34W-28M1 and 27E4 (fig. 14, section *F-F'*). This water of high dissolved-solids concentration continued to move downward and degrade the quality of the main zone between wells 7N/34W-27K7 and 29N6 (fig. 14, section *F-F'*). Ground water sampled from well 7N/34W-29N6 had an average dissolved-solids concentration of 2,012 mg/L. West of well 7N/34W-29N6 and east of well 7N/35W-23Q4, little if any leakage occurred from the overlying shallow zone, as indicated by relatively constant dissolved-solids concentrations and $\delta^{18}O$ values in the underlying water-bearing zones beneath the western plain.

The main zone overlies the lower aquifer throughout the eastern and central parts of the Lompoc plain (see fig. 14). Upward leakage from the lower aquifer beneath the central plain and lateral movement along the southern and northern margins of the plain contributed significant quantities of water to the main zone. Production wells in the main zone between wells 7N/34W-29N6 and 7N/35W-23Q4 yielded water with an average dissolved-solids concentration of about 1,800 mg/L (fig. 12). This decrease in dissolved solids was the result of leakage of water of low dissolved-solids concentration from the lower aquifer. The increase in dissolved solids in samples from well 7N/35W-23Q4 in the western plain (fig. 14, section *F-F'*) probably was the result of upward migration of water of high dissolved-solids concentration from underlying consolidated rocks. Sparse chemical analyses indicate that dissolved-solids concentrations of water in the consolidated rocks were approximately 11,000 mg/L (D.A. Cole, Unocal Corporation, written commun., 1989). As shown in figure 14 (section *F-F'*), the consolidated rocks directly underlie the main zone in the western Lompoc plain.

At the eastern edge of the coastal area, concentrations of dissolved solids in the main zone were lower in samples from well 7N/35W-21G2 than in samples from well 7N/35W-23Q4 in the western plain (fig. 14, section *F-F'*). Less clay and silt in the shallow zone at well 7N/35W-21G2 has probably allowed free interchange of water between the shallow, middle, and main zones in this area, similar to the northwestern plain (Upson and Thomasson, 1951, p. 146). Also, average dissolved-solids concentrations (fig. 12) indicate that the eastern edge of the coastal area probably received recharge from the Santa Ynez River. Thus, recharge from the Santa Ynez River in this region apparently diluted the water entering the main zone through seepage from the underlying consolidated rocks.

Water of extremely high dissolved-solids concentration in consolidated rocks has a high proportion of sodium and chloride ions and is almost completely depleted in sulfate, thus indicating reducing conditions. The influence of this water entering the main zone in the western plain was manifested by increases in the dissolved-solids concentrations, due primarily to increases in sodium and chloride (table 6). In the western plain, the main zone directly overlies the consolidated rocks (fig. 14, section *F-F'*). Pictorially, the water-quality diagrams in figure 12 indicate an increase in sodium and chloride concentrations but virtually no change in sulfate concentration. Simple mixing of dissolved constituents indicates that less than 3 percent of the water from consolidated rocks (containing 11,000 mg/L dissolved solids) was needed to increase the dissolved-solids concentration of the water in the main zone to the concentrations in this area during 1987-88.

At the western edge of the coastal area, average dissolved-solids concentration exceeded 8,000 mg/L in the shallow zone and 4,300 mg/L in the main zone. Oxygen-18 isotope data indicate that water from the main zone was heavier (less negative) near the coast than in the western plain. This suggests that isotopically heavier seawater or irrigation-return water in



F
F'
G
G'
H
H'
FEET
SEA LEVEL
Coastal Area
Western Plain
Central Plain
Northeastern Plain
Eastern Plain
East River Area
Northwestern Plain
Southern Plain
Northern Plain
Lompoc Upland
Santa Ynez River
7N/35W-17K21, Q6
7N/35W-21G2
7N/35W-23Q4,Q3,Q2,Q1
7N/35W-25D3 (projected)
7N/34W-29N7,N6,N5,N4,N3
7N/34W-28M2,M1
7N/34W-27E4
7N/34W-27K6,K7,K5,K4
7N/34W-26R2
7N/35W-35E1 (projected)
7N/35W-26L4,L2,L1
7N/35W-23B2
7N/34W-29F1,F2 (projected)
7N/34W-20P3,20K6
7N/34W-15E3
BEND IN SECTION
SECTION G-G'
SECTION H-H'
SECTION I-I'
SECTION F-F'

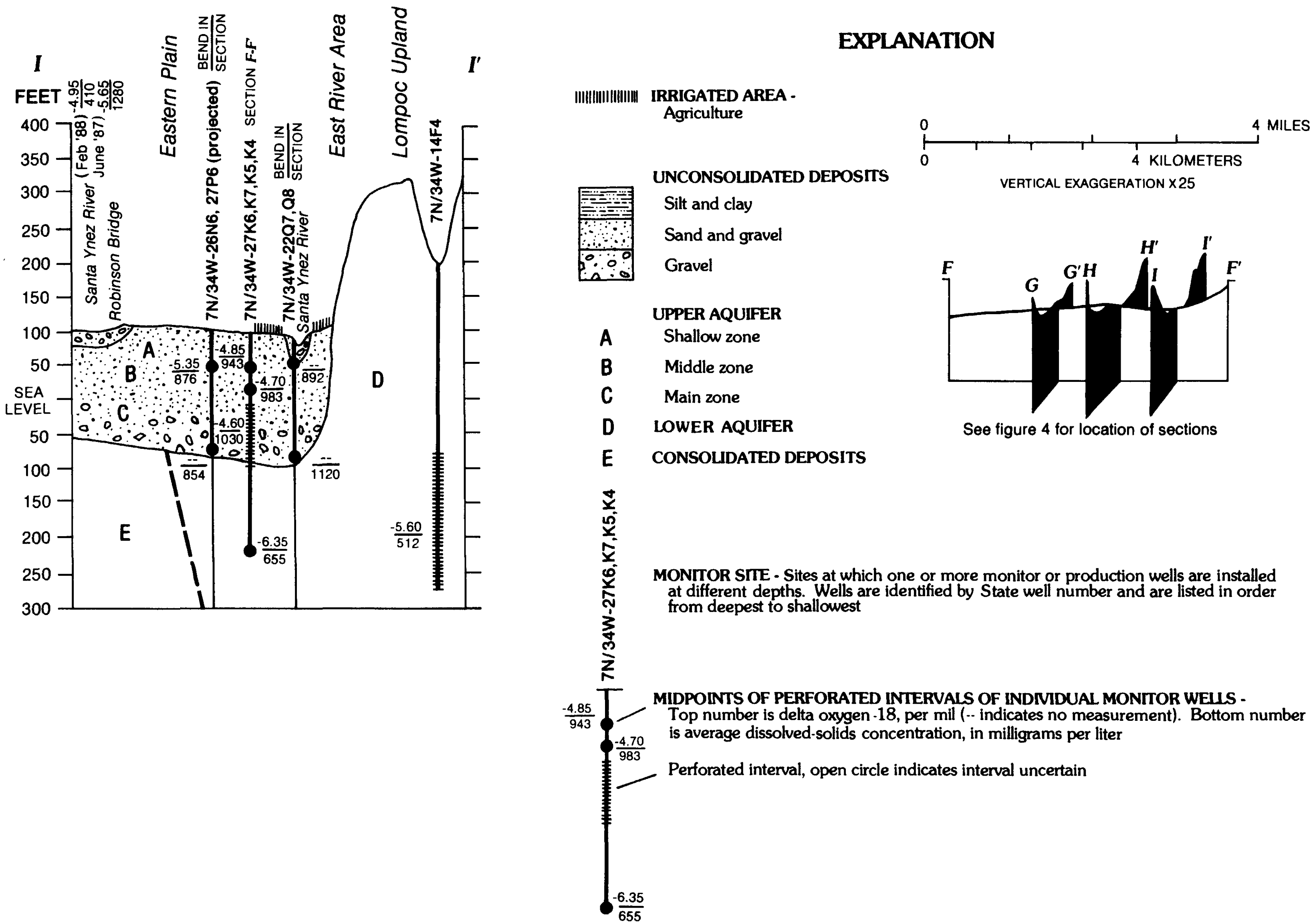


Figure 14. Generalized geohydrologic sections showing distribution of delta oxygen-18 and dissolved-solids concentration for selected monitor wells, 1987-88. (Location of sections is shown in figure 4.)

the shallow zone, rather than the isotopically lighter (more negative) water from the underlying consolidated rocks, affected the chemical quality of water in the shallow and main zones. Water from both zones was dominated by sodium and chloride in concentrations greater than those found in samples from the shallow zone beneath irrigated fields, which further suggests that seawater was the source of the high dissolved-solids concentration. Lateral migration of seawater into the upper aquifer was unlikely because hydraulic head in the shallow and main zones (fig. 9) were significantly above sea level and thus the direction of ground-water movement was toward the Pacific Ocean. However, vertical migration of seawater from the overlying estuary was possible because the silt and clay layers of the shallow zone are relatively thin near the coast (fig. 14), and the difference in hydraulic head between zones indicates that water could have moved downward from the shallow zone to the main zone (fig. 9).

SEASONAL CHANGES

Wells in the monitoring network were sampled several times during 1987-88 to determine seasonal changes in the chemical quality of ground water. Most of the sampling was concentrated at four cluster sites (sites at which three or more monitor wells were installed at different depths) (fig. 8). Dissolved-solids concentrations from the cluster sites in the central plain are shown in figure 15.

Dissolved-solids concentration in water from the middle and main zones of the upper aquifer and from the lower aquifer did not change significantly at any of the cluster sites. However, as shown in figure 15, changes in the dissolved-solids concentration were significant in the shallow zone. These changes were believed to be the result of irrigation and planting practices on cultivated fields adjacent to the cluster sites. Additional water-quality data would need to be collected to determine if these changes were cyclic or if they were part of a long-term trend.

LONG-TERM CHANGES

Upper Aquifer

Shallow zone--Long-term water-quality data were scarce for the shallow zone because few wells have been perforated solely within this zone. However, available data indicate that prior to irrigated farming, the water quality of the shallow zone in the eastern plain probably was similar to that of the main zone

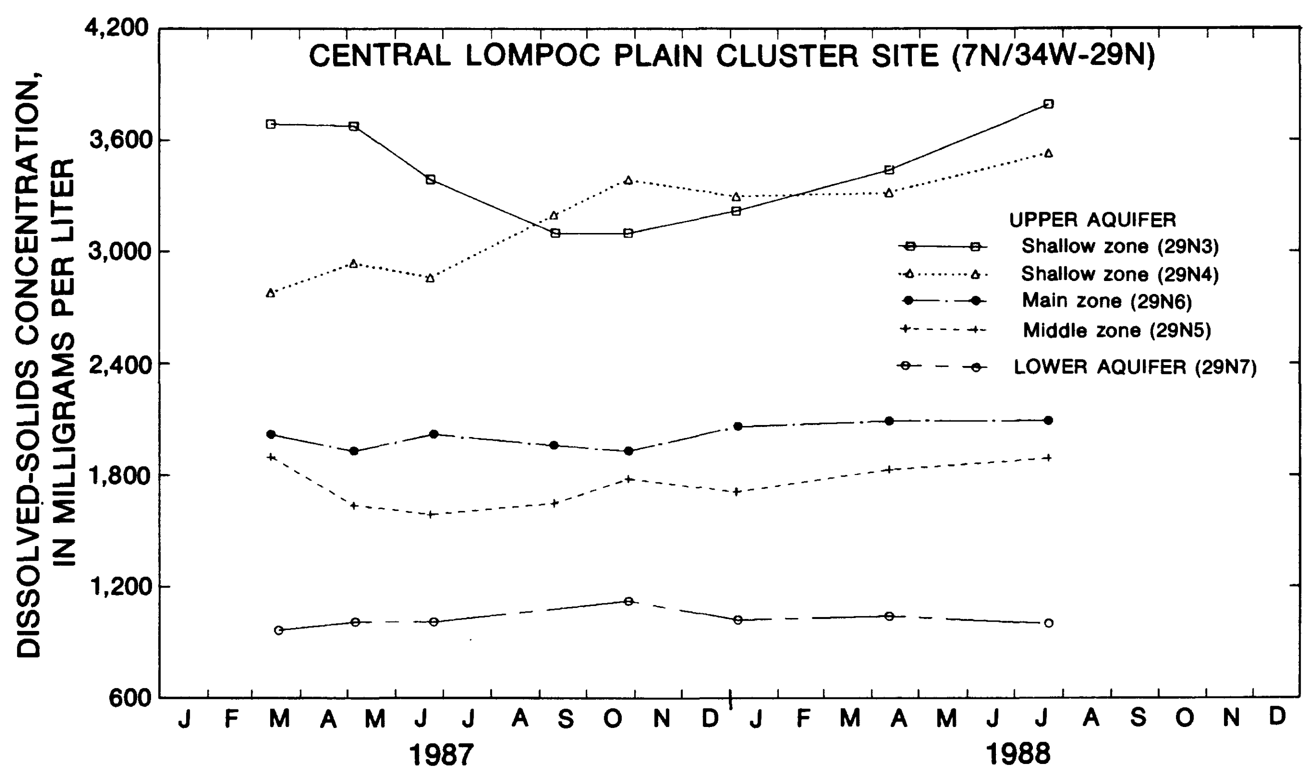


Figure 15. Dissolved-solids concentration of samples from wells at the central Lompoc plain cluster site. (See figure 8 for location of wells.)

(Miller, 1976, p. 65). Miller (1976, p. 65) reported that four samples collected in 1935 from the shallow zone in the eastern plain contained from 860 to 1,350 mg/L of dissolved solids. Ground-water samples collected from the shallow zone in the eastern plain during this study indicate that average dissolved-solids concentration was about 950 mg/L (fig. 12). In the northeastern plain, the concentration of dissolved-solids in the shallow zone prior to irrigated farming also was similar to concentrations measured in 1988, although markedly higher than in the eastern plain. A ground-water sample collected in 1941 from well 7N/34W-28F1 in the northeastern plain had a specific conductance (which provides an indication of ionic concentration) of 5,620 μS/cm (microsiemens per centimeter at 25 °C) compared to an average specific conductance of 4,200 μS/cm for samples collected in 1987-88.

Available data from the shallow zone in the central plain, however, indicate a significant increase in dissolved solids from 1948 to 1988. A sample collected in 1948 from well 7N/34W-31C3 in the central plain had a specific conductance of 1,700 μS/cm. Samples from this same area in 1988 had specific conductance values greater than 4,400 μS/cm, indicating more than a twofold increase in dissolved solids between 1948 and 1988.

Historical data from the western plain indicate that the shallow zone in this area contained poor-quality ground water prior to significant irrigated farming. A sample collected in 1943 from well 7N/35W-23J3 had a specific conductance of 4,530 μS/cm. A possible explanation for the poor-quality ground water prior to significant irrigated farming is that this part of the plain formerly was a marshland. Water discharging to the marshland resulted in the evaporation and accumulation of salts in the fine-grained deposits of the shallow zone. Samples collected during this study, however, indicate that the quality of water in the shallow zone has continued to deteriorate from 1943 to 1988. Samples taken from wells 7N/35W-23Q1 and 7N/35W-23Q2 in 1987-88 had specific-conductance values and dissolved-solids concentrations in excess of 6,000 μS/cm and 5,200 mg/L, respectively. In the western plain, the most likely sources of the continued water-quality degradation in the shallow zone were irrigation-return flow that has been enriched with dissolved solids by evaporation, dissolution of soluble salts (Miller, 1976, p. 65), and accumulation of salts from upgradient fields.

Middle zone.--All but one of the wells perforated in the middle zone that were sampled for chemical analysis in 1987-88 were drilled by the U.S. Geological Survey. Historical water-quality data for the middle zone generally were not available. Relatively low dissolved-solids concentrations during 1987-88 suggest that only slight changes have occurred in the water quality of the middle zone in most areas. However, in the northeastern plain, dissolved-solids concentrations were considerably higher; the higher concentrations suggest that leaching of water from the shallow zone probably had degraded the water quality of the middle zone.

Main zone.--Because of the dependence on the main zone as a source for irrigation water, water-quality data have been collected over a long period of time at several locations on the Lompoc plain. Graphs of changes in dissolved-solids concentration with time are shown in figure 16. The graphs include data from more than one well at a particular location in the Lompoc area. The inclusion of data from adjacent wells that were perforated in the same zone enables the presentation of a longer, more complete history of each area.

Dissolved-solids concentrations of samples from the city of Lompoc municipal supply wells closest to the Santa Ynez River (7N/34W-27Q2, 34A4, and 34B1) had increased only slightly since the wells were first sampled in the early to mid-1960's (fig. 16*A*). Concentrations of dissolved solids in samples from these wells were about 1,000 mg/L in 1987-88 and probably reflected the average of the dissolved-solids concentrations of the Santa Ynez River during low flows (800 to 1,300 mg/L) and high flows (350 to 800 mg/L) (fig. 17). (Flows with discharges greater than 100 ft^3/s were considered here to be high flows.) Chemical analyses of water from wells indicate that dissolved-solids concentration in the eastern plain increased from about 900 mg/L in 1935 (well 7N/34W-27E1 in fig. 16*A*) to almost 1,500 mg/L in 1988. This increase in dissolved-solids concentration might have been partly a result of the construction of Bradbury Dam to form Lake Cachuma in 1953. As shown in figure 7, the frequency of high flows (equal to or greater than 100 ft^3/s or 72,400 acre-ft/yr) measured at the Santa Ynez River near the Narrows decreased from about 22 percent prior to 1953 to less than 10 percent since the construction of Bradbury Dam. Figure 17 shows that the concentration of dissolved solids in river-water samples collected during 1978-88 was inversely related to discharge in the Santa Ynez River. Because the regulation of the Santa Ynez River has decreased the frequency of high flows, the average dissolved-solids concentration in the water that recharged the main zone from this source undoubtedly has increased. However, surface-water-quality data prior to 1978 were not available to substantiate this assumption.

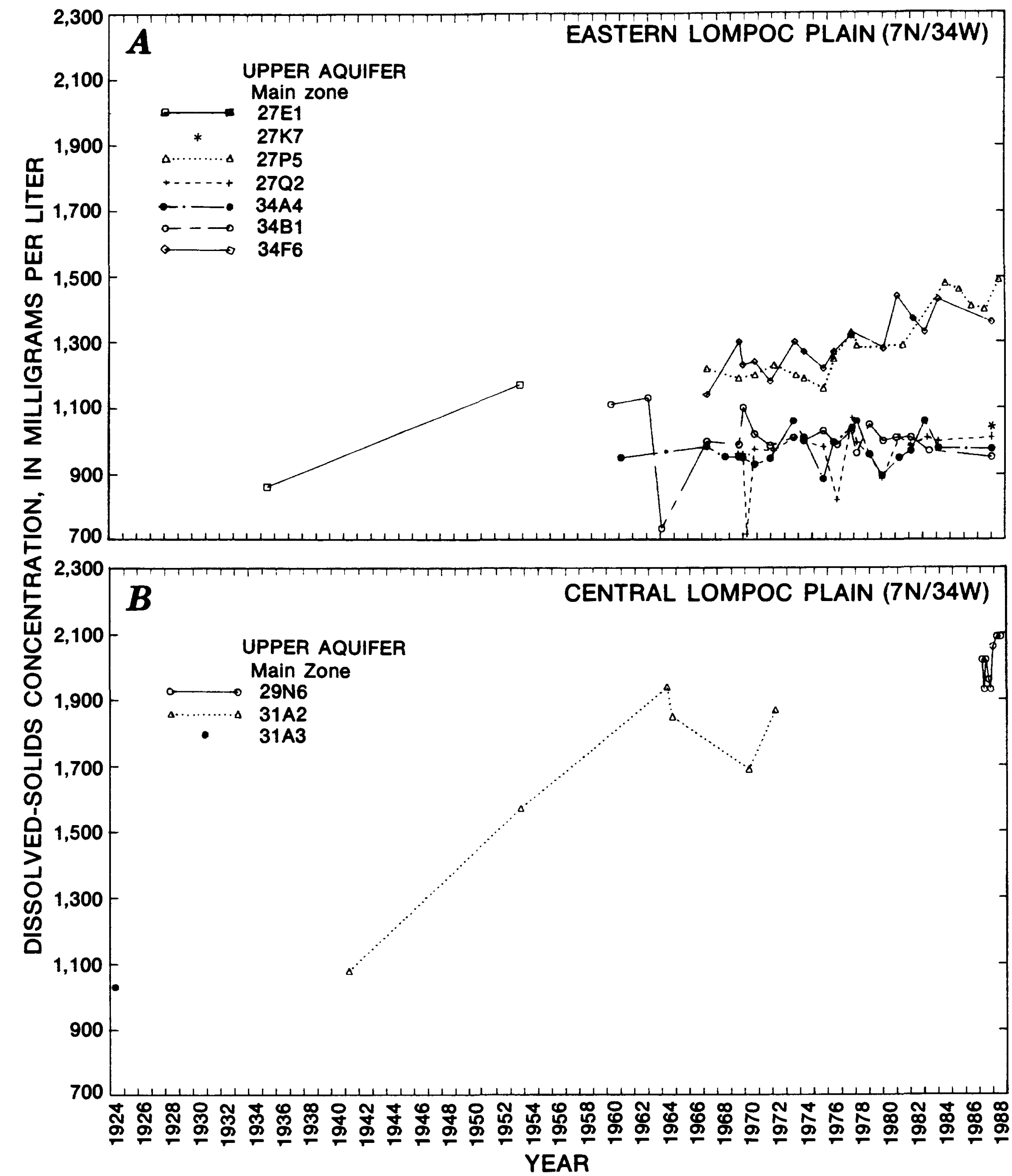


Figure 16. Dissolved-solids concentration of samples from selected wells, 1924-88. (See figure 8 for location of wells.)

Samples from the municipal supply wells farthest from the Santa Ynez River (wells 7N/34W-27P5 and 34F6) indicate an increase of almost 300 mg/L in dissolved-solids concentration from the early 1960's to 1988. Ground-water movement in the shallow and main zones in 1988 (fig. 9) indicate that the cone of depression created by the city of Lompoc municipal supply wells induced the migration of water containing high concentrations of dissolved solids from the northeastern plain (fig. 12) toward the municipal supply wells. This migration probably caused the trend of deteriorating water quality observed in the northern municipal supply wells.

Dissolved-solids concentration increased dramatically in the main zone in the central and western plain from the late 1950's to the early 1960's (fig. 16*B*, 16*C*). In both areas, dissolved-solids concentration increased from less than 1,000 mg/L to greater than 2,000 mg/L. Since the 1960's, there has been

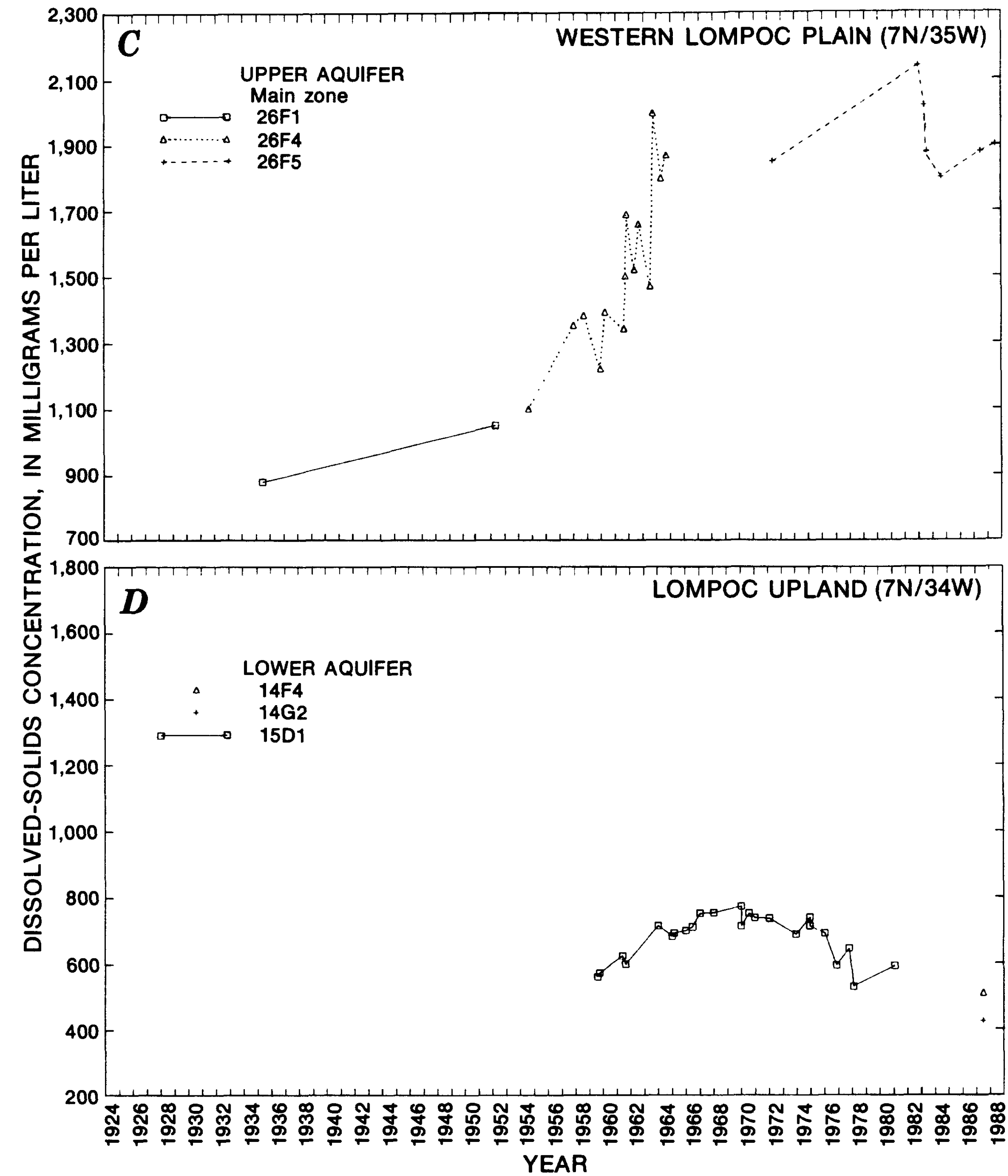


Figure 16. Continued.

only a slight increase in dissolved-solids concentration. Comparison of a dissolved-solids concentration map prepared by Miller (1976, p. 46) for the main zone in 1972 with the map presented in this report for 1987-88 data (fig. 12) indicates that the maps are almost identical over the western two-thirds of the Lompoc plain.

Dissolved-solids concentrations increased in the late 1950's in the central plain, and to a lesser degree in the western plain, because irrigation and municipal pumping in the eastern plain intercepted a large percentage of the recharge from the Santa Ynez River. Consequently, leakage of water of high dissolved-solids concentration from the shallow zone in the eastern plain, where the silt and clay layers are less extensive, became a significant source of recharge to the main zone in the western two-thirds of the Lompoc plain. Dissolved-solids concentrations have remained relatively unchanged since the 1960's because pumpage from the Lompoc plain has been relatively constant since the late 1950's (fig. 6). Therefore, the chemical quality of the main zone appears to have reached a steady-state condition.

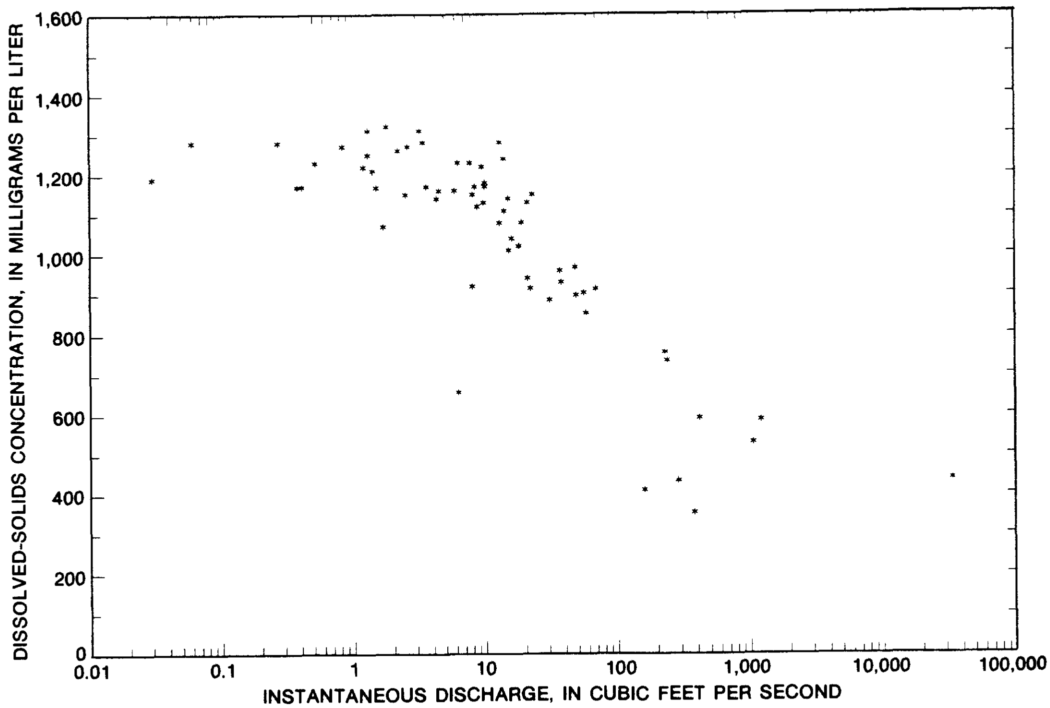


Figure 17. Instantaneous discharge and dissolved-solids concentration, Santa Ynez River at Narrows, near Lompoc (station 11133000), 1978-88). (Dissolved-solids concentration calculated from solids residue on evaporation at 180 degrees Celsius.)

Lower Aquifer

Available water-quality data for the lower aquifer in the Lompoc upland indicate that dissolved-solids concentrations have not changed significantly since the early 1960's (fig. 16*D*). This would be expected because there has been no change in the source of recharge for this area and because variation in water quality from precipitation has been negligible. Although no historical data were available for the lower aquifer beneath the plain, it is probable that there has been little change in the ground-water quality.

CONCLUSIONS

Ground water historically has been the main source for agricultural, municipal, and military water supply in the Lompoc area of the Santa Ynez River basin. Previous studies have concluded that the quality of ground water has been degraded to levels that do not meet water-quality standards recommended by the U.S. Environmental Protection Agency. These studies suggest that recharge by irrigation water is the principal cause of the deterioration. As the demand for ground water in the Lompoc area has increased, State and local regulatory agencies and water users have realized a need to reverse the trend of continued deterioration of ground-water quality. This report describes the ground-water hydrology and quality of the Lompoc area and evaluates possible sources for ground-water quality degradation in the Lompoc plain.

The Lompoc area is on the west coast of Santa Barbara County and includes the Lompoc plain, the Lompoc terrace, and the Lompoc upland. The Lompoc plain, terrace, and upland are bordered on the north by the Purisima Hills, on the east by the Santa Rita Hills, on the south by the foothills of the Santa Ynez Mountains, and on the west by the Pacific Ocean. Two principal aquifers comprise the ground-water system in the Lompoc area. The upper aquifer contains the shallow, middle, and main zones. The main zone is the principal water-bearing unit in the Lompoc plain. The lower aquifer is the principal water-bearing unit in the Lompoc upland and Lompoc terrace.

The main zone of the upper aquifer was confined or partly confined in the central and western plains by fine-grained deposits of low permeability in the overlying shallow and middle zones. Downward leakage of ground water from the shallow and middle zones was limited by these fine deposits. In the eastern plain, near the Santa Ynez River, and in the northwestern plain, the fine deposits are less continuous or absent; as a result, ground water moved freely between the shallow, middle, and main zones. In the southern plain, the main zone itself is absent, and the fine deposits in the shallow and middle zones are also less continuous or absent. Thus, ground water moved freely between the shallow and middle zones of the upper aquifer and the lower aquifer in the southern plain.

Beneath the irrigated or formerly irrigated fields in the northeastern plain, average dissolved-solids concentration was greater than 2,000 mg/L. The source of the high dissolved-solids concentrations in the middle zone in the northeastern plain was downward leakage from the shallow zone. In this area, silt and clay deposits in the shallow and middle zones are less extensive than in the central and western plain, and water moved more freely between the zones. As the ground water of high dissolved-solids concentration in the northeastern plain moved downgradient beneath the central and western plain, it was diluted by the water containing low concentrations of dissolved solids from the southern edge of the plain. The presence of water of low dissolved-solids concentration in the middle zone indicated that little, if any, of the water of high dissolved-solids concentration from the shallow zone recharged the middle zone in the western plain.

Dissolved-solids concentrations in the main zone beneath the eastern plain, near the Santa Ynez River, increased only slightly from the early 1960's to 1988. Concentrations of dissolved solids in this area were about 1,000 mg/L in 1988 and probably reflected the average dissolved-solids concentration of the Santa Ynez River during low flows (800 to 1,300 mg/L) and high flows (350 to 800 mg/L).

Dissolved-solids concentrations in the main zone beneath the eastern plain, near the northeastern plain boundary, increased from about 1,000 mg/L in the early 1960's to about 1,500 mg/L in 1988. A cone of depression created by municipal pumping from the main zone in the eastern plain has induced the migration of water containing high concentrations of dissolved solids from the middle zone in the northeastern plain toward the municipal supply wells. This migration probably has caused the deterioration of water quality in this area. Also, this increase in dissolved-solids concentration might be partly a result of the construction of Bradbury Dam to form Lake Cachuma in 1953. Since the completion of the dam, the regulation of discharge in the Santa Ynez River has reduced the frequency of high flows that contained lower dissolved-solids concentrations (350 to 800 mg/L). Consequently, the average dissolved-solids concentration in the water that recharged the main zone from this source has increased.

Dissolved-solids concentrations increased in the main zone in the central and western plains from the late 1950's to the early 1960's. In both areas, dissolved-solids concentrations increased from less than 1,000 mg/L to greater than 2,100 mg/L. These concentrations increased in the central plain, and to a lesser degree in the western plain, because irrigation and municipal pumping in the eastern plain during the late 1950's intercepted a large percentage of the recharge from the Santa Ynez River. Consequently, leakage of water of high dissolved-solids concentration from the shallow and middle zones in the northeastern plain became a significant source of recharge to the main zone in the western two-thirds of the Lompoc plain. Dissolved-solids concentrations have remained relatively unchanged from the 1960's to 1988 because pumpage from the Lompoc plain has been relatively constant since the late 1950's. Therefore, the chemical quality of the main zone in the central and western plain appears to have reached a steady-state condition.

During 1988, the dissolved-solids concentration in the main zone was diluted by as much as 300 mg/L by upward leakage of water of lower dissolved-solids concentration from the underlying lower aquifer near the boundary of the central and western plain. Near the boundary of the western plain and coastal area, the lower aquifer is less continuous or absent, and the main zone overlies consolidated rocks that contained water of high dissolved solids concentrations (greater than 11,000 mg/L). The increase in dissolved solids in this area probably was the result of upward migration of water from the underlying consolidated rocks.

In the western part of the coastal area, dissolved-solids concentrations exceeded 4,000 mg/L in the main zone in 1988. Water-quality and water-level data indicate that downward leakage of seawater from the overlying estuary, rather than lateral migration of seawater from the Pacific Ocean, was the source of ground-water degradation in this area.

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TABLES 7-10

Table 7. Well-construction data

[Measured zone or aquifer was determined on the basis of well perforations and water quality. See plate 1 and figure 8 for well locations. State well No.: See well-numbering system in text. Altitude of land surface is in feet above sea level. Depth of well, depth drilled, and perforated interval are in feet below land surface. ft, foot. >, actual value is greater than value shown. --, no data]

State well No.	Altitude of land surface (ft)	Depth of well (ft)	Depth drilled (ft)	Perforated interval (ft)
Upper Aquifer--*Shallow Zone*				
7N/34W- 22L2	93	60	60	40-60
22Q8	83.5	46	51	26-46
27F2	92	60	60	--
27K4	102.35	62	62.1	57-62
27P6	80	56.5	56.5	51.5-56.5
28B5	73.5	45	49	25-45
28F1	79.07	40	--	--
29F2	62.86	60.5	60.5	40.5-60.5
29N3	67.41	33	33	28-33
29N4	67.34	60	65	55-60
30L3[1]	59	32	32	32
31C3[1]	65	27	28	27
31R2	70.35	87.5	110	29-44
32N1	73	--	--	--
33E5	82	56.5	58	46.5-56.5
35F2[2]	100	112	140	30-54 96-101
35K14	130	60	--	--
7N/35W- 13N2[3]	60	44	103	22-44
16G1	18	46	46	--
16R1	20	80	82	20-60
17G1	10	88	140	58-78
17Q6	20	87	120	57-77
23B2	30	80	80	20-60
23J3[1]	43.43	33	33	33
23Q1	37.11	27.5	27.5	23-27.5
23Q2	37.22	51	51	46-51
23Q5LYS	37	11	--	10.8-11
25F6	47	19.4	--	--
25F7[1]	47	30	32	30
26L1	36.09	22.5	22.5	17.5-22.5
26L3LYS	36	8	16	7.8-8
Upper Aquifer--*Middle Zone*				
7N/34W- 26R2	114	--	--	--
27E4	89	58.5	60	48.5-58.5
27K5	102.59	97.5	97.5	92.5-97.5
27N6	79	95.5	95.5	85.5-95.5
28M1	78	72	77	62-72
28Q1	70	67	70	57-67
29H3	71.17	75	80	65-75

Footnotes at end of table.

Table 7. Well-construction data--*Continued*

State well No.	Altitude of land surface (ft)	Depth of well (ft)	Depth drilled (ft)	Perforated interval (ft)
	Upper Aquifer--*Middle Zone*--Continued			
7N/34W- 29L1	72	85	--	--
29N5	67.36	95	100	90-95
7N/35W- 23Q3	37.1	82.5	82.5	77.5-82.5
26L2	35.77	82	82	77-82
	Upper Aquifer--*Main Zone*			
7N/34W- 19J1	61	186	186	130-154 159-165
22Q7	83.5	185	189	165-185
26N6	106	140	149	120-140
27E1	87	158	158	--
27F1	94	170	185	105-170
27F4	96.79	172	178	110-172
27G5	100	190	216	102-190
27K7	98.63	175	195	95-165
27N5	85.71	195	200	105-180
27P5	92.35	172	172	100-172
27Q2	98.97	185	190	95-175
28B4	73.5	124	129	114-124
28M2	78	162.5	167	142.5-162.5
29F1	62.67	164.5	180	144.5-164.5
29J1	75	182	186	133-182
29N6	66.70	160	600	140-160
30L5	60	200	--	--
31A2	68	175	182	--
31A3	67	--	160	--
34A4	108.63	170	176	150-170
34B1	101.52	192	195	96-192
34F6	103.30	140	148	80-140
35K9[4]	101	124	128	52-80 112-124
7N/35W- 17K20	24	126	160	96-116
17K21	9	175	200	155-175
17M1	10	120	169	115-120
21G2	20	180	205	150-170
22H1	36	170	--	--
22J1	32	180	185	133-180
23E2	37	190	212	170-190
23K1	40	--	--	--
23Q4	37.32	190	440	160-180

Footnotes at end of table.

Table 7. Well-construction data--*Continued*

State well No.	Altitude of land surface (ft)	Depth of well (ft)	Depth drilled (ft)	Perforated interval (ft)
		Upper Aquifer--*Main Zone*--Continued		
7N/35W- 24J4	52	171	171	165-170
24K5	51	172	174	130-135 140-170
24P3	50	195	198	155-175
25D3	42	178	350	168-178
25J3	52.40	175.5	176	170-174
25F5	47	175	184	145-175
26F1	36.84	176	186	117-176
26F4	35	190	190	--
26F5	35	192	192	151-176
26H1	46	177	180	137-177
		Lower Aquifer		
6N/34W- 4G4	97.5	75	77	65-75
6C1	103	100	100	88-100
7N/33W- 16G2	520	410	--	--
17M1	360	290	--	--
19D1	270	552	760	228-552
19Q2	280	900	900	320-720 760-890
20G3[5]	400	511	--	190
21G2	430	>310	--	--
28D1	355	>277	--	--
28D3	360	600	640	440-590
7N/34W- 9H5	275	853	960	653-853
10R1	390	4,072	4,072	--
11D1	500	3,750	3,750	--
12E1	386	385	385	345-385
13D1	450	3,784	3,784	--
14F2	268	408	500	148-408
14F3	268	397	450	169-397
14F4	265	568	580	280-530
14G2	255	568	--	276-550
14L1	250	550	--	200-550
15B1	345	3,549	3,549	--
15D1	180	790	796	450-790
15D3	180	683	730	458-683
15E2	200	580	600	425-580
15E3	200	520	--	200-340 420-520

Footnotes at end of table.

Table 7. Well-construction data–*Continued*

State well No.	Altitude of land surface (ft)	Depth of well (ft)	Depth drilled (ft)	Perforated interval (ft)
		Lower Aquifer--Continued		
7N/34W- 15P1	300	920	924	200-900
20K6	75	210	314	--
20P3	71	320	685	260-320
22J6	97	135	135	--
23R2	121	--	690	--
24N1	130	159	183	115-159
26H3	112.92	66.9	123	--
26Q5	105	151	157	135-140
27A9	79	--	930	--
27K6	98.63	383	1,025	270-350
29N7	66.70	420	600	320-360 380-400
35B3	95	137	340	117-137
7N/35W- 26L4	36	299	340	259-299
27P1	260	577	677	562-577
28K3	65	--	440	--
28R1	120	510	551	470-510
31B1	85	472	472	--
31J1	160	591	625	155-244 571-591
33J2	177	465	530	170-210 375-465
33J3	220	460	660	96-160 428-460
33J4	219	462	502	370-462
35E1	52.8	71.5	72	--

[1]Perforated at bottom of well point.
[2]Upper perforations in river-channel deposits. Aquifer opposite lower perforations uncertain.
[3]Perforated in alluvium of tributary stream to Santa Ynez River.
[4]Upper perforations in river-channel deposits; lower perforations in main zone.
[5]Depth to bottom of perforations unknown.

Table 8. Continuous-record water-level measurements, October 1987-December 1988

[State well No.: See well-numbering system in text. See figure 8 for location of wells. Water levels in feet below land-surface datum, mean values. --, no data]

State well No. 7N/34W-29N7 (Lower Aquifer)
Latitude/longitude 3439261202930
Altitude of land-surface 66.70 feet above sea level. Perforated interval 320-360, 380-400 feet below land-surface datum.

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	31.67	29.08	28.40	27.98	26.91	--	--	--	34.70	37.81	37.76	38.72	--	33.12	31.26
2	31.80	28.93	28.62	27.94	26.90	--	--	--	35.56	37.95	37.96	39.15	--	33.46	31.14
3	31.92	28.82	28.80	27.93	27.12	--	--	--	36.16	37.67	38.67	39.16	--	33.42	31.21
4	32.16	28.76	28.77	27.89	27.40	--	--	--	36.71	36.61	39.02	38.93	35.79	33.88	31.10
5	31.99	28.76	28.60	27.84	27.50	--	--	--	36.41	35.91	39.33	37.61	35.60	34.44	30.73
6	32.22	28.95	28.30	--	27.61	--	--	--	35.52	35.97	39.45	36.78	35.34	34.37	30.74
7	32.47	29.08	28.07	27.82	27.96	--	--	--	35.84	36.69	39.01	37.38	35.19	34.01	31.00
8	32.45	29.14	27.93	27.81	28.05	--	--	--	36.57	37.26	37.87	38.04	35.21	34.20	31.69
9	32.64	29.15	27.94	27.84	--	--	--	--	37.42	37.74	37.98	38.34	35.30	34.20	32.18
10	32.60	28.97	27.92	27.85	--	--	--	--	37.53	38.11	38.66	38.61	34.93	33.82	32.13
11	32.40	28.72	27.84	27.87	--	--	--	--	37.59	37.54	38.85	38.40	35.17	33.72	32.08
12	31.52	28.50	27.75	27.93	--	--	--	33.86	37.33	37.59	38.69	37.52	35.55	33.35	31.76
13	31.05	28.31	27.63	27.87	--	--	--	34.11	36.48	37.97	39.09	37.25	35.23	32.70	31.77
14	30.78	28.26	27.59	27.72	--	--	--	34.33	36.85	38.33	38.62	37.62	34.85	32.16	32.09
15	30.73	28.36	27.58	27.42	--	--	--	34.35	37.39	38.76	37.42	37.87	34.47	31.78	31.91
16	31.35	28.46	27.32	27.16	--	--	--	33.93	37.72	38.76	37.18	37.77	33.96	31.59	31.48
17	31.43	28.67	27.22	26.86	--	--	--	34.11	37.99	38.71	37.48	37.48	33.38	31.42	31.00
18	31.19	28.77	27.19	26.78	--	--	--	34.29	38.16	38.07	37.76	36.90	33.71	31.41	30.75
19	30.84	28.98	27.24	26.73	--	--	--	34.61	37.72	37.93	38.05	36.23	34.07	31.88	30.41
20	30.72	29.26	27.51	26.76	--	--	--	35.11	36.84	38.37	38.56	36.17	34.72	31.74	--
21	30.54	29.54	--	26.69	--	--	--	35.71	36.65	38.73	38.15	36.32	35.43	31.52	--
22	30.19	29.76	27.76	26.68	--	--	--	36.00	36.84	39.01	37.20	36.72	35.47	32.04	--
23	29.68	29.64	27.84	26.76	--	--	--	35.52	36.96	--	37.52	37.49	34.76	32.46	--
24	29.24	29.67	27.90	26.75	--	--	--	35.45	37.27	--	37.92	37.67	33.85	32.35	--
25	28.88	29.45	28.01	26.76	--	--	--	36.01	37.32	--	38.46	37.18	33.51	31.82	--
26	28.50	29.10	28.16	26.84	--	--	--	36.26	36.66	37.98	39.03	36.26	33.75	31.29	--
27	28.33	28.73	28.22	26.86	--	--	--	36.61	35.86	38.57	39.48	35.97	34.16	30.91	--
28	--	28.44	28.25	26.94	--	--	--	37.15	36.24	39.06	39.33	35.90	34.32	30.63	--
29	--	28.29	28.09	26.99	--	--	--	36.91	36.91	39.43	38.51	36.52	34.09	30.77	--
30	29.53	28.19	28.04	27.08	--	--	--	35.67	37.23	39.45	38.44	36.94	33.63	31.14	--
31	29.25	--	28.01	27.04	--	--	--	34.83	--	38.85	38.58	--	33.00	--	--

Table 8. Continuous-record water-level measurements, October 1987-December 1988--*Continued*

State well No. 7N/35W-23Q4 (Upper Aquifer, Main Zone)
Latitude/longitude 3440081203209
Altitude of land surface 37.32 feet above sea level. Perforated interval 160-180 feet below land-surface datum.

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	--	16.29	15.36	16.67	15.13	26.19	--	23.44	26.50	24.42	27.05	37.21	--	--	--
2	--	16.21	15.37	18.43	15.09	27.44	--	22.64	23.93	23.32	28.06	36.10	--	--	--
3	--	16.11	15.37	15.90	15.69	26.17	--	18.80	24.62	28.39	29.82	38.44	--	--	--
4	--	15.93	15.37	17.23	18.03	28.18	--	19.43	22.73	34.73	30.47	37.16	30.01	--	--
5	--	15.83	15.37	19.12	18.82	25.40	--	17.31	22.94	32.21	31.83	27.40	29.21	--	--
6	--	15.78	15.37	17.81	17.24	25.38	--	21.34	26.10	27.42	32.09	28.92	24.77	--	--
7	--	15.73	15.28	17.96	17.29	25.50	--	19.55	25.07	25.34	32.40	33.51	23.74	--	--
8	--	15.67	15.07	17.62	16.96	--	--	22.59	24.47	25.01	30.19	33.08	23.49	--	--
9	--	15.63	15.01	15.97	16.08	--	--	23.92	24.07	25.64	33.66	30.65	22.33	--	--
10	--	15.67	14.98	16.56	16.22	--	--	20.13	23.42	30.02	34.91	35.53	21.96	--	--
11	--	15.91	14.85	17.10	18.24	--	--	23.69	23.39	30.17	35.06	33.90	23.57	--	--
12	--	16.12	15.14	18.39	22.65	--	--	31.49	31.02	28.83	35.51	31.05	24.78	--	--
13	--	17.08	15.21	18.42	21.30	--	--	29.44	30.08	26.60	35.64	30.96	24.83	--	--
14	--	16.26	15.11	19.12	20.62	--	--	30.12	26.26	22.49	32.48	32.05	25.62	--	--
15	--	15.61	15.36	20.88	24.84	--	--	29.18	25.16	24.09	30.00	33.22	24.57	--	--
16	--	17.11	14.82	18.01	25.26	--	26.08	32.50	23.56	23.17	35.56	30.52	20.91	--	--
17	--	16.70	14.46	17.55	24.42	--	27.85	31.00	24.83	27.45	34.70	31.47	21.94	--	--
18	--	16.10	14.35	22.45	25.07	--	25.56	29.66	24.69	28.57	35.53	28.62	24.04	--	--
19	--	16.57	14.25	24.52	26.72	--	21.48	25.95	29.94	24.67	36.36	27.61	25.23	--	--
20	--	16.91	14.23	25.40	24.08	--	27.37	25.51	30.85	23.31	37.57	31.58	26.55	--	--
21	--	16.89	13.85	21.98	23.90	--	29.77	23.52	27.99	26.28	33.53	32.14	25.03	--	--
22	--	16.36	13.82	19.08	22.92	--	30.57	31.75	26.92	26.62	31.38	33.69	22.83	--	--
23	--	17.03	13.16	16.48	22.91	--	31.18	30.05	24.57	25.44	32.65	30.74	21.22	--	--
24	--	16.93	15.34	15.28	25.86	--	31.76	26.27	23.58	--	33.57	31.77	21.60	--	--
25	--	17.52	14.72	13.94	23.28	--	31.10	27.45	23.91	--	34.85	26.80	21.10	--	--
26	--	17.02	13.49	13.25	22.82	--	28.28	24.94	32.25	30.91	32.38	25.72	22.67	--	--
27	--	16.06	14.34	12.87	19.86	--	24.93	24.78	29.78	31.76	34.17	29.88	23.53	--	--
28	--	15.68	13.83	12.70	20.92	--	25.96	21.98	24.00	35.54	33.23	33.68	24.98	--	--
29	--	15.51	14.28	13.05	23.43	--	25.70	27.18	23.15	35.61	31.86	34.45	23.73	--	--
30	16.60	15.34	16.10	13.03	--	--	22.15	34.78	24.65	35.24	33.92	34.29	20.81	--	--
31	16.40	--	15.89	13.79	--	--	--	32.15	--	27.87	36.86	--	--	--	--

Table 9. Chemical analyses of ground water in the Lompoc area

[Measured zone or aquifer was determined on the basis of well perforations and water quality. State well No.: See well-
mg/L, milligrams per liter; µg/L, micrograms per liter; <, actual value is less than value shown; --, no data. See figure 8 for

State well No.	Date	Specific conductance (µS/cm)	pH (standard units)	Temperature, water (°C)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)
Upper Aquifer--*Shallow Zone*							
7N/34W- 22Q8	12-21-88	1,220	7.2	18.0	130	60	81
27K4[1]	5-07-87	1,450	7.6	18.0	140	71	82
	6-24-87	1,400	7.7	17.0	140	64	77
	9-11-87	1,430	7.3	18.0	140	70	82
	10-28-87	1,570	7.8	18.5	150	70	77
	1-07-88	1,330	7.4	17.0	130	62	67
	4-11-88	1,330	7.3	17.5	110	51	60
	7-21-88	1,270	7.5	18.0	120	62	72
27P6[1]	3-18-87	1,300	7.8	17.5	140	70	56
	1-07-88	1,290	7.7	17.0	140	70	53
	4-14-88	1,330	7.4	16.0	140	73	60
	7-22-88	1,230	7.6	18.0	130	69	57
28B5	12-20-88	1,020	7.6	18.0	110	53	72
28F1	9-11-41	5,620	--	--	--	--	--
29F2[1]	10-30-87	2,060	8.0	17.5	160	55	230
	1-06-88	2,150	7.4	16.5	170	59	240
	4-13-88	2,210	7.3	17.0	180	64	270
	7-22-88	2,110	7.5	18.0	150	57	250
29N3[1]	3-13-87	4,500	7.5	--	440	300	250
	5-05-87	4,350	7.6	--	410	300	250
	6-23-87	3,340	7.7	16.5	390	320	170
	9-11-87	4,110	7.2	17.0	290	280	240
	10-28-87	4,150	7.5	17.5	320	300	58
	1-05-88	4,030	7.6	--	320	290	240
	4-12-88	3,880	7.4	16.0	340	330	230
	7-23-88	4,540	7.3	17.0	420	330	240
29N4[1]	3-13-87	3,510	7.5	--	320	220	210
	5-05-87	3,570	7.6	18.0	340	230	200
	6-23-87	3,210	8.0	16.5	310	270	200
	9-10-87	4,030	7.3	16.5	330	320	230
	10-28-87	4,100	7.5	17.5	300	320	230
	1-05-88	4,000	7.4	16.0	290	270	220
	4-12-88	4,100	7.4	16.0	270	290	200
	7-23-88	3,640	7.5	17.5	330	370	220
31C3	6-08-48	1,700	7.9	--	130	110	95
31R2	6-26-87	2,300	--	--	--	--	--
32N1	7-06-89	2,510	--	--	--	--	--
33E5[1]	1-07-88	4,150	7.3	17.5	370	210	240
	4-14-88	4,210	7.0	16.0	410	230	250
	7-24-88	4,240	7.2	--	470	270	240

Footnotes at end of table.

numbering sytem in text. Alkalinity: L, laboratory value. µS/cm, microsiemens per centimeter at 25 °C; °C, degree Celsius; location of wells]

Potassium, dissolved (mg/L)	Alkalinity, total, field (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Solids, sum of constituents, dissolved (mg/L)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)	Boron, dissolved (µg/L)	Manganese, dissolved (µg/L)
Upper Aquifer--*Shallow Zone*--Continued							
3.9	407	280	61	892	1.1	420	1,000
2.4	341	380	83	1,000	1.7	420	830
2.6	326	360	76	956	1.7	400	780
2.6	355	350	79	985	3.2	410	830
3.7	341	400	80	1,030	2.8	430	900
3.7	342	320	72	896	.67	420	710
1.7	302	340	67	839	.16	410	620
2.3	330	340	68	898	.69	400	700
3.6	375	280	59	872	<.10	370	820
3.6	441	260	55	885	<.10	350	920
2.7	424	280	60	909	<.10	380	950
2.8	398	250	51	836	<.10	370	900
3.3	263	300	52	779	<.10	390	300
--	--	--	840	--	--	--	--
5.0	391	340	270	1,320	<.10	630	480
7.3	436	380	290	1,430	<.10	610	560
6.5	274	440	270	1,420	.12	660	60
6.9	394	430	240	1,400	.36	600	640
1.1	418	1,800	420	3,700	46	1,100	620
2.6	427	1,900	410	3,680	30	1,100	940
3.4	421	1,700	420	3,390	26	1,000	1,200
3.6	431	1,600	360	3,100	11	1,100	1,400
2.8	426	1,600	440	3,100	24	1,000	260
3.6	440	1,800	280	3,220	.16	1,000	1,000
2.7	420	1,800	370	3,440	22	1,100	920
2.7	442	1,900	420	3,790	42	990	330
5.3	290	1,500	320	2,780	<.10	780	2,100
5.6	323	1,600	340	2,940	.31	830	2,200
4.4	369	1,500	320	2,860	<.10	900	1,100
4.5	407	1,700	350	3,200	.30	940	1,400
3.0	404	1,800	460	3,390	<.10	920	1,200
5.0	396	1,800	440	3,300	<.10	860	1,400
3.4	446	1,900	360	3,320	<.10	960	910
4.1	436	1,900	410	3,530	<.10	910	970
6.4	364	430	130	1,140	--	500	--
--	--	--	--	[2]1,909	--	--	--
--	--	--	--	[2]2,083	--	--	--
7.3	813	1,400	450	3,200	<.10	910	4,300
5.4	704	1,500	380	3,250	<.10	960	4,800
6.1	768	1,500	390	3,380	.68	920	4,500

Table 9. Chemical analyses of ground water in the Lompoc area--*Continued*

State well No.	Date	Specific conductance (µS/cm)	pH (standard units)	Temperature, water (°C)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)
			Upper Aquifer--*Shallow Zone*--Continued				
7N/34W- 35K14	5-14-87	2,880	7.3	21.0	260	130	230
7N/35W- 13N2	9-03-85	674	6.4	20.0	17	12	120
16R1	1-08-88	--	7.3	16.5	170	67	350
17G1	5-20-87	3,800	7.6	21.0	160	140	850
	9-28-88	4,210	7.5	22.0	140	160	910
17Q6	5-20-87	9,350	7.1	19.5	230	280	2,200
	6-23-88	10,700	7.1	19.5	290	350	2,200
23B2[1]	5-08-87	1,410	7.9	17.0	64	29	180
	4-15-88	--	7.7	--	69	32	180
	6-24-88	1,280	7.7	16.0	70	32	180
23J3	6-04-48	4,530	--	17.0	420	200	420
23Q1[1]	3-17-87	7,000	7.7	17.0	360	300	990
	5-07-87	7,270	7.5	18.5	360	310	970
	6-24-87	--	8.2	17.5	370	340	1,000
	9-09-87	6,770	7.1	17.5	340	310	1,000
	10-28-87	6,870	7.6	17.5	320	320	990
	1-05-88	6,940	7.5	17.5	320	290	890
	4-13-88	6,910	7.4	18.0	320	310	950
	7-24-88	6,440	7.5	17.5	350	320	1,000
23Q2[1]	3-17-87	6,280	7.8	17.0	320	280	850
	5-07-87	6,710	7.9	17.5	330	330	890
	6-24-87	5,380	7.7	17.5	330	360	870
	9-09-87	6,610	7.5	17.5	260	320	900
	10-28-87	6,680	7.8	18.0	300	370	870
	1-05-88	6,820	7.8	17.5	240	320	860
	4-13-88	6,600	7.6	17.0	290	350	850
	7-23-88	6,010	7.7	18.0	310	360	820
23Q5LYS	6-24-87	4,610	7.9	19.5	530	240	380
	9-09-87	4,680	7.6	18.5	550	250	390
	10-28-87	5,070	7.8	19.0	550	230	370
	4-11-88	5,850	7.9	15.0	590	340	430
	7-24-88	5,810	7.8	17.5	600	360	450
26L1[1]	3-18-87	3,860	7.8	17.0	140	230	450
	5-06-87	4,160	7.7	18.0	210	260	420
	6-23-87	4,000	8.1	17.5	210	280	390
	9-11-87	4,140	7.2	18.0	180	250	390
	10-28-87	4,120	7.6	17.5	200	270	380
	1-05-88	4,410	7.5	--	220	250	360
	4-12-88	4,600	7.5	18.0	220	270	410
	7-23-88	5,700	7.5	17.0	230	350	710

Footnotes at end of table.

Potassium, dissolved (mg/L)	Alkalinity, total, field (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Solids, sum of constituents, dissolved (mg/L)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)	Boron, dissolved (µg/L)	Manganese, dissolved (µg/L)
Upper Aquifer--*Shallow Zone*--Continued							
13	548	100	290	1,430	7.3	930	490
20	64	120	160	542	--	--	--
10	L507	290	550	1,770	<.10	570	1,300
23	600	270	1,400	3,240	<.10	1,700	580
21	644	250	1,500	3,410	<.10	1,500	560
58	498	1,000	3,700	7,780	<.10	1,600	590
44	507	1,100	3,900	8,240	<.10	1,600	610
2.1	160	230	220	849	<.10	270	400
1.8	L144	250	230	875	<.10	260	440
1.9	192	240	220	889	<.10	270	440
18	460	1,400	640	3,410	--	1,100	--
16	363	2,900	740	5,910	81	3,400	1,700
6.9	373	2,900	700	5,790	65	3,300	2,100
5.6	326	2,800	630	5,670	66	3,200	2,500
4.8	376	2,900	650	5,810	78	3,200	2,500
1.4	367	2,900	680	5,760	66	3,400	2,100
5.2	364	2,800	640	5,200	.76	3,100	1,900
4.4	402	3,000	630	5,730	57	3,100	540
4.5	321	3,000	660	5,860	67	3,000	1,400
11	316	2,600	760	5,130	21	2,700	680
6.3	347	2,700	730	5,260	9.3	3,000	560
6.0	367	2,600	750	5,450	65	3,100	500
6.3	381	2,700	730	5,500	74	3,200	500
3.9	364	2,700	730	5,500	63	3,100	440
6.5	376	2,800	630	5,330	50	2,900	470
5.7	354	2,800	580	5,380	61	2,800	340
6.0	394	2,700	680	5,440	67	2,800	350
9.6	L380	1,800	660	4,460	130	1,600	80
4.3	374	1,900	580	4,380	100	1,800	40
1.6	363	2,100	590	4,520	96	1,700	10
2.6	358	2,600	680	5,470	130	2,000	20
2.9	359	2,400	570	5,120	110	2,000	30
3.4	458	1,300	380	2,880	17	1,400	1,000
2.2	381	1,400	440	3,230	53	1,300	1,800
1.8	403	1,400	420	3,210	53	1,100	2,000
1.4	383	1,400	410	3,150	57	1,200	2,100
5.3	404	1,400	440	2,990	.22	1,200	1,800
1.8	L390	1,500	460	3,060	.61	1,100	1,900
1.3	444	1,600	330	3,390	58	1,300	1,900
1.4	520	2,300	450	4,630	54	1,700	2,200

Table 9. Chemical analyses of ground water in the Lompoc area--*Continued*

State well No.	Date	Specific conductance (µS/cm)	pH (standard units)	Temperature, water (°C)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)
			Upper Aquifer--*Shallow Zone*--Continued				
7N/35W- 26L3LYS	5-06-87	4,220	7.7	--	320	270	320
	6-23-87	3,320	8.1	17.5	300	260	270
	9-11-87	4,120	8.1	18.0	330	310	310
	10-28-87	4,060	8.0	18.5	300	280	300
	4-11-88	4,020	8.0	15.0	280	230	300
	7-23-88	4,080	7.8	19.0	300	280	270
			Upper Aquifer--*Middle Zone*				
7N/34W- 26R2	5-13-87	2,860	7.5	19.0	240	120	210
	4-15-88	2,480	--	18.5	--	--	--
27E4[1]	1-07-88	2,890	7.5	18.0	250	140	230
	4-14-88	2,830	7.3	17.0	240	150	230
	7-22-88	2,910	7.4	--	270	160	220
27K5[1]	3-18-87	1,340	7.8	17.0	140	70	74
	5-07-87	1,460	7.7	18.0	130	72	72
	6-24-87	1,380	8.2	17.0	140	71	73
	9-11-87	1,090	7.5	18.5	140	73	73
	10-28-87	1,520	7.6	18.0	150	74	75
	1-07-88	1,470	7.7	17.0	150	76	73
	4-11-88	1,360	7.5	17.0	150	73	77
	7-21-88	1,390	7.9	18.0	120	72	75
27N6	10-30-87	2,100	7.5	18.0	180	97	120
28M1[1]	10-30-87	3,790	7.5	18.0	180	140	460
	1-06-88	3,590	7.7	16.5	190	160	390
	4-14-88	3,560	7.6	17.0	210	180	410
	7-22-88	3,690	7.8	17.5	260	210	400
28Q1	1-07-88	2,260	7.4	17.5	180	110	110
	7-26-88	1,950	7.6	18.0	160	100	130
29H3[1]	10-30-87	2,370	7.5	18.0	180	99	190
	1-06-88	2,160	7.4	18.0	210	100	170
	4-14-88	1,920	7.3	17.0	170	94	150
	7-22-88	1,970	7.6	18.5	180	100	150
29L1	7-06-89	2,350	--	--	--	--	--
29N5[1]	3-13-87	2,590	7.4	--	210	130	210
	5-05-87	2,290	7.4	18.0	200	110	190
	6-23-87	2,250	7.8	16.5	190	100	170
	9-10-87	2,360	7.1	16.5	180	120	170
	10-28-87	2,490	7.5	17.0	200	120	170
	1-05-88	2,520	7.5	--	200	120	140
	4-12-88	2,550	7.4	16.0	220	130	150
	7-23-88	2,220	7.5	18.5	250	150	140

Footnotes at end of table.

Potassium, dissolved (mg/L)	Alkalinity, total, field (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Solids, sum of constituents, dissolved (mg/L)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)	Boron, dissolved (μg/L)	Manganese, dissolved (μg/L)
			Upper Aquifer--*Shallow Zone*--Continued				
6.4	L332	1,500	490	3,390	58	970	80
2.9	180	1,600	480	3,270	50	1,100	170
1.8	348	1,600	440	3,440	48	1,200	120
2.4	344	1,700	480	3,480	42	1,200	20
1.2	376	1,300	310	2,950	62	850	20
1.2	370	1,400	380	3,120	54	910	40
			Upper Aquifer--*Middle Zone*--Continued				
6.4	448	640	360	1,990	24	850	60
--	--	--	--	--	--	--	--
6.4	591	1,100	140	2,250	<.10	1,200	2,600
4.5	536	1,100	170	2,250	<.10	1,200	2,700
4.0	598	1,100	170	2,320	.13	1,200	2,900
3.3	299	370	79	954	<.10	430	620
2.8	301	360	89	945	<.10	400	630
2.8	323	390	84	993	<.10	430	620
2.9	336	380	88	996	<.10	420	600
8.5	320	390	86	1,010	<.10	430	630
3.5	318	380	80	991	<.10	400	610
2.7	396	350	75	1,000	<.10	380	620
2.7	344	380	82	973	<.10	400	530
1.2	340	680	150	1,460	<.10	600	590
4.4	233	1,500	220	2,700	6.5	1,700	1,400
3.0	285	1,700	200	2,880	8.2	1,700	1,500
2.4	280	1,600	240	2,910	16	1,700	980
2.6	304	1,700	250	3,110	18	1,600	960
3.5	506	630	220	1,600	<.10	560	1,500
2.5	509	450	150	1,340	.39	550	980
8.4	422	670	150	1,580	<.10	560	1,200
8.6	531	590	140	1,570	<.10	610	1,100
6.1	480	490	130	1,360	<.10	480	890
7.0	490	500	120	1,390	<.10	460	1,000
--	--	--	--	[2]1,739	--	--	--
4.2	438	840	200	1,860	.76	560	1,500
4.6	445	640	190	1,640	.55	550	1,200
4.7	438	640	190	1,590	<.10	530	1,300
5.0	460	660	200	1,650	.42	520	1,600
4.4	462	760	210	1,780	.18	530	1,600
4.7	446	710	230	1,710	<.10	470	1,500
4.1	452	810	210	1,830	<.10	490	1,800
4.9	476	810	210	1,890	.25	460	1,900

Table 9. Chemical analyses of ground water in the Lompoc area--*Continued*

State well No.	Date	Specific conductance (µS/cm)	pH (standard units)	Temperature, water (°C)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)
			Upper Aquifer--*Middle Zone*--Continued				
7N/35W- 23Q3[1]	5-07-87	1,900	7.6	17.5	190	92	100
	6-24-87	1,390	7.8	17.0	190	84	110
	9-09-87	1,800	7.5	18.0	170	82	110
	10-28-87	1,970	7.7	18.0	150	79	130
	1-05-88	1,750	7.5	18.0	160	78	97
	4-13-88	1,950	7.4	18.0	180	87	99
	7-24-88	2,130	7.6	18.0	210	110	140
26L2[1]	5-06-87	1,090	7.5	18.0	68	48	84
	6-23-87	1,080	7.7	18.5	71	48	85
	9-11-87	1,090	7.2	18.5	67	46	82
	10-28-87	1,120	7.5	17.5	69	46	82
	1-05-88	--	7.4	--	57	44	84
	4-12-88	1,160	7.4	18.0	66	46	81
	7-23-88	1,110	7.4	17.5	65	46	81
			Upper Aquifer--*Main Zone*				
7N/34W- 19J1	6-30-82	1,290	7.7	19.5	110	28	120
22Q7	12-21-88	1,500	7.6	18.0	86	39	230
26N6	12-20-88	1,110	7.6	17.5	110	59	75
27E1	00-00-35	--	--	--	120	67	86
	10-02-53	1,690	--	--	170	86	110
27G5	5-07-87	1,500	7.5	19.0	150	74	89
27K7	1-19-88	1,540	--	--	150	72	110
27N5	1-07-88	--	7.2	18.0	270	140	120
27P5	5-02-67	--	--	17.0	190	81	100
	8-28-69	--	--	18.0	180	82	110
	10-30-70	--	--	17.0	180	84	100
	3-17-72	--	--	17.0	180	87	100
	10-15-73	--	--	18.0	180	84	110
	5-15-74	--	--	17.0	180	74	110
	10-15-75	--	--	17.0	170	78	83
	7-15-76	--	--	17.0	190	79	110
	10-15-77	--	--	17.0	210	87	110
	3-15-78	--	--	17.0	190	88	110
	7-17-81	--	7.6	17.0	190	96	100
	8-22-84	1,560	7.2	18.0	230	110	120
	8-22-85	1,880	7.4	18.0	240	96	130
	7-15-86	1,820	7.5	18.0	200	100	110
	6-24-87	1,990	7.5	18.0	190	95	110
	7-20-88	1,820	7.4	18.0	220	110	110

Footnotes at end of table.

Potassium, dissolved (mg/L)	Alkalinity, total, field (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Solids, sum of constituents, dissolved (mg/L)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)	Boron, dissolved (µg/L)	Manganese, dissolved (µg/L)
Upper Aquifer--*Middle Zone*--Continued							
5.1	375	350	210	1,210	<0.10	290	590
5.3	380	440	220	1,320	.58	360	440
5.1	389	370	190	1,200	.67	350	340
1.5	385	430	250	1,310	.44	390	320
5.1	394	290	180	1,080	<.10	280	300
3.9	370	380	200	1,210	.65	290	360
4.8	383	620	270	1,630	2.2	430	380
2.8	218	130	160	664	.35	130	1,300
2.9	226	120	150	654	.19	130	1,400
2.8	228	130	150	654	.26	130	1,300
5.7	216	130	150	652	.20	130	1,400
3.4	210	120	150	625	.28	120	1,200
2.7	212	120	150	631	--	130	1,400
2.6	228	120	150	644	.83	110	1,400
Upper Aquifer--*Main Zone*--Continued							
6.2	250	110	220	787	0.23	210	360
6.2	311	390	150	1,120	.55	310	910
3.0	239	350	76	854	<.10	390	720
--	281	340	87	900	--	50	--
5.5	388	440	100	1,170	--	700	--
3.7	331	410	110	1,080	<.10	480	810
5.0	345	350	130	1,030	.40	--	--
--	L414	820	150	[3]1,749	.16	--	930
4.3	310	530	100	1,220	--	0	1,000
2.7	316	530	100	1,190	--	--	540
2.6	342	520	100	1,200	--	--	580
3.5	356	510	92	1,230	--	520	670
4.4	L342	490	95	1,200	--	--	670
4.4	L352	480	95	1,190	.00	--	500
4.3	L338	480	100	1,160	.00	520	500
4.3	L376	500	100	1,250	--	330	830
4.8	L382	540	110	1,330	.10	410	670
4.7	L380	520	110	1,290	.10	520	740
4.7	L410	490	120	1,290	.25	470	720
5.0	464	560	140	1,480	<.10	520	770
5.0	454	550	130	1,460	<.10	540	830
4.7	425	580	120	1,410	<.10	510	830
4.8	443	560	130	1,400	<.10	530	830
5.2	434	610	130	1,490	<.10	500	880

Table 9. Chemical analyses of ground water in the Lompoc area--*Continued*

State well No.	Date	Specific conductance (µS/cm)	pH (standard units)	Temperature, water (°C)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)
			Upper Aquifer--*Main Zone*--Continued				
7N/34W- 27Q2	8-14-69	--	--	18.0	140	62	80
	12-15-69	--	--	20.0	130	63	76
	4-16-70	1,190	--	16.5	26	22	180
	10-16-70	--	--	19.0	140	67	75
	3-13-72	--	--	17.0	140	69	78
	9-15-73	--	7.2	17.0	160	71	78
	5-15-74	--	7.5	17.0	150	70	82
	10-15-75	--	7.3	17.0	150	65	81
	10-15-76	--	7.3	18.0	150	68	82
	11-15-77	--	7.5	17.0	150	75	82
	3-15-78	--	7.3	17.0	140	69	86
	3-15-79	--	7.3	18.0	150	68	82
	1-15-80	--	7.3	16.0	98	92	85
	4-15-81	--	7.3	16.0	140	72	83
	2-15-82	--	7.3	16.0	150	73	78
	4-15-83	--	7.4	17.0	140	69	85
	2-15-84	--	7.4	16.0	140	79	86
	1-07-88	--	7.3	17.0	160	79	86
28B4	12-20-88	1,400	7.4	18.0	140	59	110
28M2[1]	1-06-88	2,200	7.4	17.0	210	99	170
	4-14-88	2,240	7.3	18.0	210	110	170
	7-22-88	2,170	7.5	18.5	210	100	160
29F1[1]	10-30-87	1,950	7.9	17.5	140	73	180
	1-06-88	1,840	7.5	18.0	150	72	180
	4-13-88	1,870	7.4	18.5	140	70	190
	7-22-88	1,950	7.5	18.5	120	67	200
29J1	6-02-83	2,250	7.3	18.0	240	110	170
29N6[1]	3-13-87	2,580	7.7	--	270	140	150
	5-05-87	2,690	7.5	17.5	260	140	140
	6-25-87	2,680	7.4	--	290	140	130
	9-10-87	2,670	6.9	18.0	240	130	140
	10-28-87	2,730	7.6	18.0	260	140	140
	1-06-88	3,260	7.5	15.5	280	140	140
	4-12-88	2,510	7.3	18.0	270	150	140
	7-23-88	2,600	7.8	18.0	290	160	130
30L5	6-01-83	2,600	7.4	17.0	280	140	150
31A2	4-12-41	1,790	--	--	130	50	190
	9-25-53	2,190	--	19.0	240	130	100
	5-18-64	2,630	--	16.0	300	150	130
	9-29-64	2,400	--	--	270	150	130
	4-16-70	2,330	--	16.0	210	170	120
	3-15-72	2,540	--	17.0	290	150	140

Footnotes at end of table.

Potassium, dissolved (mg/L)	Alkalinity, total, field (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Solids, sum of constituents, dissolved (mg/L)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)	Boron, dissolved (µg/L)	Manganese, dissolved (µg/L)
Upper Aquifer--*Main Zone*--Continued							
6.4	303	380	110	962	--	--	670
2.2	293	430	78	961	--	--	620
6.0	69	360	84	718	--	120	--
2.4	303	430	80	975	--	--	--
2.7	300	390	69	971	--	350	580
3.5	L300	400	84	1,010	0.00	610	460
3.4	L303	390	85	998	.03	290	500
3.7	L298	390	78	982	.00	560	500
3.6	304	400	85	823	.00	270	500
4.1	L303	440	89	1,070	.10	370	750
3.5	L303	380	87	996	.10	520	580
3.5	L274	360	80	954	.10	480	520
3.4	L283	350	79	885	.10	460	480
3.7	L286	420	84	1,010	.10	640	580
5.2	L310	370	87	986	.10	460	550
5.0	L271	410	91	1,010	.10	260	630
5.3	L271	400	85	1,000	.10	440	560
--	L320	390	96	[3]1,004	<.10	--	580
4.0	332	310	160	1,030	.31	350	530
7.0	425	660	200	1,650	<.10	530	1,100
5.5	424	740	150	1,690	<.10	730	1,100
5.8	422	700	160	1,640	<.10	660	950
5.0	360	470	240	1,360	<.10	550	620
7.2	394	420	200	1,310	<.10	570	670
5.7	386	430	200	1,310	.12	600	630
6.2	348	410	200	1,250	<.10	550	570
5.4	390	760	180	1,740	<.10	820	--
5.8	466	940	190	2,020	.15	620	1,500
5.4	478	850	200	1,930	<.10	630	1,400
5.3	490	930	190	2,020	<.10	650	1,500
5.7	490	910	200	1,960	<.10	650	1,800
5.8	433	900	180	1,930	<.10	670	1,600
6.2	496	960	190	2,060	<.10	640	1,400
5.0	482	990	200	2,090	<.10	660	1,500
5.6	498	960	200	2,090	<.10	610	1,500
5.9	470	830	220	1,950	<.10	730	--
--	445	340	100	1,100	--	--	--
3.5	458	610	180	1,570	--	680	--
5.9	455	850	230	1,940	--	710	--
6.0	458	800	210	1,850	--	520	--
5.0	330	780	220	1,690	--	660	--
4.6	449	820	210	1,870	--	560	--

Table 9. Chemical analyses of ground water in the Lompoc area--*Continued*

State well No.	Date	Specific conductance (µS/cm)	pH (standard units)	Temperature, water (°C)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)
			Upper Aquifer--*Main Zone*--Continued				
7N/34W- 31A3	5-15-24	--	--	--	140	74	81
34A4	2-15-61	1,500	--	--	120	83	74
	5-02-67	--	--	17.0	150	54	98
	9-03-68	--	--	17.0	160	50	88
	8-29-69	--	--	17.0	130	61	80
	12-16-69	--	--	17.0	130	64	77
	10-29-70	--	--	19.0	130	62	75
	12-15-71	--	7.4	16.0	140	65	79
	8-15-73	--	7.3	16.0	160	71	82
	5-15-74	--	7.4	18.0	160	61	85
	10-15-75	--	7.5	17.0	150	66	85
	7-15-76	--	7.3	17.0	140	67	91
	11-15-77	--	7.3	16.0	150	68	97
	3-15-78	--	7.4	15.5	150	68	90
	2-15-79	--	7.4	16.0	140	64	86
	1-15-80	--	7.4	17.0	140	68	87
	4-15-81	--	7.4	16.0	130	61	82
	2-15-82	--	7.4	16.0	130	66	81
	2-15-83	--	7.4	17.0	150	70	100
	2-15-84	--	7.5	16.0	140	75	92
	1-07-88	--	7.3	17.0	150	74	93
34B1	5-23-60	--	--	--	150	68	130
	1-30-63	1,600	--	--	180	99	72
	2-08-64	1,290	--	--	130	70	19
	5-08-67	--	--	17.0	140	64	89
	9-09-69	--	--	17.0	140	67	80
	12-26-69	--	--	--	140	59	--
	10-20-70	--	--	18.5	150	68	77
	12-07-71	--	--	17.0	140	68	75
	8-15-73	--	7.3	17.0	150	69	80
	5-15-74	--	7.3	17.0	160	64	85
	10-15-75	--	7.3	17.0	160	70	89
	10-15-76	--	7.4	17.0	150	70	86
	10-15-77	--	7.4	17.0	150	71	85
	3-15-78	--	7.3	17.0	140	72	83
	2-15-79	--	7.3	17.0	160	76	85
	2-15-80	--	7.4	17.0	150	73	86
	1-15-81	--	7.3	16.0	150	71	86
	2-15-82	--	7.3	17.0	150	69	87
	6-15-83	--	7.3	17.0	140	66	91
	1-07-88	--	7.3	16.0	140	72	95

Footnotes at end of table.

Potassium, dissolved (mg/L)	Alkalinity, total, field (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Solids, sum of constituents, dissolved (mg/L)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)	Boron, dissolved (µg/L)	Manganese, dissolved (µg/L)
			Upper Aquifer--*Main Zone*--Continued				
--	536	260	92	1,030	--	--	--
3.7	291	380	94	949	--	230	--
4.2	277	370	100	983	--	0	580
3.8	289	380	99	952	--	0	550
2.7	268	410	100	951	--	--	420
2.3	273	430	84	949	--	--	420
2.4	269	410	84	929	--	--	330
2.9	L260	380	86	947	0.06	370	420
3.9	L278	430	100	1,060	.00	580	460
3.9	L272	410	90	1,010	.03	500	500
3.9	L269	290	90	885	.00	510	420
3.8	L272	390	100	996	.00	350	380
4.1	L284	400	100	1,040	.10	370	500
39	L288	390	110	1,060	.10	500	620
3.7	L261	380	92	960	.10	450	510
3.0	L260	340	97	895	.10	480	530
3.8	L243	390	89	949	.10	80	430
7.4	L275	370	100	969	.10	440	260
7.5	L273	420	100	1,060	.10	280	540
5.5	L272	370	90	978	.10	400	500
--	L284	380	110	[3]978	<.10	--	490
--	263	500	100	--	--	--	--
--	352	460	110	--	--	--	1,000
--	269	250	99	--	--	--	1,900
4.0	273	410	94	999	--	0	580
2.8	286	420	100	989	--	--	580
--	278	430	87	1,100	--	--	500
2.8	315	450	89	1,020	--	--	420
2.9	283	410	81	986	--	350	430
3.9	L280	400	96	1,010	.00	340	500
4.1	L296	420	90	1,000	.00	370	460
4.1	L299	400	86	1,030	.00	510	500
4.2	L300	400	91	989	.00	410	500
4.2	L293	410	84	1,030	.10	--	600
4.1	L267	370	91	964	.10	520	500
4.2	L309	400	94	1,050	.10	460	520
4.2	L306	400	96	1,000	.10	380	540
4.1	L283	390	92	1,010	.10	480	550
6.8	L301	380	89	1,010	.10	440	450
6.3	L274	370	89	970	.10	340	440
--	L285	370	100	[3]948	<.10	--	--

Table 9. Chemical analyses of ground water in the Lompoc area--*Continued*

State well No.	Date	Specific conductance (µS/cm)	pH (standard units)	Temperature, water (°C)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)
			Upper Aquifer--*Main Zone*--Continued				
7N/34W- 34F6	5-15-67	--	--	18.0	180	80	100
	9-12-69	--	--	18.0	190	83	100
	12-11-69	--	--	18.0	190	86	97
	10-20-70	--	--	18.0	190	89	92
	12-07-71	--	--	16.5	190	90	84
	9-15-73	--	7.3	17.0	200	91	100
	5-15-74	--	7.4	18.0	200	84	110
	10-15-75	--	7.4	17.0	200	83	96
	7-15-76	--	7.3	17.0	210	85	100
	10-15-77	--	7.5	17.0	210	94	100
	2-15-80	--	7.2	17.0	200	90	110
	2-15-81	--	7.3	17.0	210	98	110
	4-15-82	--	7.3	17.0	210	97	110
	2-15-83	--	7.4	18.0	210	97	110
	2-15-84	--	7.3	16.0	210	110	120
	1-07-88	--	7.2	17.0	220	110	100
7N/35W- 17K20	5-20-87	3,580	7.3	18.5	190	150	690
	6-23-88	5,290	7.2	19.0	200	170	740
17K21[1]	1-08-88	7,390	7.3	19.0	230	210	930
	4-13-88	7,280	7.2	18.0	280	250	930
	7-24-88	6,880	7.2	20.0	330	280	980
21G2	5-08-87	2,830	7.5	19.0	240	120	200
	6-23-88	2,360	7.4	19.0	270	140	200
22H1[1]	4-13-88	3,980	7.4	17.0	300	150	360
23K1	5-07-87	2,610	7.6	19.0	260	110	190
23Q4[1]	3-18-87	2,860	7.5	18.5	260	130	180
	5-07-87	2,950	7.4	19.0	270	130	190
	6-25-87	3,030	7.6	18.5	300	140	210
	10-28-87	3,150	7.5	18.5	310	150	210
	1-05-88	3,160	7.5	18.0	240	130	200
	4-13-88	3,180	7.4	18.0	280	140	200
	7-24-88	3,040	7.3	19.0	320	160	220
24K5	7-25-88	1,820	7.4	--	110	41	190
24P3	6-01-83	2,300	7.3	18.0	230	110	190
25D3	6-01-83	2,680	7.4	17.5	250	120	200
25J3	7-06-89	2,000	--	--	--	--	--
26F1	00-00-35	--	--	--	120	70	110
	4-25-52	1,730	--	--	120	100	94

Footnotes at end of table.

Potassium, dissolved (mg/L)	Alkalinity, total, field (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Solids, sum of constituents, dissolved (mg/L)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)	Boron, dissolved (µg/L)	Manganese, dissolved (µg/L)
Upper Aquifer--*Main Zone*--Continued							
3.9	355	420	110	1,140	--	--	120
2.3	361	580	130	1,300	--	--	920
2.2	374	520	120	1,230	--	--	1,000
2.3	388	520	120	1,240	--	--	920
2.7	376	440	110	1,180	--	420	1,100
3.6	L397	500	120	1,300	0.00	1	1
3.8	L395	480	120	1,270	.00	500	960
3.7	L385	450	110	1,220	.00	520	800
3.7	L398	470	120	1,270	.00	440	1,100
3.9	L404	490	130	1,320	.10	--	1,100
3.8	L383	530	120	1,280	.10	530	1,100
3.9	L388	610	130	1,440	.10	390	1,200
5.2	L412	510	130	1,370	.10	520	1,200
6.3	L402	500	120	1,330	.10	400	1,000
54	L416	520	130	1,430	.10	400	1,100
--	L438	510	150	[3]1,354	<.10	--	1,200
37	366	400	1,500	3,230	<.10	450	820
22	386	420	1,300	3,130	<.10	440	790
20	404	710	1,800	4,190	<.10	410	2,000
15	468	780	1,800	4,380	<.10	420	2,200
13	413	780	1,900	4,580	.48	380	2,200
9.0	509	550	430	1,900	<.10	320	1,100
8.7	534	600	460	2,050	<.10	310	1,300
8.7	490	930	440	2,530	<.10	850	1,500
8.5	426	690	320	1,880	<.10	700	370
12	406	870	310	2,050	<.10	550	480
13	418	790	350	2,040	<.10	530	440
13	416	940	370	2,270	<.10	590	500
3.6	410	1,000	400	2,360	.64	560	480
12	428	950	500	2,340	<.10	520	480
10	424	930	350	2,210	<.10	530	440
8.0	419	1,000	390	2,400	<.10	530	530
8.5	161	230	300	1,020	<.10	370	200
8.6	L426	600	290	1,730	<.10	870	--
9.8	490	640	310	1,870	<.10	870	--
--	--	--	--	[2]1,320	--	--	--
--	400	200	150	930	--	300	--
6.6	261	350	230	1,050	--	--	--

Table 9. Chemical analyses of ground water in the Lompoc area--*Continued*

State well No.	Date	Specific conductance (µS/cm)	pH (standard units)	Temperature, water (°C)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)
			Upper Aquifer--*Main Zone*--Continued				
7N/35W- 26F4	9-20-54	1,640	--	18.0	170	89	100
	12-19-57	2,050	--	--	170	120	120
	9-18-58	2,040	--	--	190	120	100
	12-11-59	2,000	--	--	160	100	110
	4-05-60	2,180	--	19.0	200	110	110
	8-18-61	2,070	--	--	160	120	110
	10-10-61	2,160	--	--	240	100	120
	11-01-61	2,200	--	--	390	97	110
	6-06-62	2,400	--	17.0	190	140	120
	9-19-62	2,400	--	--	230	150	110
	7-22-63	2,190	--	18.0	210	120	120
	10-15-63	2,780	--	18.0	300	160	150
	5-15-64	2,680	--	18.0	240	160	140
	9-29-64	2,500	--	--	280	140	160
26F5	6-08-72	2,640	--	18.0	260	140	140
	12-14-82	3,100	7.5	17.0	300	170	180
	6-02-83	2,730	7.3	18.5	280	160	180
	8-30-83	2,730	7.5	17.0	240	140	160
	8-22-84	1,840	7.3	18.0	240	130	170
	6-24-87	2,670	7.5	19.0	230	120	170
	7-20-88	2,300	7.5	18.5	260	150	170
26H1	6-01-83	2,240	7.3	18.0	250	120	150
			Lower Aquifer				
7N/33W- 19Q2	5-12-87	806	7.4	23.5	61	22	60
7N/34W- 14F4	6-25-87	740	7.3	--	67	21	65
14G2	6-25-87	710	7.7	21.0	57	19	56
15D1	8-10-59	--	7.6	--	78	28	78
	9-28-59	--	7.1	--	72	32	75
	6-01-61	--	8.0	--	92	34	71
	8-21-61	1,010	--	--	110	13	68
	12-27-63	--	7.6	--	120	17	86
	12-28-64	--	7.8	--	120	19	76
	12-19-65	--	7.3	--	120	20	91
	12-27-65	--	8.0	--	120	25	82
	6-15-66	--	7.2	--	140	21	98
	12-27-66	--	8.3	--	140	17	98
	12-26-67	--	7.9	--	140	26	83
	12-27-69	--	7.2	--	120	20	110
	12-30-69	--	7.6	--	130	17	100
	7-23-70	--	7.3	--	140	32	79
	12-22-70	--	7.2	--	130	20	88
	1-12-72	--	7.0	--	120	21	93
	12-12-73	--	7.2	--	130	18	89
	12-10-74	--	7.0	--	130	17	86

Potassium, dissolved (mg/L)	Alkalinity, total, field (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Solids, sum of constituents, dissolved (mg/L)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)	Boron, dissolved (µg/L)	Manganese, dissolved (µg/L)
Upper Aquifer--*Main Zone*--Continued							
6.0	399	310	180	1,100	--	260	--
5.8	335	390	300	1,350	--	180	--
5.6	340	430	280	1,380	--	350	--
6.4	288	370	260	1,220	--	240	--
5.0	406	420	270	1,390	--	460	--
6.0	276	450	280	1,340	--	190	--
5.4	357	470	320	1,500	--	310	--
5.4	398	470	350	1,690	--	330	--
5.6	314	470	370	1,520	--	260	--
5.9	372	550	360	1,660	--	260	--
6.2	410	460	260	1,470	--	210	--
5.6	408	680	430	2,000	--	230	--
6.0	310	680	390	1,800	--	190	--
8.0	342	700	380	1,870	--	170	--
6.7	441	690	300	1,850	0.11	280	--
7.6	440	800	370	2,140	.47	340	1,400
7.1	440	770	320	2,020	<.10	360	--
6.7	L426	720	300	1,870	<.10	350	1,200
6.7	426	670	280	1,800	<.10	340	1,000
6.8	438	720	320	1,880	<.10	380	1,200
7.0	414	720	300	1,900	<.10	340	1,500
5.7	L431	650	220	1,700	<.10	650	--
Lower Aquifer--Continued							
3.4	153	75	110	479	0.33	90	140
3.3	136	110	110	512	.83	110	96
2.9	146	67	89	428	.59	90	75
--	L251	130	98	563	--	400	--
--	L181	88	170	578	--	100	--
--	L275	140	110	628	--	--	--
4.0	196	120	110	600	--	240	--
--	L302	130	130	718	--	--	--
--	L299	120	130	679	--	--	--
--	L219	160	140	682	--	--	--
--	L271	140	150	714	--	--	10
--	L290	110	170	713	0	--	400
--	L322	130	150	750	--	--	3
--	L346	140	140	759	--	--	40
--	L299	180	130	767	--	100	5
--	L328	130	140	714	--	80	100
--	L260	130	170	751	--	--	--
--	L313	130	140	738	--	250	220
--	L305	140	140	732	--	190	190
--	L300	130	140	693	.01	460	0
--	L312	150	140	738	.10	--	200

Table 9. Chemical analyses of ground water in the Lompoc area--*Continued*

State well No.	Date	Specific conductance (μS/cm)	pH (standard units)	Temperature, water (°C)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)
			Lower Aquifer--Continued				
7N/34W- 15D1--*Continued*							
	12-11-74	--	7.4	--	130	16	86
	01-07-76	--	7.3	--	120	18	73
	11-16-76	--	7.3	--	95	17	96
	10-14-77	1,000	--	25.0	120	18	87
	2-01-78	--	7.8	--	82	12	79
	1-26-81	--	7.2	--	110	24	64
15D3	4-15-88	--	--	--	--	--	--
15E3	1-07-88	800	6.8	21.5	57	17	72
20K6	6-25-87	1,140	7.7	21.0	130	27	79
	6-22-88	1,040	7.7	21.5	120	27	71
20P3	5-08-87	1,010	7.3	--	13	26	120
27K6[1]	10-30-87	--	7.7	19.0	100	32	92
	1-07-88	971	7.8	20.0	90	31	95
	4-11-88	1,050	7.6	19.0	89	29	91
	7-21-88	990	7.6	20.0	82	26	82
29N7[1]	3-18-87	1,470	7.7	--	130	49	120
	5-06-87	1,480	7.7	20.0	130	51	130
	6-25-87	1,420	7.8	19.0	150	51	110
	10-28-87	1,490	7.6	19.0	140	51	110
	1-06-88	1,560	7.4	18.5	150	51	110
	4-12-88	1,490	7.4	19.0	150	54	110
	7-23-88	1,470	7.4	18.5	140	53	110
7N/35W- 26L4[1]	10-30-87	1,440	7.9	18.5	140	44	86
	1-05-88	1,550	7.5	--	150	48	83
	4-12-88	1,230	7.4	20.0	86	39	67
	7-23-88	1,150	7.2	20.0	78	43	70
33J2	6-26-87	702	7.5	18.0	37	20	81
	6-22-88	687	7.4	18.0	34	19	77
33J4	6-26-87	1,070	7.8	18.5	100	32	71
	6-22-88	1,060	7.7	19.0	110	34	72
35E1	5-14-87	607	7.2	19.0	24	11	74

[1]Isotope data are given in table 6.
[2]Dissolved-solids concentration computed from specific conductance.
[3]Solids, sum of constituents, dissolved, value does not include potassium.

Potassium, dissolved (mg/L)	Alkalinity, total, field (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Solids, sum of constituents, dissolved (mg/L)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)	Boron, dissolved (μg/L)	Manganese, dissolved (μg/L)
Lower Aquifer--Continued							
--	L297	130	150	711	0.10	--	240
--	L180	170	140	644	15	400	300
--	L220	120	130	590	--	--	170
3.8	230	140	140	647	--	200	--
--	L220	100	120	525	--	300	170
--	L210	120	140	587	3.0	--	420
--	--	--	--	--	--	--	--
3.9	L87	110	130	503	.36	110	160
3.6	246	180	110	728	<.10	190	290
3.4	254	160	120	701	.16	170	320
7.6	85	210	130	562	<.10	280	14
--	L240	180	90	--	<.10	--	0
5.2	L175	230	93	691	<.10	250	43
4.2	L218	170	80	636	<.10	240	69
4.5	220	190	83	639	<.10	230	50
4.8	345	320	100	931	<.10	480	170
5.0	350	330	110	1,010	.22	510	250
4.3	366	330	110	1,010	<.10	490	87
5.1	390	430	110	1,120	<.10	500	84
4.5	360	340	110	1,020	<.10	470	99
3.9	386	340	110	1,040	<.10	490	100
4.3	346	340	110	1,000	<.10	470	77
7.0	291	210	270	980	<.10	120	48
10	282	220	180	913	<.10	110	100
11	242	140	150	688	<.10	150	120
6.0	244	140	150	692	.24	140	94
2.9	113	38	130	423	2.5	90	<1
2.8	113	39	130	414	2.2	80	<1
4.7	190	110	180	661	.22	60	40
4.1	192	120	180	686	.20	60	50
2.6	48	23	120	368	10	50	3

Table 10. Chemical analyses for selected streams in the Lompoc area, 1987-88

[µS/cm, microsiemens per centimeter at 25°C; °C, degree Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter;

Gaging station No.	Gaging station Name	Date	Specific conductance (µS/cm)	pH (standard unit)	Temperature, water (°C)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)
11132500	Salsipuedes Creek near Lompoc	1-05-87	1,200	8.1	11.5	120	42	93
		2-03-87	1,420	8.2	12.5	--	--	--
		3-04-87	1,270	--	15.5	--	--	--
		4-06-87	1,330	8.2	19.0	--	--	--
		5-05-87	1,320	8.2	23.0	--	--	--
		6-01-87	1,300	8.3	23.5	--	--	--
		7-01-87	1,550	7.9	19.0	--	--	--
		8-03-87	1,660	8.1	24.0	--	--	--
		8-26-87	1,630	8.0	21.5	--	--	--
		10-01-87	1,510	8.0	19.0	--	--	--
		11-02-87	1,440	8.1	15.0	--	--	--
		12-01-87	1,510	8.1	11.0	--	--	--
		1-05-88	1,180	8.2	10.5	--	--	--
		2-03-88	1,480	8.2	9.5	140	57	110
		2-29-88	604	7.6	14.0	--	--	--
		4-06-88	1,530	8.1	17.5	--	--	--
		5-05-88	1,430	8.1	15.5	--	--	--
		6-02-88	1,530	8.0	24.5	--	--	--
		7-06-88	1,610	8.1	27.0	--	--	--
		8-02-88	1,520	8.0	22.5	--	--	--
		9-09-88	1,630	8.0	19.0	--	--	--
		10-04-88	1,420	7.8	13.0	--	--	--
		11-01-88	1,380	7.8	15.0	--	--	--
		11-30-88	1,820	7.9	8.0	--	--	--
11133000[1]	Santa Ynez River at Narrows near Lompoc	1-05-87	1,500	8.1	13.0	150	80	92
		2-03-87	1,600	8.2	14.5	--	--	--
		3-04-87	1,500	8.1	16.0	--	--	--
		4-06-87	1,560	8.2	16.0	--	--	--
		5-05-87	1,520	8.0	21.0	--	--	--
		6-01-87	1,550	7.8	21.0	--	--	--
		6-26-87	--	--	--	--	--	--
		1-05-88	1,370	8.1	12.0	--	--	--
		2-03-88	1,740	8.2	10.5	140	77	110
		2-29-88	662	7.8	15.5	--	--	--
		4-06-88	1,860	8.1	19.5	--	--	--
		5-05-88	1,720	8.2	15.5	--	--	--
		7-06-88	1,300	8.1	20.0	110	66	72
		8-02-88	1,520	8.0	21.0	--	--	--
11134800	Miguelito Creek at Lompoc	10-02-87	1,500	8.4	17.0	--	--	--
		11-02-87	1,380	8.3	14.5	--	--	--
		12-01-87	1,330	8.3	12.5	--	--	--
		1-05-88	827	7.9	11.5	--	--	--
		2-03-88	1,370	8.0	7.0	130	69	83
		2-29-88	552	7.6	14.5	--	--	--
		4-06-88	1,410	8.3	14.0	--	--	--
		5-05-88	1,240	8.4	13.0	--	--	--
		6-02-88	1,290	8.3	18.5	--	--	--
		7-06-88	1,460	8.5	24.0	--	--	--
		8-02-88	1,410	8.3	18.5	--	--	--
		9-09-88	1,620	8.5	17.0	--	--	--
		10-04-88	1,270	8.2	18.5	--	--	--
		12-13-88	1,340	8.3	11.0	--	--	--

[1]Isotope data are given in table 6.

<, actual value is less than value shown; --, no data]

Potassium, dissolved (mg/L)	Alkalinity, total, field (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Solids, residue at 180 °C, dissolved (mg/L)	Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)	Boron, dissolved (µg/L)	Manganese, dissolved (µg/L)
2.8	297	250	93	801	<0.100	530	34
--	--	--	--	943	--	--	--
--	--	--	--	942	--	--	--
--	--	--	--	919	--	--	--
--	--	--	--	945	--	--	--
--	--	--	--	946	--	--	--
--	--	--	--	1,020	--	--	--
--	--	--	--	1,120	--	--	--
--	--	--	--	1,130	--	--	--
--	--	--	--	1,110	--	--	--
--	--	--	--	970	--	--	--
--	--	--	--	1,010	--	--	--
--	--	--	--	824	--	--	--
3.1	374	280	120	994	<.100	650	120
--	--	--	--	374	--	--	--
--	--	--	--	990	--	--	--
--	--	--	--	964	--	--	--
--	--	--	--	967	--	--	--
--	--	--	--	1,060	--	--	--
--	--	--	--	1,080	--	--	--
--	--	--	--	1,080	--	--	--
--	--	--	--	1,090	--	--	--
--	--	--	--	1,140	--	--	--
--	--	--	--	1,270	--	--	--
3.5	308	450	96	1,110	<.100	500	15
--	--	--	--	1,220	--	--	--
--	--	--	--	1,230	--	--	--
--	--	--	--	1,180	--	--	--
--	--	--	--	1,270	--	--	--
--	--	--	--	1,280	--	--	--
--	--	--	--	--	--	--	--
--	--	--	--	919	--	--	--
4.5	361	480	120	1,280	<.100	530	50
--	--	--	--	410	--	--	--
--	--	--	--	1,260	--	--	--
--	--	--	--	1,270	--	--	--
4.0	251	370	54	904	<.100	430	<1
--	--	--	--	1,170	--	--	--
--	--	--	--	1,010	--	----	
--	--	--	--	976	--	--	--
--	--	--	--	889	--	--	--
--	--	--	--	525	--	--	--
2.5	372	260	100	940	.230	130	80
--	--	--	--	347	--	--	--
--	--	--	--	930	--	--	--
--	--	--	--	869	--	--	--
--	--	--	--	852	--	--	--
--	--	--	--	1,010	--	--	--
--	--	--	--	1,040	--	--	--
--	--	--	--	1,100	--	--	--
--	--	--	--	1,020	--	--	--
--	--	--	--	921	--	--	--