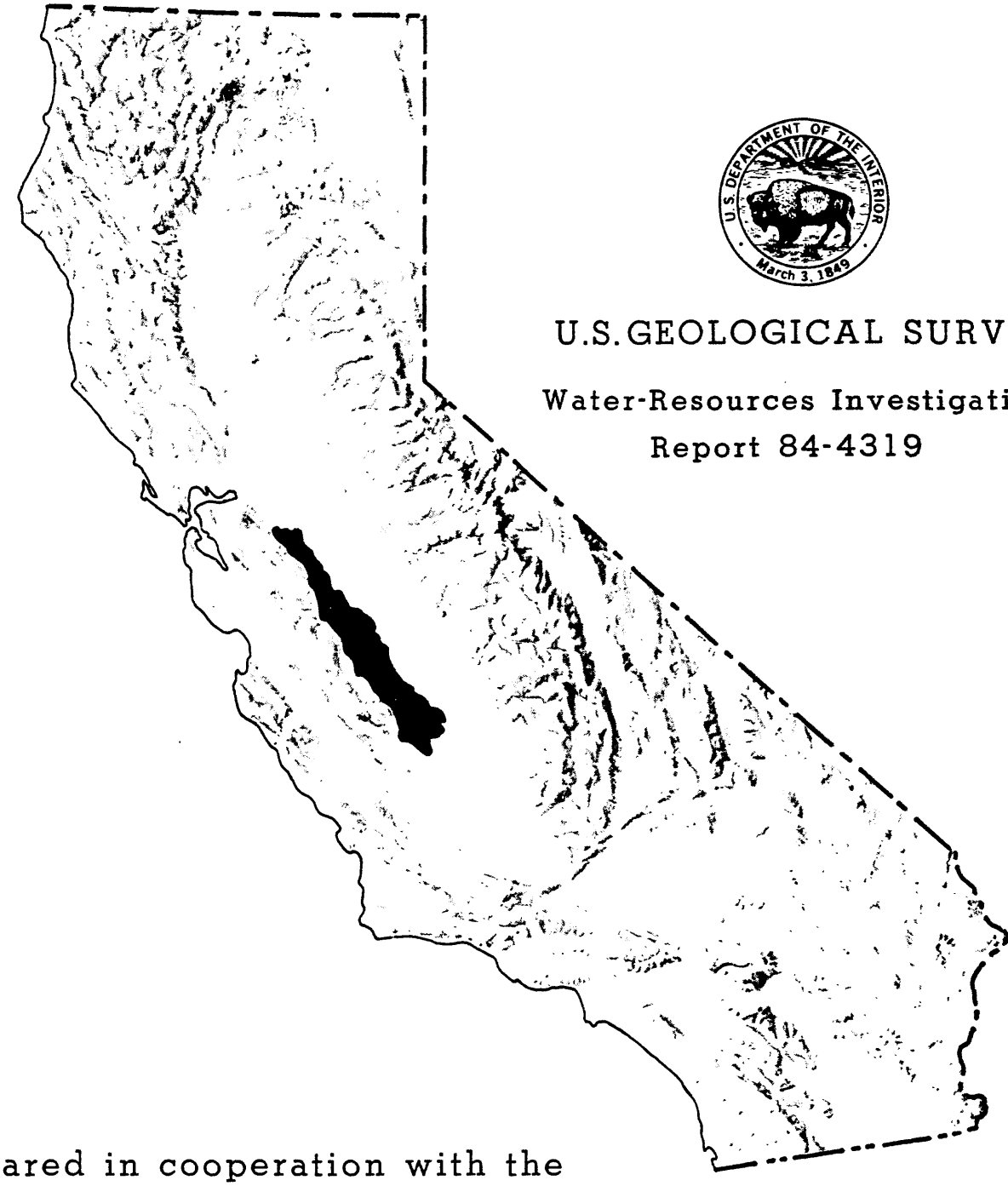
AREAL DISTRIBUTION OF SELENIUM AND OTHER INORGANIC CONSTITUENTS IN SHALLOW GROUND WATER OF THE SAN LUIS DRAIN SERVICE AREA, SAN JOAQUIN VALLEY, CALIFORNIA: A PRELIMINARY STUDY



U.S. GEOLOGICAL SURVEY

Water-Resources Investigations
Report 84-4319

Prepared in cooperation with the
U.S. BUREAU OF RECLAMATION

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UNITED STATES DEPARTMENT OF THE INTERIOR

WILLIAM P. CLARK, Secretary

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PREFACE

This report has been prepared in response to a public need for information on the quality of agricultural drainage water from the San Luis Drain service area. Discussions and data in this report are the result of a preliminary reconnaissance study designed to provide information necessary to plan and implement further scientific investigations. These investigations are needed to provide the basis for management of agricultural drainage water in the service area.

The U.S. Geological Survey and other agencies, including the U.S. Bureau of Reclamation and the U.S. Fish and Wildlife Service, recognize that selenium has been implicated as the constituent of primary environmental concern in the service area, but also recognize that to focus on this one constituent may lead to incomplete results. Each study undertaken, including the one reported here, is designed to evaluate a broad spectrum of constituents that will fully address the issue of drainage-water quality.

Previous water-quality data from the San Luis Drain service area have been released in U.S. Geological Survey reports by Presser and Barnes (1984) and Izbicki (1984). Other detailed studies are being initiated that may take 5 or more years to complete. The studies are designed to provide information that will help answer many of the questions regarding present and potential effects of drainage water in the San Joaquin Valley and the San Francisco Bay estuary. Specifically, these studies will investigate constituents identified as problems, their source, areal distribution, mobilization, and transport through geochemical processes and the ground-water system. Studies of present and potential discharge areas, such as Kesterson Reservoir also are planned.

This report focuses mainly on data from water samples that were collected and analyzed by the U.S. Geological Survey. The report also includes data from samples collected by the U.S. Bureau of Reclamation and analyzed by the Geological Survey Central Laboratory, Denver, Colo. At the request of the Bureau of Reclamation, the Geological Survey has provided review and comments on field techniques used by the Bureau of Reclamation in their studies of the San Luis Drain service area.

The authors wish to acknowledge the help of others in making this report possible. The California Department of Water Resources, San Joaquin District, provided soils information used to help interpret our data. Norman Cederquist of the U.S. Bureau of Reclamation assisted the authors in locating sampling sites. A number of U.S. Geological Survey colleagues were temporarily relocated to California to conduct the large field sampling program required for the study. We thank Kerry T. Garcia, Richard J. LeCamera, and Alan M. Preissler from Carson City, Nev.; Theresa Olsen from Tacoma, Wash.; Thomas K. Edwards from Portland, Ore.; Mack G. Croft from Bismarck, N. Dak.; Lewis W. Howells from Huron, S. Dak.; and Johnevan M. Shay, Gail L. Keeter, Michael J. Pierce, and Rick T. Iwatsubo from Sacramento, Calif. We are particularly grateful to the many landowners that allowed access to their land, and to the various water district personnel that provided assistance.

Report preparation was aided by colleagues Brian T. Yost, Richard J. Mandle, Linda S. Hamblin (editor), Arlyn Lee (editorial assistant) and Ronald L. Rodgers (illustrator). The report benefited from technical review by members of the U.S. Geological Survey San Luis Drain Technical Committee chaired by David A. Rickert, members of the U.S. Bureau of Reclamation, William R. Johnston of the Westlands Water District, and Bruce Foxworthy of the U.S. Geological Survey.

Steven J. Deverel

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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	0.3048	meters
inches	25.4	millimeters
miles	1.609	kilometers
micromho per centimeter at 25° Celsius	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:

$$°F = 1.8\ (°C) + 32.$$

Chemical concentrations in water are given in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams per liter is a unit expressing the solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter. For concentrations less than about 7,000 mg/L, milligrams per liter is equivalent to "parts per million" and micrograms per liter is equivalent to "parts per billion." Micrograms per gram (µg/g) and milligrams per kilogram (mg/kg) are used to express tissue concentrations and are equivalent to one part per million by weight.

In reference to ingestion of a substance by humans, the unit is micrograms per day (µg/d) and is equivalent to 1 millionth of a gram in one day. Microgram per kilogram (µg/kg) is the same as one part per one billion parts by weight.

AREAL DISTRIBUTION OF SELENIUM AND OTHER INORGANIC CONSTITUENTS IN SHALLOW GROUND WATER OF THE SAN LUIS DRAIN SERVICE AREA, SAN JOAQUIN VALLEY, CALIFORNIA: A PRELIMINARY STUDY

By S. J. Deverel[1], R. J. Gilliom[2], Roger Fujii[1], J. A. Izbicki[3], and J. C. Fields[4]

ABSTRACT

This study is a preliminary assessment of the areal distribution of selenium and other inorganic chemical constituents in shallow ground water of the San Luis Drain service area. In previous studies, high concentrations of selenium were detected in agricultural drainage water in parts of the service area. Shallow ground water was sampled at 130 sites during May 5-21, 1984. The sites were distributed among three different physiographic zones of the service area--the alluvial fan zone along the western edge of the area, the basin trough zone adjacent to the San Joaquin River, and the basin rim zone in between. Most of the shallow ground water throughout the service area was alkaline and slightly saline. Sulfate was the dominant anion in 62 percent of the samples and sodium was the dominant cation in 57 percent of the samples. There were significant (α = 0.05) differences between zones in which ions were dominant. Boron concentrations exceeded the water-quality criterion for irrigation use in 80 percent of the samples.

All eight priority pollutants included in the sample analyses--arsenic, cadmium, chromium, copper, lead, mercury, selenium, and zinc--were detected at least once, but only chromium, mercury, and selenium occurred in concentrations approaching water-quality criteria for protection of freshwater aquatic life. Selenium was detected in 76 percent of samples, chromium in 77 percent of samples, and mercury in 32 percent of samples. Median selenium concentrations of 10 micrograms per liter in the basin rim zone and 11 micrograms per liter in the alluvial fan zone were not significantly (α = 0.05) different from each other, but both were significantly higher than the median concentration of less than 1 microgram per liter in the basin trough zone. Six of the ten highest selenium concentrations (370 to 3,800 micrograms per liter) were in the basin rim zone and four were in the alluvial fan zone. Overall, selenium concentrations were highest in the central and southern parts of the alluvial fan and basin rim zones, and lowest in the northern parts of all zones and in the entire basin trough zone.

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(page 3 follows)

INTRODUCTION

High concentrations of selenium have been detected in agricultural drainage water in parts of the San Luis Drain service area, hereafter referred to as the service area, in the western part of the San Joaquin Valley, Calif. (Presser and Barnes, 1984). Selenium, although naturally occurring and essential to animals in minute amounts, is toxic to most organisms at high levels (National Academy of Science, 1977). High incidences of mortality and birth defects have been observed in waterfowl nesting in the area where drainage water is discharged, and high concentrations of selenium were detected in fish, plants, and birds exposed to drain water (U.S. Bureau of Reclamation, 1984b). There is concern about adverse health effects if high concentrations of selenium reach drinking-water supplies or become concentrated in game birds or food crops.

The potential seriousness of the ecological and health effects of selenium and other trace elements in drainage water, and the threat to the future of irrigated agriculture in this major crop-production area, have prompted studies by the U.S. Geological Survey, the U.S. Bureau of Reclamation, the U.S. Fish and Wildlife Service, and other agencies. Several studies are underway and others are planned of the occurrence, distribution, and environmental behavior of selenium and other trace elements in the plants, animals, earth materials, and hydrologic system of the San Luis Drain service area and adjacent lands.

This report describes the results of a short-term study of the concentrations of selenium, other trace elements, and major ions in the shallow ground water of the San Luis Drain service area. This shallow ground water inhibits crop production when the water level rises to within 3 to 5 feet of the land surface. Subsurface agricultural drains have been installed in much of the service area in order to lower the water table. The drainage water is presently (1984) discharged to the San Luis Drain, to local evaporation ponds, or to the San Joaquin River (U.S. Bureau of Reclamation, 1984c). This report provides a preliminary assessment of the areal distribution of selenium, other trace elements, and major ions in the shallow ground water of the service area and will serve as a guide for other related studies.

Description of Area

The San Luis Drain service area consists of about 1.2 million acres of the western part of the San Joaquin Valley in the Central Valley of California (fig. 1). Irrigation of the west side of the San Joaquin Valley began in the 1870's with diversions of water from the San Joaquin River. This water was used to flood irrigate native pasture land close to the river. Pumping of ground water for irrigation began in the early 1900's and increased substantially in the 1920's. The Delta Mendota Canal beginning in 1951 and the San Luis Canal beginning in 1967 supply surface water to the west side of the San Joaquin Valley. The service area provides a significant part of the agricultural production in the Central Valley, which yields about 40 percent of the Nation's fruits, nuts, and vegetables (Diamond and Williamson, 1983).

Most land in the service area, as in the rest of the Central Valley, is nearly level and less than 100 feet above sea level. The western valley floor consists mainly of alluvium

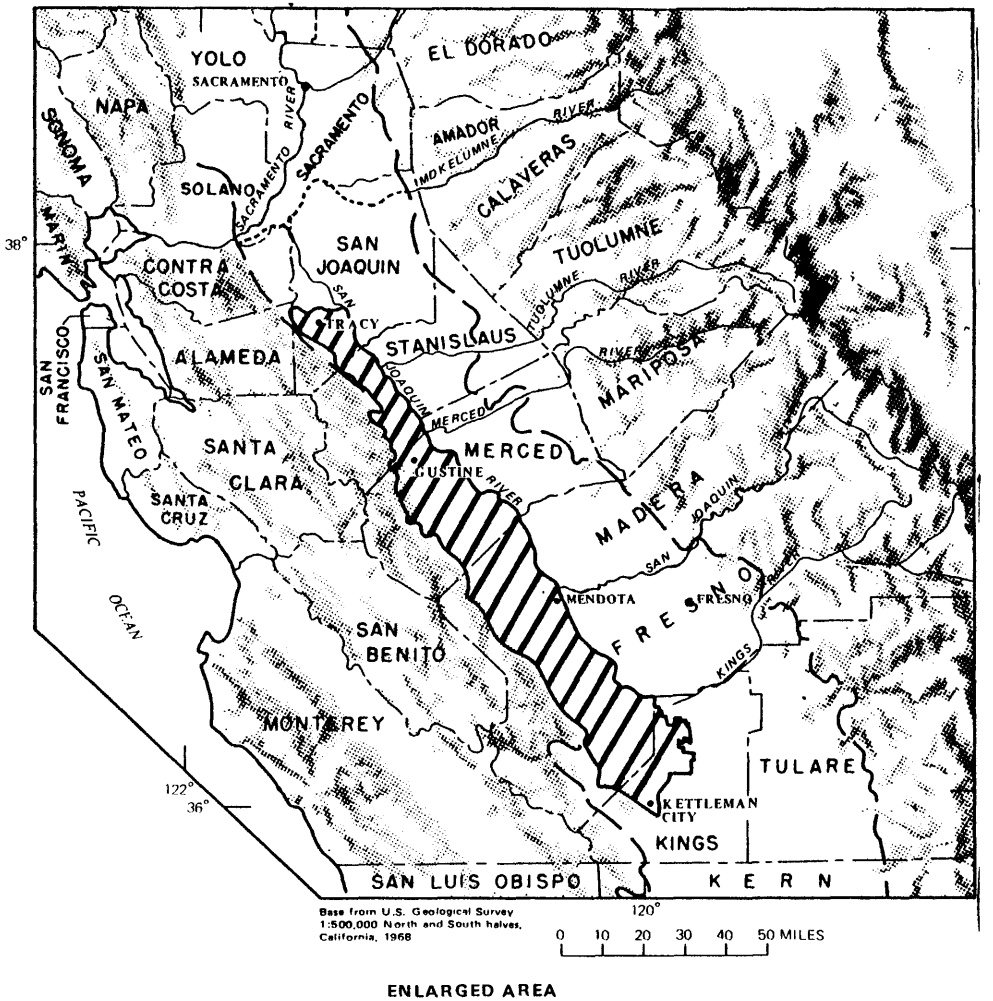
eroded from marine sedimentary rocks of the Coast Range. For the purposes of this report, the service area has been divided into three main physiographic zones (fig. 2)--the alluvial fan zone, the basin rim zone, and the basin trough zone--which differ in general soil and terrain characteristics (California Department of Water Resources, 1970). As described by the California Department of Water Resources, the alluvial fan zone consists of alluvial fans of sedimentary material from the Coast Range with moderately sloping terrain and mostly low-salinity soils, and lies between the Coast Range and the more level part of the valley. The basin rim zone also is underlain by sedimentary material mainly derived from the Coast Range, but is more level than the alluvial fan zone and has soils that are moderately to highly saline. The basin trough zone lies between the basin rim zone and the San Joaquin River. This zone is underlain by a mixture of deposits from the Coast Range and other sources, is very level, and has soils with low salinity.

The hydrology of the San Joaquin Valley reflects the complex interrelationships of natural conditions and extensive modifications by humans. Average annual precipitation in most of the San Joaquin Valley is less than 10 inches and temperatures are hot in the summer and mild in the winter (Davis and others, 1964). Streamflow in the San Joaquin River and its tributaries is fed mainly by snowmelt runoff resulting from as much as 60 inches per year of precipitation at high altitudes in the Sierra Nevada to the east. The Coast Range to the west of the valley also receives more precipitation than the valley floor--about 14 to 20 inches in the western and higher parts--but in most years provides little surface-water inflow to the valley.

Under natural (predevelopment) conditions, almost 80 percent of the streamflow in the San Joaquin Valley occurred from January to June during high precipitation and snowmelt. Water is now distributed more evenly throughout the valley and over the year by an extensive network of storage reservoirs and canals. Extensive irrigation withdrawals and large agricultural return flows, however, cause large variations in flow along different reaches of the rivers in the valley. Water leaves the valley primarily by outflow of the San Joaquin River to the San Joaquin-Sacramento Delta, and by evapotranspiration, which averages about 30 inches per year in the northern part and more than 40 inches per year in the southern part of the valley floor (Williamson, 1982).

Shallow ground water occurs within several feet of the land surface in the soil and alluvial deposits in much of the service area. The shallow ground water is underlain by discontinuous layers of clay, which vary in depth from near the land surface to about 40 feet. The clay layers impede the vertical movement of the ground water. The shallow ground water above these clay layers is often referred to locally as the "perched" ground water and in some places there may be unsaturated zones beneath the clay layers. The San Joaquin Valley also is underlain by extensive regional aquifers at depths greater than 100 feet below the land surface in most places. The shallow and regional groundwater systems seem to be poorly connected hydraulically because they are separated by the aforementioned clay layers as well as by deeper and more extensive poorly permeable materials (Page, 1985).

FIGURE 1.—Location of the San Luis Drain service area.



ENLARGED AREA

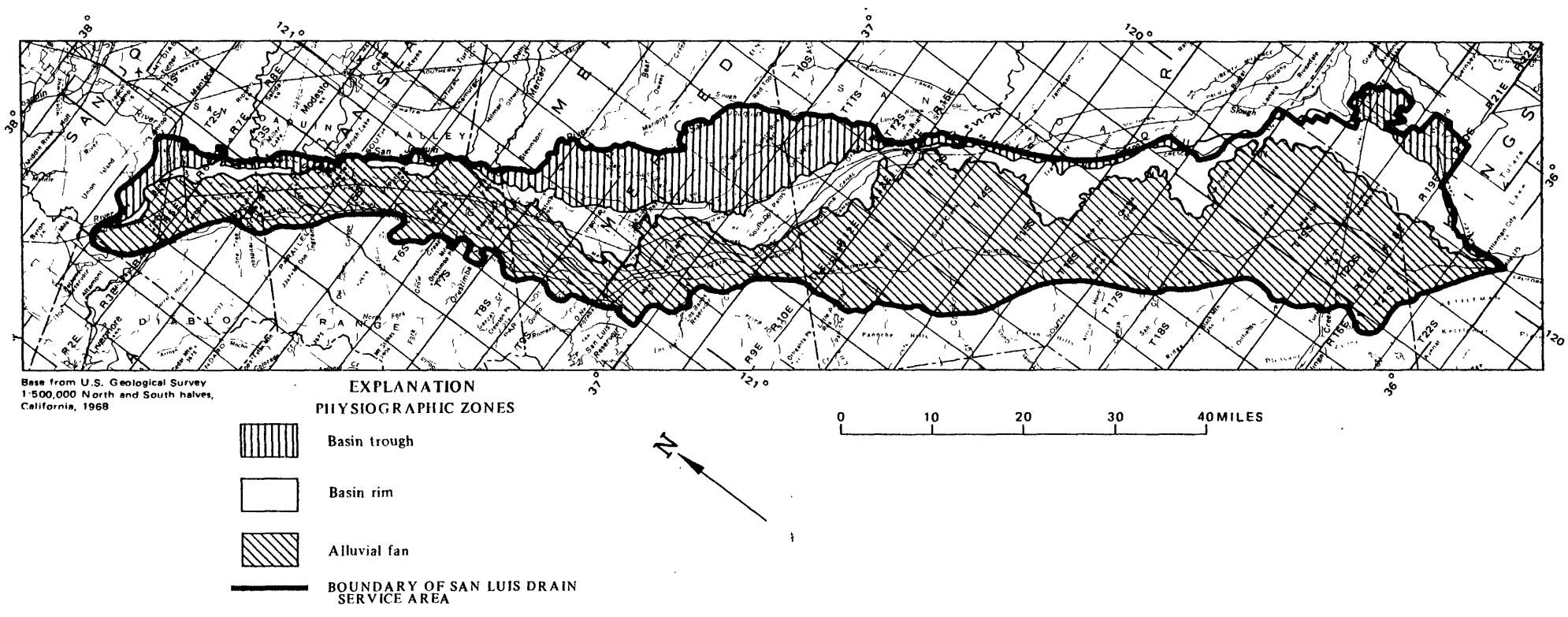


FIGURE 2.—Location of the three main physiographic zones (modified from California Department of Water Resources, 1970).

Under natural conditions, most recharge to the regional-aquifer system occurred as infiltration along the sides of the San Joaquin Valley from streams draining the Sierra Nevada and to a lesser extent, the Coast Range (Davis and Poland, 1957; Davis and others, 1964). Shallow unconfined ground water may not have existed under natural conditions except near rivers and in other areas of ground-water discharge. From about 1940-68, natural ground-water conditions were greatly modified by large withdrawals of water from the regional-aquifer system for irrigation. As a result, ground-water levels in the regional-aquifer system declined hundreds of feet and shallow ground-water levels rose because of the extensive application of irrigation water. Withdrawals from the regional-aquifer system decreased beginning about 1968 with the completion of the San Luis Unit of the Federal Central Valley Project and subsequent importation of water from northern California. Water levels in the regional-aquifer system began to rise to former positions because of the decrease in withdrawals. Increased application of irrigation water throughout the western part of the valley, where the service area is located, has caused extensive formation and enlargement of the shallow ground-water bodies that overlie the near-surface clay layers, resulting in a water table near the land surface in much of the area.

Agricultural Drainage Problems

About 253,000 acres of irrigated farmland in the San Luis Drain service area are affected by shallow water tables and inadequate drainage (U.S. Bureau of Reclamation, 1984a). A shallow water table can cause excessive moisture in the crop root zone. Salt accumulation may then occur as plants use soil moisture, leaving soluble salts in the soil water. If drainage is inadequate, salts concentrate near the land surface because of capillary movement of soil water to the land surface and evaporation of water. Periodic flushing of salts from the root zone would be necessary if crop production is to continue. One way to accomplish this is by use of subsurface drains to collect and remove shallow ground water, thus lowering the water table, and allowing irrigation water to more effectively flush excess salts from the soil.

Description of San Luis Drain

The San Luis Drain was authorized by the U.S. Congress in 1960 as a solution to the agricultural drainage problem on the west side of the valley (U.S. Bureau of Reclamation, 1984a). The drain is a concrete-lined channel extending from south to north through the western part of the valley floor (fig. 3). The drain was originally designed to receive the agricultural drainage from adjacent crop lands and convey it to the western part of the Sacramento-San Joaquin Delta. From 1968-75, 85 miles of the drain were constructed by the U.S. Bureau of Reclamation from Five Points, Calif., to a temporary terminus at Kesterson Reservoir (fig. 4). Kesterson Reservoir, although operated primarily as a drainage facility, is managed as a National Wildlife Refuge by the U.S. Fish and Wildlife Service.

Small quantities of water were discharged to Kesterson Reservoir beginning in 1972. Until 1978, the water discharged to the reservoir did not contain large quantities of subsurface drainage water. Beginning in 1978, increased quantities of subsurface drainage water were discharged, and from 1981-84 the flow into the reservoir from the San Luis Drain was primarily subsurface agricultural drainage from about 8,000 acres.

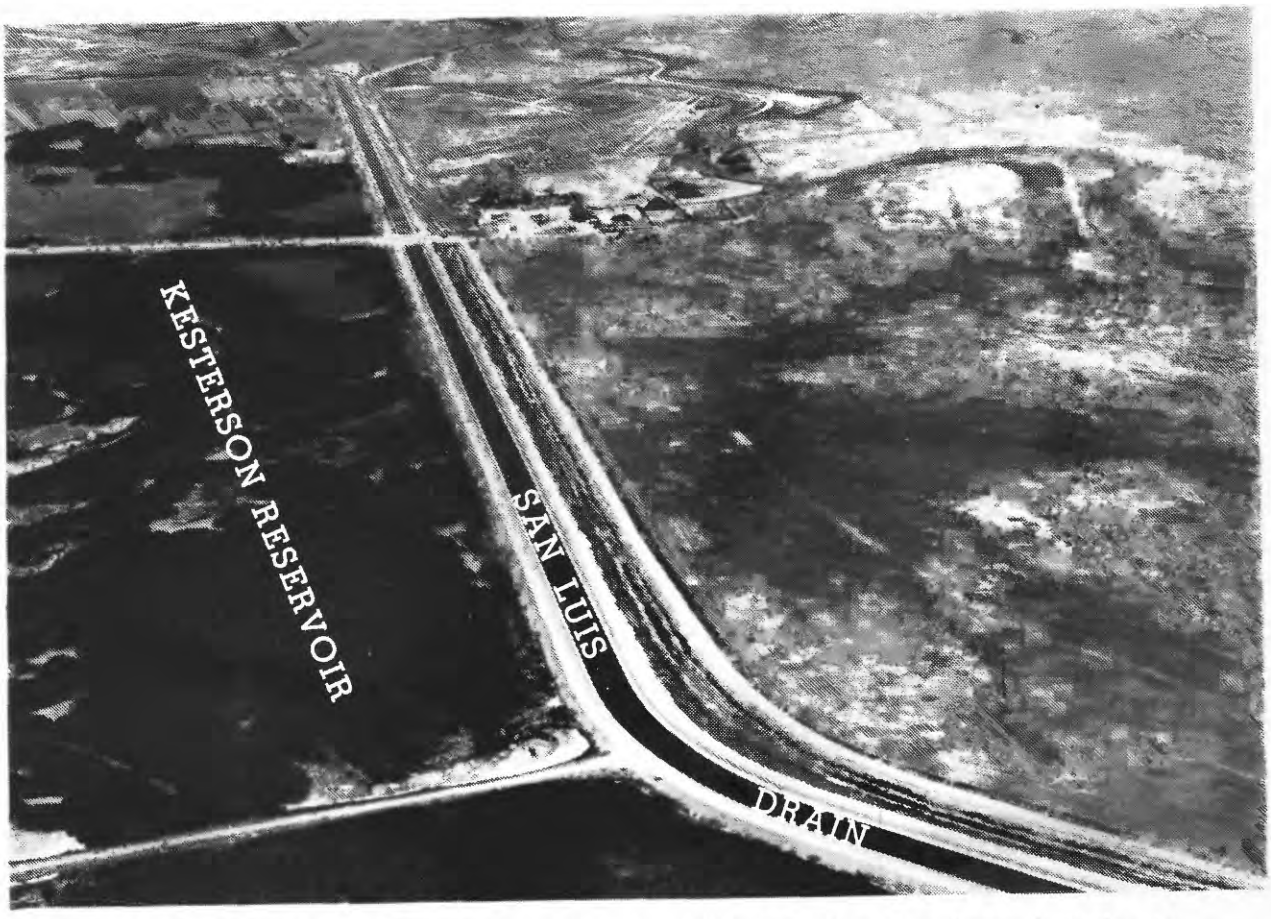


FIGURE 3.–Aerial view of the San Luis Drain, July 1984. Part of Kesterson Reservoir can be seen to the left of the Drain. (Looking north.)

CHARACTERISTICS OF SELENIUM

In previous studies, dissolved selenium concentrations in drainage water flowing into the San Luis Drain ranged from 140 to 1,400 µg/L (micrograms per liter) (Izbicki, 1984; Presser and Barnes, 1984). One farm drainage system in the service area had water that contained 4,200 µg/L of dissolved selenium (T. S. Presser and Ivan Barnes, U.S. Geological Survey, written commun., 1984). Concentrations measured in the drain ranged from 260 to 350 µg/L. The U.S. Environmental Protection Agency has set 1,000 µg/L of dissolved selenium as the minimum limit for classification as hazardous waste (U.S. Environmental Protection Agency, 1980a), however, agricultural drainage is excluded from this hazardous waste criterion. The presence of high selenium concentrations in the service area has raised concerns about possible environmental effects of drainage water and about the source of the selenium.

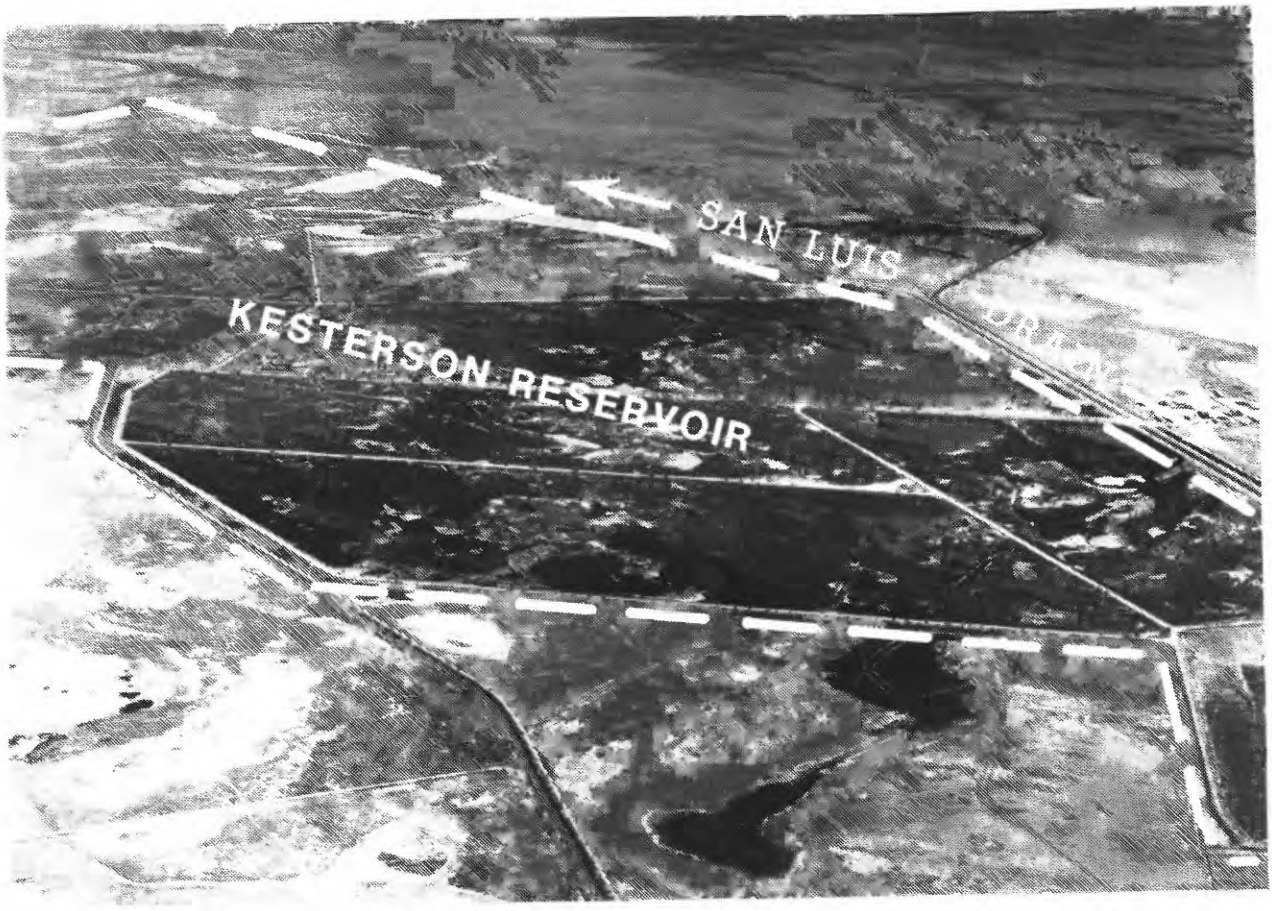


FIGURE 4.–Aerial view of a part of Kesterson Reservoir, July 1981. Dashed line is approximate boundary of Kesterson Reservoir. (Looking north.)

Chemical Species

Selenium is a naturally occurring, nonmetallic trace element which is similar to sulfur in chemical behavior (Lakin, 1973). It has four oxidation states, selenide (-2), elemental selenium (0), selenite (+4), and selenate (+6). Selenide exists in highly insoluble metal selenides, organic selenides, and as hydrogen selenide, a gas that readily decomposes in the presence of oxygen to form elemental selenium. Elemental selenium is virtually insoluble in water and seems to be an unreactive form of selenium in aquatic systems (U.S. Environmental Protection Agency, 1979). Selenite salts are moderately soluble in acidic waters and selenite seems to be the predominant form of selenium in most freshwater environments (Brooks, 1984). A combination of acidic and reducing conditions causes selenite to be reduced to insoluble elemental selenium.

Selenate is the most abundant form of dissolved selenium in alkaline aquatic systems, such as the waters in the San Luis Drain service area. Selenate is the most stable soluble form of selenium and is readily available to plants under alkaline conditions. Algae incorporate selenate and selenite into amino acids and protein, which can be more readily assimilated by animals, and thus play a role in allowing selenium to enter the food chain (Brooks, 1984).

Biological Effects

Selenium is required by mammals in small amounts, but is toxic to most organisms, including humans, in high concentrations (National Academy of Sciences, 1977; Brooks, 1984). The toxic effects of selenium are highly variable and depend on the chemical species of selenium, the type and age of the organism, the duration of exposure, the type of diet, and the presence and concentrations of other elements, such as arsenic (National Academy of Sciences, 1977). Most available information on selenium toxicity is for acute or short-term, life-threatening effects.

Ecological Effects

Selenium in water can be acutely toxic to all levels of the aquatic food chain. Moreover, it concentrates in lower organisms, such as algae, which can lead to ingestion of toxic amounts by higher organisms, such as fish and water fowl, that feed on the lower organisms (Brooks, 1984). Measured acute toxicity concentrations in water, commonly designated as the concentration that results in the death of 50 percent of the test organisms after 96 hours of exposure (96-hour LC_{50}), range from 340 to 42,000 µg/L for aquatic invertebrates and from 620 to 28,500 µg/L for fish (Brooks, 1984). Some selenium concentrations measured in water flowing into the San Luis Drain (140 to 1,400 µg/L) and in water in the drain (269 to 350 µg/L) were within these toxic ranges (Izbicki, 1984; Presser and Barnes, 1984).

The most probable cause of selenium toxicity to fish and wildlife is by bioconcentration in the food chain. Studies show that ingestion of lower organisms with high selenium concentrations is the major pathway by which selenium enters fish (Brooks, 1984). Bioconcentration factors (the concentration in the organism divided by the water concentration) range from 100 to 2,600 for algae and from 200 to 6,000 for fish (Brooks, 1984).

Wildlife that ingest fish and other aquatic organisms also may accumulate toxic quantities of selenium. Toxic effects of selenium on birds and rodents include death, reduced growth, reduced reproductive success, and deformities in hatchlings (National Academy of Science, 1977). Apparently due to large quantities of selenium ingested with fish and other food, waterfowl in the Kesterson Reservoir are experiencing high incidences of mortality and deformity of hatchlings. Of 347 nests observed in 1983, mainly of coots, 20 percent had deformed birds and 40 percent of eggs contained dead embryos (U.S. Bureau of Reclamation, 1984b). In 1984, coots were present at Kesterson Reservoir but failed to nest, apparently due to high concentrations of selenium in reproductive organs (U.S. Fish and Wildlife Service, written commun., October 1984). In the same study, the U.S. Fish and Wildlife Service found that coot liver-tissue concentrations of selenium averaged 67.8 µg/g (micrograms per gram) in 1983 and 83.7 µg/g in 1984. Coots from nearby Volta Wildlife Management Area, which receives no drainage water from the service area, had

liver-tissue concentrations averaging less than 5 µg/g. The reproductive success of ducks at Kesterson Reservoir was also lower than that observed at the Volta Wildlife Management Area.

Effects on Human Health

Humans regularly ingest selenium in food and water, and the normal dietary intake of selenium is about 200 µg/d (micrograms per day) (National Academy of Science and National Academy of Engineering, 1973). Estimated levels of intake associated with symptoms of selenium toxicity in humans range from 600 to 6,340 µg/d. Among the reported symptoms of selenium toxicity are depression, intestinal disturbances, nervousness, convulsions, diarrhea, and respiratory failure (National Academy of Science and National Academy of Engineering, 1973).

The present water-quality criterion for selenium in drinking water is 10 µg/L (U.S. Environmental Protection Agency, 1977). Consumption of 2 liters per day of water with this selenium concentration would increase dietary intake about 20 µg/d or 10 percent of the normal dietary intake of 200 µg/d. The possible means by which human exposure to selenium could increase because of selenium in waters of the service area are through drinking water contaminated with drainage water, selenium in food crops, and consumption of contaminated waterfowl. The California Department of Fish and Game has posted warnings at the Kesterson National Wildlife Refuge that hunters should limit their consumption of coots, one of the most common waterfowl in the area (U.S. Bureau of Reclamation, 1984b).

Possible Sources of Selenium

Most of the selenium in natural waters is from weathering of selenium-rich rock (U.S. Environmental Protection Agency, 1979), which is erratically dispersed throughout the world (Lakin, 1973). Most natural waters have low selenium concentrations (Lakin, 1973). Generally, alkaline oxidizing conditions favor the highest solubility of selenium (U.S. Environmental Protection Agency, 1979). The selenium detected in the agricultural drainage water in the San Luis Drain service area probably originates from the marine sedimentary rocks of the Coast Range to the west. The alluvium and associated soils of the service area are derived mainly from these marine sedimentary rocks (Davis and others, 1964); however, the processes by which selenium has become concentrated in shallow ground water are not well understood.

Achieving an understanding of why selenium is occurring in high concentrations in drainage water requires a knowledge of how selenium was transported to the valley, where it occurs in the valley, and what hydrologic and chemical conditions favor its solution into the ground water. There are several complex and interrelated processes that may affect selenium concentrations in the ground water of the service area. For example, one process that may have occurred is that chemically reduced, insoluble selenium contained in the marine sedimentary rocks was oxidized to a more soluble form as these rocks were weathered and eroded through geologic time and transported to the valley floor. By this or other mechanisms by which selenium was transported and dissolved in the ground water, evaporation of shallow ground water has likely caused concentration of selenium in some soils.

STUDY APPROACH AND METHODS

A primary goal of this preliminary study was to quickly complete an assessment of the chemistry of the shallow ground water to aid in designing more detailed studies. Therefore, rather than sampling water at selected sites over a long period of time, one sample was taken at each of many sites throughout the service area during an 18-day period. The results approximate a one-point-in-time picture of the quality of shallow ground water in the entire service area.

Field Methods

Samples of shallow ground water were collected at 130 sites in the San Luis Drain service area (fig. 5). Thirty-seven of the sites were farm drain sumps. A drain sump (fig. 6) collects subsurface drainage water from a single farm drainage system, which consists of a grid of buried permeable tile or perforated plastic pipe. Eighty-three sites were observation wells of varying construction. Ten sites were collector drains, which receive subsurface drainage water from several farm drain sumps for discharge into the San Luis Drain or other channels.

Most observation wells in Fresno County were drilled by the U.S. Bureau of Reclamation. These wells were drilled to depths ranging from 18 to 30 feet and the casing is 1- to 1.25-inch diameter polyvinyl chloride (PVC) tubing slotted at 1-inch intervals along its entire length. The well casings were capped at the bottom and the annular spaces around them were backfilled with material removed in the drilling process. In northwestern Fresno County, and in Merced and Stanislaus Counties, most sites were wells belonging to the Central California Irrigation District. These wells ranged in depth from 10 to 25 feet and had casings of 2-inch diameter PVC pipe, slotted at 4- to 6-inch intervals from 4 feet below land surface to the bottom of the well. These casings were capped at the bottom, gravel packed in the annular spaces, and sealed at the land surface with concrete.

The sumps and collector drains were sampled using a peristaltic pump to remove water from the collecting structure, usually a concrete cistern, through Teflon[1] tubing into a water-sediment churn splitter, and then into sample containers. The observation wells were sampled using tubing and positive-displacement bladder pumps constructed of Teflon. The submersible, 0.75-inch diameter bladder pump operates by allowing water to enter through a one-way valve in the bottom of the pump. Pressurized nitrogen gas is cycled in and out of a Teflon bladder inside the pump casing, displacing the water up the tubing. Prior to sampling, each well was pumped using both peristaltic and bladder pumps simultaneously until the specific conductance of the water did not vary by more than 10 percent for three consecutive well-casing volumes of water. Before each sample was taken, another well-casing volume was pumped with only the bladder pump.

Prior to sampling at each site, all sampling apparatus and containers were rinsed three times with the water to be sampled. Well water was used to rinse filters, filter holders, and sample containers. Prior to

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

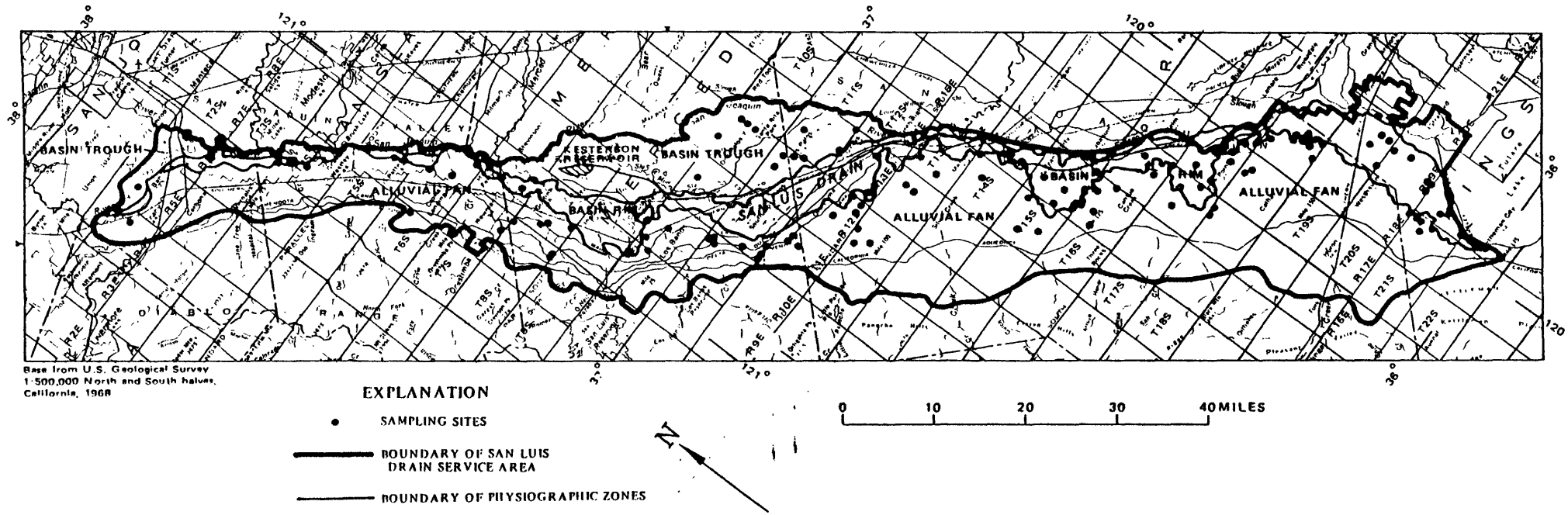


FIGURE 5.—Areal distribution of sampling sites where shallow ground-water samples were collected by the U.S. Geological Survey.

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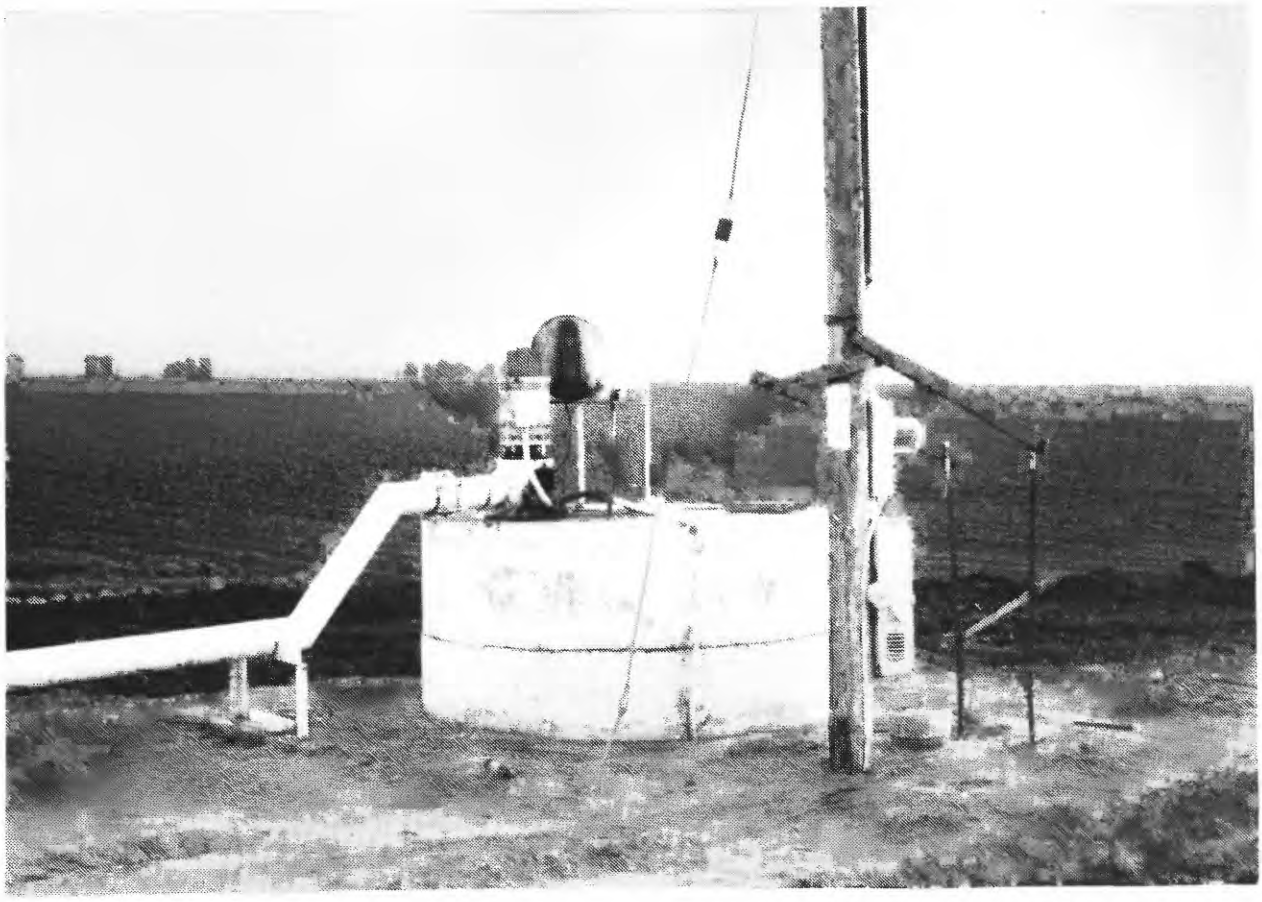


FIGURE 6.—Typical drain sump where water from a farm drainage system is collected. (Photograph taken in March 1984.)

collection of samples for laboratory analysis of inorganic constituents, unfiltered 50-milliliter samples were titrated incrementally with dilute sulfuric acid for bicarbonate and carbonate concentrations. The pH was measured with portable meters that were calibrated at each site with standardized solutions. Temperature was measured with mercury thermometers that were checked against a standardized laboratory thermometer.

Samples for analysis of dissolved constituents were pressure filtered through 0.45-micrometer membrane filters. Samples for determination of major ions and all trace elements except mercury were collected and stored in polyethylene bottles with Teflon-lined caps. Samples to be analyzed for mercury were collected and stored in glass bottles with Teflon-lined caps. All samples were acidified with nitric acid to a pH of less than 2 except those collected for determination of chloride, sulfate, bicarbonate, carbonate, pH, and specific conductance.

Laboratory Methods

All major ions and trace elements, except selenium and arsenic, were determined by methods described by Skougstad and others (1979). Calcium, magnesium, sodium, potassium, lithium, mercury, iron, and zinc

were determined by atomic absorption spectrometric methods. Cadmium, chromium, copper, lead, manganese, and molybdenum were determined by atomic absorption spectrometric methods with chelation extractions. Chloride and vanadium were determined by automated colorometric methods, and sulfate was determined by the turbidimetric procedure.

Selenium and arsenic were determined by hydride generation and atomic absorption spectrometry (Fishman and Bradford, 1982). The method used for selenium in this study is designed to determine the total concentration of all forms of selenium present in the water sample. A sample is first subjected to an oxidative digestion to release any selenium from the organic fraction. The selenium liberated by this digestion, together with the inorganic selenium originally present, is then reduced to the selenite form using a stannous chloride-potassium iodide mixture. The selenium hydride is generated by reducing the selenite form using sodium borohydride. The hydride gas is stripped from the solution by a stream of nitrogen gas and its concentration is determined by atomic absorption spectrometry. This standard U.S. Geological Survey method differs from another commonly used method described by the American Public Health Association and others (1980), which omits the first reduction step.

Data Presentation and Interpretation

This report focuses on analysis of the major-ion and trace-element data for shallow ground water collected by the U.S. Geological Survey at the 130 sites described in the "Field Methods" section. Additional trace-element data collected by the U.S. Bureau of Reclamation for related studies also are given in this report. All sites sampled by either or both the U.S. Geological Survey and the U.S. Bureau of Reclamation are described in table 5 (at end of report). Tables 6 and 7 (at end of report) list the major-ion and trace-element data that were collected by the Geological Survey for this study. Table 8 (at end of report) gives Bureau of Reclamation data for trace elements.

The general approach to interpretation of the major-ion and trace-element data presented in tables 6 and 7 was to:

- o evaluate the major ion chemistry and specific conductance of the shallow ground water in relation to the three physiographic zones of the service area,
- o evaluate the concentrations of measured trace elements in relation to the three physiographic zones, and
- o evaluate the areal distribution of selenium.

The emphasis on evaluating data in relation to the physiographic zones, which were earlier described in the "Description of Area" section, is based on the authors' belief that the differing soils and topographic positions of the three zones may influence the hydrologic and geochemical processes that affect water chemistry in the service area.

The areal distribution of the 130 sampling sites in the service area and the distribution of sites among wells, farm drains, and collector drains affects data interpretation. Some areas in each physiographic zone had no sampling sites. There were no sites in the central part of the basin rim zone and the western part of the alluvial fan zone, where the water table is low (mostly greater than 5 feet below the land surface), or in parts of the basin trough zone, where there are wetlands.

The degree to which samples from a site accurately represent the chemistry of water at that site is another factor that affects data analysis. Water samples from observation wells and farm drains generally are representative of ground water near the sample site and therefore usually one physiographic zone. Collector drains, however, convey drainage water from large areas that may include more than one physiographic zone. Statistical summaries of data for all physiographic zones combined and the map showing selenium concentrations in the service area include data from collector drains. Only data for the 120 wells and farm drains were used to assess the areal distribution of chemical constituents in relation to physiographic zones. Therefore, findings in this report regarding the areal distribution of selenium and other constituents are based on concentrations measured at single points (wells) or for small areas (farm drains), and pertain mainly to parts of the service area where shallow ground water may affect agricultural production.

Assessment of the general chemical composition of shallow ground water throughout the service area and in each physiographic zone was based on the relative concentrations of the major ions--calcium, magnesium, sodium, potassium, bicarbonate plus carbonate, chloride, and sulfate--in each sample. Medians and ranges for all major ions and related measurements are summarized for all physiographic zones and separately for each physiographic zone. Simplified Piper diagrams (Hem, 1970) are used to graphically depict the occurrence of dominant ions. Differences between the specific conductances (an indication of salinity and dissolved-solids concentrations) of the three physiographic zones were statistically tested.

The medians and ranges of concentrations for all trace elements also are summarized for all physiographic zones and separately for each physiographic zone. Concentrations of chromium and mercury, in addition to selenium, were further evaluated in relation to the three physiographic zones and differences in concentrations between zones were statistically tested.

The areal distribution of selenium in the service area is illustrated by mapping measured concentrations in relation to physiographic zones, and differences in selenium concentrations between the three physiographic zones were statistically tested. Primarily for convenience, the map of the service area showing selenium concentrations was divided into three parts--northern, central, and southern.

Limitations

As for all hydrologic studies, there are some specific limitations of the present study which are the result of its scope and design. The study was not designed to evaluate the variability with time in water chemistry. Data showing the variability of selenium concentrations with time were available for a few sites sampled by the U.S. Bureau of Reclamation during a 4-month period from March to June 1984. Data are not available for evaluating longer term variability, such as between seasons and years. There may be substantial differences in concentrations between parts of the year with different irrigation practices or precipitation, or between different years.

The service area is large and the 130 samples represent only a small sampling of shallow ground water. The 120 samples from observation wells and farm drains are believed to represent nearby ground-water conditions at the time of sampling, but the history of that ground water--where it had been and for how long--is unknown. In choosing sampling sites, no consideration was given to variations in land use and water-management practices, and the authors have made no attempt to evaluate the quality of irrigation water applied at individual sites.

The physiographic zones designated for this report provide an initial basis for study of the areal distribution of chemical constituents in the area, but are not the only divisions possible. Further divisions are possible based on more detailed soil and geologic information, and different types of physiographic zones may be designated for related studies.

AREAL DISTRIBUTION OF MAJOR IONS AND TRACE ELEMENTS

Major Ions

The concentrations of major ions and related measurements of pH and specific conductance at the 130 sites (table 6) allow an overview of the chemical composition of shallow ground water in the service area. These data are summarized in table 1 for all physiographic zones. The median (50 percent of the values are lower and 50 percent are higher) pH and

TABLE 1.--Summary of physical properties and major ions in shallow ground water from observation wells, farm drain sumps, and collector drains, May 5-21, 1984

[Data from U.S. Geological Survey. There were no data for some constituents in five samples]

Properties and constituents	All physiographic zones (130 samples)		
	Minimum	Median	Maximum
Physical properties			
Specific conductance---µmho/cm at 25°C ---	431	3,655	68,000
pH (standard units)---------	6.6	7.5	8.5
Temperature ----------°C ---	14	19.0	24.5
Cations			
Calcium ----------mg/L---	25	310	630
Magnesium ----------mg/L---	10	92	4,000
Sodium ----------mg/L---	33	460	30,000
Potassium ----------mg/L---	.6	3.0	36
Anions			
Bicarbonate plus carbonate (as HCO_3) --------mg/L---	112	290	1,150
Sulfate ----------mg/L---	39	1,700	65,000
Chloride ----------mg/L---	29	290	16,000

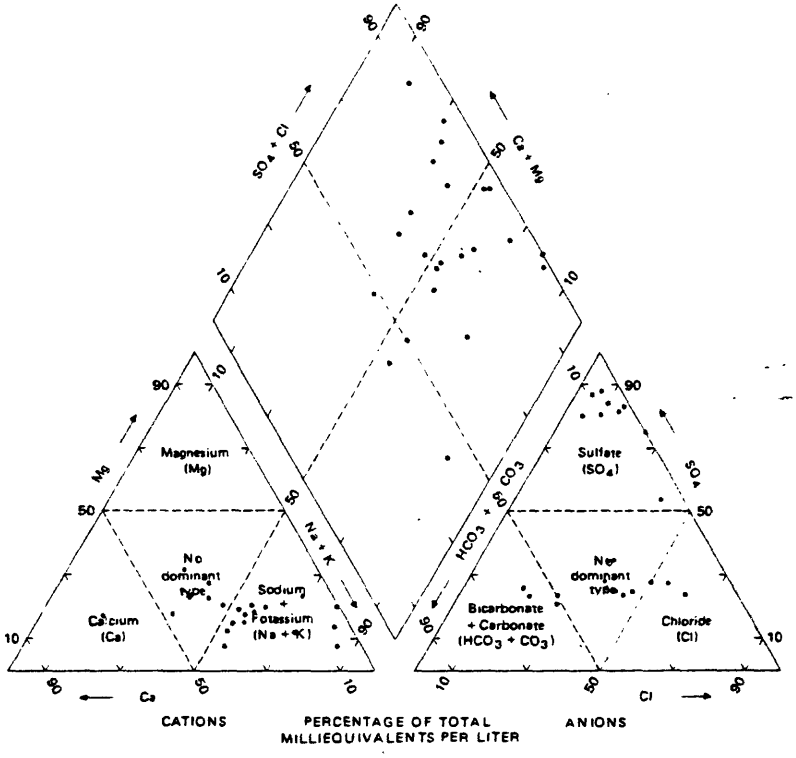
specific conductance (table 1) indicate that most of the water is alkaline--with a pH greater than 7--and slightly saline--with specific conductances greater than 3,000 micromhos per centimeter. Data for each physiographic zone (table 2) indicate that the basin rim zone generally has the highest median major-ion concentrations, followed by the alluvial fan zone and then the basin trough zone. The Kruskal-Wallis test for differences between the medians of more than two samples (Hollander and Wolf, 1973) showed that the median specific conductances of all three zones were not equal ($\alpha = 0.05$). The multiple-comparison test described by Hollander and Wolf (1973) indicates a significantly ($\alpha = 0.05$) higher specific conductance in the basin rim zone compared to the alluvial fan and basin trough zones, which were not significantly different from each other.

The chemical compositions of water samples from all physiographic zones and from each of the three zones are depicted in Piper diagrams (fig. 7), which show the relative contributions of major cations and anions to the total ion content of the water. Percentage scales along the sides of the diagrams indicate the relative concentration (in milliequivalents per liter) of each major ion. Cations are shown in the left triangle and anions in the right triangle. The central diamond integrates the data for cations and anions, but is not essential to interpreting the data. Each water sample is represented by a dot. Five samples were omitted because of incomplete data for one or more ions. The diagram for all physiographic zones includes 10 samples from collector drains that were not plotted for the individual zones.

TABLE 2.--Physical properties and major ions in shallow ground water from observation wells and farm drain sumps in three physiographic zones, May 5-21, 1984

[Data from U.S. Geological Survey]

Properties and constituents	Basin trough zone (25 samples)			Basin rim zone (40 samples)			Alluvial fan zone (55 samples)		
	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum
Physical properties									
Specific conductance--µmho/cm at 25°C	993	1,900	68,000	851	6,055	30,400	431	3,630	58,600
pH (standard units)	6.6	7.3	8.1	7.1	7.6	8.5	6.8	7.4	8.2
Temperature--°C	14.0	19.0	22.0	17.0	19.0	22.5	17.0	19.0	24.5
Cations									
Calcium--mg/L	27	120	560	54	430	600	25	290	630
Magnesium--mg/L	15	48	4,000	19	115	560	10	75	1,000
Sodium--mg/L	110	230	30,000	97	1,100	8,900	33	450	16,000
Potassium--mg/L	0.6	2.6	36	0.7	3.5	11	0.8	2.7	27
Anions									
Bicarbonate plus carbonate (as HCO_3)--mg/L	166	293	676	112	249	913	114	315	1,150
Sulfate--mg/L	120	310	65,000	93	3,450	18,000	39	1,400	37,000
Chloride--mg/L	61	220	16,000	38	455	3,900	29	265	2,900



BASIN TROUGH ZONE
(23 SAMPLES)

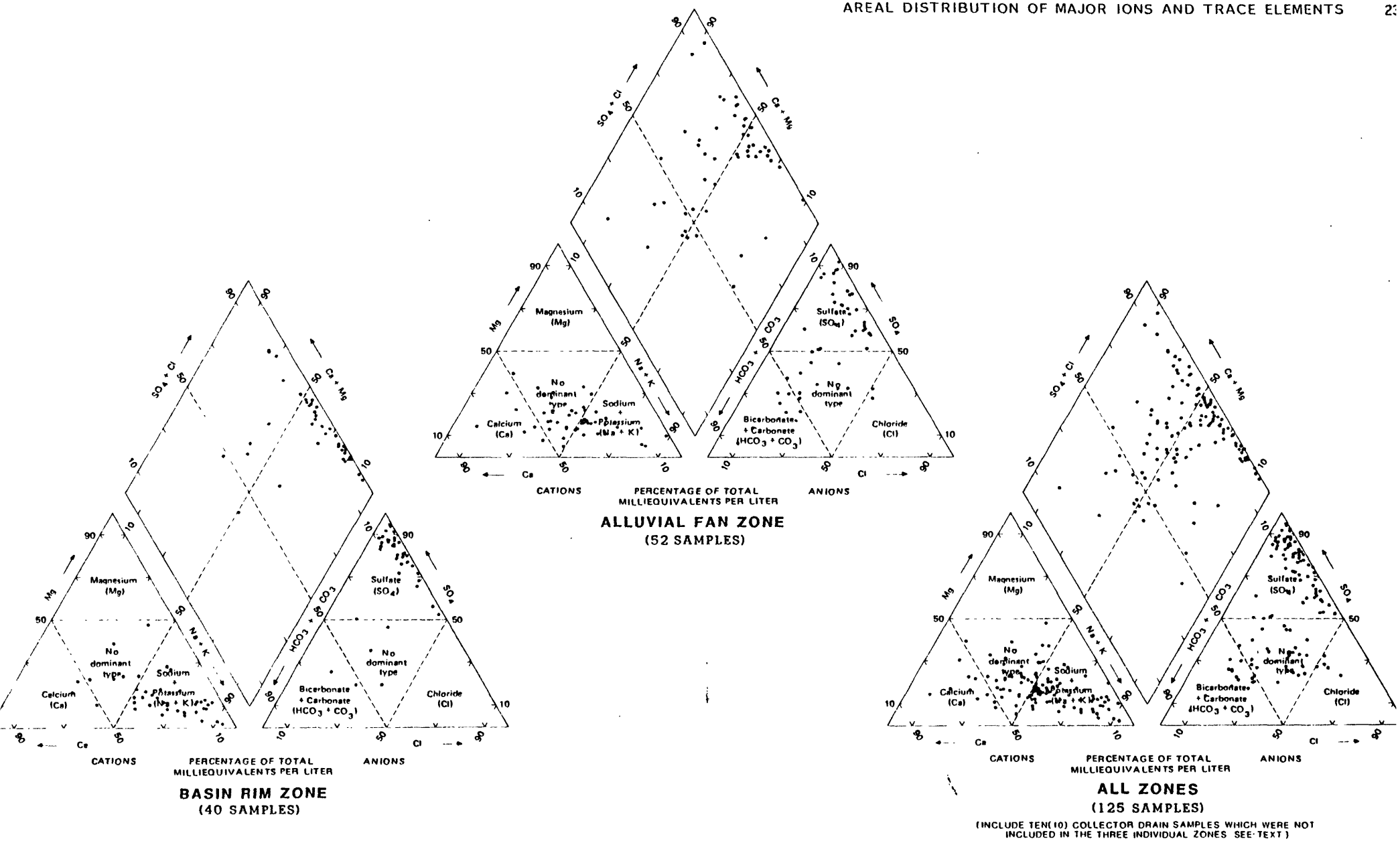


FIGURE 7.–Chemical composition of shallow ground water. (Physiographic zones and significance of the diagrams are explained in the text.)

The diagram with data for samples from all physiographic zones has 57 percent of the data in the sodium part of the cation triangle and 35 percent in the no-dominant-type part. The anion triangle shows that sulfate is dominant in 62 percent of the samples and that 22 percent of the samples had no single dominant anion.

Most data are from the alluvial fan and basin rim zones and these data dominate the results shown for all zones combined. Chi-square tests (Snedecor and Cochran, 1967) were used to evaluate whether patterns of ion dominance were similar in the three zones. No significant (α = 0.05) differences were found between zones in the frequency of samples with calcium or magnesium as the dominant cation, bicarbonate (plus carbonate) as the dominant anion, or with no dominant anion.

There were significant (α = 0.05) differences between zones in the frequency of sodium dominance and the absence of a dominant cation. The basin rim zone had the highest frequency of sodium dominance (75 percent) and the lowest frequency of samples with no dominant cation (18 percent). The alluvial fan zone had the lowest frequency of sodium dominance (42 percent) and the greatest frequency of samples with no dominant cation (46 percent). For samples from the basin trough zone, sodium was dominant in 61 percent and there was no dominant cation in 35 percent.

There were also significant (α = 0.05) differences between zones in the frequency of anion dominance by chloride and sulfate. Samples from the basin trough zone were the most frequently dominated by chloride (13 percent), compared to the other zones, and least frequently dominated by sulfate (39 percent). Samples from the basin rim zone, in contrast, were the least frequently dominated by chloride (0 percent) and most frequently dominated by sulfate. For samples from the alluvial fan zone, chloride was the dominant anion in 4 percent and sulfate was dominant in 62 percent.

Trace Elements

Medians and ranges of the 14 trace elements that were determined are summarized in table 3 from data for all zones (table 7), and in table 4 for each physiographic zone. High levels of boron were detected, with 80 percent of the samples having concentrations that exceeded the water-quality criterion of 750 µg/L for irrigation water (U.S. Environmental Protection Agency, 1977). Boron is toxic to plants, but is generally not toxic to animals. The Kruskal-Wallis test (Hollander and Wolf, 1973) showed that the median boron concentrations of the three zones were not equal (α = 0.05). Based on the multiple-comparison procedure described by Hollander and Wolf (1973), concentrations were significantly (α = 0.05) higher in the basin rim and alluvial fan zones than in the basin trough zone.

Of the remaining 13 trace elements, eight--arsenic, cadmium, chromium, copper, lead, mercury, selenium, and zinc --are priority pollutants (U.S. Environmental Protection Agency, 1979). All eight priority pollutants were detected in at least one sample, but only selenium, chromium, and mercury occur in concentrations that approach or exceed the maximum concentrations specified by water-quality criteria for freshwater aquatic life (U.S. Environmental Protection Agency, 1980b).

TABLE 3.--Summary of trace elements in shallow ground water from observation wells, farm drain sumps, and collector drains, May 5-21, 1984

[Data from U.S. Geological Survey; constituents are in micrograms per liter; <, actual value is less than the value shown. There were no data for some constituents in five samples]

Constituent	All physiographic zones (130 samples)		
	Minimum	Median	Maximum
Arsenic	<1	2	82
Boron	140	3,100	120,000
Cadmium	<1	<1	2
Chromium	<1	10	170
Copper	<1	2	23
Iron	<3	50	7,400
Lead	<1	<1	17
Lithium	14	90	430
Manganese	<1	30	2,500
Mercury	<.1	<.1	1.6
Molybdenum	<1	17	5,000
Selenium	<1	6	3,800
Vanadium	<1	14	280
Zinc	<3	11	620

Direct comparison of the measured concentrations of selenium, chromium, and mercury to the appropriate water-quality criteria was not possible because the sampling and analytical methods used in this study are different from those in the criteria specifications. The freshwater aquatic-life criterion for selenium specifies that total recoverable inorganic selenite should not exceed 260 µg/L (U.S. Environmental Protection Agency, 1980b), whereas concentrations determined for this study include all forms of dissolved selenium. Dissolved selenium concentrations are probably higher than the concentration of total recoverable inorganic selenite in most of the samples. Inorganic selenite represents one fraction of total recoverable selenium.

The freshwater aquatic-life criterion for chromium specifies that total-recoverable hexavalent chromium should never exceed 21 µg/L and that the total-recoverable trivalent chromium should not exceed 56,400 µg/L in waters with hardness of 1,000 mg/L (milligrams per liter) as $CaCO_3$ (typical for the service area). The dissolved chromium concentrations include both valence forms of chromium in unknown proportions. The freshwater aquatic-life criterion for mercury specifies that total recoverable mercury should not exceed

TABLE 4.--Trace elements in shallow ground water from observation wells and farm drain sumps in three physiographic zones, May 5-21, 1984

[Data from U.S. Geological Survey; constituents are in micrograms per liter; < , actual value is less than the value shown]

Constituent	Basin trough zone (25 samples)			Basin rim zone (40 samples)			Alluvial fan zone (55 samples)		
	Minimum	Median	Maximum	Minimum	Median	Maximum	Minimum	Median	Maximum
Arsenic	<1	2	29	<1	2	82	<1	1	18
Boron	140	720	34,000	600	7,700	46,000	180	3,100	120,000
Cadmium	<1	<1	1	<1	<1	1	<1	<1	2
Chromium	<1	<1	70	<1	13.5	170	<1	10	150
Copper	<1	1	14	<1	3	15	<1	2	23
Iron	<3	30	7,400	5	55	140	<3	45	220
Lead	<1	3	12	<1	<1	13	<1	<1	17
Lithium	17	45	280	38	90	380	14	92	430
Manganese	10	260	2,500	<2	20	1,500	<1	28	1,200
Mercury	<.1	<.1	.2	<.1	<.1	.4	<.1	<.1	1.6
Molybdenum	3	14	520	1	71	1,500	<1	11	5,000
Selenium	<1	<1	90	<1	10	3,800	<1	11	3,000
Vanadium	<1	10	280	<1	18	100	<1	14	150
Zinc	<3	10	90	<5	20	60	<5	10	620

0.0017 µg/L. The dissolved mercury concentrations determined in this study may be slightly less than the total recoverable concentrations, but should be fairly similar. The detection limit of the analytical method for dissolved mercury of 0.1 µg/L is greater than the criterion for total recoverable mercury, so that all samples in which mercury was detected contain concentrations that are greater than the aquatic-life criterion.

Although selenium was detected in 76 percent of the samples and seems to be causing the most severe water-quality problems, the measured concentrations of chromium and mercury merit discussion and careful consideration in further studies. Chromium concentrations ranged from less than 1 µg/L (the detection limit) to 170 µg/L with a median of 10 µg/L (table 3) and 77 percent of the samples contained detectable concentrations. The Kruskal-Wallis test (Hollander and Wolf, 1973) showed that the median chromium concentrations of the three zones were not equal (α =0.05). Median chromium concentrations were significantly (α = 0.05) higher in the basin rim and alluvial fan zones than in the basin trough zone. In the basin rim and alluvial fan zones, 90 percent and 87 percent of the samples, respectively, contained detectable concentrations of

chromium, compared to 32 percent of the samples in the basin trough zone. Mercury concentrations ranged from less than 0.1 µg/L (the detection limit) to 1.6 µg/L with a median of less than 0.01 µg/L (table 3), and 32 percent of the samples contained detectable concentrations. Mercury was detected in 36 percent of the samples for the basin trough zone, 43 percent for the basin rim zone, and 24 percent for the alluvial fan zone. A Chi-square test on detections of mercury (Snedecor and Cochran, 1967) indicated no significant (α = 0.05) differences between zones.

AREAL DISTRIBUTION OF SELENIUM

The areal distribution of selenium concentrations in the service area was evaluated in relation to the three physiographic zones (figs. 8-10). Selected data from the U.S. Bureau of Reclamation indicate that selenium concentrations varied little over time during March to June 1984 (figs. 8-10). Medians and ranges of selenium concentrations in the basin trough, basin rim, and alluvial fan zones are given in table 4. The Kruskal-Wallis test (Hollander and Wolf, 1973) showed that the median selenium concentrations of the three zones were not equal (α = 0.05). Selenium concentrations in the basin rim and alluvial fan zones were significantly higher than in the basin trough zone. The basin rim and alluvial fan zones were not significantly different from one another. This differs from results of similar comparisons for specific conductance, which indicated that the basin trough and alluvial fan zones were similar and that both had significantly lower concentrations than the basin rim zone.

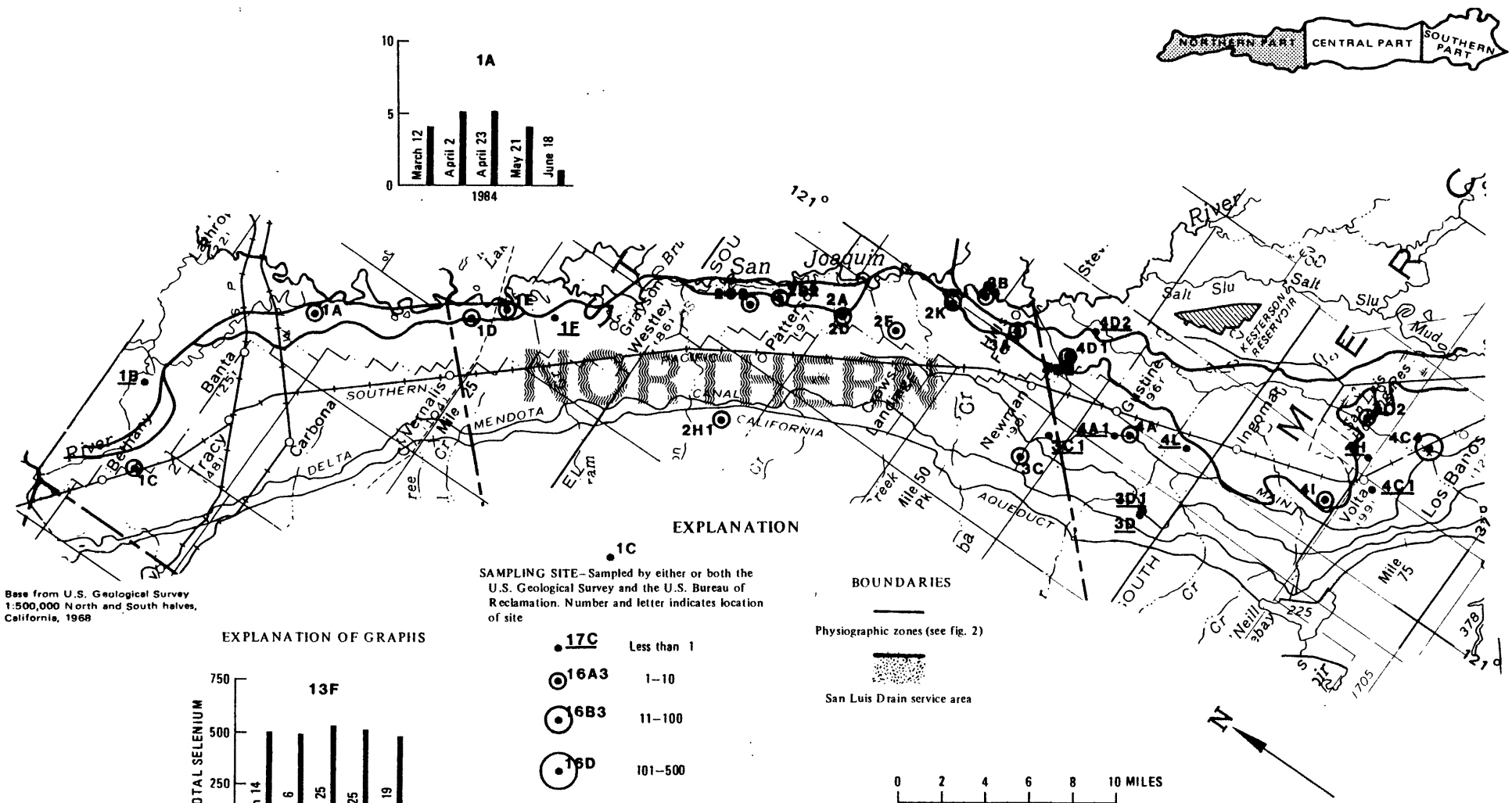


FIGURE 8.–Selenium concentrations in shallow ground water for the northern part of the service area.

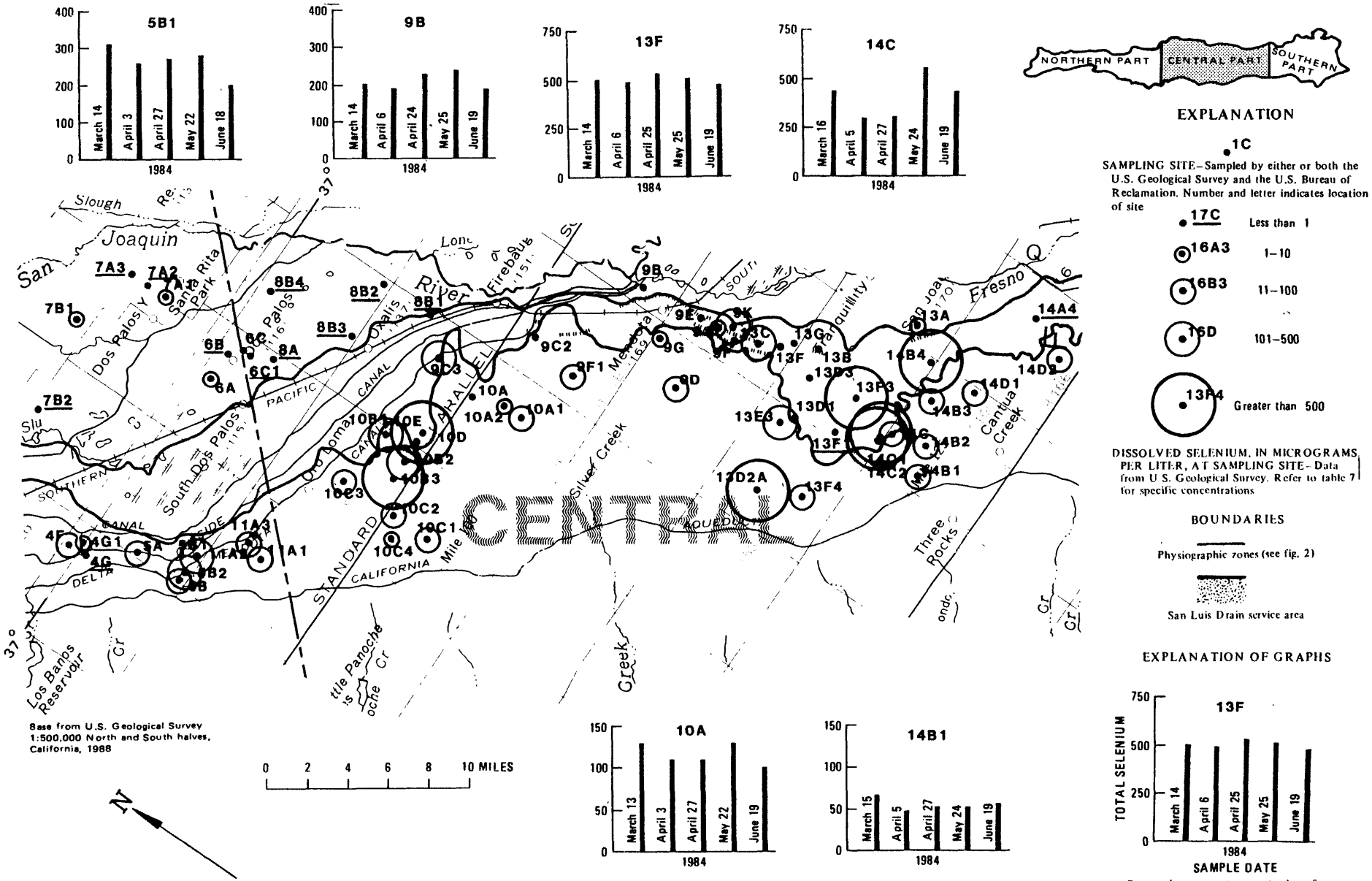


FIGURE 9.– Selenium concentrations in shallow ground water for the central part of the service area.

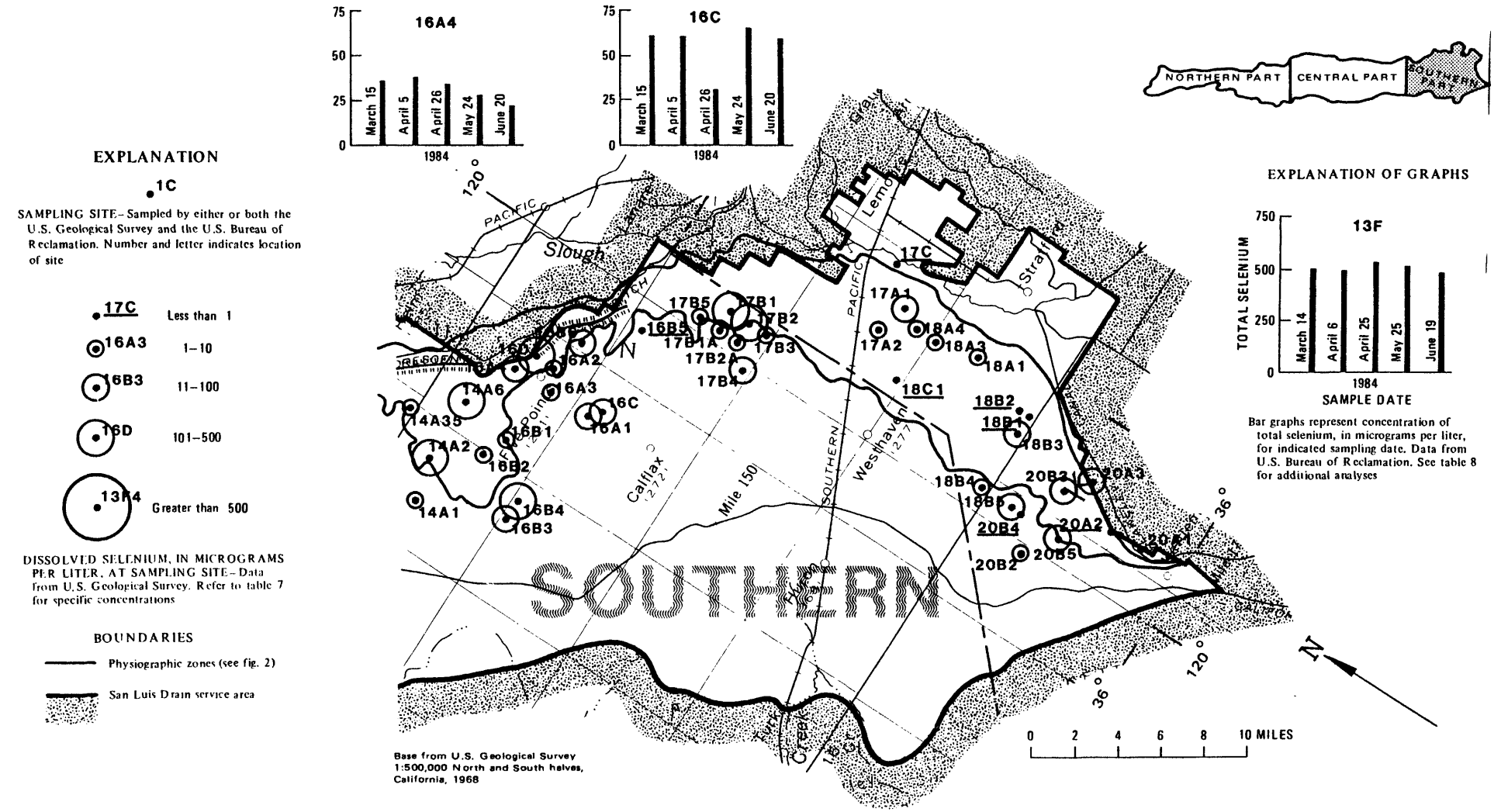


FIGURE 10.–Selenium concentrations in shallow ground water for the southern part of the service area.

The frequency distributions of selenium concentrations for the three physiographic zones (fig. 11) show the similarity of selenium concentrations in the basin rim and alluvial fan zones, and the difference between concentrations in those two zones and concentrations in the basin trough zone. The percentage of samples with less than 1 µg/L of selenium is highest in the basin trough zone, and there were no samples in the basin trough zone with concentrations greater than 100 µg/L. Six of the ten highest selenium concentrations were in the basin rim zone and the other four were in the alluvial fan zone. The highest concentration of 3,800 µg/L was in the basin rim zone, and the second highest concentration of 3,000 µg/L was in the alluvial fan zone. Overall, selenium concentrations were highest in the central and southern parts of the alluvial fan and basin rim zones, and lowest in the northern parts of all zones and in the entire basin trough zone.

Although the frequency distributions of selenium concentrations in the basin rim and alluvial fan zones are similar, there is a notable difference between the zones in the relation between selenium concentrations and specific conductance. Correlations were tested using Spearman's rank correlation procedure (Snedecor and Cochran, 1967). In the basin rim zone, with the most saline soils of the three zones, there was no significant ($\alpha = 0.05$) correlation between selenium concentrations and specific conductance. In the alluvial fan zone, there was a significant positive correlation between selenium concentrations and specific conductance, with a Spearman's rank correlation coefficient of 0.73. Although the reason for this difference is not presently clear, it seems that the processes leading to higher selenium concentrations at specific sites may be different in the two zones. The difference between the zones will require further investigation.

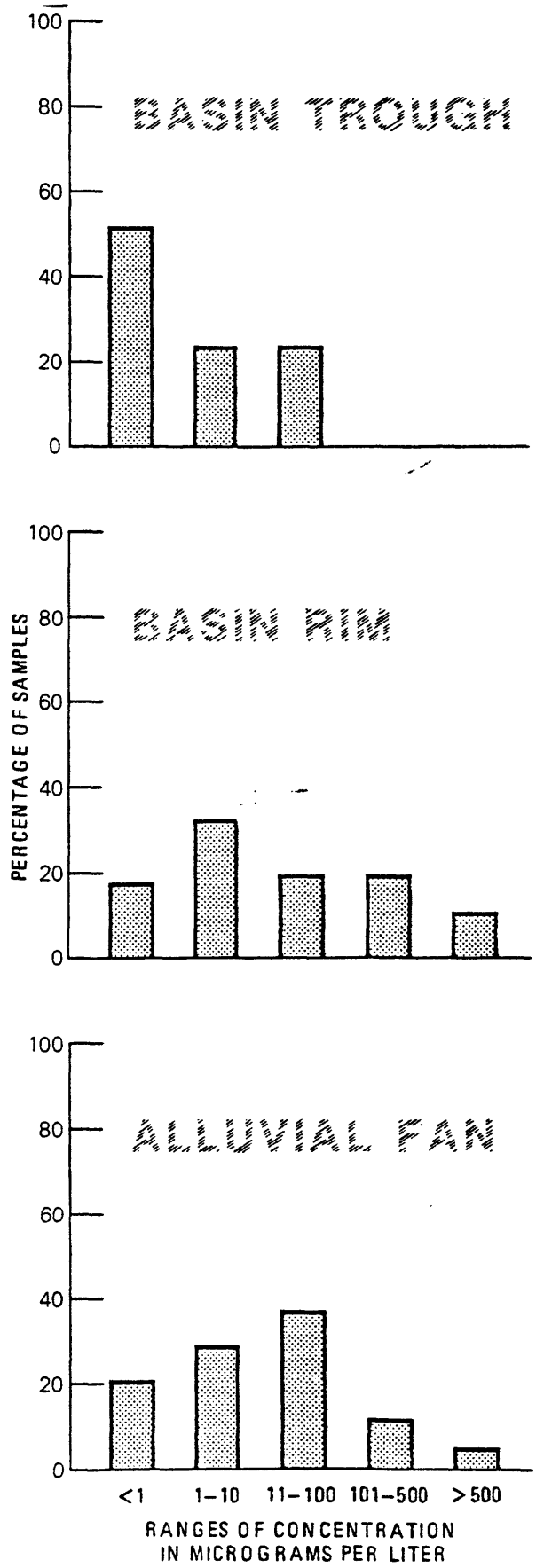


FIGURE 11.—Frequency distribution of dissolved selenium concentrations in the three physiographic zones.

CONCLUSIONS

Major conclusions of this preliminary study are:

- Most of the shallow ground water in the service area is alkaline and slightly saline.
- Sulfate and sodium were the dominant ions in most samples, although there was no dominant ion in many samples.
- Of the three main physiographic zones, samples from the basin trough zone, adjoining the San Joaquin River, had lower specific conductances in comparison to samples from the alluvial fan and basin rim zones.
- Boron concentrations exceeded U.S. Environmental Protection Agency water-quality criteria for irrigation water in 80 percent of the samples.
- All eight priority pollutants included in the sample analyses--arsenic, cadmium, chromium, copper, lead, mercury, selenium, and zinc--were detected at least once. Only chromium, mercury, and selenium occurred at some sites in concentrations approaching or exceeding U.S. Environmental Protection Agency water-quality criteria for protection of freshwater aquatic life.
- Selenium was detected in 76 percent of samples, chromium in 77 percent of samples, and mercury in 32 percent of samples.
- Median selenium concentrations in the basin rim zone (10 µg/L) and the alluvial fan zone (11 µg/L) were not significantly (α = 0.05) different from each other, but both were significantly higher than the median concentration in the basin trough zone (<1 µg/L).
- Six of the ten highest selenium concentrations were in the basin rim zone and the other four were in the alluvial fan zone.
- Overall, selenium concentrations were highest in the central and southern parts of the alluvial fan and basin rim zones, and lowest in the northern parts of all zones and in the entire basin trough zone.

ADDITIONAL STUDIES

Extensive studies of the hydrology and chemistry of ground and surface waters within and adjacent to the San Luis Drain service area are underway or planned by the U.S. Geological Survey. Several of these studies are directly aimed at addressing topics that have been raised or left unanswered by the present study of shallow ground water:

- The spatial variability of selenium and other constituents in shallow ground water in relation to localized soil, geologic, hydrologic, land-use, and water-management characteristics.
- The variability and trends in concentrations of selenium and other constituents in the shallow ground water within season, within year, and year to year.
- The geochemical and hydrologic processes that control the sources and behavior of selenium and other constituents in the shallow ground water.

For the purpose of planning comprehensive data collection that will be needed for additional studies, four water samples of deep ground water were collected in the service area and of the San Joaquin River. Selenium concentrations in the samples of the deep ground water are shown below. Of the four samples, only one sample from a deep irrigation well contained a detectable concentration of selenium (118 µg/L). As noted, however, this well could not be pumped long enough to assure a representative sample of the aquifer. This well and others near it need to be resampled as part of the comprehensive study of the deep ground water in the service area.

Location	Type of well	Depth below land surface (ft)	Selenium concentration (µg/L)	Remarks
SW¼SE¼ sec.28, T.12 S., R.14 E.	Municipal	335	<1	City of Firebaugh well #6, screened from 260 to 335 ft.
NE¼SW¼ sec.28, T.12 S., R.14 E.	do.	205	<1	City of Firebaugh well #7, screened interval unknown.
SW¼NE¼ sec.30, T.13 S., R.15 E.	do.	265	<1	City of Mendota well #1, screened from 150 to 236 ft.
SE¼SW¼ sec. 6, T.16 S., R.15 E.	Irrigation	1,089	118	Screened from 464 to 1,089 ft. For reasons beyond our control, this well could not be pumped long enough before sampling to assure a representative sample of the aquifer.

Selenium was not detected in the four water samples from the San Joaquin River. Planned studies include detailed analysis of occurrence and transport of selenium and other constituents in the San Joaquin River.

Name	Location	Date of sample	Discharge (ft^3/s)	Selenium concentration (µg/L)
San Joaquin River:				
Below Friant Dam	NW¼SW¼ sec.5, T.11 S., R.12 E.	9-6-84	88	<1
At Fremont Ford Bridge	NW¼SE¼ sec.24, T.7 S., R.9 E.	9-7-84	359	<1
Near Mendota	SW¼NE¼ sec.19, T.13 S., R.15 E.	9-6-84	198	<1
Near Newman	NE¼SE¼ sec.4, T.7 S., R.9 E.	9-7-84	622	<1

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TABLE 5.--Sites sampled by the U.S. Geological Survey and the U.S. Bureau of Reclamation

[Abbreviation: CCID, Central California Irrigation District. Location of sites shown in figures 8, 9, and 10]

Site No.	Description
1A	Lat 37°42'50", long 121°18'38", in SW¼SE¼ sec.33, T.2 S., R.6 E. Collector drain at New Jeruselum at pumping plant at Kasson Road.
1B	Lat 37°46'45", long 121°25'56", in NE¼NE¼ sec.8, T.2 S., R.5 E. Farm drain sump, 1.1 miles north of Interstate 205, west side of Tracy Boulevard.
1C	Lat 37°45'32", long 121°29'57", in NW¼SE¼ sec.14, T.2 S., R.4 E. Collector drain, south side of Grant Line Road, 0.4 mile west of Byron Road.
1D	Lat 37°37'41", long 121°13'55", in NE¼SE¼ sec.31, T.3 S., R.7 E. Collector drain, north side of Orchard Road, 0.7 mile east of River Road.
1E	Lat 37°36'54", long 121°12'53", in NE¼SE¼ sec.5, T.4 S., R.7 E. USBR observation well, northside of Dairy Road, 0.8 mile west of Pelican Road.
1F	Lat 37°35'02", long 121°12'25", in SE¼SW¼ sec.16, T.4 S., R.7 E. Observation well, east side of River Road at Burkhard Road.
2A	Lat 37°26'05", long 121°03'26", in NE¼NW¼ sec.11, T.6 S., R.8 E. Farm drain sump, south of Marshall Road, west of Alfalfa Road.
2B2	Lat 37°27'55", long 121°04'45", in SW¼SW¼ sec.27, T.5 S., R.8 E. Collector drain, east side of Elm Avenue, 0.3 mile north of Pomelo Avenue.
2C2	Lat 37°29'06", long 121°05'36", in NE¼SW¼ sec.21, T.5 S., R.8 E. Collector drain, east side of Elm Avenue, northwest side of Main Canal.
2D	Lat 37°25'49", long 121°03'27", in SE¼NW¼ sec.11, T.6 S., R.8 E. Farm drain sump, west side of Alfalfa Road, south side of canal, north of Pear Avenue.
2F	Lat 37°23'30", long 121°03'04", in SW¼SW¼ sec.24, T.6 S., R.8 E. CCID observation well 282, north side of Crows Landing Road, 0.5 mile east of Armstrong Road.
2H1	Lat 37°27'18", long 121°04'56", in SW¼SW¼ sec.34, T.5 S., R.7 E. Collector drain, 0.25 mile north of Apricot Avenue, 0.5 mile south of Sycamore Avenue.

TABLE 5.--Sites sampled by the U.S. Geological Survey and the U.S. Bureau of Reclamation--Continued

Site No.	Description
2K	Lat 37°22'33", long 121°01'14", in NW¼NE¼ sec.32, T.6 S., R.9 E. CCID observation well 279, east side of Lewis Road, 0.6 mile south of Kilburn Road.
3A	Lat 37°19'54", long 120°59'26", in NW¼NW¼ sec.16, T.7 S., R.9 E. Collector drain, manhole in Newman Line, south side of Hills Ferry Road at Stuhr Road.
3B	Lat 37°21'21", long, 120°59'02", in SW¼NE¼ sec.4, T.7 S., R.9 E. Collector drain, manhole in Newman Line, west of River Road, north side of Hills Ferry Road.
3C	Lat 37°16'31", long 121°04'32", in SW¼SE¼ sec.34, T.7 S., R.8 E. Farm drain sump, north side of Pete Miller Road, 0.5 mile west of Eastin Road.
3C1	Lat 37°16'27", long 121°02'54", in NW¼NW¼ sec.1, T.8 S., R.8 E. CCID observation well 253, east side of Schmidt Road, 0.3 mile north of Washington Road.
3D	Lat 37°11'17", long 121°03'12", in SW¼SE¼ sec.35, T.8 S., R.8 E. Collector drain, 0.05 mile east of Outside Canal, north side of Cottonwood Road, 0.25 mile west of Schmidt Road.
3D1	Lat 37°11'17", long 121°02'56", in SE¼SE¼ sec.35, T.8 S., R.8 E. CCID observation well 217, northwest corner of Schmidt and Cottonwood Roads.
4A	Lat 37°13'39", long 121°00'30", in SW¼NW¼ sec.20, T.8 S., R.9 E. Farm drain sump, east side of Main Canal, 0.4 mile south of Gun Club Road.
4A1	Lat 37°13'56", long 121°00'45", in SE¼SE¼ sec.18, T.8 S., R.9 E. CCID observation well 238, north side of Gun Club Road, west of State Highway 33.
4C1	Lat 37°04'54", long 120°55'31", in SE¼SE¼ sec.12, T.10 S., R.9 E. CCID observation well 42, west side of Volta Road, 1.2 miles north of State Highway 152.
4C2	Lat 37°06'00", long 120°52'45", in SE¼SW¼ sec.33, T.9 S., R.10 E. CCID observation well 51, northwest corner of Henry Miller Road and Monroe Avenue.
4C4	Lat 37°03'52", long 120°56'15", in NW¼SE¼ sec.16, T.10 S., R.10 E. CCID observation well 38, east side of Lover's Lane, 0.5 mile north of State Highway 152.

TABLE 5.--Sites sampled by the U.S. Geological Survey and the U.S. Bureau of Reclamation--Continued

Site No.	Description
4D1	Lat 37°17'30", long 120°58'50", in SE¼SE¼ sec.28, T.7 S., R.9 E. Farm drain sump, north of Preston Road, 0.1 mile west of Santa Fe Grade.
4D2	Lat 37°17'03", long 120°56'57", in SE¼NW¼ sec.35, T.7 S., R.9 E. Farm drain sump, northwest side of State Highway 140, 1.1 miles northeast of Santa Fe Grade.
4D3	Lat 37°17'23", long 120°58'40", in SE¼SE¼ sec.28, T.7 S., R.9 E. CCID observation well 263, 0.2 mile south of Santa Fe Grade and Preston Road on gravel road.
4F	Lat 37°00'45", long 120°50'11", in NE¼NE¼ sec.2, T.11 S., R.10 E. Farm drain sump, southwest corner of Cotton Road and Mercey Springs Road.
4G	Lat 36°59'44", long 120°50'10", in NE¼NE¼ sec.11, T.11 S., R.10 E. Farm drain sump, northside of Outside Canal, west side of Mercey Springs Road, 0.25 mile south of Almond Drive.
4G1	Lat 36°59'55", long 120°50'08", in SW¼SW¼ sec.1, T.11 S., R.10 E. CCID observation well 16, northeast corner of Almond Drive and State Highway 165.
4H	Lat 37°05'32", long 120°54'49", in NW¼SE¼ sec.6, T.10 S., R.10 E. Farm drain sump, south side of Ingomar Road, 0.35 mile west of Sylvester Road.
4I	Lat 37°05'59", long 120°57'34", in NW¼NW¼ sec.2, T.10 S., R.9 E. CCID observation well 78, south side of Henry Miller Road, 2.5 miles east of Interstate 5.
4L	Lat 37°11'18", long 120°59'27", in SW¼SW¼ sec.33, T.8 S., R.9 E. CCID observation well 220, north side of Cottonwood Road, 50 yards east of Hunt.
5A	Lat 36°57'15", long 120°49'06", in NW¼NW¼ sec.19, T.11 S., R.11 E. CCID observation well 63, south side of Cotton Gin Road, 1 mile east of Mercey Springs Road.
5B	Lat 36°55'36", long 120°49'05", in SW¼SW¼ sec.31, T.11 S., R.11 E. CCID observation well 1, north side of El Campo Road at Ward Road.
5B1	Lat 36°55'22", long 120°46'35", in SE¼SE¼ sec.32, T.11 S., R.11 E. Farm drain sump, south side of Delta Mendota Canal, north side El Campo Road.

TABLE 5.--Sites sampled by the U.S. Geological Survey and the U.S. Bureau of Reclamation--Continued

Site No.	Description
5B2	Lat 36°55'53", long 120°48'00", in NE¼SE¼ sec.31, T.11 S., R.11 E. Farm drain sump, south side of Delta Mendota Canal at mile post 88.61.
6A	Lat 36°59'46", long 120°39'09", in NW¼NW¼ sec.10, T.11 S., R.12 E. CCID observation well 93, southeast corner of Carmelia and Lexington Avenues.
6B	Lat 36°59'24", long 120°35'02", in NE¼NE¼ sec.11, T.11 S., R.12 E. CCID observation well 106, southwest corner of Palm and Carmelia Avenues.
6C	Lat 36°59'01", long 120°36'29", in SE¼SW¼ sec.12, T.11 S., R.12 E. Dos Palos drainage well no. 4, west side Bryant, 800 feet north of Valeria on west side of Main Canal.
6C1	Lat 36°58'54", long 120°36'58", in NW¼NW¼ sec.13, T.11 S., R.12 E. CCID observation well 107, southeast corner of Valeria and Palm Avenues.
7A1	Lat 37°02'53", long 120°36'56", in SW¼NW¼ sec.24, T.10 S., R.12 E. Farm drain sump, Santa Rita Ranch, northeast corner of Palm Avenue and State Highway 152.
7A2	Lat 37°03'18", long 120°36'55", in SW¼SW¼ sec.13, T.10 S., R.12 E. Farm drain sump, Santa Rita Ranch, northeast corner of Santa Rita Grade and Palm Avenue.
7A3	Lat 37°04'58", long 120°36'56", in NW¼NW¼ sec.12, T.10 S., R.12 E. Farm drain sump, southeast corner of Hutchins Road and Palm Avenue.
7B1	Lat 37°05'51", long 120°40'13", in NW¼NW¼ sec.5, T.10 S., R.12 E. Farm drain sump, south side of Henry Miller Road, 0.5 mile east of Carlucci Road.
7B2	Lat 37°04'43", long 120°45'37", in SW¼NW¼ sec.10, T.10 S., R.11 E. Farm drain sump, east side of Delta Road, south side of Criswell Avenue.
8A	Lat 36°58'02", long 120°35'56", in NE¼NE¼ sec.24, T.11 S., R.12 E. CCID observation well 115, southwest corner of Shain Avenue and Brannon Avenue.
8B1	Lat 36°53'41", long 120°29'25", in NE¼NE¼ sec.13, T.12 S., R.13 E. CCID observation well 162, west side of Douglas Avenue at Copper Avenue.

TABLE 5.--Sites sampled by the U.S. Geological Survey and the U.S. Bureau of Reclamation--Continued

Site No.	Description
8B2	Lat 36°55'39", long 120°29'24", in SE¼SE¼ sec.36, T.11 S., R.13 E. CCID observation well 164, south side of Oxalis Avenue, 0.3 mile west of Ormsby Avenue on west side of Douglas Avenue.
8B3	Lat 36°55'34", long 120°32'44", in SE¼SE¼ sec.33, T.11 S., R.13 E. CCID observation well 170, south side of Oxalis Avenue at Hudson Avenue.
8B4	Lat 36°59'45", long 120°33'42", in NW¼NW¼ sec.9 T.11 S., R.13 E. CCID observation well 127, southeast corner of Carmelia and Fairfax Avenues.
9A	Lat 36°43'12", long 120°21'34", in NE¼NW¼ sec.17, T.14 S., R.15 E. Collector drain, on west side of San Luis Drain at mile post 130.6, California Avenue.
9B	Lat 36°46'34", long 120°22'19", in NE¼NE¼ sec.30, T.13 S., R.15 E. Collector drain, discharges to west side of San Luis Drain at Bass Avenue, mile post 126.4.
9C2	Lat 36°49'16", long 120°28'25", in NE¼NE¼ sec.8, T.13 S., R.14 E. Farm drain sump, discharges to 2nd lift canal, south side of Lyon Avenue, south of Bullard Avenue.
9C3	Lat 36°51'29", long 120°30'14", in NW¼SW¼ sec.25, T.12 S., R.13 E. Farm drain sump, 0.7 mile north of Nees Avenue.
9D	Lat 36°43'10", long 120°26'25", in NW¼NW¼ sec.15, T.14 S., R.14 E. USBR observation well 15D1, south side of California Avenue at San Diego Avenue.
9E	Lat 36°44'02", long 120°21'42", in NE¼NW¼ sec.8, T.14 S., R.15 E. Collector drain, west side of San Luis Drain, 0.2 mile north of Panoche Road, mile post 129.5.
9F	Lat 36°42'20", long 120°21'36", in NE¼NW¼ sec.20, T.14 S., R.15 E. Collector drain, west side of San Luis Drain, south side of Jensen Avenue, mile post 131.6.
9F1	Lat 36°46'42", long 120°28'33", in SW¼SW¼ sec.20, T.13 S., R.14 E. USBR observation well 20N1, northeast corner of Shields Avenue and Lyons Avenue.
9G	Lat 36°44'55", long 120°24'10", in NW¼NW¼ sec.1, T.14 S., R.14 E. USBR observation well, south side of Belmont Road, 0.1 mile east of Ohio Avenue.

TABLE 5.--Sites sampled by the U.S. Geological Survey and the U.S. Bureau of Reclamation--Continued

Site No.	Description
9K	Lat 36°42'23", long 120°22'01", in SW¼SE¼ sec.17, T.14 S., R.15 E. USBR observation well 17Q2, north side of Jensen Avenue, 0.5 mile west of San Luis Drain.
10A	Lat 36°50'08", long 120°32'00", in NE¼NE¼ sec.3, T.13 S., R.13 E. Farm drain sump, south side of Herndon Road, west side of Jerrold Avenue.
10A1	Lat 36°47'35", long 120°32'02", in SW¼SW¼ sec.14, T.13 S., R.13 E. USBR observation well 14N3, northeast corner of Jerrold and Ashlan Avenues.
10A2	Lat 36°48'32", long 120°31'59", in SW¼SW¼ sec.11, T.13 S., R.13 E. USBR observation well 11N3, east side of Jerrold Avenue, approximately 50 yards north of Shaw Avenue.
10B1	Lat 36°52'09", long 120°36'08", in SE¼SE¼ sec.24, T.12 S., R.12 E. Farm drain sump, south side of 2nd lift canal, 1.2 miles north of Nees Avenue, 400 feet west of Brannon Avenue.
10B2	Lat 36°51'01", long 120°36'59", in NW¼NW¼ sec.36, T.12 S., R.12 E. Farm drain sump, 150 feet south of Nees Avenue, east side of Millux Avenue.
10B3	Lat 36°50'59", long 120°37'32", in NE¼NW¼ sec.35, T.12 S., R.12 E. Farm drain sump, south side of Nees Avenue, 0.6 mile west of Millux Avenue.
10C1	Lat 36°48'24", long 120°39'25", in NE¼NE¼ sec.16, T.13 S., R.12 E. Farm drain sump, south side of Shaw Avenue, 300 feet west of Russell Avenue.
10C2	Lat 36°50'09", long 120°39'19", in NE¼NE¼ sec.4, T.13 S., R.12 E. Farm drain sump, south side of Herndon Avenue, west of Russell Avenue.
10C3	Lat 36°52'47", long 120°39'12", in NE¼NE¼ sec.21 T.12 S., R.12 E. Farm drain sump, west side of Russel Avenue, 2 miles north of Nees Avenue.
10C4	Lat 36°49'23", long 120°40'29", in SE¼SE¼ sec.5, T.13 S., R.12 E. USBR observation well 5R2, north side of Bullard Avenue, 1 mile west of Russel Avenue.
10D	Lat 36°51'01", long 120°35'30", in NE¼NW¼ sec.31, T.12 S., R.13 E. Farm drain sump, south side of Nees Avenue, 0.5 mile east of Brannon Avenue.

TABLE 5.--Sites sampled by the U.S. Geological Survey and the U.S. Bureau of Reclamation--Continued

Site No.	Description
10E	Lat 36°51'02", long 120°35'03", in NE¼NE¼ sec.31, T.12 S., R.13 E. Farm drain sump, south side of Nees Avenue, 1.0 mile east of Brannon Avenue.
11A1	Lat 36°53'38", long 120°44'47", in NE¼NW¼ sec.15, T.12 S., R.11 E. Farm drain sump, south side of Eagle Field Road, 0.5 mile east of Hamburg Road.
11A2	Lat 36°54'08", long 120°44'47", in SE¼NE¼ sec.10, T.12 S., R.11 E. Farm drain sump, 0.5 mile north of Eagle Field Road, 0.8 mile east of Hamburg Road.
11A3	Lat 36°54'16", long 120°44'10", in SE¼NW¼ sec.11, T.12 S., R.11 E. Farm drain sump, south side of Delta Mendota Canal, 1.5 miles east of Hamburg Road.
13A	Lat 36°36'07", long 120°16'39", in NW¼NW¼ sec.30, T.15 S., R.16 E. Farm drain sump, discharges to south side of San Luis Drain, east side of Calaveras Avenue.
13B	Lat 36°38'49", long 120°19'32", in SE¼SW¼ sec.3, T.15 S., R.15 E. Collector drain, discharges to west side of San Luis Drain at mile post 136.00.
13C	Lat 36°41'25", long 120°21'03", in NE¼NE¼ sec.29, T.14 S., R.15 E. Collector drain, discharges to west side of San Luis Drain at mile post 132.7, north side of North Avenue.
13D1	Lat 36°37'59", long 120°23'08", in SE¼SE¼ sec.12, T.15 S., R.14 E. USBR observation well 9N2, northwest corner of Derrick Boulevard and Adams Avenue.
13D2A	Lat 36°37'55", long 120°21'03", in NE¼NE¼ sec.17, T.15 S., R.14 E. USBR observation well 17A3, northwest corner of Adams Avenue and Oil City Road.
13D3	Lat 36°38'45", long 120°22'04", in NW¼NW¼ sec.8, T.15 S., R.15 E. USBR observation well, southeast corner of Lincoln and Monterey Avenues.
13E3	Lat 36°38'48", long 120°24'17", in NW¼NW¼ sec.12, T.15 S., R.14 E. USBR observation well 11D1, southeast corner of Lincoln and San Bernardino Avenues.
13F	Lat 36°40'32", long 120°20'34", in NE¼NW¼ sec.33, T.14 S, R.15 E. Collector drain, west of San Luis Drain, north of Central Avenue.

TABLE 5.--Sites sampled by the U.S. Geological Survey and the U.S. Bureau of Reclamation--Continued

Site No.	Description
13F1	Lat 36°36'14", long 120°23'14", in SW¼SW¼ sec.19, T.15 S., R.15 E. USBR observation well 19N5, northeast corner of State Highway 33 and Manning Avenue.
13F3	Lat 36°36'12", long 120°21'03", in SW¼SW¼ sec.21, T.15 S., R.15 E. USBR observation well 21N1, northeast corner of Manning Avenue and Oil City Road.
13F4	Lat 36°36'12", long 120°26'31", in NE¼NE¼ sec.28, T.15 S., R.14 E. USBR observation well, southwest corner of Manning and San Diego Avenues.
13G	Lat 36°39'40", long 120°20'05", in SE¼SE¼ sec.33, T.14 S, R.15 E. Collector drain, west of San Luis Drain, south of American Avenue.
14A1	Lat 36°27'26", long 120°14'48", in NW¼NW¼ sec.16, T.17 S., R.16 E. USBR observation well 16D1, southeast corner of Sonoma and Cerini Avenues.
14A2	Lat 36°27'30", long 120°12'37", in SW¼SW¼ sec.11, T.17 S., R.16 E. USBR observation well 11N4, northeast corner of El Dorado and Elkhorn Avenues.
14A4	Lat 36°31'52", long 120°12'20", in SW¼SW¼ sec.14, T.16 S., R.16 E. USBR observation well 14N2, northeast corner of Kamm and El Dorado Avenues.
14A6	Lat 36°27'31", long 120°09'21", in SW¼SW¼ sec.8, T.17 S., R.17 E. USBR observation well 8N1, northeast corner of Cerini and Butte Avenues.
14A35	Lat 36°29'16", long 120°11'14", in SW¼SW¼ sec.36, T.16 S., R.16 E. USBR observation well 36N1, northeast corner of Colusa and Elkhorn Avenues.
14B1	Lat 36°32'37", long 120°22'11", in NE¼NE¼ sec.18, T.16 S., R.15 E. USBR observation well 18A1, west side of Monterey Road at Mountain View Avenue.
14B2	Lat 36°32'43", long 120°21'02", in SW¼SW¼ sec.9, T.16 S., R.15 E. USBR observation well 9N2, northeast corner of Oil City Road and Mountain View Avenue.
14B3	Lat 36°33'35", long 120°18'51", in SW¼SW¼ sec.2, T.16 S., R.15 E. USBR observation well 2N4, northeast corner of San Mateo and Nebraska Avenues.

TABLE 5.--Sites sampled by the U.S. Geological Survey and the U.S. Bureau of Reclamation--Continued

Site No.	Description
14B4	Lat 36°34'27", long 120°17'04", in SW¼SE¼ sec.36, T.15 S., R.15 E. USBR observation well 32Q, north side of Floral Avenue, 0.3 mile west of Calaveras Avenue.
14C	Lat 36°34'24", long 120°21'39", in NW¼NE¼ sec.5, T.16 S., R.15 E. Farm drain sump, south side of Floral Avenue, 0.5 mile east of Monterey Avenue, northeast corner of evaporation pond.
14C1	Lat 36°34'28", long 120°22'07", in SW¼SW¼ sec.32, T.15 S., R.15 E. Farm drain sump, northeast corner of Floral and Monterey Avenues.
14C2	Lat 36°34'30", long 120°22'08", in SW¼SW¼ sec.32, T.15 S., R.15 E. USBR observation well 32N2, northeast corner of Floral and Monterey Avenues.
14D1	Lat 36°32'42", long 120°16'46", in NE¼NE¼ sec.13, T.16 S., R.15 E. USBR observation well 13A2, west side of Calaveras, at south side of Mountain View Avenue.
14D2	Lat 36°30'07", long 120°13'26", in SW¼SW¼ sec.27, T.16 S., R.16 E. USBR observation well 27N1, east side of Napa Avenue at Clarkson Avenue.
16A1	Lat 36°23'12", long 120°06'10", in SE¼SE¼ sec.3, T.18 S., R.17 E. USBR observation well 3R1, northwest corner of Lassen Avenue and Paige Road.
16A2	Lat 36°24'56", long 120°06'13", in SE¼SE¼ sec.27, T.17 S., R.17 E. USBR observation well 27R4, northwest corner of Lassen and Laguna Avenues.
16A3	Lat 36°25'46", long 120°05'07", in NE¼NE¼ sec.26, T.17 S., R.17 E. USBR observation well 26A1, south side of Mount Whitney Avenue, 1.0 mile east of Lassen Avenue.
16A4	Lat 36°26'43", long 120°06'11", in SE¼SE¼ sec.15, T.17 S., R.17 E. USBR observation well 15R1, northwest corner of Lassen and Harlan Avenues.
16B1	Lat 36°25'45", long 120°09'23", in NE¼NE¼ sec.30, T.17 S., R.17 E. USBR observation well 30A1, southwest corner of Mount Whitney and Butte Avenues.
16B2	Lat 36°25'47", long 120°10'41", in SE¼SE¼ sec.24, T.17 S., R.16 E. USBR observation well 2422, northwest corner of Mount Whitney and Yuba Avenues.

TABLE 5.--Sites sampled by the U.S. Geological Survey and the U.S. Bureau of Reclamation--Continued

Site No.	Description
16B3	Lat 36°23'59", long 120°12'39", in NE¼NE¼ sec.3, T.18 S., R.16 E. USBR observation well 3A1, southwest corner of Parkhurst Road and El Dorado Avenue.
16B4	Lat 36°23'59", long 120°11'35", in NE¼NE¼ sec.2, T.18 S., R.16 E. USBR observation well 2A1, southwest corner of Parkhurst Road and Colusa Avenue.
16B5	Lat 36°23'12", long 120°01'45", in SW¼SW¼ sec.4, T.18 S., R.18 E. USBR observation well 4N1, northeast corner of Paige Road and Howard Avenue.
16B6	Lat 36°24'57", long 120°03'55", in SW¼SW¼ sec.30, T.17 S., R.18 E. USBR observation well 30N, northeast corner of Laguna and Madera Avenues.
16C	Lat 36°23'08", long 120°05'54", in NW¼NW¼ sec. 11, T.18 S., R.17 E. Farm drain sump, south side of Paige Road, 0.2 mile east of Lassen Avenue.
16D	Lat 36°26'25", long 120°05'05", in SE¼NE¼ sec.23, T.17 S., R.17 E. Farm drain sump, west side Siskiyou Avenue, 0.75 mile north of Mount Whitney Avenue.
17A1	Lat 36°15'18", long 119°54'14", in NW¼NW¼ sec.27, T.19 S., R.19 E. USBR observation well 27D2, southeast corner of State Highway 198 and 25th Avenue.
17A2	Lat 36°15'20", long 119°55'17", in SW¼SW¼ sec.21, T.19 S., R.19 E. USBR observation well 21N2, northeast corner of Center Avenue and State Highway 198.
17B1	Lat 36°20'36", long 119°58'29", in SW¼SW¼ sec.24, T.18 S., R.18 E. USBR observation well 24N1, northeast corner of Oakland and Dickenson Avenues.
17B1A	Lat 36°20'36", long 119°59'37", in SW¼SW¼ sec.23, T.18 S., R.18 E. USBR observation well 23N2, northeast corner of Oakland and Jameson Avenues.
17B2	Lat 36°19'50", long 119°58'40", in SW¼SW¼ sec.25, T.18 S., R.18 E. USBR observation well 25N1, northeast corner of Packard and Dickenson Avenues.
17B2A	Lat 36°19'43", long 119°59'37", SW¼SW¼ sec.26, T.18 S., R.18 E. USBR observation well 26N3, northeast corner of Jameson and Packard Avenues.

TABLE 5.--Sites sampled by the U.S. Geological Survey and the U.S. Bureau of Reclamation--Continued

Site No.	Description
17B3	Lat 36°18'51", long 119°58'32", in SW¼SW¼ sec.36, T.18 S., R.18 E. USBR observation well 36N5, northeast corner of Ford and Dickenson Avenue.
17B4	Lat 36°18'51", long 120°00'40" in SW¼SW¼ sec.34, T.18 S., R.18 E. USBR observation well 34N1, northeast corner of Ford and Bishop Avenue.
17B5	Lat 36°21'29", long 119°59'39", in SW¼SW¼ sec.14, T.18 S., R.18 E. USBR observation well 14N1, northeast corner of Jameson Avenue and Cadillac.
17C	Lat 36°16'37", long 119°52'06", in NW¼SW¼ sec.13, T.19 S., R.19 E. Farm drain sump, east side of 23rd Avenue, 1.5 miles north of State Highway 198.
18A1	Lat 36°11'21", long 119°53'11", in SE¼NE¼ sec.15, T.20 S., R.19 E. USBR observation well 15H1, southwest corner of Laurel Creek and 24th Avenue.
18A3	Lat 36°13'34", long 119°54'13", in NW¼NW¼ sec.3, T.20 S., R.19 E. USBR observation well 3D1, southeast corner of Kent and 25th Avenues.
18A4	Lat 36°14'27", long 119°54'12", in NW¼NW¼ sec.34, T.19 S., R.19 E. USBR observation well 34D1, southwest corner of Mitchell Peak and 25th Avenue.
18B1	Lat 36°08'17", long 119°54'19", in SE¼SE¼ sec.33, T.20 S., R.19 E. USBR observation well 33R1, northwest corner of Nevada and 25th Avenues.
18B2	Lat 36°09'08", long 119°54'19", in NE¼NE¼ sec.33, T.20 S., R.19 E. USBR observation well 33A1, southwest corner of Manteca and 25th Avenue.
18B3	Lat 36°08'17", long 119°55'23", in SE¼SE¼ sec.32, T.20 S., R.19 E. USBR observation well 32R1, northwest corner of Nevada and 26th Avenues.
18B4	Lat 36°08'16", long 119°59'00", in SW¼SE¼ sec.35, T.20 S., R.18 E. USBR observation well 35Q1, north side of Nevada Avenue, 0.1 mile east of 29th Avenue from South Avenue.
18B5	Lat 36°07'22", long 119°59'05", in NW¼NW¼ sec.12, T.21 S., R.18 E. USBR observation well 12D3, southeast corner of 29th and Quail Avenues.

TABLE 5.--Sites sampled by the U.S. Geological Survey and the U.S. Bureau of Reclamation--Continued

Site No.	Description
18C1	Lat 36°13'36", long 119°56'25", in SE¼SE¼ sec.31, T.19 S., R.19 E. USBR observation 31R1, less than 0.1 mile west of intersection of 27th and Kent Avenues.
20A1	Lat 36°02'08", long 119°57'30", in NE¼NW¼ sec.7, T.22 S., R.19 E. USBR observation well 7C2, 0.1 mile south of Quail Avenue on west side of Highway 41.
20A2	Lat 36°03'03", long 119°57'24", in SW¼SE¼ sec.31, T.21 S., R.19 E. USBR observation well 31Q1, north side of Quebec Avenue, 0.5 mile east of 28th Avenue.
20A3	Lat 36°04'48", long 119°55'49", in SW¼SW¼ sec.21, T.21 S., R.19 E. USBR observation well 21N1, northeast corner of Pueblo and 26th Avenues.
20B2	Lat 36°05'41", long 120°00'25", in SE¼SE¼ sec.15, T.21 S., R.18 E. USBR observation well 15R1, north side of Omaha Avenue, west of 30th Avenue.
20B3	Lat 36°05'40", long 119°56'53", in SW¼SW¼ sec.17, T.21 S., R.19 E. USBR observation well 17N1, northeast corner of Omaha and 27th Avenues.
20B4	Lat 36°05'40", long 119°59'03", in SW¼SW¼ sec.13, T.21 S., R.18 E. USBR observation well 13N1, northeast corner of Omaha and 29th Avenues.
20B5	Lat 36°04'49", long 119°59'03", in SW¼SW¼ sec.24, T.21 S., R.18 E. USBR observation well 24N3, northeast corner of Pueblo and 29th Avenues.

TABLE 6.--Chemical analyses of major ions

[Data from U.S. Geological Survey. Abbreviations: USGS, U.S. Geological Survey. USGS identification No.: Unique number for each well based on the latitude and longitude of the well. First six digits are latitude, next eight digits are longitude, and final two digits are a sequence number to uniquely identify each well. Specific conductance, in micromhos per centimeter at 25 degrees Celsius; pH, in standard units; temperature, in degrees Celsius; and constituents, in milligrams per liter]

Site No.	USGS identification No.	Date of sample	Specific conductance	pH	Temperature	Calcium, dissolved (Ca)	Magnesium, dissolved (Mg)	Sodium, dissolved (Na)	Potassium, dissolved (K)	Bicarbonate plus carbonate (as HCO_3)	Sulfate, dissolved (SO_4)	Chloride, dissolved (Cl)
1A	374250121183801	5-14-84	2,550	7.4	19.0	180	71	340	2.0	366	580	420
1B	374645121255601	5- 5-84	3,860	7.9	14.0	260	190	560	15	632	740	1,000
1C	374532121295701	5- 5-84	2,800	7.5	17.0	140	64	380	1.1	392	370	500
1D	373741121135501	5- 5-84	2,950	7.4	18.5	130	82	410	1.1	499	680	320
1E	373654121125301	5- 6-84	1,020	7.4	17.5	96	35	110	3.3	316	230	120
1F	373502121122501	5- 6-84	2,300	7.1	20.0	230	72	230	2.5	328	380	520
2B2	372755121044501	5- 4-84	927	8.4	--	48	24	120	3.1	159	160	130
2C2	372906121053601	5- 5-84	3,750	7.2	17.0	200	150	450	1.3	601	780	580
2D	372549121032701	5- 5-84	1,160	7.7	21.0	79	34	110	3.6	183	260	110
2F	372330121030401	5- 7-84	675	6.8	18.0	76	19	33	7.5	214	98	58
2H1	372718121045601	5- 6-84	3,060	7.1	17.0	190	93	370	1.0	480	520	500
2K	372233121011401	5- 7-84	3,300	7.5	19.0	92	220	340	1.5	913	340	470
3A	371954120592601	5- 7-84	2,380	7.4	17.0	86	120	280	2.2	620	380	300
3B	372121120590201	5- 5-84	2,150	7.4	19.5	91	110	240	2.0	694	310	220
3C	371631121043201	5- 7-84	1,720	7.4	17.0	140	71	140	2.7	330	470	130
3C1	371627121025401	5- 7-84	840	7.0	19.5	69	31	66	3.6	318	93	66
3D	371117121031201	5- 6-84	1,750	7.6	19.5	74	54	200	.7	287	220	260
3D1	371117121025601	5- 6-84	1,000	7.3	20.0	79	35	64	2.3	374	88	68
4A	371339121003001	5- 5-84	590	8.2	18.0	31	15	61	3.0	114	86	72
4A1	371356121004501	5- 7-84	1,550	7.1	18.0	200	67	56	27	980	64	57
4C1	370454120553101	5- 8-84	1,200	7.4	20.0	68	35	130	3.6	427	150	69
4C2	370600120524501	5- 8-84	1,790	8.1	22.0	27	18	380	3.6	676	210	130
4C4	370352120561501	5- 6-84	4,570	7.5	20.0	100	83	860	2.6	1,150	810	460
4D1	371730120585001	5- 5-84	9,200	7.3	17.0	320	390	1,600	1.2	617	4,100	790
4D2	371703120565701	5-21-84	10,400	7.4	19.5	220	360	2,000	3.2	542	3,300	1,800
4D3	371723120584001	5- 7-84	13,000	7.7	17.0	250	280	3,200	4.4	488	7,600	700
4F	370045120501101	5- 6-84	6,430	7.3	18.5	370	200	930	2.7	420	2,400	870
4G	365944120501001	5- 5-84	661	7.9	21.5	43	17	69	1.0	189	97	50
4G1	365955120500801	5- 9-84	1,910	7.4	20.5	180	86	120	3.0	403	490	120
4H	370532120544901	5- 6-84	2,830	7.4	17.0	140	120	290	1.4	499	480	430
4I	370559120573401	5- 7-84	2,080	7.2	18.5	140	110	160	4.7	732	220	220
4L	371118120592701	5- 8-84	1,730	7.5	19.5	85	70	210	2.9	614	150	170
5A	365715120490601	5-14-84	3,550	7.2	19.0	230	80	450	5.4	385	580	660
5B	365536120490501	5-15-84	5,000	7.5	18.5	540	70	670	4.3	280	2,500	210
5B1	365522120463501	5-15-84	7,080	7.2	17.5	610	140	980	2.4	250	2,400	1,100
5B2	365553120480001	5-14-84	6,160	7.1	18.5	510	110	790	1.9	226	2,100	790
6A	365946120390901	5- 8-84	1,970	7.1	19.5	120	50	260	2.6	385	330	250
6B	365924120350201	5-14-84	1,780	6.6	19.0	120	48	170	4.7	166	200	390
6C1	365854120365801	5- 8-84	1,100	7.0	19.0	34	15	170	2.0	209	120	150
7A1	370253120365601	5- 8-84	1,150	7.2	17.5	99	37	110	.9	283	160	180
7A2	370318120365501	5- 8-84	1,600	7.3	17.5	130	46	140	.7	293	190	270
7A3	370458120365601	5- 8-84	1,470	7.1	19.0	120	44	130	1.5	340	--	--
7B1	370551120401301	5-10-84	1,420	7.3	18.5	71	37	190	.8	325	200	200
7B2	370443120453701	5-10-84	1,480	6.9	17.5	60	35	200	2.6	173	200	300
8A	365802120355601	5- 9-84	1,400	7.0	19.6	84	27	190	9.1	466	170	140
8B1	365341120292501	5- 9-84	1,160	7.0	18.5	77	40	110	1.6	385	120	120
8B2	365539120292401	5- 9-84	1,900	7.1	18.5	120	34	230	.9	314	290	230
8B3	365534120324401	5- 9-84	1,080	6.6	20.0	64	25	110	2.4	212	120	170
8B4	365945120334201	5- 9-84	993	7.4	18.5	56	22	130	.6	378	130	61
9A	364312120213401	5- 8-84	8,810	7.4	18.0	560	280	1,400	4.6	240	3,500	1,400
9C2	364916120282501	5- 9-84	5,630	7.4	17.5	440	220	120	2.7	226	3,700	580
9C3	365129120301401	5-15-84	6,840	7.5	17.5	360	180	1,100	3.3	322	3,300	440
9D	364310120262501	5-20-84	5,120	7.3	20.5	590	140	650	4.1	382	2,400	600
9F1	364642120283301	5-16-84	3,660	7.4	18.5	320	75	310	6.0	323	440	120
9G	364455120241001	5-20-84	4,940	7.4	20.0	320	120	750	8.3	475	1,700	630
9K	364223120220101	5-16-84	13,100	8.5	18.5	400	66	2,900	4.3	112	5,500	1,500
10A1	364735120320201	5- 8-84	3,630	7.6	24.5	100	27	740	2.7	659	940	470
10A2	364832120315901	5- 9-84	2,810	7.5	--	230	43	410	2.0	239	1,200	170
10B1	365209120360801	5- 8-84	5,190	7.7	22.5	350	130	760	2.6	154	2,700	270
10B2	365101120365901	5-15-84	8,930	7.2	18.5	440	220	1,600	4.5	315	3,800	1,000

TABLE 6.--Chemical analyses of major ions--Continued

Site No.	USGS identification No.	Date of sample	Specific conductance	pH	Temperature	Calcium, dissolved (Ca)	Magnesium, dissolved (Mg)	Sodium, dissolved (Na)	Potassium, dissolved (K)	Bicarbonate plus carbonate (as HCO_3)	Sulfate, dissolved (SO_4)	Chloride, dissolved (Cl)
10B3	365059120373201	5-16-84	10,400	7.3	17.0	520	230	2,000	3.7	347	3,900	1,400
10C1	364824120392501	5- 9-84	4,650	--	17.5	340	120	640	3.3	278	2,000	440
10C2	365009120391901	5-16-84	5,090	7.2	17.5	480	100	630	2.2	187	1,700	760
10C3	365247120391201	5-21-84	4,880	7.3	19.0	300	71	710	2.1	233	1,600	640
10C4	364923120402901	5- 9-84	2,200	7.5	20.5	280	47	200	12.0	142	870	160
10D	365101120353001	5-15-84	14,200	7.4	17.5	600	150	2,800	4.3	269	4,400	2,300
10E	365102120350301	5-15-84	24,200	7.5	17.0	530	340	5,800	6.5	383	6,300	3,900
11A1	365338120444701	5-21-84	4,780	7.5	18.0	500	86	480	1.8	166	1,600	710
11A2	365408120444701	5-10-84	3,440	8.2	23.0	310	68	410	2.6	128	1,100	440
11A3	365416120441001	5-10-84	4,830	7.1	19.0	310	93	660	2.0	315	1,400	760
13A	363607120163901	5-15-84	6,250	7.5	18.5	470	250	920	7.8	288	3,400	210
13C	364125120210301	5- 8-84	1,130	7.5	19.5	460	330	2,400	3.8	242	5,200	1,600
13D1	363243120210201	5-10-84	19,900	7.8	19.0	430	210	4,600	4.7	277	10,000	--
13D2A	363755120210301	5-20-84	58,600	8.1	20.5	220	400	13,000	7.5	711	--	2,900
13D3	363845120220401	5-10-84	49,500	--	20.5	280	1,000	16,000	13	283	37,000	2,000
13E3	363848120241701	5-10-84	8,800	7.4	19.0	580	150	1,600	7.8	201	4,900	320
13F1	363614120231401	5-17-84	30,400	7.8	19.5	460	110	8,900	5.5	334	14,000	3,100
13F3	363612120210301	5-17-84	23,900	8.0	18.5	480	130	6,900	11.0	290	13,000	1,300
13F4	363612120263101	5-18-84	4,380	7.4	18.2	510	38	630	3.9	328	2,400	72
14A1	362726120144801	5-18-84	1,170	7.6	19.0	120	34	100	1.6	245	390	40
14A2	362730120123701	5-18-84	5,660	7.9	19.0	600	92	1,000	2.2	128	3,100	580
14A4	363152120122001	5-17-84	17,000	8.1	20.0	420	350	4,200	1.8	133	9,800	560
14A6	362731120092101	5-17-84	1,700	7.6	19.0	96	33	260	3.2	420	460	82
14A35	362916120111401	5-17-84	3,050	7.5	19.0	460	110	1,400	6.0	216	3,400	42
14B1	363237120221101	5-16-84	5,800	7.5	19.0	500	110	880	5.0	268	3,100	280
14B2	363243120210201	5-15-84	3,280	7.4	18.5	560	90	160	2.5	233	1,800	69
14B3	363335120185101	5-15-84	4,900	7.5	19.0	480	250	470	8.9	236	2,900	160
14B4	363427120170401	5-15-84	11,000	7.9	21.0	440	530	2,000	2.2	236	6,000	860
14C	363424120213901	5-16-84	9,200	7.5	17.5	540	120	1,700	6.8	355	4,000	680
14C1	363428120220701	5-14-84	3,650	8.4	20.5	230	33	630	9.6	263	1,600	80
14C2	363430120220801	5-16-84	10,200	--	18.0	480	94	2,200	7.1	236	4,700	720
14D1	363242120164601	5-16-84	2,100	7.6	19.0	410	49	59	1.8	187	1,100	29
14D2	363007120132601	5-17-84	4,900	7.5	18.0	530	200	510	1.9	374	2,500	230
16A1	362312120061001	5-17-84	6,010	7.4	20.0	430	--	770	6.7	318	3,000	300
16A2	362456120061301	5-17-84	4,930	7.6	19.0	630	61	540	2.1	155	2,000	120
16A3	362546120050701	5-17-84	3,490	7.6	18.0	510	66	300	4.5	283	1,700	190
16A4	362643120061101	5-16-84	8,760	7.7	20.0	450	110	1,800	2.4	121	4,300	630
16B1	362545120092301	5-16-84	1,020	7.5	17.5	65	21	130	3.2	328	150	64
16B2	362547120104101	5-16-84	851	7.6	19.0	54	19	97	3.6	269	93	38
16B3	362359120123901	5-15-84	1,750	7.4	18.0	130	40	240	2.4	511	380	120
16B4	362359120113501	5-16-84	13,200	7.5	19.0	420	350	2,800	6.9	261	6,500	1,200
16B5	362312120014501	5-17-84	431	7.6	18.0	25	10	37	2.5	116	39	34
16B6	362457120035501	5-17-84	4,470	7.8	19.0	490	110	450	1.6	119	2,400	150
16C	362308120055401	5-19-84	7,050	7.5	19.0	450	160	1,100	2.8	242	2,700	880
16D	362625120050501	5-19-84	15,600	7.8	17.5	430	310	3,600	3.2	352	9,000	710
17A1	361518119541401	5-18-84	5,500	7.7	20.0	470	120	790	4.4	201	2,800	170
17A2	361520119551701	5-18-84	2,900	7.6	19.5	410	72	200	1.4	188	1,500	62
17B1	362036119582901	5-19-84	16,100	7.7	20.0	400	240	3,900	6.3	544	8,900	780
17B1A	362036119593701	5-17-84	1,160	7.1	18.5	120	39	120	3.3	673	99	58
17B2	361950119584001	5-20-84	9,180	7.3	19.0	550	220	1,600	4.5	280	4,500	800
17B2A	361943119593701	5-17-84	1,010	7.6	19.5	73	24	130	2.1	373	160	49
17B3	361851119583201	5-18-84	7,840	7.2	19.5	490	250	1,500	2.1	643	3,900	700
17B4	361851120004001	5-18-84	3,020	7.6	19.5	210	62	370	1.0	333	1,000	230
17B5	362129119593901	5-17-84	3,050	7.5	19.0	440	110	230	6.0	216	1,800	42
17C	361637119520601	5-19-84	17,500	7.7	19.5	210	360	4,100	4.2	288	9,700	1,300
18A1	361121119531101	5-18-84	6,450	7.5	22.0	490	110	1,100	4.3	247	3,500	300
18A3	361334119541301	5-19-84	3,290	7.6	20.0	380	110	260	2.0	187	2,000	64
18A4	361427119541201	5-20-84	5,600	7.5	21.0	460	130	910	4.3	198	3,600	110
18B1	360817119541901	5-18-84	11,800	7.9	19.5	400	140	2,700	1.0	220	6,600	480
18B2	360908119541901	5-18-84	26,200	7.7	19.5	380	560	7,400	2.5	252	18,000	640
18B3	360817119552301	5-18-84	5,420	7.5	19.5	480	100	800	2.0	232	3,000	170
18B4	360816119590001	5-17-84	3,300	7.5	21.0	290	48	--	1.1	420	3,300	97
18B5	360722119590501	5-17-84	2,740	7.5	19.0	230	78	320	5.3	590	590	180
18C1	361336119562501	5-20-84	17,800	8.1	20.0	550	320	4,100	3.2	161	12,000	350
20A2	360303119572401	5-18-84	26,000	7.8	20.0	430	430	6,000	5.0	288	14,000	2,300
20A3	360448119554901	5-18-84	68,000	7.4	20.0	350	4,000	30,000	36	290	65,000	16,000
20B2	360541120002501	5-20-84	3,610	7.2	19.5	430	100	370	1.5	423	1,800	87
20B3	360540119565301	5-18-84	5,800	7.7	19.5	560	69	930	11	175	2,800	370
20B4	360540119590301	5-19-84	1,000	8.0	20.5	30	83	200	.8	315	190	49
20B5	360449119590301	5-20-84	4,010	7.4	20.5	550	72	460	.7	336	2,300	110

TABLE 7.--Chemical analyses

[Data from U.S. Geological Survey. Abbreviations: USGS, U.S. Geological Survey. USGS identification No.: Unique number for each site based on the latitude and longitude of the site. First six digits are latitude, next eight digits are longitude, and final two digits are a sequence number to uniquely identify each site. Constituents are in micrograms per liter. <, actual value is less than the value shown]

Site No.	USGS identification No.	Date of sample	Arsenic, dissolved (As)	Boron, dissolved (B)	Cadmium, dissolved (Cd)	Chromium, dissolved (Cr)	Copper, dissolved (Cu)
1A	374250121183801	5-14-84	1	2,800	<1	30	1
1B	374645121255601	5- 5-84	5	2,000	<1	<1	<1
1C	374532121295701	5- 5-84	5	2,500	<1	1	3
1D	373741121135501	5- 5-84	<1	3,600	<1	40	<1
1E	373654121125301	5- 6-84	<1	1,100	<1	5	<1
1F	373502121122501	5- 6-84	18	1,200	<1	1	3
2B2	372755121044501	5- 4-84	2	540	<1	<1	1
2C2	372906121053601	5- 5-84	<1	1,800	<1	10	<1
2D	372549121032701	5- 5-84	1	600	<1	6	3
2F	372330121030401	5- 7-84	1	230	<1	<1	5
2H1	372718121045601	5- 6-84	<1	1,200	<1	2	<1
2K	372233121011401	5- 7-84	2	1,400	<1	170	1
3A	371954120592601	5- 7-84	1	1,900	<1	10	2
3B	372121120590201	5- 5-84	<1	1,400	<1	20	1
3C	371631121043201	5- 7-84	3	430	<1	1	4
3C1	371627121025401	5- 7-84	1	560	<1	<1	4
3D	371117121031201	5- 6-84	<1	870	<1	1	1
3D1	371117121025601	5- 6-84	2	290	<1	6	2
4A	371339121003001	5- 5-84	1	300	<1	<1	2
4A1	371356121004501	5- 7-84	2	580	<1	1	1
4C1	370454120553101	5- 8-84	6	920	<1	<1	2
4C2	370600120524501	5- 8-84	24	2,700	<1	2	<5
4C4	370352120561501	5- 6-84	15	6,300	<1	70	11
4D1	371730120585001	5- 5-84	<1	5,900	<1	6	2
4D2	371703120565701	5-21-84	2	7,600	<1	<1	2
4D3	371723120584001	5- 7-84	3	8,000	<1	<1	12
4F	370045120501101	5- 6-84	2	8,800	<1	50	2
4G	365944120501001	5- 5-84	1	430	<1	2	1
4G1	365955120500801	5- 9-84	1	1,800	<1	50	<10
4H	370532120544901	5- 6-84	7	1,700	<1	10	<1
4I	370559120573401	5- 7-84	5	1,100	<1	<1	<10
4L	371118120592701	5- 8-84	2	2,000	2	<1	4
5A	365715120490601	5-14-84	<1	3,500	<1	50	2
5B	365536120490501	5-15-84	2	3,400	<1	1	2
5B1	365522120463501	5-15-84	<1	7,000	<1	10	2
5B2	365553120480001	5-14-84	<1	5,900	<1	10	2
6A	365946120390901	5- 8-84	13	480	<1	<1	<10
6B	365924120350201	5-14-84	2	270	1	<1	<1
6C1	365854120365801	5- 8-84	<1	590	<1	<1	1
7A1	370253120365601	5- 8-84	2	170	<1	1	<2
7A2	370318120365501	5- 7-84	4	140	<1	<1	<2
7A3	370458120365601	5- 8-84	3	190	<1	<1	1
7B1	370551120401301	5-10-84	3	380	<1	<1	2
7B2	370443120453701	5-10-84	1	550	<1	<1	<10
8A	365802120355601	5- 9-84	2	2,000	<1	<1	3
8B1	365341120292501	5- 9-84	<1	270	<1	<1	<1
8B2	365539120292401	5- 9-84	11	330	<1	<1	1
8B3	365534120324401	5- 9-84	2	370	<1	<1	1
8B4	365945120334201	5- 9-84	29	330	<1	<1	3
9A	364312120213401	5- 8-84	<1	8,800	<1	20	--

of trace elements

Iron, dissolved (Fe)	Lead, dissolved (Pb)	Lithium, dissolved (Li)	Manganese, dissolved (Mn)	Mercury, dissolved (Hg)	Molybdenum, dissolved (Mo)	Selenium, dissolved (Se)	Vanadium, dissolved (V)	Zinc, dissolved (Zn)
50	3	90	<10	<0.1	2	6	14	<10
50	3	30	1,300	<.1	13	<1	23	<10
50	<1	80	10	<.1	4	2	40	50
60	<1	90	<10	<.1	4	4	6	<10
11	<1	48	5	<.1	3	2	1	9
--	<1	110	--	.2	1	<1	17	--
8	<1	21	31	<.1	4	2	5	12
70	<1	130	20	<.1	1	2	12	10
6	<1	76	8	<.1	3	6	4	5
72	3	26	490	<.1	<1	3	<1	18
40	<1	130	20	<.1	<1	2	12	20
10	<1	90	<10	<.1	1	3	29	<10
20	5	90	10	<.1	3	3	11	10
40	<1	60	30	<.1	3	2	4	<10
7	<1	160	<1	<.1	2	4	16	12
<3	<1	31	27	<.1	<1	<1	3	10
<3	<1	140	<1	.1	3	<1	10	5
<3	<1	36	<1	.2	<1	<1	7	11
14	<1	15	2	<.1	3	1	3	11
170	4	62	1,200	<.1	1	<1	4	19
5	5	32	88	<.1	5	<1	19	8
62	<1	32	300	.1	38	4	40	<3
60	<1	50	60	<.1	32	19	40	<10
70	<1	160	70	.4	24	--	16	20
50	<1	100	210	.1	40	<1	50	10
50	<1	190	230	.1	63	5	18	60
70	<1	80	40	.7	3	11	22	20
8	2	31	2	.1	10	<1	8	12
<3	<1	87	4	<.1	1	6	6	8
50	<1	40	250	.3	8	<1	29	<10
50	<1	40	1,500	.1	3	1	17	<10
26	2	52	510	<.1	9	<1	15	14
30	<1	100	<10	<.1	<1	22	22	10
90	<1	260	20	<.1	12	64	14	10
50	<5	430	20	<.1	3	260	40	10
60	<1	340	<10	<.1	6	160	26	10
50	5	40	150	<.1	33	2	22	<10
8	<1	34	2,500	.1	3	<1	5	17
<3	<1	17	330	.1	3	<1	4	<3
4	5	45	270	<.1	9	2	14	11
<3	12	45	260	<.1	14	<1	12	5
7	6	39	940	<.1	13	<1	10	12
<3	5	33	390	<.1	33	1	18	4
4,000	3	23	780	<.1	6	<1	7	3
<3	2	36	580	<.1	15	<1	4	6
7,400	3	32	1,500	<.1	8	<1	9	3
5	6	58	570	<.1	3	<1	16	15
<3	3	29	770	<.1	6	<1	<1	13
<3	3	39	53	<.1	25	<1	32	4
80	4	290	40	<.1	26	1	40	20

TABLE 7.--Chemical analyses of

Site No.	USGS identification No.	Date of sample	Arsenic, dissolved (As)	Boron, dissolved (B)	Cadmium, dissolved (Cd)	Chromium, dissolved (Cr)	Copper, dissolved (Cu)
9C2	364916120282501	5- 9-84	1	10,000	<1	20	<20
9C3	365129120301401	5-15-84	1	11,000	<1	40	2
9D	364310120262501	5-20-84	<1	3,600	<1	10	2
9F1	364642120213601	5-16-84	<1	1,700	<1	20	3
9G	364455120241001	5-20-84	1	3,100	<1	5	3
9K	364223120220101	5-16-84	7	37,000	<1	10	<5
10A1	364735120320201	5- 8-84	1	3,000	<1	1	--
10A2	364832120315901	5- 9-84	1	2,400	<1	20	<20
10B1	365209120360801	5- 8-84	<1	9,400	<1	15	<10
10B2	365101120365901	5-15-84	<1	14,000	<1	32	7
10B3	365059120373201	5-16-84	<1	16,000	<1	52	5
10C1	364824120392501	5- 9-84	1	7,400	<1	20	--
10C2	365009120391901	5-16-84	<1	9,200	<1	80	2
10C3	365247120391201	5-21-84	<1	9,500	<1	110	2
10C4	364923120402901	5- 9-84	2	2,400	<1	5	<10
10D	365101120353001	5-15-84	--	24,000	<1	110	7
10E	365102120350301	5-15-84	2	46,000	<1	16	12
11A1	365338120444701	5-21-84	<1	3,700	<1	15	<1
11A2	365408120444701	5-10-84	1	3,400	<1	10	20
11A3	365416120441001	5-10-84	<1	9,900	<1	58	--
13A	363607120163901	5-15-84	3	6,900	<1	9	<5
13C	364125120210301	5- 8-84	1	10,000	<1	32	<20
13D1	363759120230801	5-10-84	5	37,000	<1	70	--
13D2A	363755120210301	5-20-84	4	100,000	<1	150	17
13D3	363845120220401	5-10-84	2	120,000	<1	60	23
13E3	363848120241701	5-10-84	3	14,000	<1	2	16
13F1	363614120231401	5-17-84	2	17,000	<1	75	9
13F3	363612120210301	5-17-84	2	15,000	<1	58	9
13F4	363612120263101	5-18-84	1	1,600	<1	<1	<5
14A1	362726120144801	5-18-84	2	950	<1	38	1
14A2	362730120123701	5-18-84	2	12,000	<1	4	2
14A4	363152120122001	5-17-84	1	29,000	<1	10	3
14A6	362731120092101	5-17-84	2	1,500	<1	12	3
14A3S	362916120111401	5-17-84	2	2,300	<1	4	<15
14B1	363237120221101	5-16-84	2	5,800	<1	<1	<5
14B2	363243120210201	5-15-84	1	720	<1	<1	3
14B3	363335120185101	5-15-84	2	4,000	<1	6	2
14B4	363427120170401	5-15-84	<1	14,000	<1	40	<5
14C	363424120213901	5-16-84	3	5,500	<1	7	8
14C1	363428120220701	5-14-84	12	13,000	<1	2	7
14C2	363430120222081	5-16-84	4	5,700	<1	20	5
14D1	363242120164601	5-16-84	2	470	<1	20	<5
14D2	363007120132601	5-17-84	2	3,900	<1	70	2
16A1	362310120061501	5-17-84	2	8,600	<1	60	<10
16A2	362312120061001	5-17-84	4	2,400	<1	40	<5
16A3	362546120050701	5-17-84	2	1,100	<1	1	<5
16A4	362643120061101	5-16-84	1	25,000	<1	150	2
16B1	362545120092301	5-16-84	2	930	<1	20	10
16B2	362547120104101	5-16-84	1	640	<1	10	2
16B3	362359120123901	5-15-84	1	1,300	<1	40	4
16B4	362359120113501	5-16-84	2	29,000	<1	50	4
16B5	362312120014501	5-17-84	2	180	<1	1	<5
16B6	362457120035501	5-17-84	<1	3,100	<1	33	<5
16C	362308120055401	5-19-84	1	6,000	<1	50	2
16D	362625120050501	5-19-84	2	25,000	<1	50	3

trace elements--Continued

Iron, dissolved (Fe)	Lead, dissolved (Pb)	Lithium, dissolved (Li)	Manganese, dissolved (Mn)	Mercury, dissolved (Hg)	Molybdenum, dissolved (Mo)	Selenium, dissolved (Se)	Vanadium, dissolved (V)	Zinc, dissolved (Zn)
70	<1	200	20	<0.1	35	--	20	<10
30	<1	200	20	.3	52	110	15	10
50	<1	240	150	<.1	17	15	13	<10
70	2	130	30	<.1	20	17	2	10
100	2	270	1,000	<.1	16	8	18	<10
20	<1	120	60	<.1	470	150	54	20
130	<1	100	150	1.6	62	18	19	10
20	4	140	10	<.1	26	7	3	<10
70	<1	180	20	<.1	130	110	14	10
30	<1	310	20	.1	31	490	40	10
60	<1	320	30	<.1	21	920	35	20
30	<1	240	20	<.1	4	80	6	20
50	1	140	20	<.1	2	55	19	20
30	2	120	10	.2	5	44	19	<10
40	1	70	40	<.1	7	4	3	20
50	<1	380	20	.1	25	--	79	20
80	<1	340	20	.2	49	3,800	84	20
40	<1	250	<10	.1	5	90	23	<10
80	2	180	30	<.1	4	55	17	10
90	<1	160	40	.5	4	--	24	20
60	<1	110	20	.1	200	10	11	10
80	<1	270	30	.2	100	370	40	50
140	4	200	40	<.1	160	--	40	620
210	3	200	90	<.1	5,000	3,000	150	70
220	5	390	50	.3	2,100	--	65	60
80	2	250	50	<.1	20	210	14	40
140	6	180	50	.2	1,500	<1	100	40
130	8	140	20	<.1	920	1,900	43	30
20	2	210	50	<.1	15	26	<1	50
<3	<1	81	5	<.1	30	4	4.6	33
20	<1	100	10	.1	200	330	18	10
90	<5	190	70	<.1	820	<1	36	40
15	13	63	2	<.1	11	360	7.3	17
100	<5	40	80	<.1	22	8	2	10
350	4	250	200	.2	41	59	6	20
20	1	190	10	.1	27	12	3.7	10
30	<1	190	30	<.1	6	22	4	10
30	<1	270	10	.3	200	580	32	20
20	1	100	<10	.2	25	33	24	10
60	3	250	20	<.1	49	510	24	30
130	3	150	40	.2	57	920	33	20
220	<1	90	10	<.1	13	12	1	10
30	8	200	30	<.1	13	62	7	20
60	<1	60	130	<.1	23	36	6	20
30	1	60	250	<.1	17	8	3	20
30	<1	40	30	<.1	25	2	1.0	<10
30	2	70	20	.1	80	32	19	20
11	17	49	2	<.1	7	7	1	23
5	3	38	2	<.1	13	2	3	17
<3	4	92	2	<.1	8	24	5	10
100	3	100	120	<.1	210	300	36	20
13	<1	14	20	<.1	5	<1	2	5
40	3	40	30	<.1	48	24	1	<10
30	2	80	<10	.1	22	55	27	10
50	<5	90	30	.1	270	160	26	20

TABLE 7.--Chemical analyses of

Site No.	USGS identification No.	Date of sample	Arsenic, dissolved (As)	Boron, dissolved (B)	Cadmium, dissolved (Cd)	Chromium, dissolved (Cr)	Copper, dissolved (Cu)
17A1	361518119541401	5-18-84	1	7,400	<1	41	<5
17A2	361520119551701	5-18-84	2	2,800	<1	<1	<5
17B1	362036119582901	5-19-84	2	18,000	<1	10	4
17B1A	362036119593701	5-17-84	82	1,400	1	<1	8
17B2	361950119584001	5-20-84	<1	8,100	<1	<1	1
17B2A	361943119593701	5-17-84	2	660	<1	5	9
17B3	361851119583201	5-18-84	1	9,900	<1	2	<5
17B4	361851120004001	5-18-84	1	3,200	<1	40	2
17B5	362129119593901	5-17-84	2	2,300	<1	4	15
17C	361637119520601	5-19-84	3	16,000	<1	<1	3
18A1	361121119531101	5-18-84	3	7,100	<1	4	3
18A3	361334119541301	5-19-84	1	4,400	<1	9	1
18A4	361427119541201	5-20-84	3	9,200	<1	2	6
18B1	360817119541901	5-18-84	1	19,000	<1	20	3
18B2	360908119541901	5-18-84	1	40,000	<1	20	6
18B3	360817119552301	5-18-84	<1	6,600	<1	20	3
18B4	360816119590001	5-17-84	<1	2,300	--	20	2
18B5	360722119590501	5-17-84	2	1,700	<1	47	2
18C1	361336119562501	5-20-84	2	26,000	<1	20	4
20A2	360303119572401	5-18-84	<1	14,000	<1	1	5
20A3	360448119554901	5-18-84	2	34,000	<1	40	14
20B2	360541120002501	5-20-84	<1	1,600	<1	30	2
20B3	360540119565301	5-18-84	<1	4,900	<1	40	4
20B4	360540119590301	5-19-84	2	640	<1	10	1
20B5	360449119590301	5-20-84	<1	2,900	<1	50	1

trace elements--Continued

Iron, dissolved (Fe)	Lead, dissolved (Pb)	Lithium, dissolved (Li)	Manganese, dissolved (Mn)	Mercury, dissolved (Hg)	Molybdenum, dissolved (Mo)	Selenium, dissolved (Se)	Vanadium, dissolved (V)	Zinc, dissolved (Zn)
70	4	60	10	0.1	95	26	6	10
100	5	40	50	<.1	26	2	3	50
40	4	110	80	<.1	41	170	23	30
11	<1	38	1,200	<.1	7	1	<1	25
50	<1	90	20	<.1	47	370	24	<10
12	4	41	2	<.1	12	1	3	29
110	3	110	50	<.1	20	8	17	20
50	<1	60	<10	<.1	22	11	6	<10
100	<5	40	80	<.1	22	8	2	10
80	1	50	20	<.1	330	<1	44	40
30	1	50	340	<.1	170	1	16	20
30	<1	50	10	<.1	100	6	4	10
60	3	70	150	<.1	140	1	10	20
70	3	90	30	<.1	590	<1	26	20
120	4	140	80	<.1	700	<1	53	30
100	3	70	20	<.1	83	15	6	20
60	3	60	30	<.1	15	4	3	10
<10	<1	80	<10	.1	5	17	7.6	<10
110	3	90	10	<.1	630	<1	30	30
100	6	150	80	<.1	550	<1	41	50
430	3	280	100	.1	520	90	280	90
20	<2	90	20	<.1	6	7	6	10
60	8	60	30	<.1	55	30	10	20
5	<1	32	2	<.1	11	<1	3	7
40	<1	80	<10	<.1	88	13	7	<10

TABLE 8.--Chemical analyses of trace elements for

[Data from U.S. Bureau of Reclamation. Abbreviations: USGS, U.S. Geological Survey. USGS identification No.: Unique number for each site based on the latitude and longitude of the site. First six digits are latitude, next eight digits are longitude, and final two digits are a sequence number to uniquely identify each site. Constituents are in micrograms per liter. <, actual value is less than the value shown]

Site No.	USGS identification No.	Date of sample	Arsenic, total (As)	Boron, total (B)	Cadmium, total (Cd)	Chromium, total (Cr)	Copper, total (Cu)
1A	374250121183801	3-12-84	<1	2,500	<1	44	4
		4- 2-84	<1	2,300	<1	43	5
		4-23-84	<1	2,800	<1	36	3
		5-21-84	<1	2,900	2	24	3
		6-18-84	<1	2,800	<1	36	4
1B	374645121255601	3-12-84	2	1,100	<1	3	3
		5-21-84	2	1,200	1	<2	4
		6-18-84	2	1,200	<1	3	3
2A	372605121032601	3-12-84	<1	1,400	<1	4	3
		4-23-84	<1	1,400	<1	3	3
		5-21-84	<1	1,400	1	4	2
		6-18-84	1	1,200	<1	1	6
3B	372121120590201	3-12-84	1	1,600	<1	20	3
		4-23-84	1	1,500	<1	30	6
		5-21-84	<1	1,500	<1	26	9
		6-18-84	<1	1,500	<1	28	3
4A	371339121003001	3-12-84	<1	590	<1	5	2
		5-21-84	<1	570	<1	4	1
		6-18-84	<1	620	<1	6	4
4D2	371703120565701	3-12-84	3	7,000	<1	2	3
		4-23-84	3	7,800	<1	3	2
		5-21-84	2	7,300	<1	<2	3
		6-18-84	2	7,000	<1	3	4
4F	370045120501101	3-14-84	3	8,600	<1	45	3
		4- 3-84	2	8,900	<1	48	4
		4-24-84	2	10,000	<1	52	3
		5-22-84	1	10,000	<1	52	3
4H	370532120544901	3-12-84	7	1,800	<1	12	3
		4- 2-84	8	1,800	<1	12	4
		4-24-84	9	1,900	<1	22	2
		5-21-84	9	1,800	<1	12	2
		6-19-84	8	1,900	<1	15	3
5B1	365522120463501	3-14-84	<1	6,900	<1	10	3
		4- 3-84	<1	6,800	<1	7	5
		4-27-84	<1	6,500	<1	14	15
		5-22-84	<1	7,000	<1	11	4
		6-18-84	<1	7,600	<1	13	10
6C	365901120362901	3-13-84	2	380	<1	1	2
		4- 2-84	2	350	<1	2	3
		4-24-84	2	390	<1	2	2
		5-22-84	<1	430	<1	<2	5
		6-18-84	1	390	<1	<1	4
7B1	370551120401301	3-13-84	3	320	<1	1	3
		4-24-84	2	320	<1	2	2
		5-21-84	2	330	<1	2	6
		6-18-84	1	350	<1	1	3

samples collected by the U.S. Bureau of Reclamation

Iron, total (Fe)	Lead, total (Pb)	Manganese, total (Mn)	Mercury, total (Hg)	Molybdenum, total (Mo)	Nickel, total (Ni)	Selenium, total (Se)	Silver, total (Ag)	Zinc, total (Zn)
670	<1	30	<0.1	2	6	4	<1	10
180	2	<10	<.1	2	11	5	<1	10
180	<1	10	<.1	2	6	5	<1	20
190	2	20	<.1	3	23	4	<1	<10
270	<1	20	<.1	2	<1	<1	<1	<10
30	2	120	<.1	14	<1	5	<1	<10
20	2	90	<.1	24	11	2	<1	--
40	1	110	<.1	15	1	<1	<1	30
50	11	<10	<.1	<1	3	2	<1	10
140	<1	<10	<.1	1	7	2	<1	20
60	<1	30	.9	1	30	1	<1	<10
20	18	<10	<.1	<1	9	<1	<1	20
50	<1	60	<.1	4	4	3	<1	<10
1,000	<1	1,600	.1	3	14	2	<1	10
890	<1	2,900	<.1	1	47	2	2	--
100	1	30	<.1	3	4	<1	<1	10
50	<1	10	<.1	<1	<1	<1	<1	<10
80	3	20	<.1	2	24	1	<1	20
40	2	<10	<.1	1	12	<1	<1	30
20	3	290	.1	34	16	2	<1	20
30	<1	260	<.1	35	7	1	<1	20
20	<1	240	<.1	48	14	<1	<1	30
50	<1	220	<.1	39	1	<1	<1	20
90	7	40	.5	3	5	10	<1	10
50	<1	40	.5	4	12	14	<1	20
50	<1	50	.5	4	8	13	<1	20
50	1	30	1.0	4	30	12	<1	20
10	6	260	.1	6	<1	<1	<1	<10
<10	<1	250	<.1	8	26	<1	<1	<10
60	<1	250	<.1	6	9	<2	<1	20
90	<1	290	<.1	8	32	<1	<1	10
10	<1	290	<.1	7	10	<1	<1	10
90	<1	10	<.1	3	3	310	<1	10
30	<1	20	<.1	4	11	260	<1	20
50	5	10	<.1	4	<1	270	<1	20
20	<1	20	<.1	4	8	280	<1	40
70	<1	20	<.1	4	3	200	<1	20
5,500	<1	1,400	<.1	3	<1	2	<1	<10
4,900	<1	1,500	<.1	5	<1	<1	<1	<10
4,900	<1	1,600	<.1	4	3	<1	<1	20
5,100	<2	1,500	<.1	4	69	<1	<1	30
4,800	<1	1,500	<.1	5	2	<1	<1	<10
40	<1	580	<.1	18	2	2	<1	<10
140	<1	620	<.1	20	7	<1	<1	20
150	<1	2,200	<.1	28	11	<1	<1	--
<10	<1	400	<.1	23	1	<1	<1	10

TABLE 8.--Chemical analyses of trace elements for samples

Site No.	USGS identification No.	Date of sample	Arsenic, total (As)	Boron, total (B)	Cadmium, total (Cd)	Chromium, total (Cr)	Copper, total (Cu)
8B1	365341120292501	3-13-84	<1	290	<1	1	4
		4- 3-84	<1	280	<1	3	2
		4-24-84	<1	290	<1	2	1
		5-22-84	<1	280	<1	<2	5
		6-18-84	<1	290	<1	<1	2
9A	364312120213401	3-14-84	<1	9,100	<1	24	5
		4- 6-84	<1	12,000	<1	28	4
		4-25-84	1	9,200	<1	30	3
9B	364634120221901	3-14-84	<1	8,200	<1	32	5
		4- 6-84	<1	8,000	<1	26	5
		4-24-84	<1	8,300	<1	31	3
		5-25-84	<1	10,000	<1	28	5
		6-19-84	<1	9,900	<1	24	5
9C3	365129120301401	3-13-84	1	10,000	<1	29	4
		4- 3-84	1	12,000	<1	44	5
		4-25-84	1	11,000	<1	42	3
		5-22-84	<1	10,000	<1	28	5
		6-19-84	1	11,000	<1	34	6
9E	364402120214201	4- 6-84	<1	7,800	<1	22	5
		4-25-84	<1	8,000	<1	19	4
		5-25-84	<1	7,600	1	16	6
9F	364220120213601	3-14-84	<1	8,400	<1	37	6
		4- 6-84	1	11,000	<1	30	5
		4-25-84	1	8,700	<1	31	3
		5-25-84	<1	14,000	<1	26	3
		6-19-84	<1	9,700	<1	23	3
10A	365008120320001	3-13-84	<1	6,100	<1	31	6
		4- 3-84	<1	7,000	<1	28	6
		4-27-84	<1	6,500	<1	27	3
		5-22-84	<1	6,200	1	24	5
		6-19-84	<1	6,600	<1	34	4
10B2	365101120365901	3-13-84	1	11,000	<1	40	4
		4- 3-84	<1	13,000	<1	36	6
		4-27-84	<1	13,000	<1	32	4
		5-22-84	<1	11,000	<1	40	11
		6-19-84	<1	12,000	<1	53	6
10C2	365009120391901	3-13-84	<1	8,800	<1	78	3
		4- 3-84	<1	8,900	<1	70	3
		5-22-84	<1	9,100	<1	82	3
		6-19-84	<1	9,600	<1	140	9
10E	365102120350301	3-13-84	2	48,000	<1	25	13
		4- 2-84	3	47,000	<1	25	12
		4-27-84	2	46,000	<1	22	10
		5-22-84	1	47,000	<1	24	15
		6-19-84	3	46,000	<1	13	14
11A3	365416120441001	3-14-84	<1	9,400	<1	74	2
		4- 3-84	<1	9,300	<1	60	4
		5-22-84	<1	7,100	<1	52	5

collected by the U.S. Bureau of Reclamation--Continued

Iron, total (Fe)	Lead, total (Pb)	Manganese, total (Mn)	Mercury, total (Hg)	Molybdenum, total (Mo)	Nickel, total (Ni)	Selenium, total (Se)	Silver, total (Ag)	Zinc, total (Zn)
9,300	<1	1,000	<0.1	8	4	<1	<1	10
9,200	<1	940	<.1	9	<1	<1	<1	<10
8,200	<1	1,200	<.1	7	3	<1	<1	20
8,300	<1	1,000	<.1	9	41	<1	<1	10
8,100	<1	930	<.1	8	4	<1	<1	10
100	<1	40	<.1	36	12	210	<1	20
60	<1	30	<.1	58	24	190	<1	10
210	<1	50	<.1	31	10	180	<1	20
190	1	30	<.1	23	3	200	<1	20
90	<1	20	<.1	22	23	190	<1	10
110	<1	20	.1	28	5	230	<1	20
140	<1	20	.2	46	65	240	<1	20
150	6	20	.2	43	19	190	<1	20
80	2	10	<.1	43	3	140	<1	10
30	1	20	<.1	49	47	--	<1	<10
240	<1	--	<.1	47	15	150	<1	20
40	<1	20	<.1	55	60	150	<1	20
20	<1	10	.2	47	14	150	<1	20
190	<1	30	<.1	30	22	140	<1	10
150	1	30	<.1	33	13	150	<1	20
250	<1	40	<.1	40	16	150	<1	--
90	<1	20	<.1	24	14	300	<1	20
50	<1	10	--	37	14	310	<1	10
30	<1	10	<.1	29	5	230	<1	10
70	1	20	<.1	--	23	370	<1	--
110	<1	20	<.1	31	14	330	<1	20
310	<1	<10	<.1	21	11	130	<1	10
80	2	<10	<.1	25	8	110	<1	10
80	<1	10	.1	24	10	110	<1	20
<10	<1	10	<.1	29	80	130	<1	20
50	6	<10	<.1	23	14	100	<1	20
200	<1	20	<.1	26	2	280	<1	<10
90	<1	10	<.1	33	20	520	<1	20
80	2	20	<.1	32	10	470	<1	10
580	5	20	<.1	32	59	350	<1	30
150	<1	10	<.1	29	5	310	<1	20
90	4	10	<.1	2	4	42	<1	10
60	<1	<10	<.1	2	12	48	<1	<10
820	<1	30	<.1	2	10	56	<1	--
3,300	6	70	<.1	2	21	54	<1	30
130	<1	20	<.1	35	<1	4,200	<1	20
90	<1	20	<.1	45	6	4,000	<1	20
130	<1	20	<.1	37	10	4,400	<1	40
80	<1	30	<.1	56	62	4,300	<1	30
90	<1	10	<.1	41	7	3,400	<1	20
50	<1	30	.7	5	<1	20	<1	10
10	2	30	.5	6	5	21	<1	20
<10	<1	10	.7	5	36	20	<1	40

TABLE 8.--Chemical analyses of trace elements for samples

Site No.	USGS identification No.	Date of sample	Arsenic, total (As)	Boron, total (B)	Cadmium, total (Cd)	Chromium, total (Cr)	Copper, total (Cu)
13B	363849120193201	3-14-84	2	19,000	<1	27	4
		4- 6-84	2	18,000	<1	30	5
		4-25-84	1	18,000	<1	33	4
		5-24-84	<1	13,000	<1	22	6
		6-19-84	1	20,000	<1	20	6
13C	364125120210301	3-14-84	1	15,000	<1	30	5
		4- 6-84	2	19,000	<1	36	5
		4-25-84	1	14,000	<1	29	2
		5-25-84	<1	16,000	<1	28	6
		6-19-84	<1	20,000	<1	44	5
13F	364032120203401	3-14-84	1	15,000	<1	43	7
		4- 6-84	1	12,000	<1	34	4
		4-25-84	1	11,000	<1	40	2
		5-25-84	<1	11,000	<1	36	3
		6-19-84	1	14,000	<1	30	4
13G	363940120200501	3-14-84	4	78,000	<1	74	9
		4- 6-84	3	77,000	<1	88	9
		4-25-84	3	84,000	<1	86	7
		5-24-84	2	72,000	<1	74	9
		6-19-84	3	78,000	<1	70	8
14A4	363152120122001	3-15-84	3	31,000	<1	52	17
		4- 5-84	2	28,000	<1	55	12
		4-26-84	2	29,000	<1	26	--
		5-24-84	3	29,000	<1	58	22
14B1	363237120221101	3-15-84	3	6,000	<1	25	16
		4- 5-84	2	5,700	<1	4	9
		4-27-84	2	5,600	<1	10	8
		5-24-84	2	5,200	<1	46	31
		6-19-84	3	4,900	<1	10	1
14C	363424120213901	3-16-84	2	6,000	<1	7	9
		4- 5-84	2	5,600	<1	6	11
		4-27-84	3	4,500	<1	28	18
		5-24-84	2	5,300	<1	12	11
		6-19-84	1	5,600	<1	5	9
16A4	362643120061101	3-15-84	2	21,000	<1	180	14
		4- 5-84	2	22,000	<1	260	16
		4-26-84	2	25,000	<1	240	9
		5-24-84	2	18,000	<1	240	14
		6-20-84	2	24,000	<1	240	20
16B4	362359120113501	5-24-84	3	14,000	<1	200	31
		6-20-84	<1	12,000	<1	68	6
16C	362308120055401	3-15-84	<1	6,100	<1	48	5
		4- 5-84	<1	6,100	<1	64	3
		4-26-84	1	5,100	<1	55	4
		5-24-84	<1	6,400	2	50	2
		6-20-84	<1	6,700	<1	56	3
16D	362625120050501	4- 5-84	2	27,000	<1	44	7
		4-26-84	2	21,000	<1	62	4
		5-24-84	<1	28,000	<1	42	3
		6-20-84	1	24,000	<1	40	6

collected by the U.S. Bureau of Reclamation--Continued

Iron, total (Fe)	Lead, total (Pb)	Manganese, total (Mn)	Mercury, total (Hg)	Molybdenum, total (Mo)	Nickel, total (Ni)	Selenium, total (Se)	Silver, total (Ag)	Zinc, total (Zn)
50	<1	20	<0.1	120	7	1,000	<1	30
80	4	20	<.1	160	160	860	<1	<10
120	<1	10	<.1	140	12	680	<1	20
60	3	20	.1	110	84	520	<1	30
30	3	20	<.1	190	17	620	<1	30
70	3	40	<.1	83	1	400	<1	20
70	<1	20	<.1	110	40	450	<1	10
20	<1	20	<.1	72	5	350	<1	10
60	<1	30	<.1	110	7	470	<1	40
130	<1	30	<.1	150	7	400	<1	20
90	<1	20	<.1	67	10	500	<1	20
70	1	20	<.1	57	24	490	<1	10
30	<1	20	<.1	45	7	530	<1	20
70	<1	10	<.1	74	12	510	<1	--
270	<1	20	<.1	74	20	480	<1	20
140	14	50	.1	1,400	6	1,200	<1	40
170	<1	40	.1	1,100	29	1,200	<1	50
130	<1	40	<.1	1,300	7	1,400	<1	50
80	<1	40	.2	1,400	--	--	1	50
170	<1	30	.2	1,200	12	850	<1	80
11,000	<1	220	<.1	820	37	34	<1	60
5,800	<1	170	<.1	750	84	40	<1	30
570	3	--	<.1	800	20	35	<1	30
14,000	1	280	.1	900	98	--	<1	60
5,400	2	390	.2	38	16	70	<1	50
870	3	190	<.1	42	27	50	<1	20
1,700	<1	180	.1	48	14	55	<1	80
17,000	3	510	<.1	45	110	54	<1	90
2,200	<1	300	<.1	48	42	59	<1	30
170	3	<10	<.1	37	10	440	<1	30
60	<1	10	<.1	44	38	300	<1	20
5,100	<1	110	.1	42	15	310	<1	60
60	<1	<10	<.1	54	78	560	<1	20
60	6	20	<.1	50	14	440	<1	40
11,000	<1	170	<.1	63	7	36	<1	40
13,000	4	190	<.1	72	51	38	<1	30
3,000	3	70	.1	94	18	34	<1	60
11,000	<1	170	<.1	100	67	28	<1	--
13,000	<1	210	<.1	91	52	22	<1	80
30,000	<1	520	<.1	40	880	130	<1	90
420	1	30	<.1	26	11	92	<1	50
970	3	20	<.1	19	9	60	<1	20
50	<1	<10	<.1	23	31	60	<1	<10
720	3	30	<.1	28	6	30	<1	20
130	<1	10	<.1	28	13	64	1	40
230	<1	<10	.1	26	8	58	<1	20
610	5	30	<.1	250	37	--	<1	20
80	2	20	<.1	78	12	280	<1	40
80	<1	10	<.1	240	13	130	<1	40
370	4	20	<.1	250	12	150	<1	30

TABLE 8.--Chemical analyses of trace elements for samples

Site No.	USGS identification No.	Date of sample	Arsenic, total (As)	Boron, total (B)	Cadmium, total (Cd)	Chromium, total (Cr)	Copper, total (Cu)
17B1	362036119582901	3-15-84	3	17,000	<1	30	16
		5-24-84	3	17,000	2	40	7
		6-21-84	3	19,000	<1	28	7
17C	361637119520601	3-15-84	3	35,000	<1	2	3
		4- 4-84	2	34,000	<1	2	6
		4-26-84	2	30,000	<1	8	6
		5-23-84	2	14,000	<1	9	6
		6-20-84	6	--	<1	--	10
18A1	361121119531101	3-15-84	5	7,100	<1	200	66
		4- 4-84	5	7,200	<1	240	73
		4-26-84	4	7,000	<1	42	13
		5-23-84	3	7,000	<1	48	13
		6-20-84	3	6,900	<1	23	9
18B1	360817119541901	4- 4-84	2	20,000	<1	38	13
		4-26-84	2	19,000	<1	41	8
		5-23-84	2	21,000	<1	60	18
20A1	360208119573001	3-15-84	41	4,600	<1	13	14
20A3	360448119554901	4- 4-84	3	35,000	<1	60	27
		4-25-84	4	22,000	<1	55	25
		5-23-84	3	38,000	<1	66	25
		6-20-84	5	33,000	<1	53	24
20B3	360540119565301	3-15-84	5	2,800	<1	800	410
		4- 4-84	5	3,200	<1	470	180
		4-25-84	3	4,100	<1	150	35
		6-20-84	3	6,300	<1	80	53

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Iron, total (Fe)	Lead, total (Pb)	Manganese, total (Mn)	Mercury, total (Hg)	Molybdenum, total (Mo)	Nickel, total (Ni)	Selenium, total (Se)	Silver, total (Ag)	Zinc, total (Zn)
8,500	2	170	<0.1	33	16	150	<1	40
2,800	7	90	<.1	48	47	130	1	30
320	<1	40	<.1	43	23	170	<1	30
470	4	640	<.1	1,000	10	<1	<1	50
960	<1	610	<.1	900	20	2	<1	50
930	1	340	<.1	880	12	--	<1	50
730	<1	30	<.1	270	17	<1	<1	20
3,400	<1	60	<.1	180	30	<1	1	30
6,700	38	1,600	.3	140	110	2	<1	180
56,000	16	1,400	<.1	160	280	<1	<1	130
4,600	<1	440	<.1	170	25	3	<1	30
10,000	<1	530	<.1	200	79	<1	<1	50
3,600	<1	500	<.1	190	41	<1	<1	30
5,300	<1	110	<.1	600	50	1	<1	40
3,300	<1	80	<.1	590	12	9	<1	30
12,000	2	220	<.1	750	79	<1	<1	60
2,600	2	860	<.1	620	13	29	<1	30
5,400	<1	200	<.1	490	54	120	6	100
3,200	<1	140	<.1	520	21	--	5	100
3,300	<1	130	<.1	470	38	110	6	90
1,500	<1	140	<.1	520	24	110	8	90
360,000	73	5,200	.7	25	510	10	<1	1,000
160,000	38	1,900	.4	33	500	15	<1	390
26,000	7	310	.1	26	95	19	--	80
39,000	6	510	<.1	80	120	29	<1	130