CHEMICAL QUALITY OF GROUND WATER IN SACRAMENTO AND WESTERN PLACER COUNTIES, CALIFORNIA

By Karen L. Johnson

U.S. GEOLOGICAL SURVEY

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CONVERSION FACTORS

For readers who prefer to use metric units rather than inch-pound units, the conversion factors for the terms used in this report are listed below.

Multiply	By	To obtain
acres	0.4047	square hectometers
feet (ft)	0.3048	meters
miles (mi)	1.609	kilometers
square miles (mi^2)	2.590	square kilometers
micromhos per centimeter at 25° Celsius (µmho/cm at 25°C)	1.000	microsiemen per centimeter at 25° Celsius

Water temperature is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation: °F=1.8(°C)+32.

Air temperature is given in degrees Fahrenheit (°F), which can be converted to degrees Celsius (°C) by the following equation: °C=(°F-32)/1.8.

Chemical concentration is given in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams and micrograms per liter are units expressing the weight of the solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to 1 milligram per liter. For concentrations less than 7,000 mg/L, the numerical value is about the same as for concentrations in parts per million.

Chemical concentration in terms of ionic interacting values is given in milliequivalents per liter (meq/L). Milliequivalents per liter is numerically equal to equivalents per million.

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ABSTRACT

Chemical quality of ground water was investigated in Sacramento and western Placer Counties during the summer of 1982. Chemical analyses of water samples from 209 wells indicate that the ground water is suitable for domestic and most agricultural uses. Water from wells near the Sacramento River and a few wells near Lincoln had high concentrations of dissolved solids and some trace elements. Although chemical water types varied, 53 percent of the wells had a combination of calcium magnesium bicarbonate water. More than 90 percent of the wells sampled had water with a low to medium sodium-salinity hazard when used for irrigation.

1.0 INTRODUCTION

1.1 Location and General Features

Water Use and Agricultural Activities Are Described

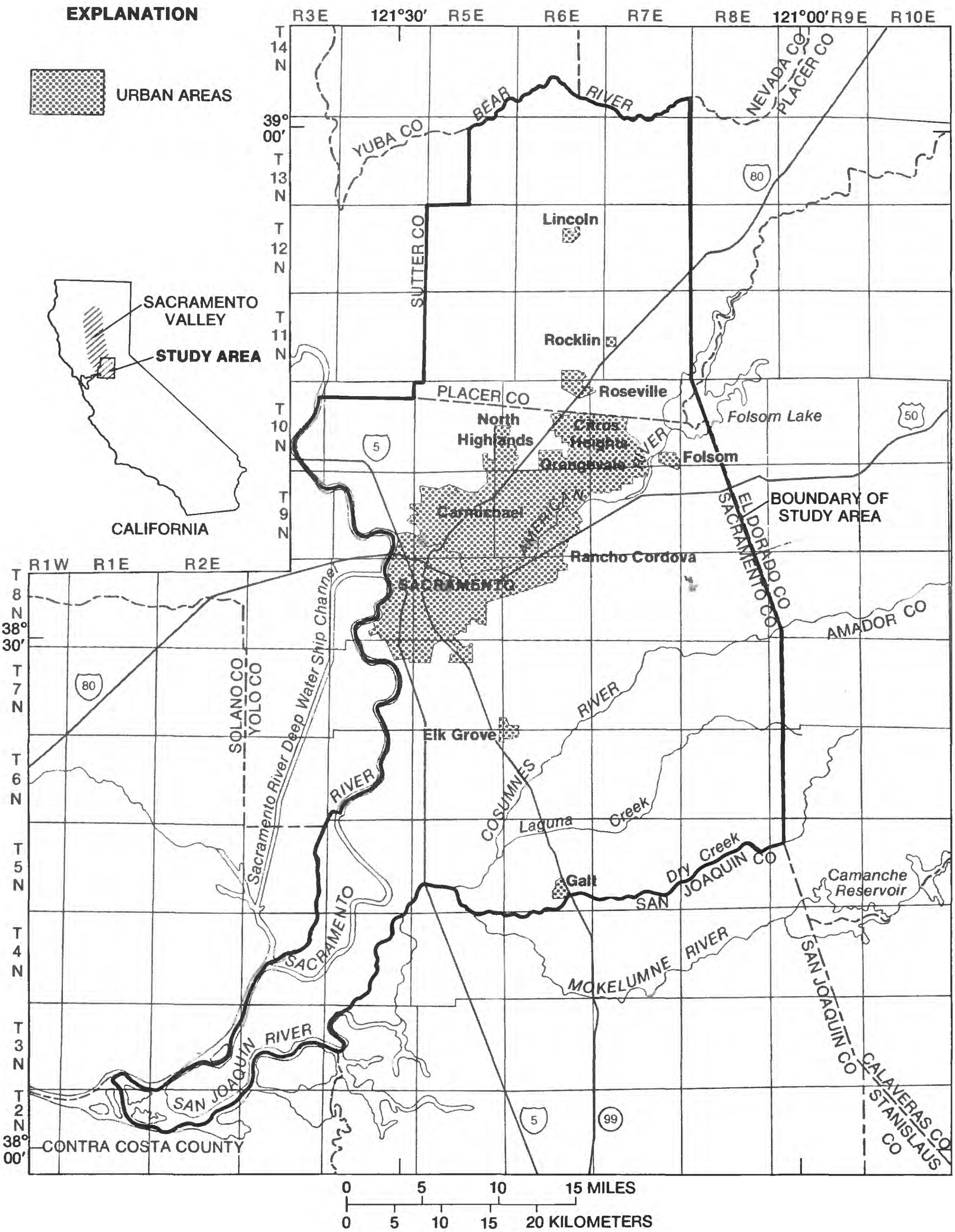
The area of this report includes 1,300 mi^2 of the southeastern Sacramento Valley. The area has both urban and rural environments.

The area studied includes about 1,300 mi^2 of Sacramento and western Placer Counties, and lies in the southeastern part of the Sacramento Valley. The area is bounded by the Sacramento River on the west, the foothills of the Sierra Nevada on the east, Dry Creek and the San Joaquin River on the south, and the Bear River on the north.

The city of Sacramento and adjoining urban communities are the largest metropolitan area in north-central California. The study area is also a major agricultural area. Dairy farming is the predominant agricultural activity in Sacramento County (Sacramento County, 1983),whereas, rice is the principal crop produced in western Placer County (John Wilson, Placer County Agricultural Department, oral commun., 1984).

Use of ground water in Sacramento County has increased since the installation of domestic wells in the 1850's. Increased irrigation and urbanization have continued to draw on ground water until it is now nearly one-half of the total water supply of Sacramento County (CH2M/Hill, 1976).

Although Placer County is becoming increasingly urbanized, ground water within the county is used primarily for irrigation. Diversions from the Bear River supplement ground water for irrigation in the northwestern part of Placer County (Grant Ardell, California Department of Water Resources, oral commun., 1983).



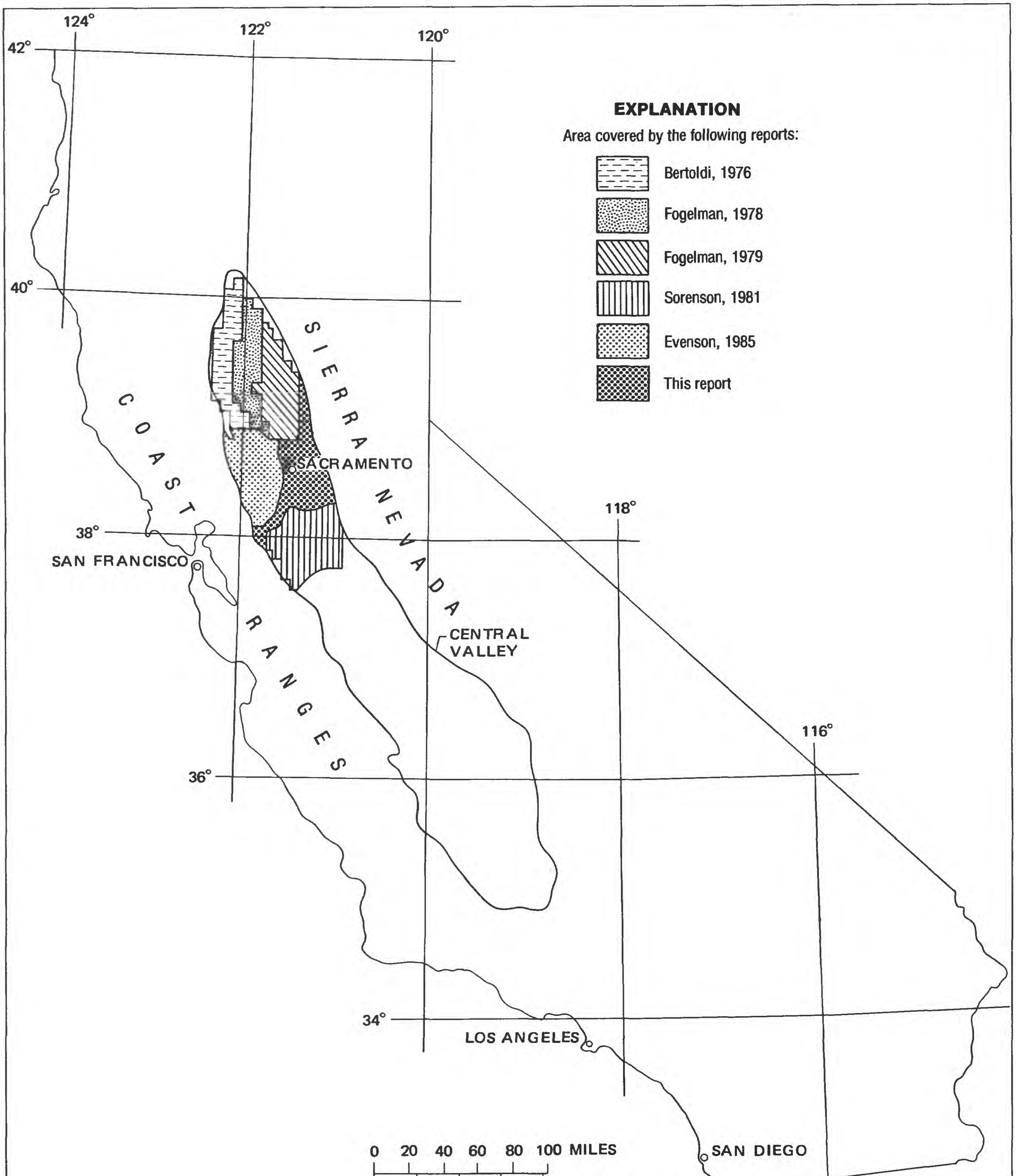
Location and general features.

1.2 Purpose, Scope, and Previous Studies

Ground-Water Quality in Sacramento and Western Placer Counties Was Investigated

A network of wells was chosen to represent ground-water quality. These wells were sampled and the data were analyzed.

This report is the sixth in a series of reports, prepared by the U.S. Geological Survey in cooperation with the California Department of Water Resources, that document the chemical quality of ground water in the Sacramento Valley. This report describes the inorganic chemical quality of ground water in Sacramento and western Placer Counties in 1982. The scope of the study included (1) collection of well data, mainly from drillers' reports; (2) a selective field inventory of wells chosen from data collected; (3) collection of ground-water samples for chemical analysis from 209 selected wells; (4) classification of ground water into chemical types based on percentages of specific ionic components; and (5) identification of areas or well sites where specific chemical constituents in ground water exceeded recommended limits for domestic or agricultural uses.



Areas included in reports of ground-water quality in Sacramento Valley.

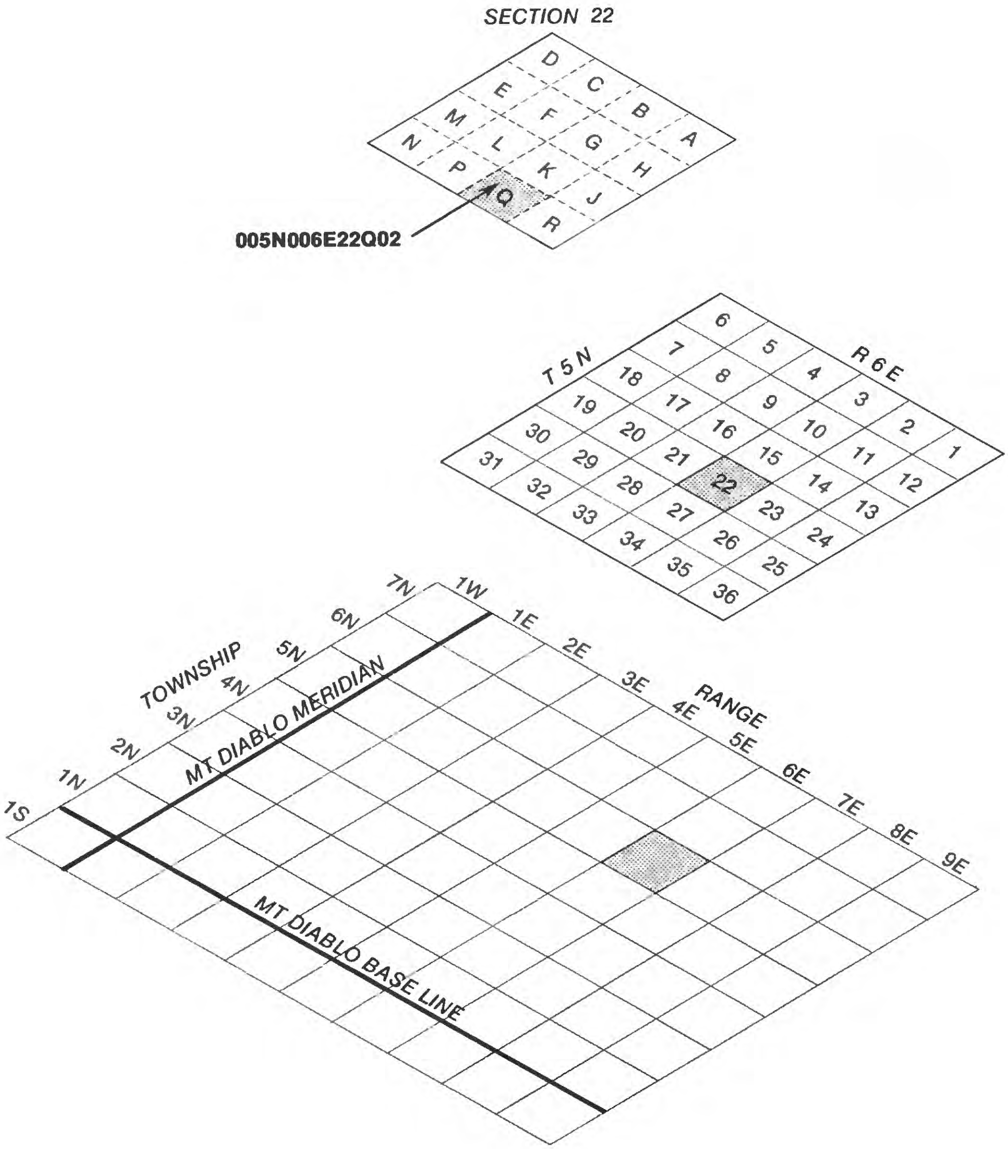
1.0 INTRODUCTION--Continued

1.3 Well-Numbering System

Wells Are Numbered According To Their Location Within a Township

The well-numbering system is based on the rectangular subdivision of public lands.

Wells are identified according to their location in the rectangular system for the subdivision of public lands. The identification consists of the township number, north or south; the range number, east or west; and the section number. Each section is further divided into sixteen 40-acre tracts lettered consecutively (except I and 0), beginning with A in the northeast corner of the section and progressing in a sinusoidal manner to R in the southeast corner. Within the 40-acre tract, wells are sequentially numbered in the order they are inventoried. The final letter refers to the Mount Diablo base line and meridian. Because all wells in the study area are referenced to Mount Diablo base line and meridian (M), the final letter will be omitted.



Well-numbering system.

2.0 GEOLOGY AND HYDROLOGY

2.1 Geomorphic Units

Geomorphic Units Are Described

The area is principally in the Central Valley geomorphic province with a small part in the Sierra Nevada.

The area lies in two geomorphic provinces, the Central Valley and the Sierra Nevada. The area within the Central Valley has been divided into five units: The Sacramento-San Joaquin Delta, flood plains, flood basins, low alluvial plains, and dissected alluvial uplands (Olmsted and Davis, 1961).

Under natural conditions, the Sacramento-San Joaquin Delta was a tidal marsh traversed by the meandering sloughs of the Sacramento, San Joaquin, and Mokelumne Rivers where they joined and entered into Suisun Bay (Piper and others, 1939). Most of the area has been confined by artificial levees to produce a series of islands used extensively for agriculture. These islands are composed of peat and other organic sediments and they are continually subsiding. The altitude of these islands is often lower than the surrounding water.

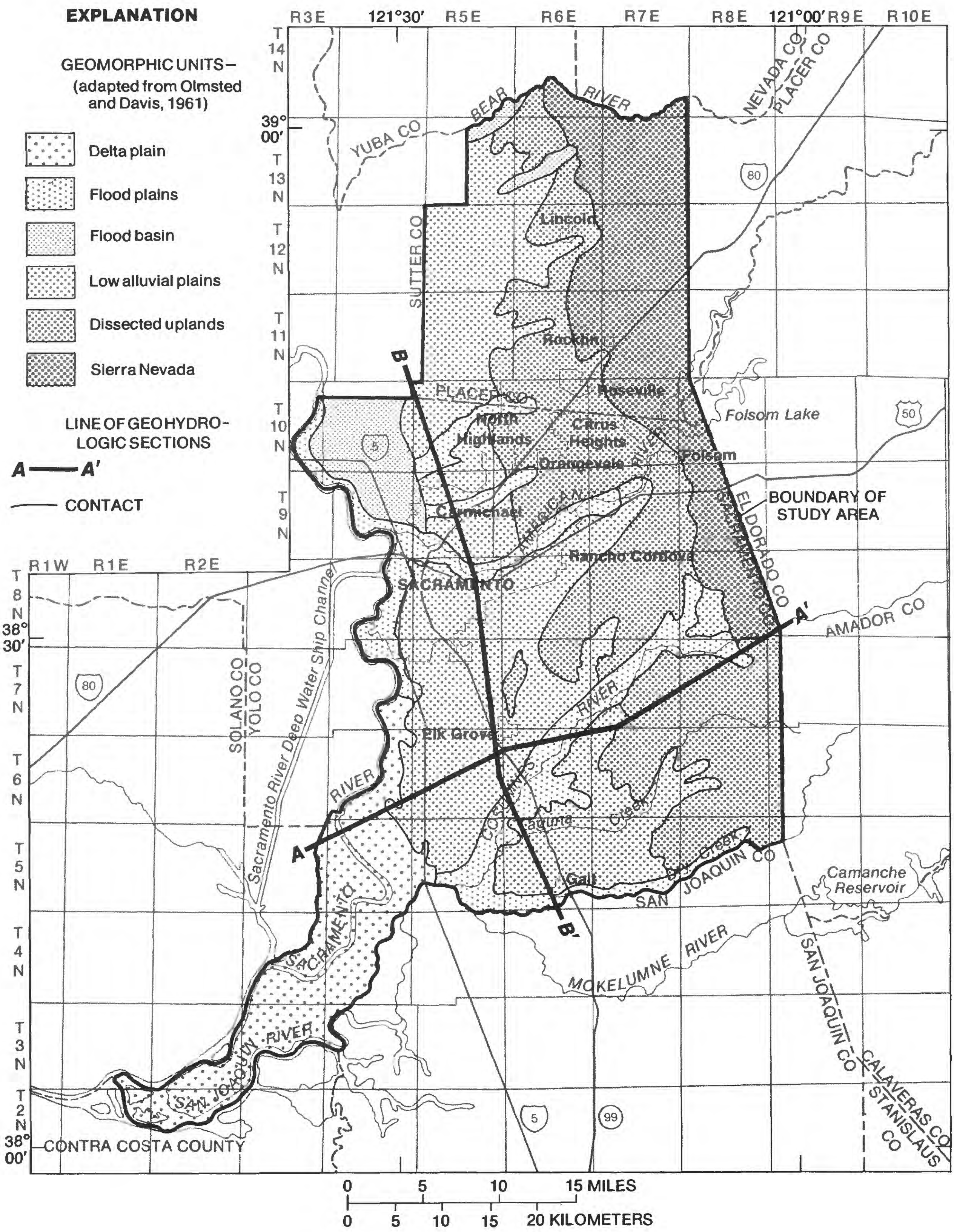
Although there is no sharp definition between the delta plain and the river flood plains, for this report the boundary was arbitrarily chosen to be the zero-elevation contour which roughly coincides with the contact between the organic and inorganic soils (California Department of Water Resources, 1974). The flood plains of the Sacramento, American, and Cosumnes Rivers, as well as several smaller tributaries consist primarily of unconsolidated inorganic sediments.

The flood basin is low, nearly flat, poorly drained land north of the American River and east of the Sacramento River. Prior to the construction of levees along the rivers, the Sacramento River periodically overflowed its banks and excess water accumulated in the basin to form a broad, shallow, temporary lake. With the construction of the levees, this area seldom floods.

Low alluvial plains slope gently upward from the Sacramento River. The southern area of Sacramento County was described by Piper and others (1939) as part of the Victor Plain; coalesced alluvial fans built up by the Mokelumne River and smaller streams from the Sierra Nevada. Little or no deposition is taking place on most of the low alluvial plains and a condition approaching equilibrium exists where many of the soils have matured profiles containing hardpan (Olmsted and Davis, 1961).

Dissected alluvial uplands border the alluvial plains to the east. This subunit is typified by rolling topography; rounded knolls and ridges separated by minor intermittent streams. The underlying sediments are being uplifted with the foothills of the Sierra Nevada and are eroding (Olmsted and Davis, 1961).

The northeastern section of the study area is part of the Sierra Nevada geomorphic province. This area is underlain by hard, non-water-bearing rocks, and is characterized by steep-sided hills and narrow, rocky stream channels.



Geomorphic units.

Seven Geohydrologic Units Supply Water to Wells

The subsurface geology of Sacramento County has been studied by the California Department of Water Resources (1974). The wells sampled penetrate seven different geohydrologic units.

The California Department of Water Resources (1974) has studied the subsurface geology of Sacramento County and compiled several cross sections from drillers' logs and other data. These cross sections were used to determine the geologic formation in which the sampled wells were finished. Cross sections were not available for most of Placer County, therefore differentiation of geologic formation was not possible in the northern section of the study area unless the well penetrated bedrock (the Sierra Nevada basement complex) according to the driller's log.

The Victor Formation (of former usage and as used by Olmsted and Davis, 1961) is exposed at the surface throughout much of the study area, primarily in the low alluvial plain. The formation is a mix of sand, silt, and clay deposited by shifting streams that drained the Sierra Nevada during Pleistocene age (California Department of Water Resources, 1978). Grain size and clay content vary considerably both laterally and vertically within the formation, and the yield from wells indicates this variability.

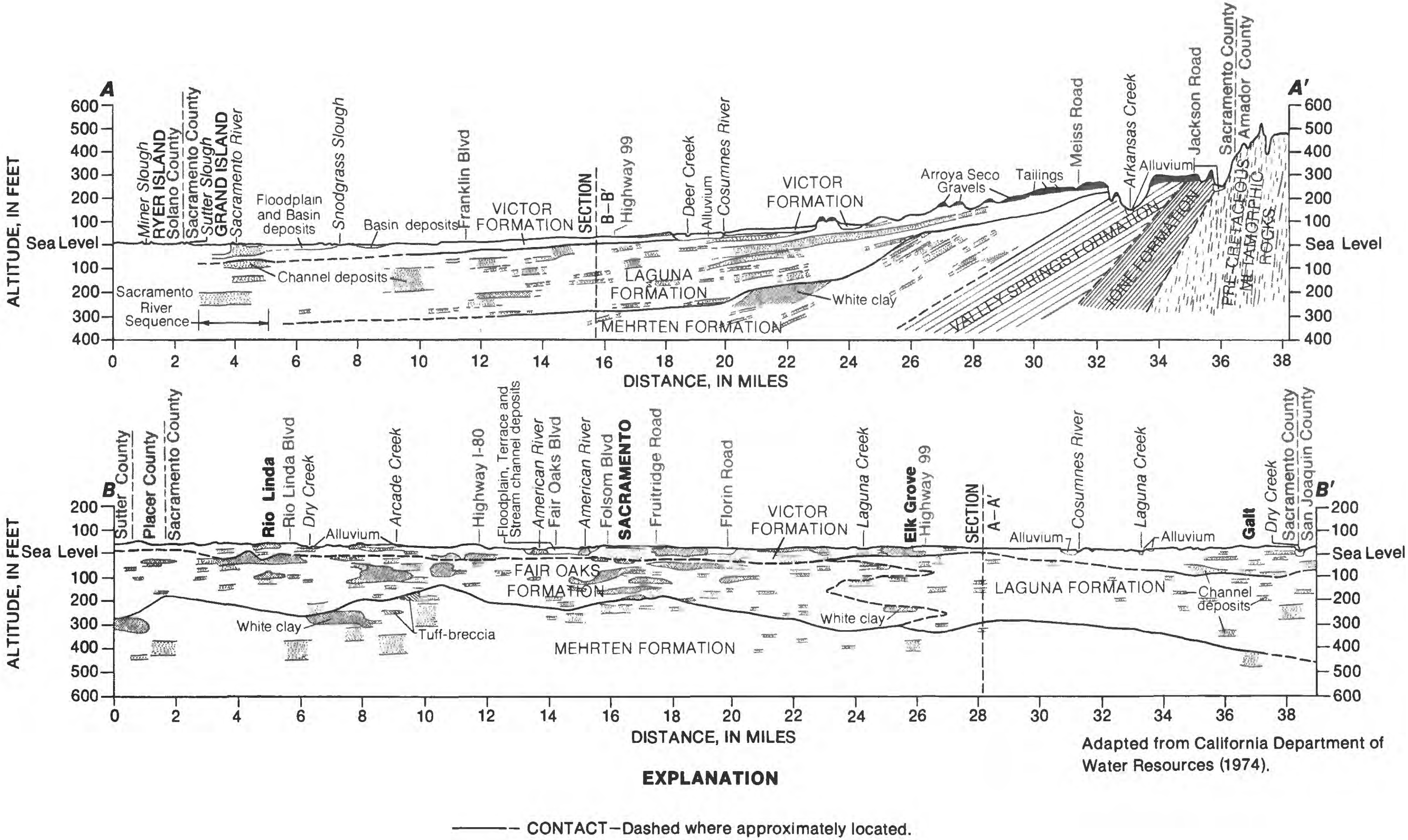
The Fair Oaks and Laguna Formations underlie the Victor Formation and are exposed to the east of it. These formations consist of poorly bedded layers of silt, clay, sand, and gravel deposited by meandering streams in the late Pliocene and early Pleistocene age. The Fair Oaks Formation of Shlemon (1967) bears a strong resemblance to the Laguna Formation in composition and age, but features numerous beds of white to gray-white tuff and tuffaceous silts which are not present in the Laguna Formation (California Department of Water Resources, 1974). The Fair Oaks Formation crops out as far south as the American River and is a subsurface unit as far south as Laguna Creek, where it intertongues with the Laguna Formation. The permeability of these formations varies throughout, depending on the type of material present.

The Mehrten Formation, which conformably underlies the Fair Oaks and Laguna Formations, is strikingly different from the overlying formations. It is composed of volcanic detritus most likely deposited in the early Pliocene age and Miocene age. Two distinctly different units make up the Mehrten Formation. One unit is composed of gray to black andesitic sands interbedded with blue or brown clay; the other is a hard, gray tuffbreccia.

The Valley Springs Formation is exposed only on the eastern side of Sacramento County. It underlies the Mehrten Formation and consists of rhyolitic and volcanic fragments of Pliocene and Miocene age. The formation contains varying amounts of rhyolite ash, vitreous tuff, quartz sand containing abundant glass shards, pale beds of ashy clay, and fragments of pumice (California Department of Water Resources, 1974). Permeability of the unit is low due to the presence of clay and pumiceous material.

The Ione Formation, the most prevalent of the Eocene Series on the eastern side of the Sacramento Valley, was deposited in a deltaic environment and yields fresh to brackish water to wells (Olmsted and Davis, 1961). Yields from this formation are small because of the low permeabilities of these sediments (California Department of Water Resources, 1974).

The basement complex of the Sierra Nevada was penetrated by several of the wells sampled in this study. The unit is made up of hard, non-water-bearing sedimentary and metamorphic rock. Interlacing joints and fissures carry water through the rock and make it available to the wells penetrating them. The quantity of water can vary greatly within a small area.



Geohydrologic sections (see section 2.1 for location).

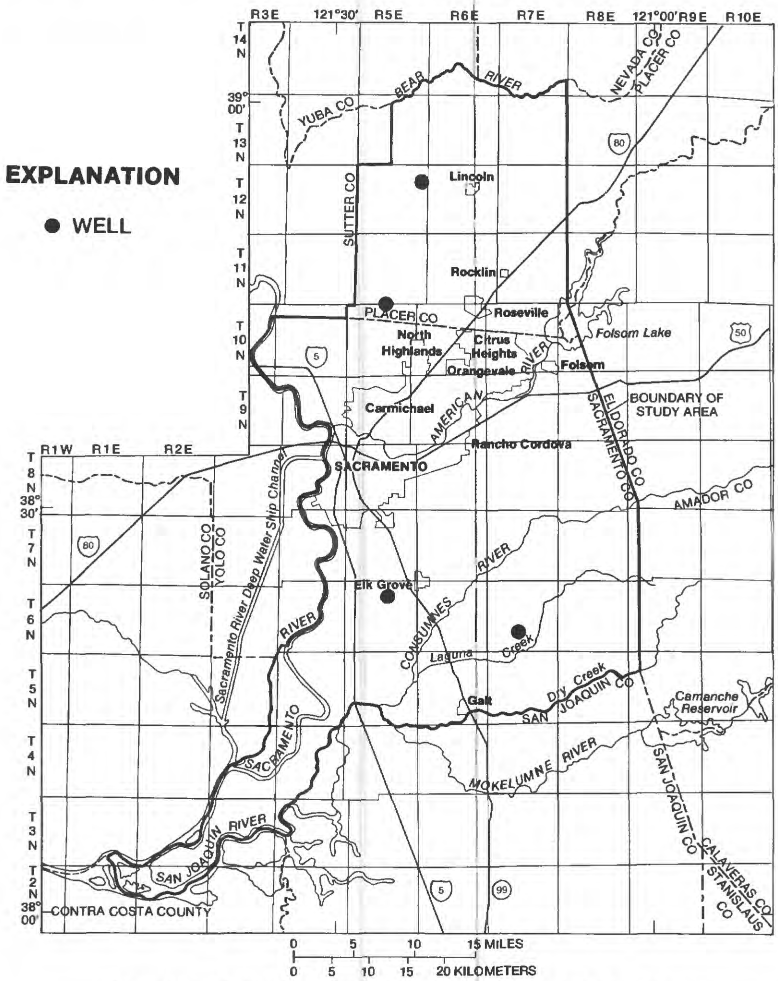
2.0 GEOLOGY AND HYDROLOGY--Continued
2.3 Water Levels

Water Levels Are Declining in Most of the Area.

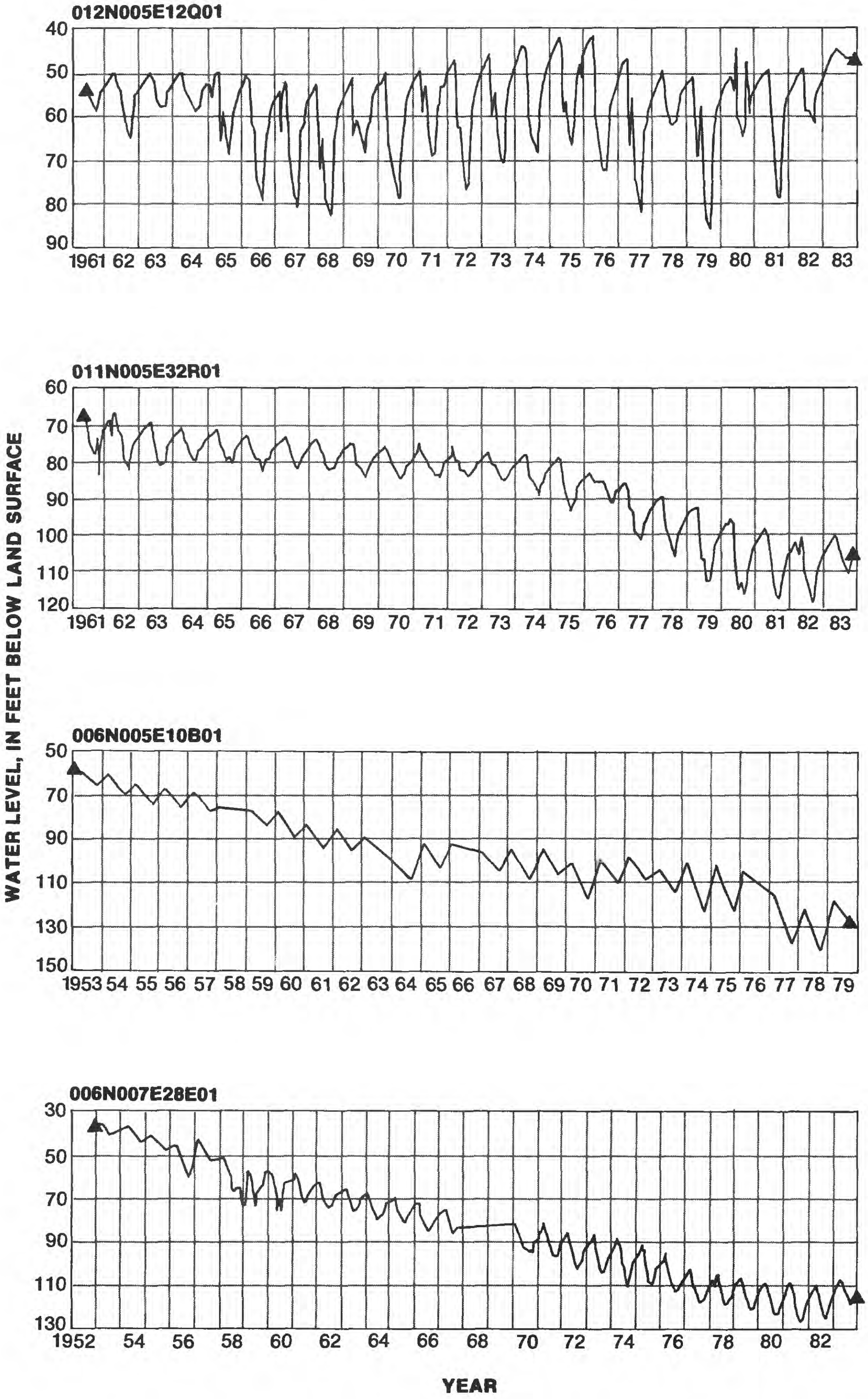
Water levels in four wells indicate that water-level declines are greatest in southern Sacramento County.

The California Department of Water Resources has been monitoring water levels in several wells for 20 years or more. Four of these wells were chosen to illustrate water-level conditions in different parts of the study area. Water levels generally are 50 to 100 feet lower in southern Sacramento County than they are in Placer County. Water levels in wells 006N005E10B01 and 006N007E28E01 have declined an average of 2.5 ft/yr from 1954-82. Seasonal fluctuations are from 5 to 10 feet. Extensive ground-water pumpage for irrigation and slow recharge could account for this decline.

In Placer County, west of Lincoln, ground-water levels are affected by surface-water diversions from the Bear River. Since the mid-1960's, water levels for well 012N005E12Q01 showed a slight, but definite rise with only a small decline during the drought of 1976-77. Water levels for well 011N005E32R01, south and farther west of the area of rising water levels, shows a water-level decline of nearly 2 ft/yr from 1962-82. This decline is less than that shown for the two wells in southern Sacramento County.



Location of wells for which water levels were measured.



Water levels in four wells represent water-level conditions.

3.0 CHEMICAL QUALITY OF GROUND WATER

3.1 Methods of Data Collection and Analysis

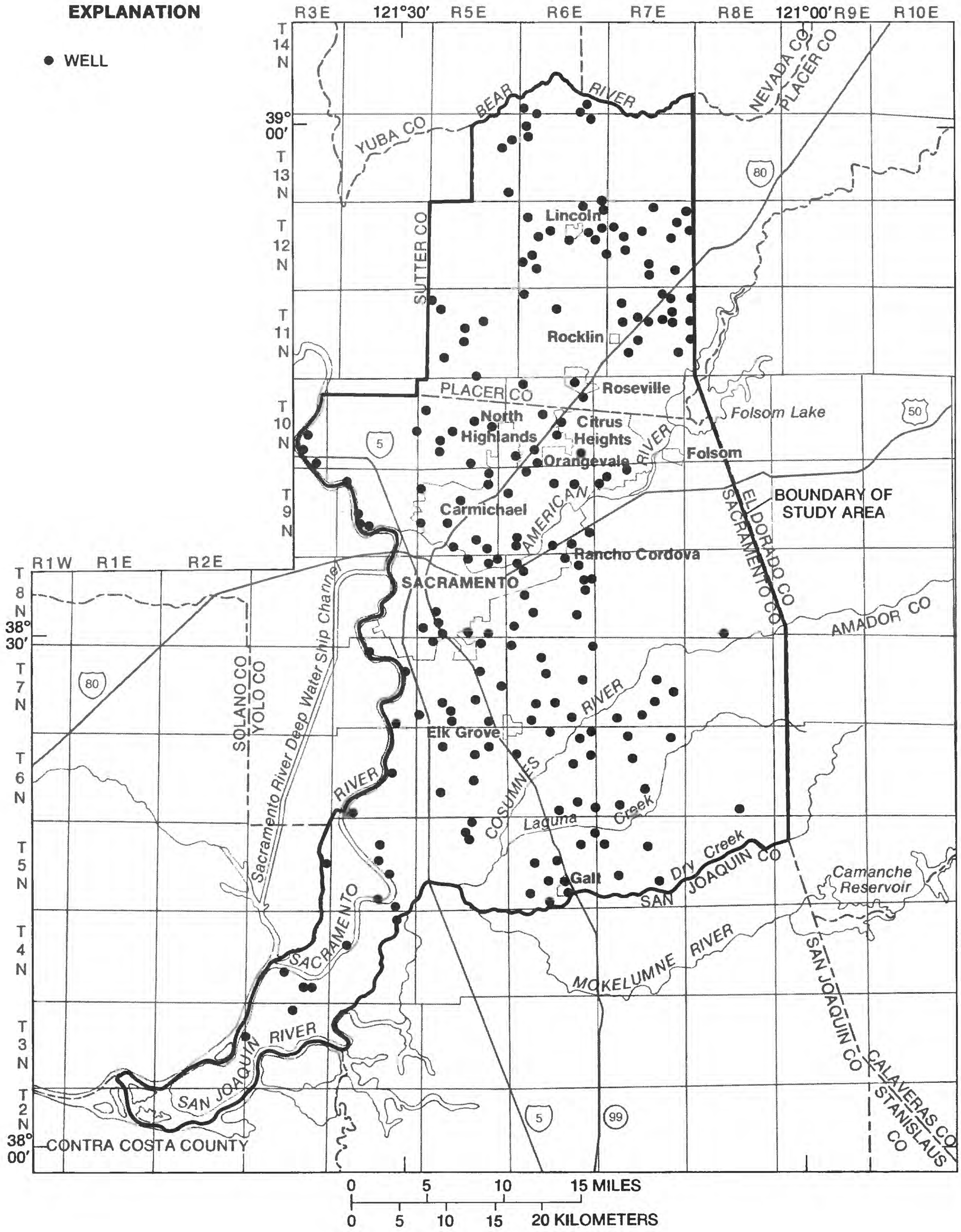
Methods Used for Collecting Ground-water Quality Data are Discussed.

Construction data and locations for about 1,000 wells in Sacramento and Placer Counties were collected from field inventories and California Department of Health Services files. During September 1982, water samples were collected from 209 of these wells.

Between April and August of 1982, about 1,000 wells were inventoried in Sacramento and western Placer Counties. About two-thirds of these wells were domestic or irrigation wells located from drillers' reports filed with the California Department of Water Resources. Most other wells are used for public-water supply and are monitored for exceedance of water-quality criteria by the California Department of Health Services. Construction data and locations for these wells were obtained from their files.

In September 1982, water samples were collected for chemical analysis from 209 of the 1,000 wells. Field determinations of alkalinity, specific conductance, pH, and temperature were made onsite at the time of sampling. Samples were shipped to the Geological Survey Central Laboratory in Arvada, Colo., for analysis of selected constituents and properties.

Chemical analyses of samples from the 209 wells were used to define areas with similar chemical characteristics. Areal distributions of selected chemical constituents are described and illustrated in the following sections. Contacts between the distribution of constituent values are drawn to show general ranges. In some areas, contacts are approximate because of a lack of data. For some chemical constituents, contacts could not be determined because the water from wells in or near the same area did not have similar characteristics or the values of the constituents were uniformly low. For these constituents, only the concentration values which exceeded water-quality criteria are shown on the maps.



Locations of sampled wells.

Water-Quality Data Are Compared to Recommended Standards.

Water quality is discussed in terms of potential effects on humans and irrigated agriculture. Concentrations are compared to Federal standards for public drinking-water supplies and recommendations for irrigation applications.

A total of 209 wells were sampled, including 106 domestic water-supply wells, 33 irrigation wells, 57 public water-supply wells, and 13 wells used for commercial, industrial, or other uses. Many of the domestic wells also were used for irrigation or stock on small 5- to 20-acre ranchettes. Generally, all wells in a particular area, regardless of use, were drilled to similar depths; therefore, all the samples were analyzed and compared to standards for drinking and irrigation water.

This report is concerned only with the potential effects of selected chemical constituents of water on humans or crops. Industrial water-quality standards vary with industry and will not be discussed here. Detailed discussions of chemical constituents and properties of the water are limited to those for which governmental agencies have established standards and recommended limits and which are most likely to indicate degraded water quality.

Federal drinking water standards and recommended maximum concentrations for chemical constituents are used only for comparison and represent statutory limitations only on public drinking-water supplies. The primary drinking-water regulations (U.S. Environmental Protection Agency [EPA], 1975) are for constituents potentially harmful to human health. The secondary drinking-water regulations (U.S. Environmental Protection Agency, 1979) are for elements or conditions that may be objectionable to water consumers esthetically but generally are not harmful to human health.

Ayers and Branson (1975) and the National Academy of Sciences and National Academy of Engineering (1973) provide recommendations for maximum concentrations of certain elements in water to be used for irrigation. There are no regulations on irrigation water and recommendations vary with the type of crop, soil, and farming practice. Unless otherwise noted, recommendations given in this report are for irrigation waters used continuously on all soils.

Recommended limits for selected chemical constituents in drinking water

Constituent	EPA drinking-water regulations (mg/L)	
	Primary	Secondary
Arsenic	0.05	---
Chloride	---	250
Fluoride	[1]1.6	---
Iron	---	0.3
Manganese	---	0.05
Nitrate (as nitrogen)	10	---
Sulfate	---	250
Dissolved solids	---	500

[1]Recommended concentration based on mean annual maximum air temperature from 72 to 79°F.

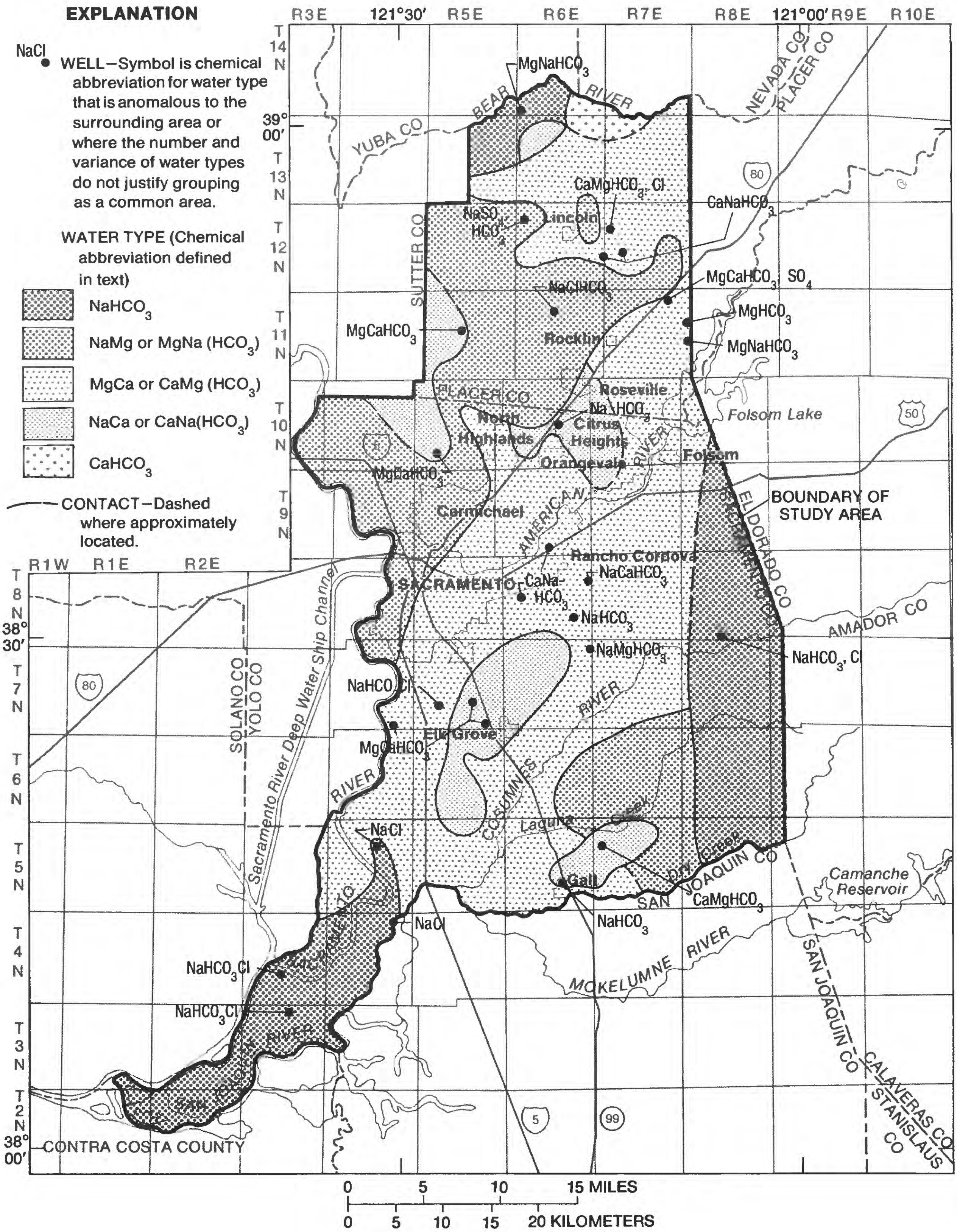
3.3 Water Types

Five Major Water Types Were Found

Water types varied throughout the study area. Fifty-three percent of the wells sampled had a combination of magnesium calcium bicarbonate water. Ninety-four percent of the wells had bicarbonate water.

Water can be classified into general chemical types by use of a system based on the relative percentages of cations and anions (in milliequivalents) in the water (Piper, Garrett, and others, 1953). For example, a sodium bicarbonate water type has 50 percent or more of the cations as sodium and 50 percent or more of the anions as bicarbonate. In a magnesium calcium bicarbonate water, magnesium and calcium are first and second, respectively, in order of abundance among the cations, but neither amounts to 50 percent of the cations.

Major water type combinations in the study area were magnesium calcium (MgCa), sodium magnesium (NaMg), and sodium calcium (NaCa) bicarbonates (HCO_3). Sodium bicarbonate ($NaHCO_3$) and calcium bicarbonate ($CaHCO_3$) water types also were present. Magnesium calcium (MgCa) or calcium magnesium (CaMg) ions represented the most abundant cation water type, accounting for 53 percent of the analyses. In 94 percent of the wells, bicarbonate was the predominate anion.



Areal distribution of water types.

3.0 CHEMICAL QUALITY OF GROUND WATER--Continued

3.4 Dissolved Solids

Dissolved Solids Are Highest Along the Sacramento River and Near Lincoln

Dissolved-solids concentrations ranged from 58 to 1,070 mg/L with a mean of 230 mg/L and a median of 186 mg/L.

High concentrations of dissolved solids are objectionable in drinking water because of possible physiological effects, unpalatable tastes, and corrosion or encrustations on water-supply systems. These effects are directly related to the concentrations of individual constituents that are dissolved in the water. Unless the water has a concentration of a particular element which exceeds the recommended limit for that element, water which has less than 500 mg/L of dissolved solids is usually acceptable to most consumers (U.S. Environmental Protection Agency, 1979).

The dissolved-solids concentrations ranged from 58 to 1,070 mg/L, with a mean of 230 mg/L and a median of 186 mg/L. Eleven wells exceeded the recommended maximum concentration for dissolved solids of 500 mg/L. These wells were along the Sacramento River and near Lincoln. The wells near Lincoln probably penetrate the brackish waters of the Ione Formation, degrading their water quality.

Boron Concentrations Generally Were Low

Boron concentrations had a mean of 0.25 mg/L and a median of 0.12 mg/L. Three wells near Lincoln had concentrations as high as 6.8 mg/L.

At present, there are no recommended limits for boron concentrations in drinking water. In 1971, the Drinking Water Standards Technical Review Committee removed the suggested limit of 1 mg/L stating that there was insufficient information to suggest that a limit was needed for physiological reasons (National Academy of Sciences and National Academy of Engineering, 1973).

Boron is essential to plant growth but concentrations of more than 0.75 mg/L can be toxic to plants. Because crops vary in their tolerance to boron, three standards have been set according to the boron tolerance of the crop. The recommended maximum concentration of boron for use on sensitive crops is 0.75 mg/L; semitolerant crops, 1.0 mg/L; and tolerant crops, 2.0 mg/L (U.S. Salinity Laboratory Staff, 1954).

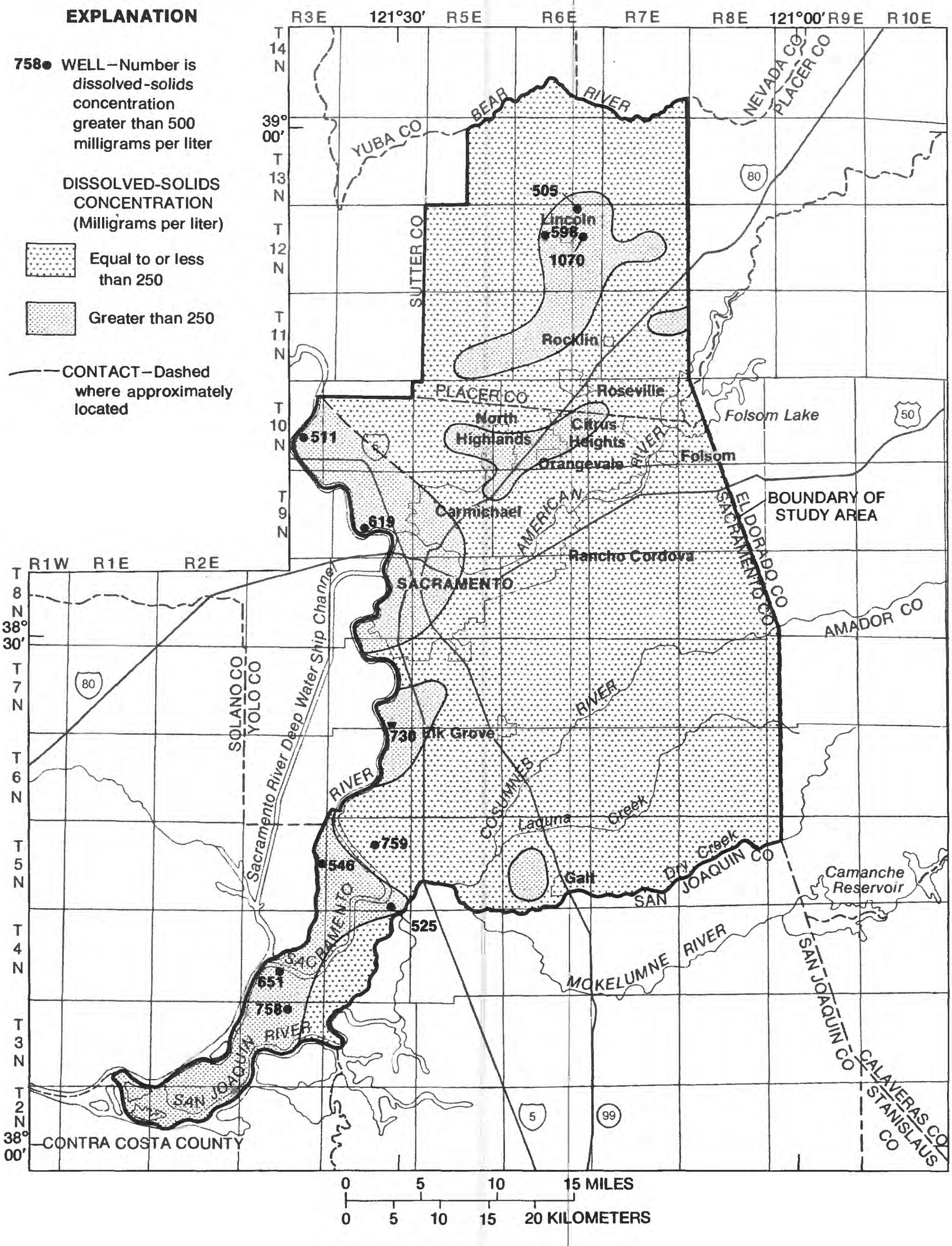
The concentrations of boron in samples from 13 wells exceeded 0.75 mg/L. The highest concentrations, 4.5, 5.6, and 6.8 mg/L, were in samples from three wells east of Lincoln. This water is not suitable for irrigation use on any crop. Water from the other 10 wells between Roseville and Lincoln or along the Sacramento River had boron concentrations ranging from 0.76 to 1.6 mg/L. The mean concentration for the entire area was 0.25 mg/L and the median was 0.12 mg/L.

Relative tolerance of plants to boron

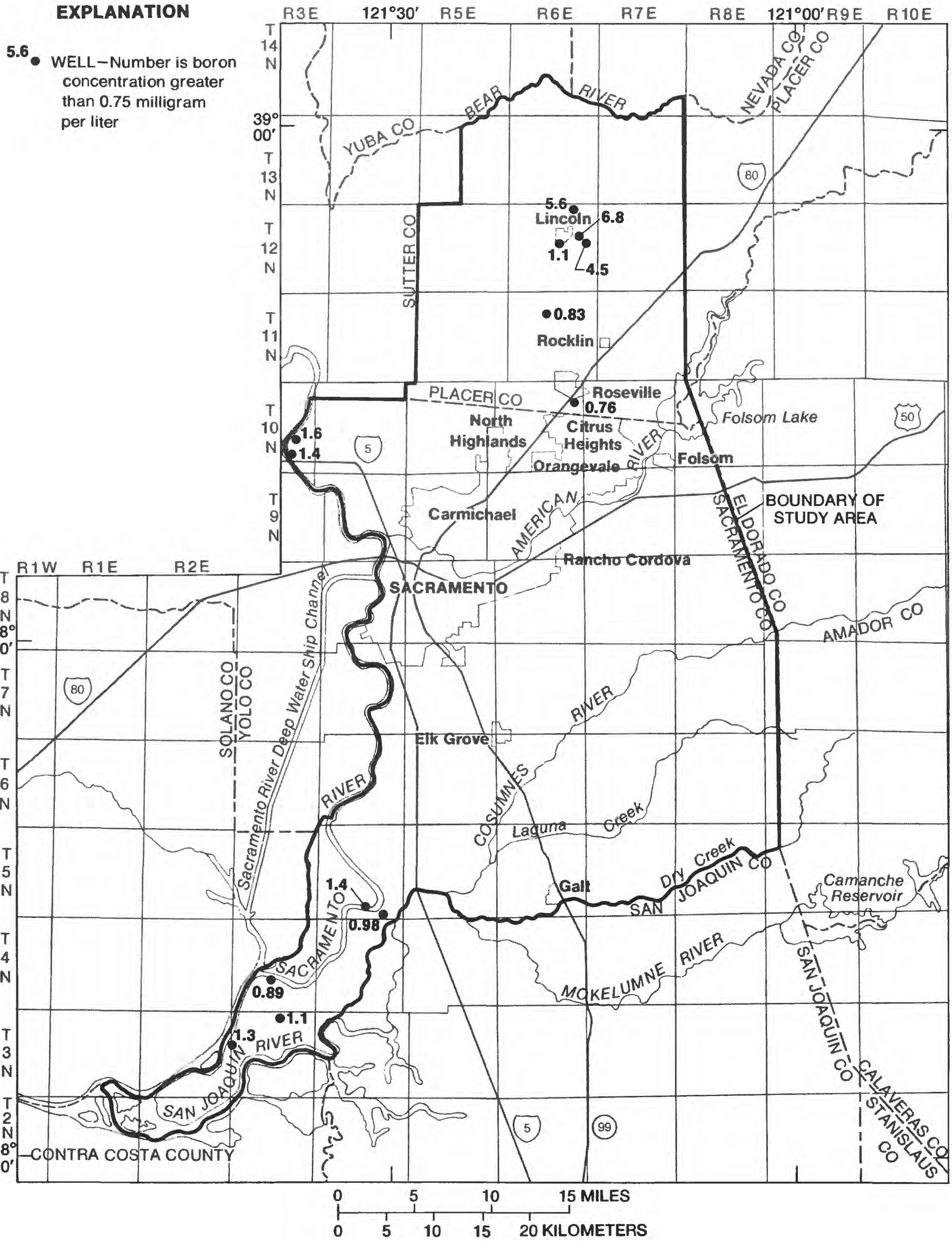
(In each group, the plants first named are considered as being more sensitive and the last named more tolerant.)

Sensitive (0.75 mg/L)	Semitolerant (1.0 mg/L)	Tolerant (2.0 mg/L)
Citrus fruits	Lima bean	Carrot
Avocado	Sweet potato	Lettuce[1]
Thornless blackberry	Bell pepper[1]	Cabbage[1]
Apricot	Tomato[1]	Turnip
Peach[1]	Pumpkin	Onion
Cherry	Oat[1]	Broad bean
Kadota fig	Milo	Alfalfa[1]
Grape (Sultanina and Malaga)[1]	Corn[1]	Garden beet
	Wheat[1]	Sugar beet[1]
Apple[1]	Barley[1]	Asparagus[1]
Pear[1]	Olive	Athel (Tamaris Aphylla)
Plum[1]	Field pea	
Navy bean[1]	Radish	
Jerusalem artichoke	Potato	
Black walnut[1]	Sunflower (native)[1]	
Pecan		

[1]Major crops grown in Sacramento County and western Placer County.



Areal distribution of dissolved solids.



Wells with boron exceeding 0.75 mg/L.

3.0 Chemical Quality of Ground Water--Continued

3.6 Chloride

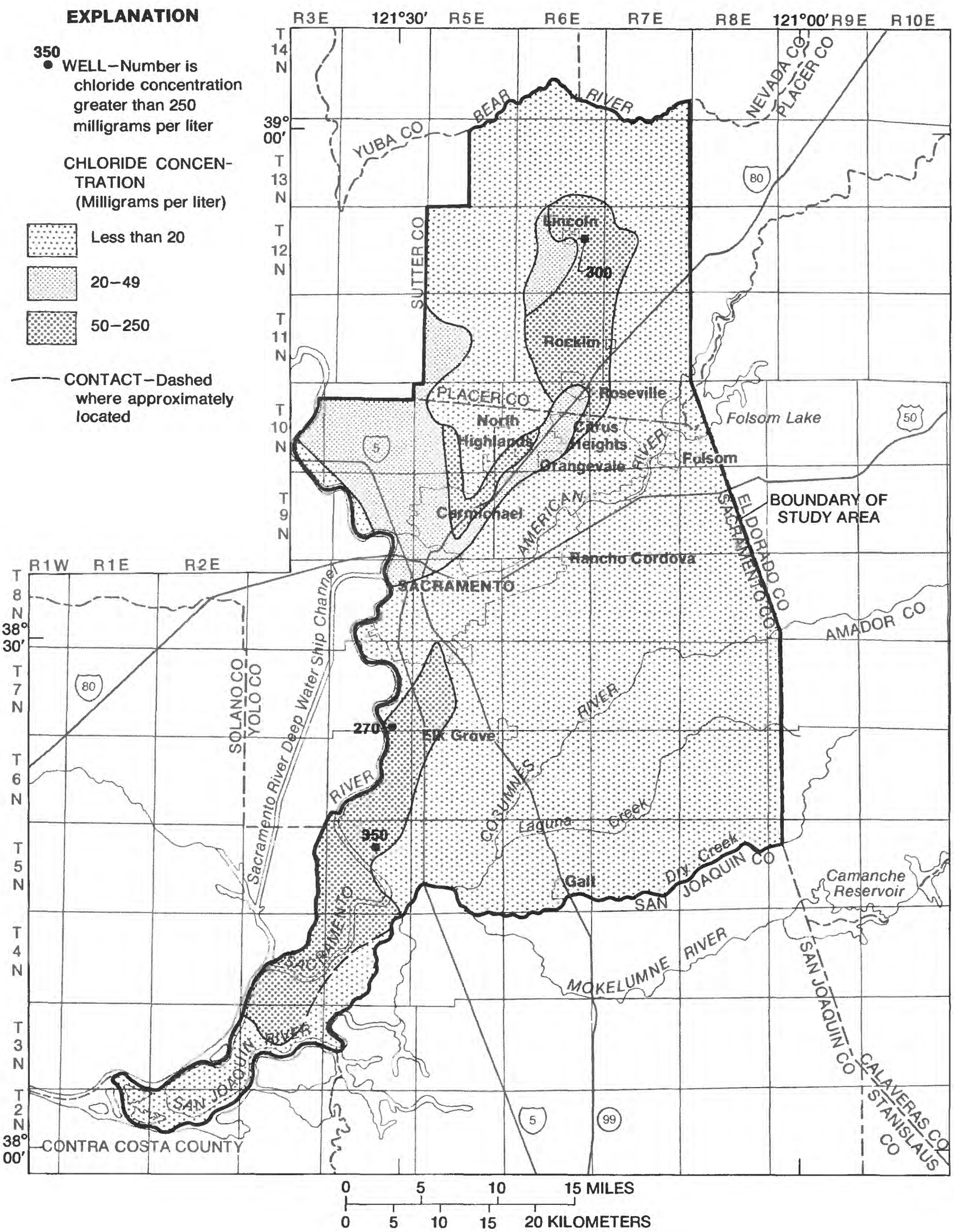
Low Chloride Concentrations Found in Ground Water

Chloride concentrations ranged from 1.0 to 350 mg/L with a mean of 23 mg/L and a median of 9.2 mg/L.

High chloride concentrations in drinking water may produce a salty taste and can lead to corrosion of water fixtures, but generally are not considered a health hazard. For taste preference, the U.S. Environmental Protection Agency (1979) recommends that the maximum concentration of chloride in public-water supplies not exceed 250 mg/L.

High chloride concentrations generally are accompanied by high concentrations of other constituents, and for agricultural purposes, toxic levels of some of the other constituents usually occur before toxic levels of chloride are reached. Crop types, environmental conditions, and irrigation management practices are all important in determining chloride toxicity in plants (National Academy of Science and National Academy of Engineering, 1973).

Chloride concentrations ranged from 1.0 to 350 mg/L with a mean of 23 mg/L, and a median of 9.2 mg/L. Chloride concentrations in water from three wells exceeded the recommended drinking water limit of 250 mg/L. The higher chloride concentrations generally were along the Sacramento River south of Sacramento, and in the Roseville-Lincoln area.



Areal distribution of chloride.

Ground Water is Generally Soft to Moderately Hard

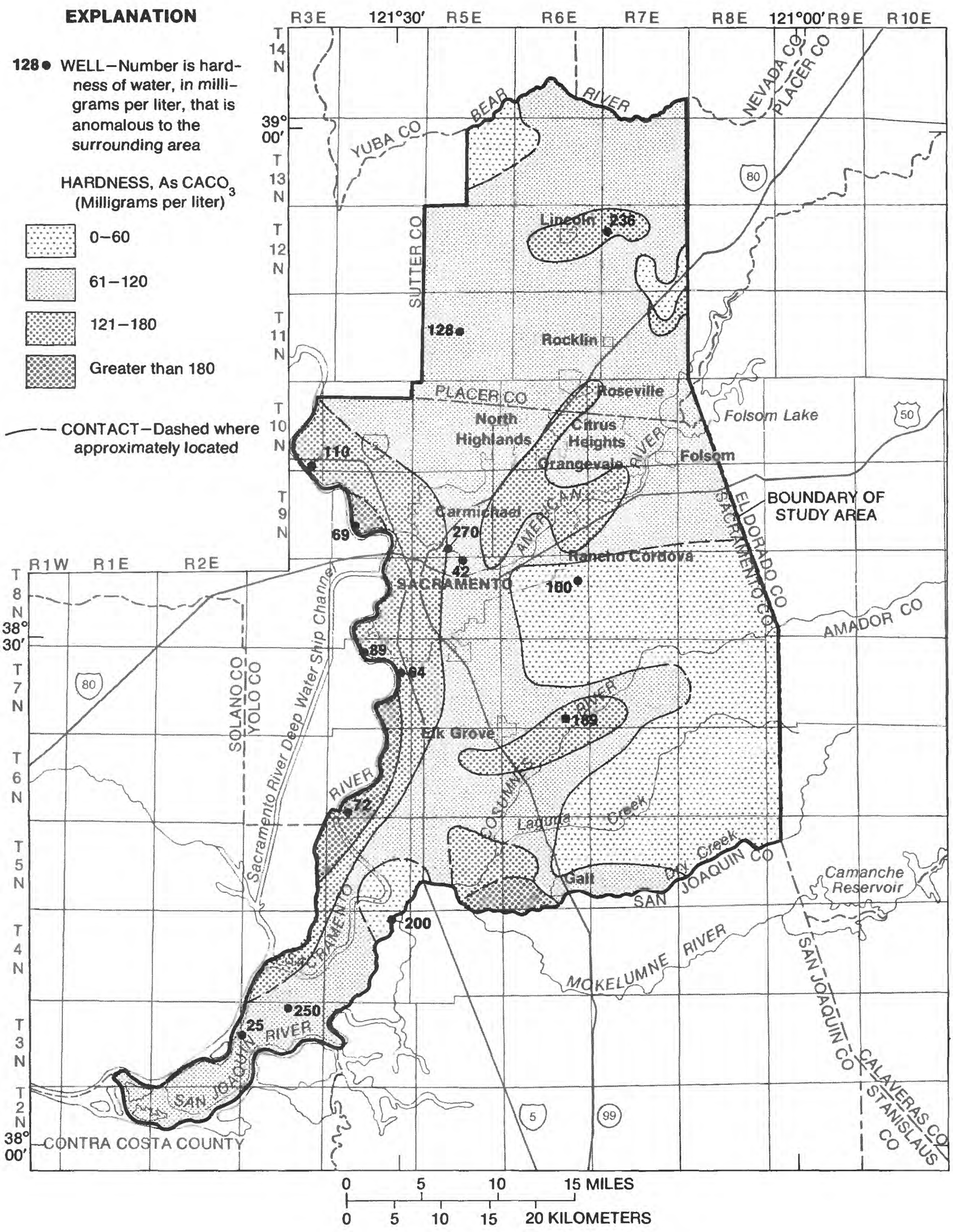
Hardness ranged from 12 to 441 mg/L with a mean of 100 mg/L and a median of 84 mg/L.

Hardness in water generally is associated with effects observed in the use of soap, with the scaling of utensils, or with incrustations left in water pipes. Most of the effects of hardness are attributable to the presence of calcium and magnesium (Hem, 1970). Hardness is reported as an equivalent concentration of calcium carbonate (Skougstad and others, 1979).

The adjectives--hard and soft--as applied to water are relative and inexact, therefore, the following classification by Hem (1970) is used to quantify the terms.

Hardness ranged from 12 to 441 mg/L with a mean of 100 mg/L and a median of 84 mg/L. Most of the area, 76 percent, had soft to moderately hard water. The very hard water was primarily in the west near the Sacramento River.

Classification	Hardness range (mg/L)	Distribution (percentage of wells)
Soft	0-60	2
Moderately hard	61-120	54
Hard	121-180	17
Very hard	Greater than 180	7



Areal distribution of hardness.

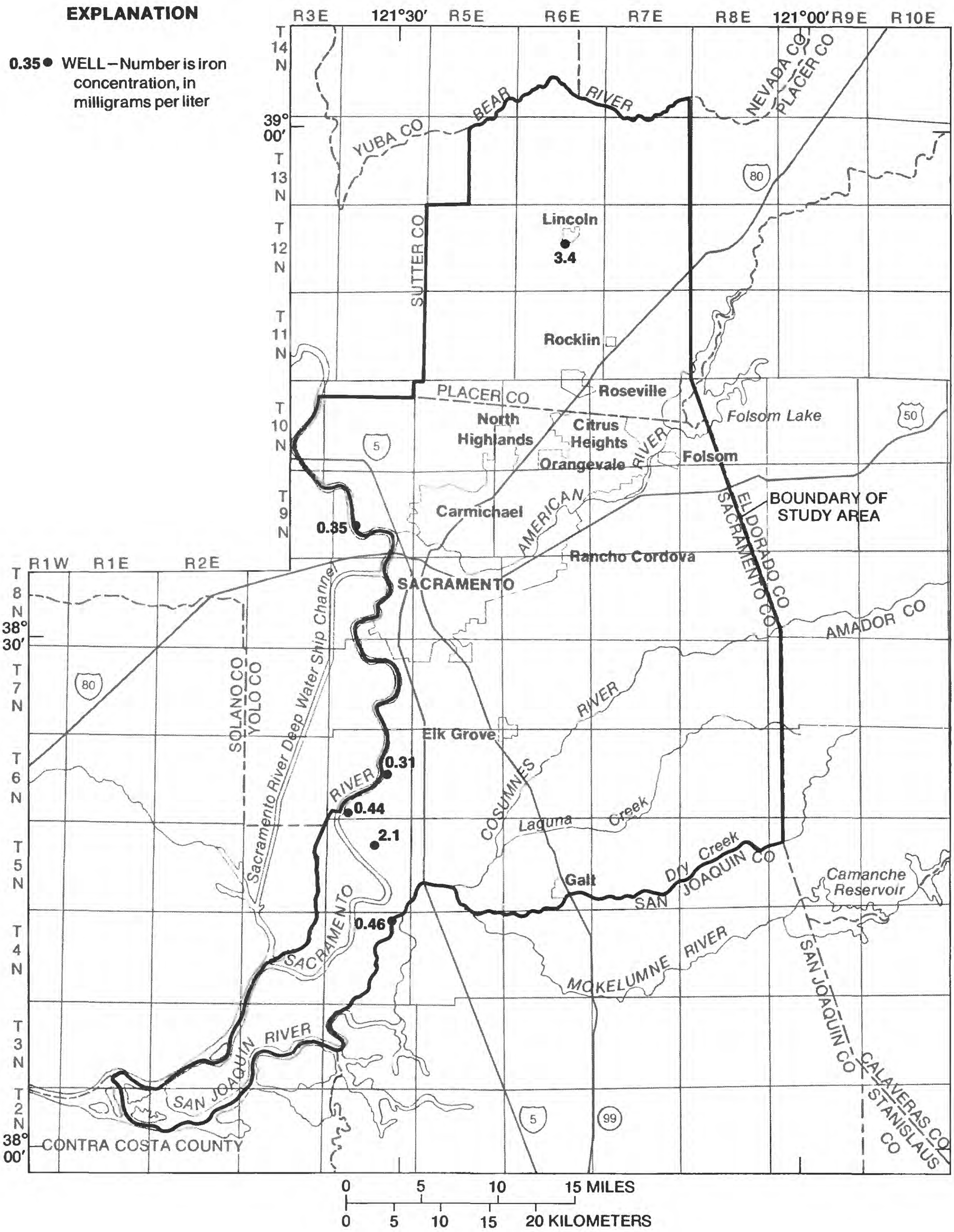
3.8 Iron

Dissolved Iron Concentrations Were Low In Most Areas

Iron concentrations had a mean of 0.06 mg/L and a median of 0.005 mg/L. Samples from six wells exceeded concentrations of 0.3 mg/L.

The presence of large amounts of iron in drinking water generally is not harmful, but may be objectionable because of taste, staining, and accumulation in pipes. Based on these considerations, the U.S. Environmental Protection Agency (1979) recommends a concentration of 0.3 mg/L soluble iron in public water-supply sources.

Iron concentrations varied from less than 0.003 to 3.4 mg/L, with a mean of 0.06 mg/L and a median of 0.005 mg/L. Concentrations of iron samples from six wells exceeded 0.3 mg/L. Five of these wells were along the Sacramento River and one was near Lincoln.



Wells with iron exceeding 0.3 mg/L.

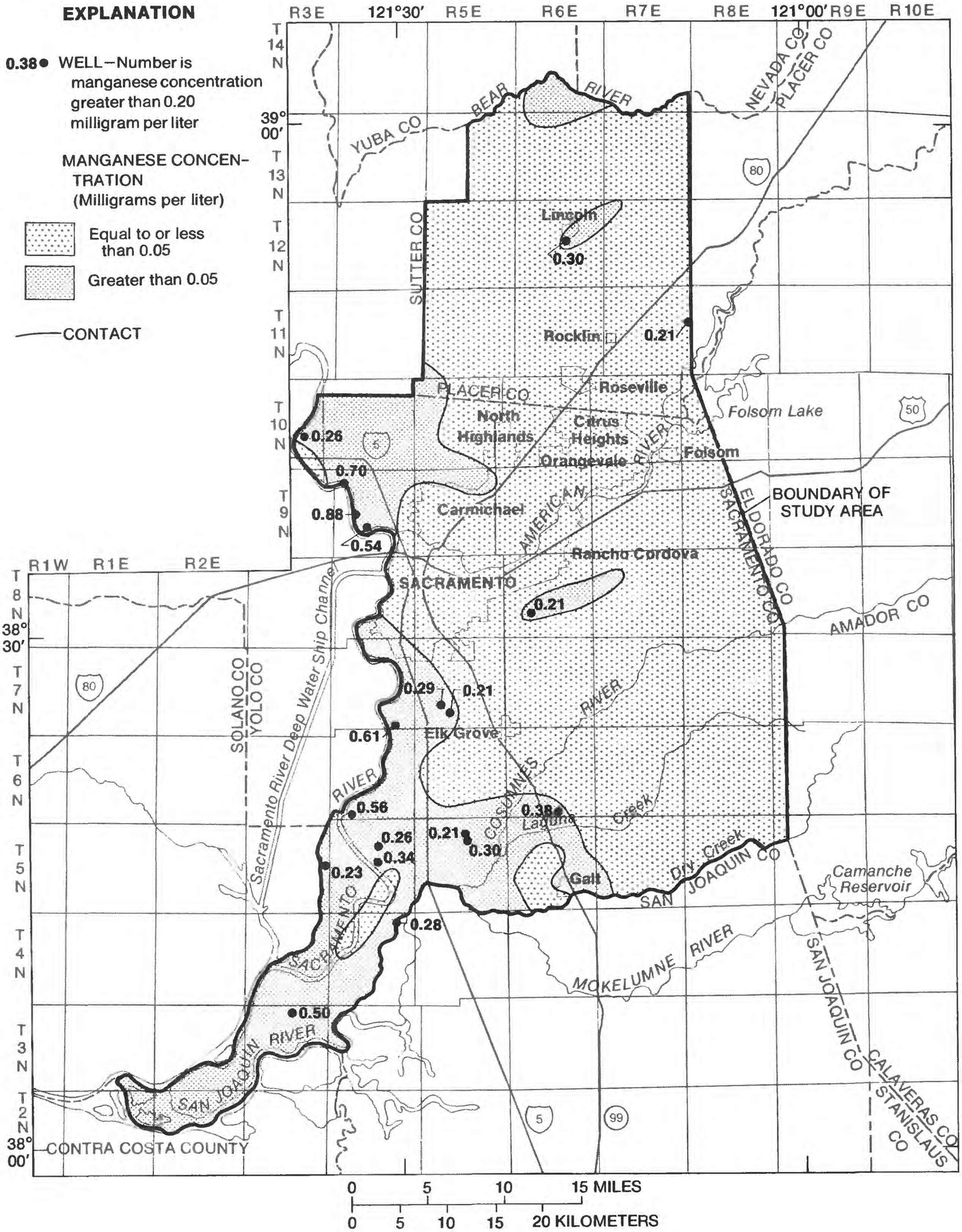
3.9 Manganese

Dissolved Manganese Concentrations Were High in Western Part of Area

Manganese concentrations varied from less than 0.001 to 0.88 mg/L with a mean of 0.052 and a median of 0.002 mg/L.

Manganese, like iron, is objectionable in drinking water because of its taste, staining abilities, and accumulation in pipes. On acid soils, irrigation water that has as little as a few tenths of a milligram of manganese can be toxic to some crops. For these reasons, the U.S. Environmental Protection Agency (1979) recommended a maximum manganese concentration of 0.05 mg/L in public-water supplies. The National Academy of Science and National Academy of Engineering (1973) recommended a maximum manganese concentration of 0.2 mg/L for irrigation water.

High manganese concentrations generally are associated with high iron concentrations but more wells exceeded acceptable concentrations of manganese than iron. Samples from 43 wells, mostly in the western part of the study area, exceeded 0.05 mg/L. Of these wells, 19 exceeded 0.20 mg/L, and were as high as 0.88 mg/L. The mean concentration was 0.052 mg/L for all 209 wells, however, the median was only 0.002 mg/L.



Areal distribution of manganese.

3.10 Nitrogen

Nitrate Contamination is Possible from Domestic and Agricultural Sources

Nitrate nitrogen varied from less than 0.1 to 19 mg/L with a mean of 1.4 mg/L and a median of 1.0 mg/L.

All water samples taken in this study were analyzed for dissolved nitrate plus nitrite and reported as nitrogen. The most abundant form of nitrogen in ground water is nitrate (Hem, 1970), therefore, the sum of the two chemical forms was considered to be mostly nitrate.

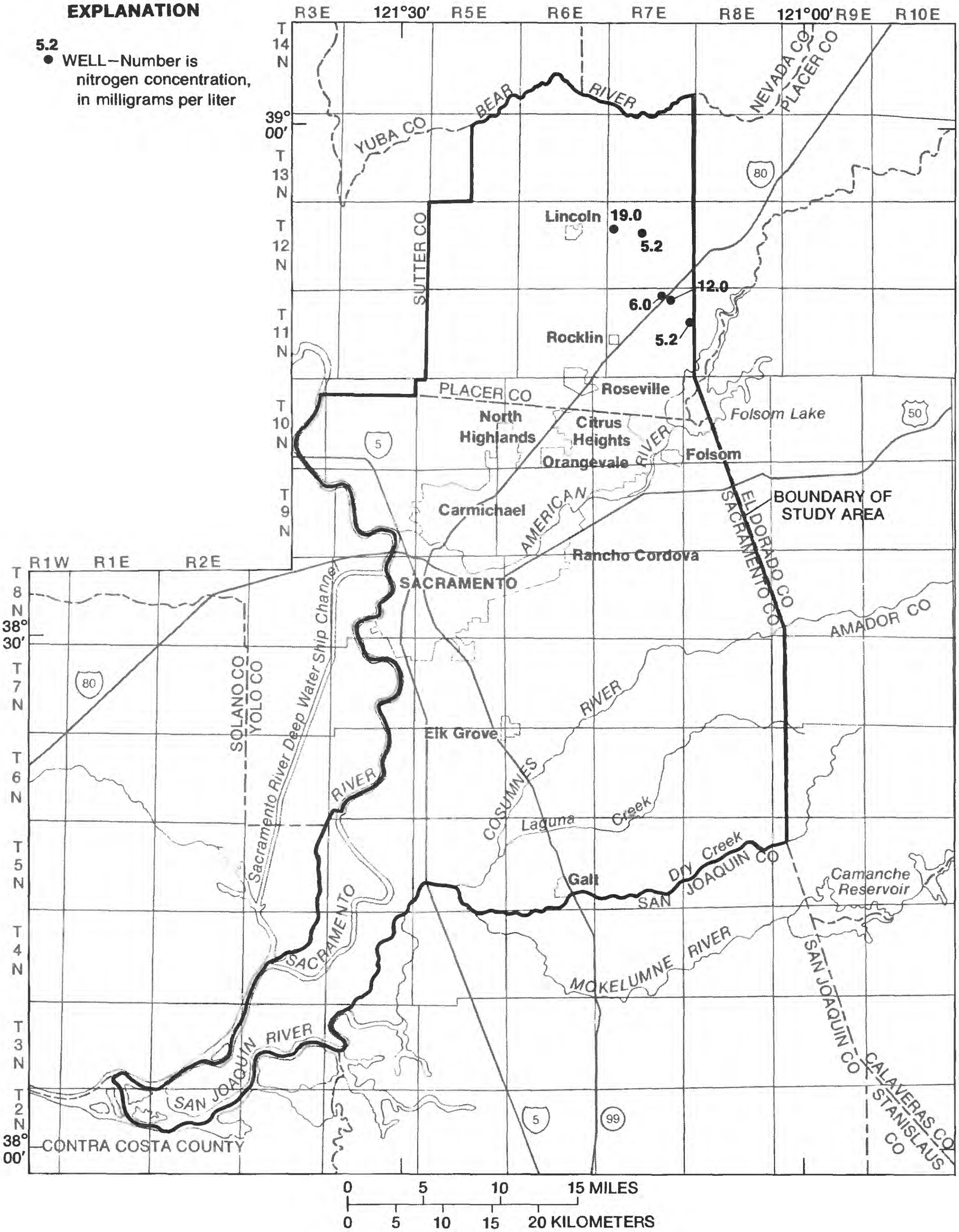
A temporary blood disorder in infants, known as methemoglobinemia, has been associated with the ingestion of waters containing nitrate concentrations greater than 10 mg/L (as nitrogen)(National Academy of Science and National Academy of Engineering, 1973). Although serious and occasionally fatal, this condition is rare in the United States where public-water supplies are used. High nitrate concentrations frequently are found in shallow wells on farms and in rural communities where wells have been inadequately sealed from barnyard drainage, fertilizers, or septic tank contamination. Nitrate contamination also may travel through fractures in bedrock which supply water to some wells.

Because of the adverse health effects of nitrate in infants, the recommended maximum concentration of nitrate (as nitrogen) in drinking water is 10 mg/L (U.S. Environmental Protection Agency, 1975). Nitrate is considered an asset in irrigation water; therefore, no limits for nitrate nitrogen in irrigation water have been established.

Nitrate concentrations in ground water generally were low with a mean of 1.4 mg/L and a median of 1.0 mg/L. Only two wells sampled exceeded 10 mg/L of nitrate nitrogen; these wells were 011N007E02P01 and 012N007E07P01, with values of 12 and 19/mg/L. In the same general area, three other wells had values greater than 5.0 mg/L. All five samples were taken from shallow wells that penetrate fractures in the Sierra Nevada basement complex. The average depth where water may first enter the well is only 37 ft. This suggests that surface contamination of the water may be a factor rather than a natural source of nitrate in the area.

EXPLANATION

5.2
● WELL—Number is nitrogen concentration, in milligrams per liter



Wells with nitrogen exceeding 5.0 mg/L.

3.11 Sodium, Salinity, and Classification of Irrigation Water

Water Was Classified by its Sodium and Salinity for Hazard to Irrigation.

More than 90 percent of the ground water in the area has a low to medium sodium-salinity hazard when used for irrigation.

Sodium in drinking water can adversely affect individuals who must restrict sodium in their diets. The amount of sodium that can cause these effects varies, therefore, no standards for sodium concentrations in drinking water have been established.

Sodium in irrigation water may have detrimental effects on soil structure, infiltration, and permeability. Good drainage is essential for management of salinity or dissolved-solids concentration in irrigated farming. Several combined factors determine the sodium effect of water for irrigation. These factors include the SAR (Sodium Adsorption Ratio), its relation to dissolved solids, and RSC (Residual Sodium Carbonate).

Adsorption of sodium from irrigation water is a function of the proportion of sodium to calcium and magnesium. When the amount of adsorbed sodium exceeds 10 to 15 percent of the total cations of the exchange complex, the soil becomes dispersed and less permeable. To estimate the degree to which sodium will be adsorbed by a soil from a given water, the U.S. Salinity Laboratory (1954) defined the SAR:

$$SAR = \frac{Na^{+1}}{\sqrt{\frac{Ca^{+2} + Mg^{+2}}{2}}}$$

where all concentrations are expressed as milliequivialents per liter (meq/L).

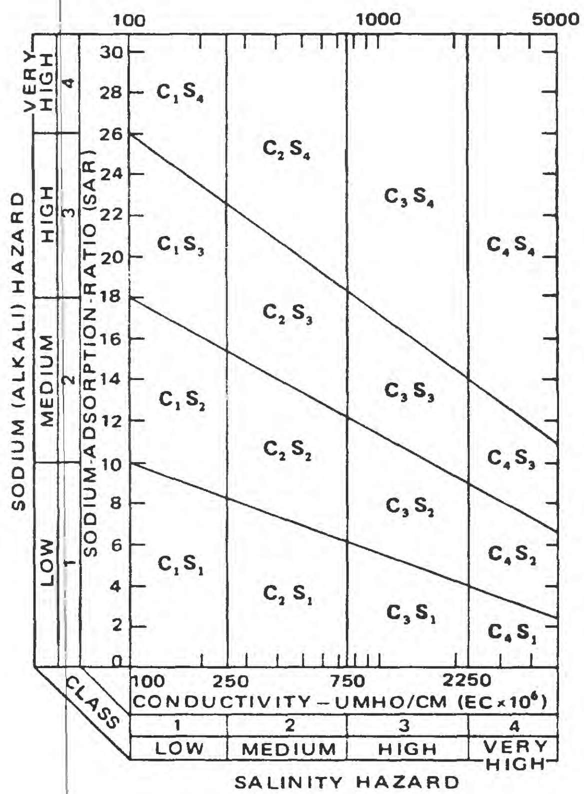
Salinity can be expressed in terms of specific conductance, a quantity proportioned to dissolved-solids concentrations. This classification system is only a guide. With proper irrigation management practices, all water could be used for irrigation (Don Suarez, U.S. Salinity Laboratory, oral commun., 1984).

The U.S. Salinity Laboratory has devised a classification system that will help evaluate the suitability of water for irrigation when SAR and conductivity (specific conductance) are known. The classification diagram for determining the sodium-salinity hazard is given. Areal distribution of classes determined from this diagram shows that most of the area has a low to medium sodium-salinity hazard.

The sodium hazard may be increased if high concentrations of bicarbonate ions are present. The bicarbonate ions will precipitate calcium and magnesium as carbonates, thereby allowing the proportion of sodium ions in solution to increase. This condition was defined by Eaton (1950) as residual sodium carbonate (RSC):

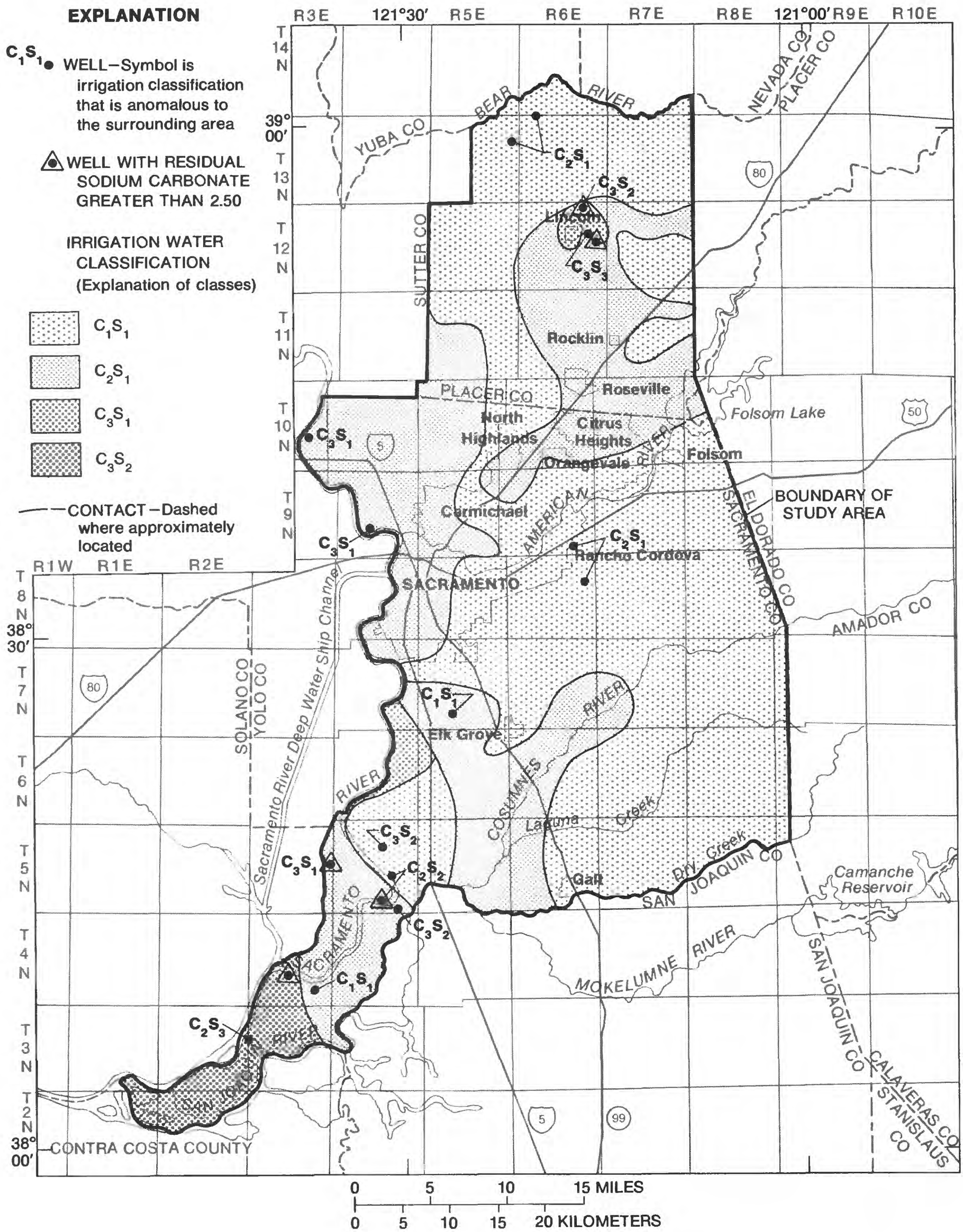
$$RSC = (CO_3^{-2} + HCO_3^{-1}) - (Ca^{+2} + Mg^{+2})$$

where all concentrations are expressed as milliequivalents per liter. Generally, an RSC of less than 1.25 meq/L will not change or affect SAR values, whereas an RSC greater than 2.50 meq/L will increase the sodium hazard. Of the 209 samples taken, more than 90 percent had RSC values less than 1.25 meq/L. Only five samples had values exceeding 2.50 meq/L. The low to medium sodium hazard represented by the SAR values of these five wells may be increased by the high RSC values.



(Modified from U.S. Salinity Laboratory Staff, 1954, p. 80)

Method of classifying irrigation water based on dissolved-solids concentration and sodium hazards.



Areal distribution of irrigation water classes.

3.12 Sulfate

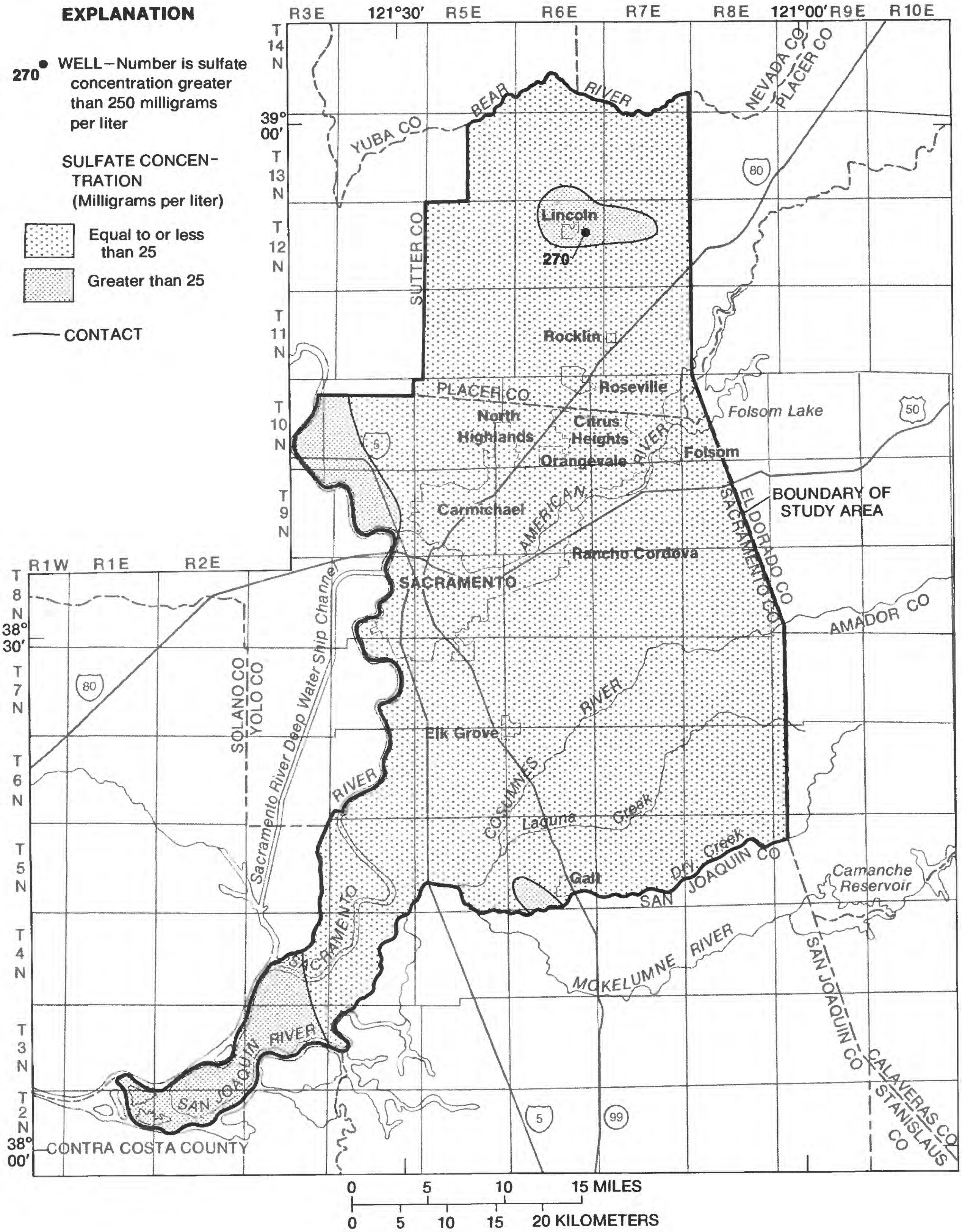
Low Sulfate Concentrations Found

Sulfate concentrations in 43 percent of the samples were less than the detection limit of 5 mg/L.

Poor taste and a cathartic effect are associated with high concentrations of sulfate in water. Moderately high concentrations of sulfate (200-300 mg/L) may have a cathartic effect on people accustomed to water with low sulfate concentrations (U.S. Environmental Protection Agency, 1975). Acclimatization to these waters usually occurs so quickly that sulfate is not considered a health hazard.

The U.S. Environmental Protection Agency (1979) recommends a maximum sulfate concentration of 250 mg/L.

The sulfate levels for the area were very low. Only one well, 012N006E14C01, exceeded the limit with a value of 270 mg/L. Sulfate concentrations in 43 percent of the samples were less than the detection limit of 5 mg/L.



Areal distribution of sulfate.

3.13 Trace Elements

A Few Trace Elements Exceed Recommended Limits

Arsenic, fluoride, mercury, and molybdenum were present in levels exceeding recommended limits for drinking or irrigation water in only a few wells.

Substances that typically occur in concentrations less than 1.0 mg/L are referred to as minor or trace elements. In addition to boron, iron, and manganese, which already have been discussed, all samples were analyzed for arsenic and fluoride. Twenty-three of the samples also were analyzed for an additional 13 trace elements, however, most of these elements occurred in negligible amounts. Arsenic, fluoride, mercury, and molybdenum were the only elements occurring in concentrations which exceeded the recommended limits for drinking or irrigation water.

Arsenic generally is recognized as being toxic to plants and animals, including humans. The U.S. Environmental Protection Agency (EPA, 1975) and the California Department of Health (1977) recommend that public water-supply sources contain no more than 0.05 mg/L of arsenic. The National Academy of Sciences and National Academy of Engineering (1973) recommend that the maximum concentrations of arsenic in irrigation water be 0.10 mg/L for continuous use on all soils.

Samples from two wells in southwest Sacramento County exceeded the recommended concentration of arsenic for drinking water; 004N004E02J01 with a concentration of 0.12 mg/L and 005N005E03P01 of 0.08 mg/L. The U.S. Environmental Protection Agency and National Academy of Sciences and National Academy of Engineers (1973) reports that adverse health effects have not been reported from the ingestion of waters with concentrations as high as 0.10 mg/L. Several studies to determine the toxicity level of arsenic in soils indicate that the U.S. Environmental Protection Agency standards provide an adequate margin for safety for most crops (National Academy of Sciences and National Academy of Engineers, 1973). As long as crops which are extremely sensitive to arsenic, such as rice, are avoided in this area, problems should not arise.

Excessive concentrations of fluoride on acid soils can produce toxicity in plants. For this reason, the National Academy of Sciences and National Academy of Engineering (1973) recommend a maximum concentration of 1.0 mg/L of fluoride in irrigation water for continuous use on all soils. Water from two wells, 012N006E02C01 and 012N006E14C01, exceeded this limit. Soils in the area of these wells are classified as slightly acidic (Holmes and others, 1915; and Weir, 1950) so there is a potential fluoride toxicity problem. The recommended limit for fluoride in drinking water is greater than that for irrigation water (1.6 mg/L), and neither sample exceeded that limit.

Water from one well, 012N006E14C01, also exceeded the recommended maximum concentrations for mercury and molybdenum. This water also had a dissolved-solids concentration of 1,100 mg/L and high values for many other constituents. The well probably has penetrated the Ione Formation and is drawing from that brackish water supply.

Trace elements measured in water samples

[Recommended limits--Number in parentheses is number of wells that exceeded the recommended limit. Drinking water: Recommended by the U.S. Environmental Protection Agency (1975). Continuous use of irrigation water: Recommended by the National Academy of Sciences, National Academy of Engineering (1973)]

Trace elements	Range of concentration (mg/L)	Recommended limits (mg/L)	
		EPA drinking water limits	Continuous use of irrigation water
Aluminum	<0.01-0.03	--	5.0
Arsenic	<0.001-0.12	0.05(2)	.1(1)
Boron	<0.01-6.8	--	.75(13)
Cadmium	<0.001	.01	.1
Chromium	0.001-0.018	.05	.1
Cobalt	<0.001-0.017	--	.05
Copper	<0.001-0.010	1.0	.2
Fluoride	<0.1-1.5	1.6	1.0
Iron	<0.003-3.4	.3	5.0
Lead	<0.001-0.009	.05	5.0
Lithium	<0.004-0.56	--	2.5
Manganese	<0.001-0.88	.05(43)	.2(19)
Mercury	<0.001-0.0029	.002(1)	--
Molybdenum	<0.001-0.016	--	.01(1)
Nickel	<0.001-0.012	--	.2
Selenium	<0.001-0.003	.01	.02
Vanadium	<0.001-0.089	--	.1
Zinc	<0.003-0.14	5.0	2.0

4.0 CONCLUSIONS

Analyses of water samples from 209 wells in Sacramento and western Placer Counties indicate that ground-water quality varies from excellent, low in dissolved solids and trace elements; to marginal, approaching or exceeding established standards for several constituents. In general, the poorer quality water came from wells in the west near the Sacramento River or in the vicinity of Lincoln.

The Sacramento River has a dissolved-solids concentration of less than 100 mg/L; therefore, infiltration of water from the river would not explain the higher concentrations of dissolved solids in ground water near the river. An easy explanation for this trend was not apparent.

Near Lincoln, four wells had water with higher dissolved-solids and chloride concentrations than wells in the surrounding township. These analyses indicated that dissolved-solids concentrations of 499 to 1,070 mg/L compared to the concentrations at the surrounding wells which were 187 to 285 mg/L. Chloride concentrations for water from these four wells ranged from 53 to 300 mg/L, whereas, concentrations for the surrounding wells ranged from 6.3 to 27 mg/L of chloride. Other authors (Bryan, 1923; and Allen, 1929) have reported wells yielding water containing more than 6,000 mg/L of dissolved solids and more than 3,000 mg/L of chloride in this same locality. These wells were drilled to depths greater than 600 feet, and reportedly extracted water from the Marine Eocene deposits. The four wells sampled in this study are all fairly shallow, less than 250 feet, and probably withdraw water from the near-shore deposits of the Ione Formation. This formation yields fresh to brackish water to wells depending on their depth and location (California Department of Water Resources, 1974).

Two wells in eastern Sacramento County seem to be drawing water from the Valley Springs Formation. The silica concentrations from these samples were 82 and 92 mg/L, compared to a mean concentration of 59 mg/L for the entire area. Both samples had 55 percent sodium compared to an average 33 percent; however, chloride concentrations were similar to those from samples in the area to the west.

Vertical distributions of water types and concentration ranges for the rest of the area were difficult to determine. Most of the wells sampled in this study were drilled to depths representative of other wells in the vicinity. Many of the wells were producing from more than one aquifer. Samples from the few wells which were deeper than surrounding wells (700 feet as compared to 200-300 feet) had water-quality analyses similar to those of the shallower wells. There seemed to be no great difference between the quality of water in the Fair Oaks Formation (Shlemon, 1967), and the Laguna and Mehrten Formations.

Only three wells drew water from the Victor Formation (of former usage and as used by Olmsted and Davis, 1961) exclusively and they were along the Sacramento River. These samples had concentrations of several constituents which approached or exceeded the recommended standards. Many samples from wells along the river which penetrated other formations also had high concentrations. For this reason, the three samples from the Victor Formation may not be indicative of the quality of water in the entire formation. Samples from wells producing from the Victor and other formations had similar constituent concentrations as those samples from wells not drawing from the Victor Formation; therefore, the quality of the water in the Victor Formation probably does not differ greatly from that in the Fair Oaks, Laguna, and Mehrten Formations.

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6.0 ANALYSES OF WATER FROM WELLS FOR SELECTED CHEMICAL CONSTITUENTS

WELL NO.: Based on the rectangular subdivision of public lands. See section 1.3 in report for detailed explanation.
SITE IDENTIFICATION NO.: Unique number for each well based on the latitude and longitude of the well. First six digits are latitude, next seven digits are longitude and final two digits are a sequence number to uniquely identify each well.
GEOLOGIC UNIT: Code indicating geologic formation which is the primary aquifer for that well. Where several formations are penetrated by one well, the lowest or oldest is listed here as primary. The three numbers indicate the age of the formation and the four letters identify the formation. 112VCTR, Victor Formation (Pleistocene); 112CNTL, Fair Oaks Formation (Pleistocene-Pliocene); 121LGUN, Laguna Formation (Pliocene); 121MRTN, Mehrten Formation (Pliocene-Miocene); 122VSPG, Valley Springs Formation (Miocene); 124IONE, Ione Formation (Eocene); 200BMCX, Basement complex (Pre-Tertiary). In the northern part of the study area, where differentiation of the alluvial aquifers was not possible, 111AVSN was used as a general term for alluvial deposits of the Sierra Nevada.

WELL NO.	SITE IDENTIFICATION NO.	DATE OF SAMPLE	GEO-LOGIC UNIT	SPE-CIFIC CON-DUCT-ANCE (UMHO/CM)	PH (STAND-ARD UNITS)	TEMPER-ATURE (°C)	HARD-NESS (MG/L AS $CACO_3$)	HARD-NESS, NONCAR-BONATE (MG/L $CACO_3$)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)
003N003E03H01	380803121371801	82-09-17	112VCTR	1190	7.8	17.5	250	0	37	38	190
003N003E07N01	380647121413801	82-09-17	121LGUN	662	8.3	17.5	25	0	5.2	2.9	160
004N003E22N01	381016121381501	82-09-17	121LGUN	1080	7.8	16.0	140	0	19	23	200
004N003E26G01	380945121363301	82-09-17	121LGUN	571	7.9	16.0	80	0	14	11	89
004N003E26H01	380948121360901	82-09-17	121LGUN	229	7.4	16.0	60	0	11	7.8	27
004N004E02J01	381330121301201	82-09-20	121LGUN	495	7.5	16.5	200	0	32	29	34
004N004E17A01	381206121332901	82-09-17	112VCTR	294	8.2	16.0	26	0	5.8	2.8	63
005N003E13G01	381646121352301	82-09-20	112VCTR	912	8.1	17.5	340	0	35	62	97
005N004E10G03	381759121314101	82-09-20	121LGUN	1290	7.9	17.5	220	79	62	17	190
005N004E15L02	381658121315701	82-09-20	121LGUN	189	7.2	16.0	67	0	14	7.7	12
005N004E22R01	381554121312601	82-09-20	121LGUN	299	8.4	16.0	12	0	2.9	1.1	70
005N004E34G01	381427121313701	82-09-20	121LGUN	524	8.1	16.5	28	0	6.2	3.1	130
005N004E35F01	381433121304101	82-09-20	121LGUN	888	8.1	17.0	59	0	14	5.9	190
005N005E03B01	381915121250401	82-09-24	121LGUN	274	7.6	19.0	93	0	19	11	22
005N005E03P01	381832121252301	82-09-28	121LGUN	265	8.0	20.0	90	0	20	9.7	26
005N005E10C02	381809121251201	82-09-28	121LGUN	375	8.0	19.5	150	0	29	19	27
005N006E01R01	381824121154901	82-09-15	121LGUN	149	7.3	19.5	47	0	9.6	5.6	12
005N006E11G01	381758121171701	82-09-15	121LGUN	168	7.8	19.5	53	0	11	6.1	16
005N006E15G01	381706121182901	82-09-15	121LGUN	205	7.6	19.5	72	0	14	8.9	15
005N006E17R03	381636121201201	82-09-15	121LGUN	381	7.4	18.0	160	0	32	19	22
005N006E21Q02	381554121192601	82-09-15	121LGUN	228	8.0	19.0	77	0	17	8.3	20
005N006E22Q02	381546121181801	82-09-22	121MRTN	215	7.7	22.0	49	0	10	5.7	26
005N006E24M01	381604121165201	82-09-15	121LGUN	178	7.7	19.5	61	0	14	6.4	15
005N006E27J01	381509121180901	82-09-22	121MRTN	223	7.4	20.0	76	0	16	8.8	16
005N006E29G03	381524121204101	82-09-15	121LGUN	562	7.9	18.5	240	0	56	25	36
005N006E29G04	381523121203901	82-09-15	121LGUN	670	7.4	18.0	310	0	70	32	36
005N006E33G02	381428121193601	82-09-15	121LGUN	493	7.2	17.5	220	0	43	27	28
005N007E07P02	381735121152901	82-09-22	121LGUN	170	7.7	20.5	58	0	12	6.8	11
005N007E10P01	381738121120001	82-09-09	121MRTN	159	7.4	21.0	46	0	9.6	5.2	15
005N007E20K02	381613121134901	82-09-22	121MRTN	200	7.2	21.0	74	0	15	8.8	9.9
005N007E23N01	381600121111401	82-09-09	121LGUN	151	7.2	20.0	47	0	9.4	5.8	14
006N004E14P03	382202121304001	82-09-20	121LGUN	772	7.7	18.5	300	28	68	32	50
006N004E32E02	381942121341401	82-09-20	121LGUN	190	7.5	16.0	72	0	14	9.1	9.1
006N005E08G01	382320121270601	82-09-24	121LGUN	300	7.8	19.5	110	0	23	13	21
006N005E10Q01	382249121245601	82-09-24	121LGUN	329	7.7	19.0	130	0	24	18	18
006N005E11B02	382332121234101	82-09-24	121LGUN	229	7.9	19.5	64	0	13	7.7	25
006N005E22G01	382140121244401	82-09-24	121LGUN	268	7.7	19.5	100	0	18	14	16
006N005E29G02	382044121265901	82-09-24	121LGUN	243	7.9	19.5	84	0	17	10	19
006N006E01B02	382424121160601	82-09-14	121LGUN	323	7.7	18.5	130	0	25	16	20
006N006E02Q01	382346121165801	82-09-14	121LGUN	216	7.9	19.0	79	0	16	9.5	15
006N006E04A01	382424121190401	82-09-14	121LGUN	306	7.7	17.0	130	0	25	16	14
006N006E07Q01	382259121213401	82-09-14	121LGUN	314	8.0	21.5	140	0	25	18	16
006N006E12P01	382300121162201	82-09-14	121MRTN	222	7.8	20.5	73	0	14	9.2	19
006N006E14E01	382233121173701	82-09-22	121MRTN	229	7.5	19.5	77	0	16	9.1	17
006N006E26Q01	382012121171101	82-09-22	121LGUN	191	7.6	19.5	59	0	11	7.7	14
006N006E34F01	381955121182201	82-09-22	121LGUN	218	7.4	20.0	62	0	12	7.9	21
006N006E36A01	381958121153901	82-09-22	121LGUN	168	7.2	20.5	51	0	9.3	6.8	12
006N007E02K01	382357121102001	82-09-09	121MRTN	147	7.4	21.5	38	0	7.3	4.7	15
006N007E04E01	382410121131901	82-09-08	121LGUN	197	7.6	21.0	56	0	10	7.6	18
006N007E16D02	382240121131801	82-09-08	121MRTN	145	7.4	21.0	37	0	6.8	4.8	15

PERCENT SODIUM	SODIUM AD-SORPTION RATIO	POTASSIUM, DISSOLVED (MG/L AS K)	ALKALINITY FIELD (MG/L AS $CACO_3$)	SULFATE DISSOLVED (MG/L AS SO_4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED MG/L AS SIO_2)	SOLIDS, RESIDUE AT 180 DEG C DISSOLVED (MG/L)	NITROGEN, NO_2+NO_3 DISSOLVED (MG/L AS N)	PHOSPHORUS, ORTHO, DISSOLVED (MG/L AS P)	ALUMINUM, DISSOLVED (UG/L AS AL)	ARSENIC, DISSOLVED (UG/L AS AS)	BORON, DISSOLVED (UG/L AS B)	IRON, DISSOLVED (UG/L AS FE)	MANGANESE, DISSOLVED (UG/L AS MN)
62	5	2.2	323	46	210	<0.1	39	720	<0.10	0.26	<10	11	1100	5	500
93	14	1.7	340	70	13	.2	40	451	<.10	.21	<10	11	1300	6	20
75	7	2.4	289	27	190	.1	38	651	<.10	.42	30	17	890	<3	200
70	4	.8	156	8.0	72	<.1	38	313	.10	1.20	<10	50	370	84	160
49	2	1.0	100	7.0	12	.1	39	153	.10	.86	<10	17	120	290	140
27	1	.9	249	<5.0	19	.2	43	298	<.10	.30	20	120	220	460	280
84	6	.7	131	<5.0	10	.2	27	194	<.10	.70	20	3	340	8	42
38	2	2.6	476	7.0	51	.2	39	546	<.10	.16	<10	7	630	7	230
64	6	4.7	146	<5.0	350	<.1	43	759	<.10	.02	10	3	520	59	260
28	.7	1.6	85	10	11	.1	50	133	<.10	.23	<10	16	60	2100	340
92	9	.7	153	<5.0	6.5	.3	40	211	<.10	.40	<10	11	560	11	15
91	11	1.0	274	<5.0	19	.2	23	338	<.10	.28	<10	7	1400	<3	37
87	11	1.7	182	<5.0	190	.2	42	525	<.10	.16	<10	11	980	14	52
34	1	1.7	130	<5.0	7.5	.1	48	171	<.10	.09	<10	23	40	44	180
38	1	1.5	131	<5.0	8.1	<.1	53	190	<.10	.24	<10	82	80	92	210
28	1	1.6	--	7.0	14	<.1	46	--	-	.11	10	38	60	120	300
35	.8	1.8	49	<5.0	8.8	.2	84	169	2.7	.04	<10	2	110	<3	1
38	1	2.5	77	5.0	5.4	.1	51	140	<.10	.06	<10	8	140	110	79
31	.8	1.6	80	<5.0	12	.2	68	188	2.3	.09	<10	7	130	<3	<1
23	.8	2.0	174	6.0	15	.2	63	269	2.2	.07	<10	8	130	<3	<1
36	1	1.4	108	<5.0	7.8	.1	53	161	.39	.06	<10	20	150	7	2
52	2	2.8	98	<5.0	5.1	.1	62	171	.13	.07	<10	11	160	22	68
33	.9	2.8	90	<5.0	4.3	.1	54	153	<.10	.04	<10	4	130	9	60
31	.8	2.4	98	7.0	5.9	.1	60	170	<.10	.06	<10	7	60	33	41
24	1	1.8	261	35	17	.1	55	363	.99	.05	<10	16	170	<3	21
20	.9	1.9	313	40	24	.1	58	463	2.0	.04	10	10	150	<3	25
22	.8	2.2	218	45	11	<.1	58	352	.96	.05	<10	7	140	100	140
28	.6	2.4	67	<5.0	6.4	.1	81	170	2.0	.04	<10	2	30	4	3
41	1	1.6	54	<5.0	7.1	.2	82	166	2.4	.05	<10	2	120	<3	<1
22	.5	2.9	87	5.0	5.1	.1	83	183	.74	.06	<10	2	30	6	6
38	.9	1.2	57	<5.0	8.5	.3	83	169	1.7	.11	<10	2	130	<3	2
26	1	2.7	--	<5.0	100	<.1	43	454	<.10	.01	<10	<1	80	310	150
21	.5	1.6	82	9.0	6.3	<.1	28	122	<.10	.07	<10	11	50	440	560
29	.9	1.7	138	<5.0	9.4	.1	55	198	.67	.06	<10	11	40	<3	5
22	.7	1.6	149	<5.0	13	.2	65	222	1.8	.11	<10	6	30	<3	2
45	1	.9	113	<5.0	3.7	<.1	50	161	<.10	.13	<10	28	50	10	50
25	.7	2.0	123	<5.0	7.2	.1	66	179	.79	.06	<10	5	30	<3	<1
33	.9	1.7	116	<5.0	7.2	.1	60	164	<.10	.07	<10	10	40	11	3
25	.8	3.5	146	18	6.0	<.1	69	245	2.1	.03	<10	2	110	<3	2
28	.8	3.2	103	6.0	4.1	.1	69	180	.85	.04	<10	3	110	7	2
19	.6	2.9	130	24	5.2	.1	67	231	1.8	.04	<10	3	120	<3	2
20	.6	1.6	139	5.0	12	.2	66	199	2.6	.06	10	4	120	<3	<1
35	1	2.6	108	<5.0	5.2	.2	79	199	.58	.04	<10	2	120	<3	1
31	.9	2.7	102	<5.0	6.5	.2	75	186	.97	.04	<10	2	40	12	5
33	.8	3.1	71	7.0	8.2	.1	79	168	1.4	.07	<10	4	30	4	3
41	1	1.7	85	13	8.3	<.1	60	171	<.10	.13	<10	2	70	160	380
33	.7	1.8	54	5.0	8.8	.2	88	177	2.4	.10	<10	2	30	5	12
45	1	1.9	52	<5.0	6.7	.3	88	153	1.8	.08	<10	4	130	11	5
40	1	1.2	79	<5.0	9.3	.2	78	159	1.3	.07	<10	1	120	5	<1
46	1	1.2	54	<5.0	6.7	.3	85	150	1.7	.14	<10	3	130	<3	2

WELL NO.	SITE IDENTIFICATION NO.	DATE OF SAMPLE	GEO-LOGIC UNIT	SPE-CIFIC CON-DUCT-ANCE (UMHO/CM)	PH (STAND-ARD UNITS)	TEMPER-ATURE (°C)	HARD-NESS (MG/L AS $CACO_3$)	HARD-NESS, NONCAR-BONATE (MG/L $CACO_3$)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)
006N007E21R01	382103121121801	82-09-09	121LGUN	128	7.2	21.0	37	0	7.2	4.6	11
006N007E32C01	381957121140501	82-09-09	121LGUN	160	7.3	21.0	46	0	8.6	6.0	14
006N008E34E01	381956121053401	82-09-29	122VSPG	106	7.4	22.5	21	0	4.4	2.4	14
007N004E09A02	382843121322901	82-09-21	112CNTL	293	8.0	16.0	89	0	16	12	31
007N004E14H02	382747121300201	82-09-28	112CNTL	166	8.2	16.5	64	0	15	6.5	12
007N004E35K01	382451121301601	82-09-28	112CNTL	1050	7.9	17.5	440	220	99	47	58
007N005E02C02	382934121240801	82-09-28	121MRTN	212	8.0	20.0	76	0	16	8.8	15
007N005E05C01	382937121272201	82-09-16	112CNTL	373	7.8	19.0	140	38	30	17	17
007N005E14D01	382756121242201	82-09-23	112CNTL	196	7.8	19.5	63	0	13	7.3	17
007N005E22R01	382619121244001	82-09-23	112CNTL	315	7.8	19.0	120	0	23	14	23
007N005E24A01	382658121221801	82-09-23	112CNTL	204	7.8	20.0	66	0	14	7.6	18
007N005E28P02	382535121262901	82-09-23	112CNTL	244	7.8	19.5	84	0	17	10	19
007N005E29A01	382611121264301	82-09-23	121MRTN	608	7.6	23.0	130	0	29	13	75
007N005E31C01	382511121282101	82-09-23	112CNTL	426	7.9	19.5	150	0	37	15	28
007N005E33F01	382504121261401	82-09-23	121MRTN	277	7.6	20.5	90	0	20	9.8	25
007N005E35J01	382453121232801	82-09-23	112CNTL	288	7.7	19.5	110	0	20	15	16
007N006E01J01	382917121153701	82-09-07	121MRTN	202	7.5	21.0	57	0	11	7.2	17
007N006E06L01	382911121214301	82-09-07	121LGUN	192	7.7	21.5	60	0	13	6.8	17
007N006E09M01	382823121195001	82-09-07	121LGUN	200	7.6	20.0	59	0	13	6.4	20
007N006E16L01	382734121194101	82-09-07	121LGUN	196	7.8	20.0	58	0	12	6.8	18
007N006E24D01	382709121163501	82-09-07	121LGUN	289	7.4	20.0	110	0	19	14	17
007N006E27E01	382556121184501	82-09-07	121LGUN	265	7.5	19.5	100	0	18	14	15
007N006E29C01	382614121203501	82-09-14	121MRTN	195	8.0	22.0	68	0	14	7.9	16
007N006E32K01	382448121203101	82-09-07	121LGUN	238	7.6	20.0	92	0	17	12	14
007N006E35E01	382508121173201	82-09-07	121LGUN	410	6.9	15.0	190	33	33	26	13
007N007E15R02	382718121111901	82-09-08	121MRTN	215	7.3	20.0	79	0	16	9.5	12
007N007E23H01	382650121101501	82-09-08	121MRTN	219	7.5	20.0	88	0	17	11	11
007N007E27B02	382609121113301	82-09-07	121MRTN	233	7.5	21.0	88	0	17	11	12
007N007E32F01	382503121140701	82-09-08	121LGUN	306	7.5	20.5	120	0	24	15	14
007N007E33A01	382518121122101	82-09-08	121MRTN	233	7.7	21.5	90	0	18	11	15
008N005E01C02	383457121225601	82-09-23	121MRTN	247	7.8	20.0	110	2	23	12	9.3
008N005E03B01	383456121245801	82-09-22	112CNTL	112	7.7	17.0	42	0	7.3	5.8	6.1
008N005E11A01	383410121233001	82-09-22	112CNTL	177	7.3	17.0	70	0	15	8.0	6.4
008N005E29C01	383124121273001	82-09-28	121MRTN	350	7.9	19.0	150	14	31	17	15
008N005E29Q01	383046121270201	82-09-28	121MRTN	333	8.0	19.0	140	18	33	14	15
008N005E31A02	383035121275301	82-09-28	121MRTN	334	7.8	19.0	140	13	31	15	15
008N005E32K01	383012121271601	82-09-28	121MRTN	179	8.0	19.0	63	0	14	6.9	12
008N005E34Q01	382955121245701	82-09-16	121MRTN	190	7.8	20.0	70	0	16	7.3	13
008N005E35Q01	382952121234401	82-09-28	121MRTN	184	8.0	20.0	71	0	16	7.6	13
008N006E03H01	383448121180001	82-09-16	121MRTN	164	7.9	19.5	61	0	14	6.3	8.7
008N006E07B01	383359121213501	82-09-16	121MRTN	212	7.9	18.5	80	0	21	6.8	9.6
008N006E08E03	383355121210101	82-09-16	121MRTN	145	7.8	21.0	56	0	13	5.6	7.0
008N006E11B01	383402121171001	82-09-23	121MRTN	115	7.4	20.0	37	0	7.9	4.3	7.7
008N006E13B01	383311121160301	82-09-23	112CNTL	166	8.1	21.5	53	0	12	5.6	15
008N006E13E01	383254121164001	82-09-23	121MRTN	252	7.6	22.0	100	0	22	12	12
008N006E13M01	383238121164301	82-09-23	121MRTN	150	8.0	21.0	53	0	11	6.1	10
008N006E20D03	383216121205901	82-09-27	121MRTN	145	8.0	20.0	56	0	15	4.4	9.8
008N006E26L01	383103121172001	82-09-27	121MRTN	169	7.8	19.5	34	0	6.9	4.0	26
008N006E29A01	383131121200701	82-09-27	121LGUN	157	7.8	20.5	60	0	13	6.7	10
008N006E31B02	383028121212801	82-09-27	121LGUN	176	8.0	20.0	64	0	14	7.0	13
008N008E33Q01	382954121060401	82-09-29	122VSPG	212	6.8	20.5	45	6	9.9	4.9	26
009N004E08F01	383858121340801	82-09-10	112CNTL	526	7.9	17.0	160	0	28	21	56
009N004E20A01	383738121333401	82-09-10	112CNTL	362	7.6	15.5	160	9	30	21	10
009N004E27D01	383623121321301	82-09-10	112CNTL	925	7.7	18.0	370	0	70	48	80
009N004E28D07	383604121325201	82-09-10	112CNTL	257	7.5	16.0	69	0	11	10	30

PER- CENT SO- DIUM	SODIUM AD- SORP- TION RATIO	POTAS- SIUM, DIS- SOLVED (MG/L AS K)	ALKA- LINITY FIELD (MG/L AS $CACO_3$)	SULFATE DIS- SOLVED (MG/L AS SO_4)	CHLO- RIDE, DIS- SOLVED (MG/L AS CL)	FLUO- RIDE, DIS- SOLVED (MG/L AS F)	SILICA, DIS- SOLVED MG/L AS SIO_2)	SOLIDS, RESIDUE AT 180 DEG. C DIS- SOLVED (MG/L)	NITRO- GEN, NO_2+NO_3 DIS- SOLVED (MG/L AS N)	PHOS- PHORUS, ORTHO, DIS- SOLVED (MG/L AS P)	ALUM- INUM, DIS- SOLVED (UG/L AS AL)	AR- SENIC, DIS- SOLVED (UG/L AS AS)	BORON, DIS- SOLVED (UG/L AS B)	IRON, DIS- SOLVED (UG/L AS FE)	MANGA- NESE, DIS- SOLVED (UG/L AS MN)
38	0.8	1.2	48	<5.0	5.1	0.3	89	144	1.4	0.19	<10	2	120	<3	2
39	.9	1.3	51	<5.0	8.5	.2	88	161	2.4	.14	<10	2	120	<3	<1
55	1	2.9	38	<5.0	3.8	.3	92	148	2.9	.26	<10	2	10	4	<1
42	1	2.4	139	<5.0	3.0	.2	47	189	<.10	.32	10	1	260	130	99
28	.7	2.8	84	<5.0	6.2	<.1	36	123	<.10	.10	10	1	40	28	110
22	1	4.1	221	<5.0	270	.1	39	730	<.10	.06	<10	3	60	86	610
29	.8	2.5	76	<5.0	8.6	.1	62	168	1.4	.05	20	4	20	15	2
20	.6	3.5	107	<5.0	54	<.1	58	259	.31	.01	<10	4	20	8	4
36	1	2.0	110	<5.0	6.5	.1	61	156	.32	.09	<10	8	30	<3	16
30	1	2.4	151	<5.0	11	<.1	62	211	<.10	.05	<10	4	30	<3	2
36	1	2.0	98	<5.0	5.0	<.1	58	153	.40	.07	<10	4	30	<3	2
32	.9	1.8	116	<5.0	7.2	.1	62	173	.51	.05	<10	8	30	<3	<1
55	3	5.0	153	<5.0	110	<.1	60	366	<.10	.04	<10	3	400	110	290
28	1	2.6	159	<5.0	44	<.1	43	258	<.10	.07	<10	11	40	41	210
37	1	1.9	131	<5.0	11	<.1	54	186	.37	.10	<10	17	40	39	160
23	.7	1.4	121	6.0	13	.2	67	206	2.1	.06	<10	3	20	<3	5
38	1	1.6	95	<5.0	6.5	.2	71	170	1.2	.10	<10	2	130	<3	<1
37	1	2.0	85	<5.0	7.5	.1	64	170	.55	.05	<10	6	140	<3	3
42	1	1.4	87	<5.0	7.9	.2	51	160	1.0	.06	<10	4	130	6	<1
39	1	2.1	87	<5.0	5.4	.2	63	166	.74	.07	<10	3	140	<3	<1
26	.7	1.2	112	6.0	9.5	.2	71	211	2.4	.10	<10	3	120	<3	<1
24	.7	2.0	120	<5.0	8.1	.2	71	210	1.1	.05	<10	2	130	4	2
33	.9	3.5	98	<5.0	3.4	.1	67	180	<.10	.04	<10	1	210	83	180
24	.7	2.8	108	<5.0	4.9	.1	66	186	.44	.06	<10	4	140	<3	<1
13	.4	1.3	157	34	6.7	.1	65	286	2.5	.07	<10	1	130	<3	<1
24	.6	2.4	89	7.0	5.4	.2	71	169	.90	.08	<10	2	130	<3	<1
21	.5	1.4	93	<5.0	5.9	.2	64	181	1.5	.06	<10	1	110	<3	<1
23	.6	1.3	103	<5.0	5.4	.2	64	182	.80	.09	<10	1	130	<3	<1
20	.6	2.1	125	<5.0	16	.1	69	224	.87	.04	<10	2	130	<3	1
26	.7	2.3	108	<5.0	5.4	.1	71	179	.61	.05	<10	1	120	<3	<1
15	.4	4.2	105	5.0	11	<.1	60	186	.92	--	10	2	30	10	<10
23	.4	1.4	58	<5.0	2.8	.1	61	109	.42	.08	<10	4	10	<3	<1
16	.3	2.3	73	10	6.7	<.1	57	141	1.0	.09	<10	2	20	31	<1
18	.6	3.3	134	12	18	<.1	57	252	4.1	.04	10	5	40	15	2
19	.6	2.7	123	10	15	.1	60	247	4.8	.04	<10	5	20	12	4
19	.6	3.1	126	8.0	18	.1	60	246	4.0	.04	10	4	30	4	1
28	.7	2.4	78	<5.0	8.3	.1	60	154	1.3	.04	<10	6	20	5	2
28	.7	3.2	92	<5.0	5.8	<.1	64	151	.38	.03	<10	6	20	<3	12
27	.7	2.7	89	<5.0	5.4	<.1	64	157	.49	.05	<10	4	20	7	<1
23	.5	2.8	72	<5.0	5.2	<.1	61	140	1.4	.04	<10	1	20	<3	<1
20	.5	3.1	80	9.0	4.8	<.1	50	157	3.7	.01	<10	2	20	<3	<1
20	.4	3.4	66	<5.0	3.5	<.1	59	125	.33	<.01	<10	2	20	6	3
30	.6	1.0	51	<5.0	6.2	.1	58	112	1.7	.10	<10	1	20	8	<1
37	.9	1.6	100	<5.0	4.0	.1	59	135	<.10	.06	<10	<1	20	<3	99
19	.5	4.6	130	<5.0	7.5	.1	67	187	<.10	.06	<10	1	50	220	190
28	.6	2.3	86	<5.0	4.6	<.1	61	130	.62	.07	<10	1	40	13	110
27	.6	2.1	71	<5.0	3.7	<.1	48	112	.93	.02	10	3	20	10	2
62	2	.8	69	<5.0	8.0	.3	68	150	.25	.24	<10	2	<10	3	1
26	.6	2.4	97	<5.0	5.5	.1	55	117	<.10	.02	10	4	20	14	210
30	.7	2.1	77	<5.0	7.4	.1	60	139	1.4	.03	<10	3	20	28	2
55	2	1.4	39	25	19	.4	82	192	1.4	.30	<10	3	40	14	1
43	2	1.9	233	16	23	.1	47	400	<.10	.12	<10	27	250	220	700
12	.4	2.1	153	26	10	<.1	35	299	<.10	.08	<10	8	200	300	880
32	2	2.4	438	60	30	.1	52	619	<.10	.07	<10	14	300	92	550
48	2	2.0	113	11	7.2	.1	36	186	<.10	.19	<10	12	230	350	110

6.0 ANALYSES OF WATER FROM WELLS FOR SELECTED CHEMICAL CONSTITUENTS--continued

WELL NO.	SITE IDENTIFICATION NO.	DATE OF SAMPLE	GEO-LOGIC UNIT	SPE-CIFIC CON-DUCT-ANCE (UMHO/CM)	PH (STAND-ARD UNITS)	TEMPER-ATURE (°C)	HARD-NESS (MG/L AS $CACO_3$)	HARD-NESS, NONCAR-BONATE (MG/L $CACO_3$)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)
009N005E01F01	383953121225601	82-09-21	121MRTN	284	7.6	21.0	98	0	18	13	19
009N005E01P01	383929121230501	82-09-21	121MRTN	448	7.6	23.0	120	1	23	14	49
009N005E07H01	383904121280801	82-09-21	121MRTN	267	7.6	20.0	89	0	16	12	20
009N005E15B01	383822121245901	82-09-21	121MRTN	220	7.0	20.0	78	0	13	11	14
009N005E19J02	383703121280701	82-09-21	121MRTN	417	7.5	19.5	130	0	24	17	32
009N005E21H01	383714121255001	82-09-21	121MRTN	392	7.3	21.5	110	0	22	14	33
009N005E23L02	383700121241001	82-09-29	121MRTN	218	7.8	20.0	85	6	16	11	12
009N005E26G02	383622121234901	82-09-10	121MRTN	210	7.7	20.0	83	0	15	11	11
009N005E34D01	383547121253101	82-09-21	121MRTN	612	7.5	20.0	270	36	47	36	23
009N005E36E01	383531121231101	82-09-23	121MRTN	313	7.6	19.0	130	0	29	13	14
009N006E05B01	384012121202801	82-09-16	121MRTN	246	7.8	19.5	97	0	19	12	15
009N006E07N01	383829121221001	82-09-29	121MRTN	313	7.1	18.0	140	11	28	16	16
009N006E10F01	383903121181801	82-09-27	121MRTN	182	7.5	20.0	69	0	16	7.0	11
009N006E11G01	383903121171301	82-09-27	121MRTN	193	7.6	18.0	82	10	18	8.9	7.7
009N006E21M01	383706121195601	82-09-27	121MRTN	202	7.7	19.5	90	0	18	11	8.2
009N006E25F01	383628121162401	82-09-23	121MRTN	229	7.9	19.0	92	0	21	9.5	10
009N006E30Q02	383602121212701	82-09-29	121MRTN	188	7.8	19.5	81	0	16	10	8
009N006E31G01	383535121213001	82-09-22	121MRTN	208	7.9	19.0	82	0	17	9.7	8
009N006E34M02	383514121184001	82-09-16	121MRTN	229	7.9	19.0	78	0	22	5.7	17
009N006E35C03	383547121172901	82-09-23	121MRTN	402	7.0	19.5	180	10	37	21	17
009N007E04M02M	383943121132701	82-09-27	121MRTN	220	8.0	20.5	92	0	22	9.0	12
009N007E07A02M	383908121144001	82-09-27	121MRTN	--	7.6	19.0	140	0	33	14	19
009N007E07F01M	383906121151601	82-09-27	121MRTN	246	7.7	19.0	86	0	22	7.6	18
010N003E23H01M	384230121364601	82-09-30	112CNTL	842	7.8	18.0	320	0	54	44	86
010N003E26E01M	384140121375001	82-09-30	112CNTL	593	8.1	17.0	190	0	36	24	70
010N003E36N01	384017121364101	82-09-10	112CNTL	324	8.0	20.0	110	0	19	15	25
010N005E08M01	384359121273901	82-09-30	112CNTL	272	8.2	20.0	80	0	21	6.8	28
010N005E14N01	384257121243401	82-09-16	121MRTN	286	7.8	19.5	110	0	19	16	16
010N005E19C01	384251121284301	82-09-30	112CNTL	283	8.1	19.0	86	0	22	7.6	26
010N005E20R01	384202121265201	82-09-22	112CNTL	313	7.9	20.0	95	0	20	11	25
010N005E21K01	384224121261401	82-09-22	121MRTN	360	7.8	23.0	110	8	21	13	32
010N005E24B01	384243121224801	82-09-21	121MRTN	202	7.5	20.0	73	0	13	9.8	14
010N005E29H01	384143121270601	82-09-22	112CNTL	313	7.6	21.0	110	0	21	15	19
010N005E34H01	384046121243501	82-09-30	112CNTL	225	7.5	20.0	67	0	12	8.9	21
010N006E02K01	384458121171001	82-09-24	112CNTL	339	7.2	20.0	120	0	27	12	25
010N006E05L03	384504121211401	82-09-17	121MRTN	202	7.6	20.0	58	0	11	7.4	19
010N006E12E01	384413121163801	82-09-24	121MRTN	472	7.1	20.5	130	0	33	12	44
010N006E16K01	384306121193301	82-09-17	121MRTN	172	7.5	20.0	50	0	9.3	6.6	16
010N006E22B01	384254121182101	82-09-16	121MRTN	404	7.5	19.5	98	0	21	11	48
010N006E22L01	384218121183101	82-09-17	121MRTN	374	7.1	21.0	140	5	28	16	28
010N006E29J01	384123121201001	82-09-16	121MRTN	334	6.8	20.0	80	0	17	9.2	38
010N006E31A01	384108121211601	82-09-17	121MRTN	314	7.5	20.5	--	--	--	11	27
010N006E33N01	384026121195401	82-09-17	121MRTN	--	7.0	19.5	170	19	35	19	30
010N006E35A01	384103121170401	82-09-17	121MRTN	276	7.5	19.5	100	0	22	11	17
011N005E06Q02	384930121273001	82-09-14	111AVSN	242	7.9	20.0	78	0	15	9.8	21
011N005E08F01	384904121263001	82-09-14	111AVSN	240	7.2	21.0	69	0	14	8.2	24
011N005E15B01	384821121240001	82-09-14	111AVSN	233	7.4	20.5	74	0	13	10	20
011N005E16Q01	384747121250501	82-09-14	111AVSN	333	7.6	21.0	130	0	23	17	22
011N005E21G01	384729121252201	82-09-14	111AVSN	327	7.6	21.0	85	0	19	9.1	34
011N005E29F01	384636121262701	82-09-14	111AVSN	266	7.6	20.0	77	0	15	9.6	27
011N005E34P01	384510121242301	82-09-14	111AVSN	239	7.5	20.0	63	0	11	8.5	26
011N006E06A01	385017121203401	82-09-14	111AVSN	271	7.8	20.5	72	0	13	9.6	29
011N006E09H01	384907121183601	82-09-17	111AVSN	393	7.2	20.0	71	0	16	7.6	50
011N007E01Q01	384934121083301	82-09-15	200BMCX	176	6.4	18.0	62	8	12	7.9	7.6
011N007E02P01	384942121095601	82-09-15	200BMCX	420	6.6	18.0	160	75	26	22	19

PER-CENT SO-DIUM	SODIUM AD-SORP-TION RATIO	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY FIELD (MG/L AS $CACO_3$)	SULFATE DIS-SOLVED (MG/L AS SO_4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED MG/L AS SIO_2)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)	NITRO-GEN, NO_2+NO_3 DIS-SOLVED (MG/L AS N)	PHOS-PHORUS, ORTHO, DIS-SOLVED (MG/L AS P)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	AR-SENIC, DIS-SOLVED (UG/L AS AS)	BORON, DIS-SOLVED (UG/L AS B)	IRON, DIS-SOLVED (UG/L AS FE)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)
29	0.9	1.8	105	5.0	21	0.2	81	220	0.73	0.07	<10	2	100	5	1
47	2	3.0	114	8.0	72	.2	80	312	<.10	.12	10	1	510	<3	67
32	.9	1.5	92	7.0	21	.2	73	208	.99	.06	<10	6	120	<3	<1
28	.7	1.2	96	<5.0	14	.2	77	184	1.2	.09	<10	4	20	280	21
34	1	3.1	170	11	45	.2	73	279	.99	.04	<10	3	280	<3	<1
38	1	3.7	112	<5.0	57	.1	76	265	.30	.03	<10	3	260	<3	<1
23	.6	3.4	80	<5.0	19	.1	75	179	.52	.04	<10	2	20	4	2
22	.5	3.0	100	<5.0	15	.1	70	167	.52	.05	<10	3	20	<3	<1
16	.6	4.8	230	27	50	.1	70	402	.67	.06	<10	2	20	4	1
19	.6	1.7	160	13	9.2	.1	52	209	2.7	.13	<10	1	10	<3	<1
25	.7	1.8	103	<5.0	15	.1	79	199	1.0	.05	<10	2	20	<3	<1
20	.6	2.0	125	8.0	20	.1	76	245	1.7	.12	<10	1	20	28	6
25	.6	3.1	82	<5.0	7.2	<.1	61	147	.81	.03	<10	1	60	6	30
16	.4	3.3	72	6.0	8.0	<.1	56	153	.51	.04	<10	1	20	11	2
16	.4	3.1	98	5.0	4.6	<.1	60	159	.90	.04	<10	1	10	3	<1
18	.5	4.0	103	7.0	6.1	<.1	60	173	.88	.07	10	3	10	<3	27
17	.4	2.6	89	5.0	5.3	<.1	59	132	.69	.05	<10	2	10	4	2
18	.4	3.2	85	10	4.8	<.1	58	153	1.1	.07	<10	2	10	<3	<1
31	.9	1.8	98	6.0	8.5	<.1	33	149	2.2	.03	<10	1	10	<3	<1
17	.6	1.6	169	30	8.7	<.1	53	273	3.4	.12	10	1	20	<3	<1
22	.6	2.5	98	7.0	7.5	.1	51	154	.78	.02	10	1	50	<3	<1
22	.7	4.0	144	12	14	<.1	55	234	3.3	.03	<10	1	<10	13	2
30	.9	4.6	102	17	9.1	<.1	55	178	.45	.03	10	2	90	23	3
37	2	3.2	371	58	33	.1	36	511	<.10	.07	10	9	1600	250	260
44	2	2.5	259	26	38	.1	34	369	<.10	.04	<10	5	1400	100	9
33	1	1.6	125	27	12	.1	40	231	<.10	.13	<10	20	260	8	27
42	1	1.6	105	<5.0	19	.2	39	171	<.10	.06	<10	18	190	4	76
23	.7	1.4	126	<5.0	14	.2	79	219	.82	.07	<10	3	60	<3	<1
39	1	1.8	102	5.0	24	.2	36	171	<.10	.07	<10	16	130	29	88
36	1	2.6	95	8.0	39	.2	69	228	.95	.03	<10	7	180	<3	7
39	1	2.8	98	11	58	.1	78	270	1.5	.03	10	4	280	15	<1
29	.7	.9	98	<5.0	17	.3	82	181	1.1	.18	<10	4	20	<3	<1
26	.8	1.9	128	<5.0	18	.2	70	214	2.2	.07	<10	6	70	5	4
40	1	1.5	80	<5.0	15	.3	80	183	1.2	.07	<10	3	70	8	4
31	1	2.0	150	8.0	27	.2	79	240	2.2	.10	<10	2	150	9	1
41	1	1.2	75	<5.0	15	.3	85	183	1.6	.12	10	4	70	11	<1
42	2	1.5	136	21	63	.2	80	334	1.3	.09	<10	2	760	36	6
40	1	1.1	71	<5.0	10	.3	82	160	.76	.07	<10	3	50	<3	<1
51	2	1.8	120	17	47	.2	80	291	.78	.05	20	1	610	10	4
31	1	1.6	131	8.0	43	.2	84	281	2.9	.10	<10	1	80	17	3
50	2	1.9	108	9.0	38	.2	81	250	.58	.07	<10	2	360	22	4
--	--	1.7	110	15	55	.2	84	336	.55	.10	<10	2	70	<3	<1
28	1	2.6	147	8.0	29	.2	77	235	2.9	.08	<10	1	220	<3	38
26	.8	2.6	112	6.0	17	.2	76	216	1.9	.10	<10	1	40	<3	<1
37	1	1.1	93	<5.0	14	.3	61	181	2.6	.05	<10	6	160	<3	1
42	1	1.8	94	5.0	16	.2	73	194	1.0	.04	10	5	230	<3	<1
37	1	1.1	92	<5.0	15	.3	75	188	1.5	.06	10	5	170	11	10
27	.9	.8	141	<5.0	22	.2	69	248	.64	.08	20	6	180	<3	<1
46	2	2.0	107	<5.0	35	.2	71	285	1.2	.04	10	6	320	<3	14
43	1	1.5	103	<5.0	22	.2	72	208	1.5	.06	10	8	270	<3	<1
47	1	1.1	--	<5.0	20	.3	79	210	1.6	.07	10	7	210	<3	<1
46	2	1.0	86	6.0	30	.2	81	225	1.6	.10	10	3	240	<3	<1
60	3	1.6	71	16	64	.3	80	285	2.4	.15	<10	4	830	5	<1
21	.4	1.1	55	15	7.9	<.1	43	159	1.9	.04	10	<1	120	8	6
20	.7	3.9	81	52	20	<.1	56	328	12	.05	10	2	130	4	<1

6.0 ANALYSES OF WATER FROM WELLS FOR SELECTED CHEMICAL CONSTITUENTS--continued

WELL NO.	SITE IDENTIFICATION NO.	DATE OF SAMPLE	GEO-LOGIC UNIT	SPE-CIFIC CON-DUCT-ANCE (UMHO/CM)	PH (STAND-ARD UNITS)	TEMPER-ATURE (°C)	HARD-NESS (MG/L AS $CACO_3$)	HARD-NESS, NONCAR-BONATE (MG/L $CACO_3$)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)
011N007E03J01	384956121102901	82-09-15	200BMCX	195	6.4	18.0	66	13	14	7.6	10
011N007E05P01	384930121130901	82-09-15	200BMCX	270	6.6	18.0	81	0	16	10	24
011N007E09N01	384846121122701	82-09-16	200BMCX	360	7.0	20.0	120	0	25	15	33
011N007E11P01	384847121100301	82-09-15	200BMCX	278	6.8	18.0	100	2	17	15	15
011N007E13B01	384833121083401	82-09-15	200BMCX	237	7.0	18.0	96	0	12	16	12
011N007E14C01	384839121095001	82-09-15	200BMCX	209	6.7	17.0	75	3	12	11	12
011N007E15A01	384837121103301	82-09-15	200BMCX	183	6.8	17.0	68	4	11	9.9	9.8
011N007E16A01	384837121113301	82-09-15	200BMCX	178	6.7	18.0	57	0	11	7.2	12
011N007E17D01	384829121133001	82-09-15	200BMCX	260	6.7	18.0	89	25	20	9.6	16
011N007E21M01	384708121121801	82-09-16	200BMCX	160	7.1	21.0	61	0	17	4.4	11
011N007E24G01	384733121082901	82-09-15	200BMCX	340	6.8	17.5	110	6	19	16	23
011N007E26A01	384648121092801	82-09-15	200BMCX	255	6.8	17.0	99	0	20	12	15
011N007E29B01	384650121130001	82-09-16	200BMCX	210	6.6	17.0	82	20	20	7.8	12
012N006E01B01	385528121151401	82-09-10	200BMCX	248	6.8	19.0	95	2	20	11	16
012N006E01J01	385459121144801	82-09-08	200BMCX	298	7.0	19.0	120	0	24	15	16
012N006E02C01	385530121163601	82-09-08	124IONE	786	8.0	20.5	93	0	23	8.7	140
012N006E07H01	385416121202301	82-09-08	111AVSN	294	7.4	22.0	79	0	15	10	30
012N006E12R01	385404121145901	82-09-08	200BMCX	232	7.2	21.0	88	9	19	9.9	12
012N006E13N01	385309121155001	82-09-09	124IONE	827	7.9	20.0	130	0	28	15	140
012N006E14C01	385350121163301	82-09-08	124IONE	1650	7.8	21.5	170	0	39	17	320
012N006E15P01	385310121173501	82-09-08	111AVSN	369	7.0	25.5	130	0	24	18	23
012N006E16C01	385341121185501	82-09-08	124IONE	839	7.3	22.0	140	5	26	19	130
012N006E17G01	385326121193601	82-09-08	111AVSN	412	7.1	21.0	180	29	32	24	25
012N006E19P01	385207121205401	82-09-09	111AVSN	311	7.6	20.0	120	15	21	16	15
012N006E20M01	385222121201401	82-09-09	111AVSN	289	7.3	20.5	100	0	18	14	20
012N006E29C01	385200121195701	82-09-09	111AVSN	308	7.5	20.5	83	0	15	11	31
012N007E01P02	385449121084401	82-09-10	200BMCX	261	6.7	18.0	93	8	16	13	11
012N007E03F01	385520121105401	82-09-10	200BMCX	231	6.9	18.0	93	0	16	13	12
012N007E07P01	385359121141601	82-09-09	200BMCX	605	7.0	19.0	240	100	50	27	25
012N007E11J01	385412121092301	82-09-09	200BMCX	260	6.8	19.0	110	0	19	15	13
012N007E13C02	385350121083901	82-09-10	200BMCX	252	6.8	19.0	100	0	18	14	12
012N007E14L01	385326121095901	82-09-09	200BMCX	127	6.8	19.5	40	0	7.2	5.4	11
012N007E16F01	385329121121501	82-09-09	200BMCX	266	6.5	19.0	130	33	26	15	10
012N007E17E01	385331121133601	82-09-09	200BMCX	127	6.9	20.0	43	0	8.8	5.1	8.3
012N007E19M01	385240121144401	82-09-09	200BMCX	287	6.9	20.5	100	0	21	12	23
012N007E20F02	385241121132001	82-09-09	200BMCX	163	6.8	18.0	52	4	11	5.9	12
012N007E26Q02	385121121093401	82-09-10	200BMCX	135	6.5	20.0	42	0	7.8	5.4	9.1
012N007E28H01	385142121113301	82-09-10	200BMCX	229	6.6	18.5	78	3	13	11	14
012N007E33A01	385114121113501	82-09-10	200BMCX	70	6.6	19.5	22	0	4.9	2.3	4.2
013N005E12Q02	385914121215801	82-09-07	111AVSN	225	7.5	22.0	54	0	12	5.9	26
013N005E13D02	385856121222501	82-09-07	111AVSN	328	7.6	22.0	51	0	13	4.4	51
013N005E36D01	385625121222401	82-09-24	111AVSN	233	7.4	20.5	85	0	16	11	15
013N006E02C01	390038121163901	82-09-07	200BMCX	208	7.0	25.0	93	6	26	6.9	6.6
013N006E02J01	390015121160101	82-09-07	200BMCX	--	7.1	20.5	130	0	32	11	9.9
013N006E05B01	390047121193801	82-09-07	200BMCX	285	8.2	23.5	68	0	20	4.5	36
013N006E07A01	385949121203001	82-09-07	111AVSN	138	7.1	24.5	39	0	8.0	4.6	12
013N006E07J01	385922121202601	82-09-07	111AVSN	156	6.9	22.0	49	0	11	5.2	14
014N006E31Q01	390100121204201	82-09-08	111AVSN	182	7.5	20.5	68	0	12	9.2	15
014N006E35P01	390057121163501	82-09-24	111AVSN	244	7.0	19.0	110	0	28	8.8	9.6

PER- CENT SO- DIUM	SODIUM AD- SORP- TION RATIO	POTAS- SIUM, DIS- SOLVED (MG/L AS K)	ALKA- LINITY FIELD (MG/L AS $CACO_3$)	SULFATE DIS- SOLVED (MG/L AS SO_4)	CHLO- RIDE, DIS- SOLVED (MG/L AS CL)	FLUO- RIDE, DIS- SOLVED (MG/L AS F)	SILICA, DIS- SOLVED MG/L AS SIO_2)	SOLIDS, RESIDUE AT 180 DEG. C DIS- SOLVED (MG/L)	NITRO- GEN, NO_2+NO_3 DIS- SOLVED (MG/L AS N)	PHOS- PHORUS, ORTHO, DIS- SOLVED (MG/L AS P)	ALUM- INUM, DIS- SOLVED (UG/L AS AL)	AR- SENIC, DIS- SOLVED (UG/L AS AS)	BORON, DIS- SOLVED (UG/L AS B)	IRON, DIS- SOLVED (UG/L AS FE)	MANGA- NESE, DIS- SOLVED (UG/L AS MN)
24	0.5	3.0	53	11	5.6	0.1	47	146	6.0	0.03	20	4	110	5	2
38	1	2.7	95	14	12	.2	66	207	2.8	.17	<10	1	150	10	1
36	1	4.7	--	18	11	.2	63	256	<.10	.06	<10	1	150	83	3
23	.7	2.6	102	10	7.3	<.1	49	259	4.9	.07	10	1	110	<3	<1
20	.5	5.5	--	17	6.0	.2	54	166	.12	.05	<10	<1	120	7	210
25	.6	2.9	72	9.0	8.2	.1	49	150	3.8	.04	10	<1	110	6	<1
23	.5	2.3	64	16	4.6	.1	48	138	2.3	.05	10	1	120	<3	<1
30	.7	4.0	70	6.0	4.5	.1	48	136	2.1	.06	<10	<1	110	<3	<1
27	.8	4.0	65	22	9.7	<.1	51	237	4.9	.05	<10	<1	110	<3	<1
28	.6	1.4	63	--	2.5	.1	73	156	.27	.11	<10	1	120	<3	<1
30	1	4.9	107	36	10	.1	57	243	5.2	.06	10	1	120	<3	<1
24	.7	4.4	121	8.0	7.9	.1	50	180	<.10	.08	<10	1	110	120	62
24	.6	2.1	62	19	5.0	<.1	57	173	3.1	.08	<10	<1	110	4	<1
26	.7	1.4	93	18	6.3	.4	52	199	4.8	.04	<10	1	130	4	150
22	.6	1.2	130	13	6.9	.3	45	198	2.3	.03	<10	1	200	<3	<1
76	7	1.4	227	99	53	1.5	28	505	<.10	.03	<10	1	5600	12	7
45	2	.6	93	14	27	.4	70	222	1.3	.09	<10	2	540	7	4
22	.6	3.3	79	13	9.9	.2	47	187	4.3	.04	10	1	160	9	<1
69	5	2.0	303	36	58	.9	29	499	1.3	.03	<10	1	4500	<3	<1
80	11	1.8	179	270	300	1.2	29	1070	.15	.03	<10	1	6800	83	41
27	.9	.3	144	20	26	<.1	24	281	.29	.01	<10	<1	150	3400	300
66	5	.8	138	150	80	.4	72	598	4.7	.08	<10	3	1100	3	<1
23	.8	.4	150	21	25	.1	68	285	3.5	.04	<10	1	170	<3	2
22	.6	.4	103	11	16	.2	65	--	4.2	.09	10	2	130	<3	<1
30	.9	.7	113	10	10	.2	75	217	1.4	.08	<10	2	170	<3	<1
45	2	1.1	100	8.0	25	.2	81	221	1.6	.12	<10	3	530	<3	1
20	.5	1.0	86	22	6.4	<.1	46	172	1.3	.02	<10	<1	150	<3	9
22	.6	.9	98	15	5.5	.1	38	166	1.2	.02	<10	1	170	15	16
18	.7	4.5	133	30	51	.1	49	484	19	.04	20	1	120	26	19
20	.6	.80	132	<5.0	3.1	.1	44	164	.12	.05	<10	1	120	98	41
20	.5	.9	108	14	7.2	.1	38	171	1.5	.03	<10	1	140	42	2
36	.8	1.3	59	<5.0	2.4	.2	59	111	.25	.07	<10	2	130	4	<1
14	.4	2.3	94	34	3.9	.1	40	258	5.2	.02	10	7	120	27	8
29	.6	.7	46	6.0	4.2	.1	21	--	1.6	.02	<10	1	290	6	<1
32	1	3.5	121	10	9.8	.1	54	197	1.6	.06	<10	3	120	9	1
32	.7	2.2	48	8.0	12	.1	66	140	2.2	.10	<10	14	150	<3	<1
30	.6	3.3	50	10	3.9	.1	50	112	1.0	.05	<10	2	140	9	2
27	.7	2.6	75	14	5.1	.2	66	192	4.9	.11	<10	6	140	<3	<1
28	.4	1.5	34	<5.0	1.0	.1	32	58	.32	.03	<10	1	140	16	1
51	2	.9	68	13	18	.3	79	204	1.3	.11	<10	2	230	6	<1
68	3	1.7	--	22	45	.3	81	279	1.7	.09	<10	2	530	15	2
27	.7	1.1	130	9.0	9.1	.2	72	192	.68	.08	<10	2	50	47	4
13	.3	.6	87	8.0	6.7	.1	21	133	1.1	.02	<10	<1	140	4	1
15	.4	.7	127	7.0	6.6	<.1	23	170	.84	.02	<10	<1	130	11	2
53	2	1.8	112	11	17	.3	33	184	<.10	.05	<10	2	170	22	29
40	.9	.8	44	13	5.3	.3	70	145	1.0	.30	<10	4	140	15	7
38	.9	.9	53	18	6.8	.3	60	145	.32	.24	<10	5	140	220	15
32	.8	.3	82	6.0	4.7	.3	68	156	1.7	.17	<10	2	130	<3	<1
16	.4	1.7	140	10	5.9	<.1	26	152	.54	.02	10	<1	10	9	55

7.0 ANALYSES OF WATER FROM WELLS FOR SELECTED TRACE ELEMENTS

WELL NO.: Based on the rectangular subdivision of public lands. See section 1.3 in report for detailed explanation.
SITE IDENTIFICATION NO.: Unique number for each well based on the latitude and longitude of the well. First six digits are latitude, next seven digits are longitude and final two digits are a sequence number to uniquely identify each well.

WELL NO.	SITE IDENTIFICATION NO.	DATE OF SAMPLE	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COBALT, DIS-SOLVED (UG/L AS CO)	COPPER, DIS-SOLVED (UG/L AS CU)	LEAD, DIS-SOLVED (UG/L AS PB)	LITHIUM DIS-SOLVED (UG/L AS LI)	MERCURY DIS-SOLVED (UG/L AS HG)
004N003E26G01	380945121363301	82-09-17	<1	<1	<1	<1	<1	4	<0.1
005N003E13G01	381646121352301	82-09-20	<1	<1	3	1	<1	<4	<.1
005N005E03P01	381832121252301	82-09-28	<1	1	<1	<1	2	5	.2
005N006E22Q02	381546121181801	82-09-22	<1	<1	<1	<1	4	<4	<.1
005N006E29G04	381523121203901	82-09-15	<1	<1	<1	1	<1	7	<.1
005N007E10P01	381738121120001	82-09-09	<1	10	2	<1	<1	<4	<.1
006N006E07Q01	382259121213401	82-09-14	<1	10	<1	4	2	<4	<.1
007N006E29C01	382614121203501	82-09-14	<1	<1	<1	1	<1	<4	<.1
008N005E01C02	383457121225601	82-09-23	<1	<1	<1	1	<1	4	.1
008N005E29Q01	383046121270201	82-09-28	1	<1	<1	1	2	6	.2
008N005E35Q01	382952121234401	82-09-28	<1	<1	<1	1	1	<4	<.1
009N005E23L02	383700121241001	82-09-29	<1	4	<1	<1	9	4	<.1
009N006E05B01	384012121202801	82-09-16	<1	8	<1	1	<1	8	.1
009N007E04M02	383943121132701	82-09-27	<1	<1	<1	<1	<1	12	<.1
010N003E36N01	384017121364101	82-09-10	<1	<1	4	<1	<1	7	<.1
010N005E21K01	384224121261401	82-09-22	1	<1	<1	5	<1	10	.7
010N006E02K01	384458121171001	82-09-24	<1	<1	<1	2	<1	19	<.1
010N006E22L01	384218121183101	82-09-17	1	<1	<1	4	<1	16	.1
011N005E16Q01	384747121250501	82-09-14	<1	<1	20	1	1	<4	.1
011N005E34P01	384510121242301	82-09-14	<1	20	<1	2	<1	<4	.1
011N007E15A01	384837121103301	82-09-15	<1	<1	3	10	<1	9	.1
012N006E14C01	385350121163301	82-09-08	<1	2	10	<5	<5	560	2.9
012N006E17G01	385326121193601	82-09-08	<1	1	5	<5	<5	6	.1

WELL NO.	DATE OF SAMPLE	MOLYB-DENUM, DIS-SOLVED (UG/L AS MO)	NICKEL, DIS-SOLVED (UG/L AS NI)	SELE-NIUM, DIS-SOLVED (UG/L AS SE)	STRON-TIUM, DIS-SOLVED (UG/L AS SR)	VANA-DIUM, DIS-SOLVED (UG/L AS V)	ZINC, DIS-SOLVED (UG/L AS ZN)	CARBON, ORGANIC DIS-SOLVED (MG/L AS C)
004N003E26G01	82-09-17	4	<1	<1	150	12	19	1.4
005N003E13G01	82-09-20	4	2	<1	470	<1	44	2.7
005N005E03P01	82-09-28	5	2	<1	190	<1	<3	--
005N006E22Q02	82-09-22	3	2	<1	120	2	4	.50
005N006E29G04	82-09-15	3	1	3	670	<1	6	.70
005N007E10P01	82-09-09	3	1	<1	110	<1	10	<.30
006N006E07Q01	82-09-14	3	<1	<1	230	<1	6	.50
007N006E29C01	82-09-14	2	<1	<1	130	<1	11	.30
008N005E01C02	82-09-23	--	2	<1	240	14	3	--
008N005E29Q01	82-09-28	<1	1	<1	290	19	7	.50
008N005E35Q01	82-09-28	2	3	<1	150	21	16	.70
009N005E23L02	82-09-29	<1	<1	<1	170	16	5	.80
009N006E05B01	82-09-16	2	<1	1	180	16	6	.40
009N007E04M02	82-09-27	2	<1	<1	250	12	7	.40
010N003E36N01	82-09-10	3	2	<1	220	<1	13	17
010N005E21K01	82-09-22	--	4	<1	250	89	20	--
010N006E02K01	82-09-24	--	5	<1	260	13	17	.80
010N006E22L01	82-09-17	--	7	<1	290	15	22	1.0
011N005E16Q01	82-09-14	--	12	<1	190	<1	140	1.1
011N005E34P01	82-09-14	--	1	<1	99	<1	57	.60
011N007E15A01	82-09-15	--	3	<1	69	<1	7	.60
012N006E14C01	82-09-08	16	10	<1	620	<1	8	1.1
012N006E17G01	82-09-08	1	5	<1	280	<1	80	.70