EVALUATION OF GROUND-WATER MONITORING NETWORK, SANTA CRUZ COUNTY, CALIFORNIA

By G. G. Blankenbaker and C. D. Farrar

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations

Open-File Report 81-139

Prepared in cooperation with the

SANTA CRUZ COUNTY FLOOD CONTROL

AND WATER CONSERVATION DISTRICT

April 1981

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, Secretary

GEOLOGICAL SURVEY

Doyle G. Frederick, Acting Director

For additional information write to:

District Chief
Water Resources Division
U.S. Geological Survey
345 Middlefield Rd.
Menlo Park, Calif. 94025

CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS

The inch-pound system of units is used in this report. 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	ha (hectares)
ft (feet)	0.3048	m (meters)
gal/min (gallons per minute)	0.06309	L/s (liters per second)
mi (miles)	1.609	km (kilometers)
mi^2 (square miles)	2.59	km^2 (square kilometers)

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called mean sea level. NGVD of 1929 is referred to as sea level in this report.

EVALUATION OF GROUND-WATER MONITORING NETWORK, SANTA CRUZ COUNTY, CALIFORNIA

By G. G. Blankenbaker and C. D. Farrar

ABSTRACT

The Santa Cruz County Flood Control and Water Conservation District seeks to improve the existing network of observation wells for monitoring water levels and ground-water quality in the Pajaro Valley subarea and the Aptos-Soquel, San Lorenzo, and Santa Cruz Coastal subbasins. The proposed network, consisting of 92 wells, is designed to monitor changes in storage and quality of ground water resulting from climatic changes and management-induced stresses.

Water levels would be measured semiannually, in April and September, in all wells of the proposed network. A few key wells would be measured monthly.

In addition to the currently monitored characteristics--temperature, specific conductance, pH, and chloride ion concentration--annual sampling and analysis for major ions and nutrients is proposed. The network would also include sampling and analysis for trace elements once every 4 years.

More frequent analyses are proposed in areas where water-quality problems are known to exist or where potential water-quality problems are recognized. Analyses for major ions, nutrients, and trace elements are included in the proposed network to provide baseline data for monitoring long-term changes in water quality and to detect any unexpected changes in quality.

INTRODUCTION

Most of the water used in Santa Cruz County (fig. 1), which includes part of the Pajaro Valley subarea (pl. 1), the Aptos-Soquel and the San Lorenzo subbasins, and part of the Santa Cruz Coastal subbasin (pl. 2), is supplied by ground water. The Santa Cruz County Flood Control and Water Conservation District is responsible for the management and protection of the ground-water resources in the county. To fulfill that responsibility, the district has recognized the need to maintain an efficient and effective ground-water-level and ground-water-quality monitoring program that covers the entire county.

Several agencies have been measuring ground-water levels and collecting ground-water samples in the county for a number of years. The U.S. Geological Survey, in cooperation with the Santa Cruz County Flood Control and Water Conservation District, undertook a study to evaluate the current ground-water monitoring network and to suggest changes that would improve the network. The network proposed in this report is designed to monitor changes in ground-water storage and quality resulting from climatic changes and management-induced stresses, including pumping, induced recharge, and waste-disposal practices.

Previous Investigations and Acknowledgments

Reports describing the water resources of parts of Santa Cruz County include: Aptos-Soquel area by Hickey (1969); Scotts Valley area by Akers (1968); Pajaro Valley area by Muir (1972 and 1974); Monterey Bay region by Muir (1977); western Santa Cruz County by Akers and Jackson (1977); and north-central Santa Cruz County by Johnson (1980).

The cooperation of the following agencies in supplying information relevant to the completion of this report is gratefully acknowledged: California Department of Water Resources, Central Santa Cruz County Water District, Citizens Utilities of Felton, City of Santa Cruz, City of Watsonville, Forest Lakes Mutual Water Company, Lompico County Water District, Monterey County Flood Control and Water Conservation District, San Lorenzo County Water District, Santa Cruz County Community Resources Agency, Santa Cruz County Flood Control and Water Conservation District, Scotts Valley County Water District, and Soquel Creek County Water District.

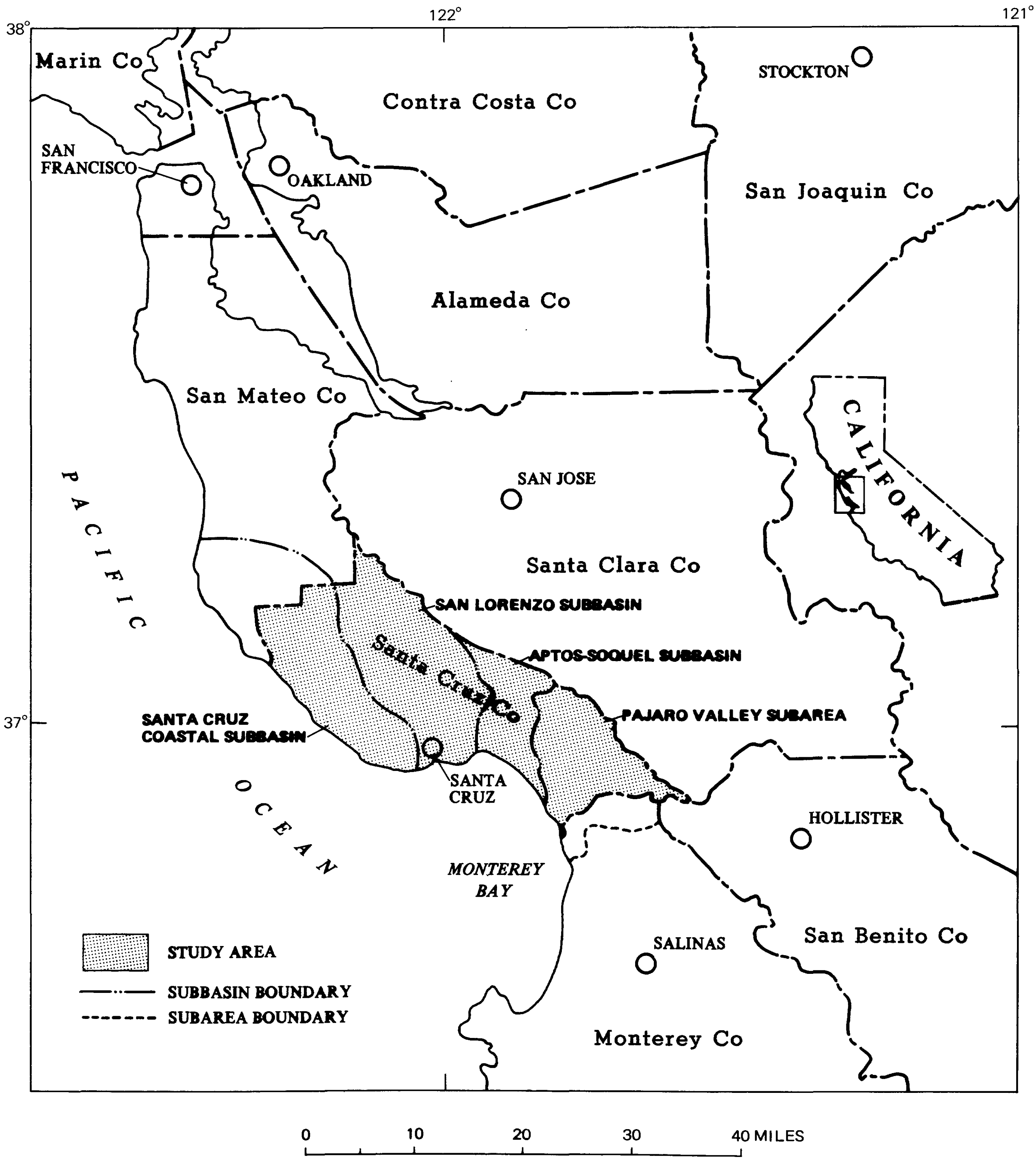
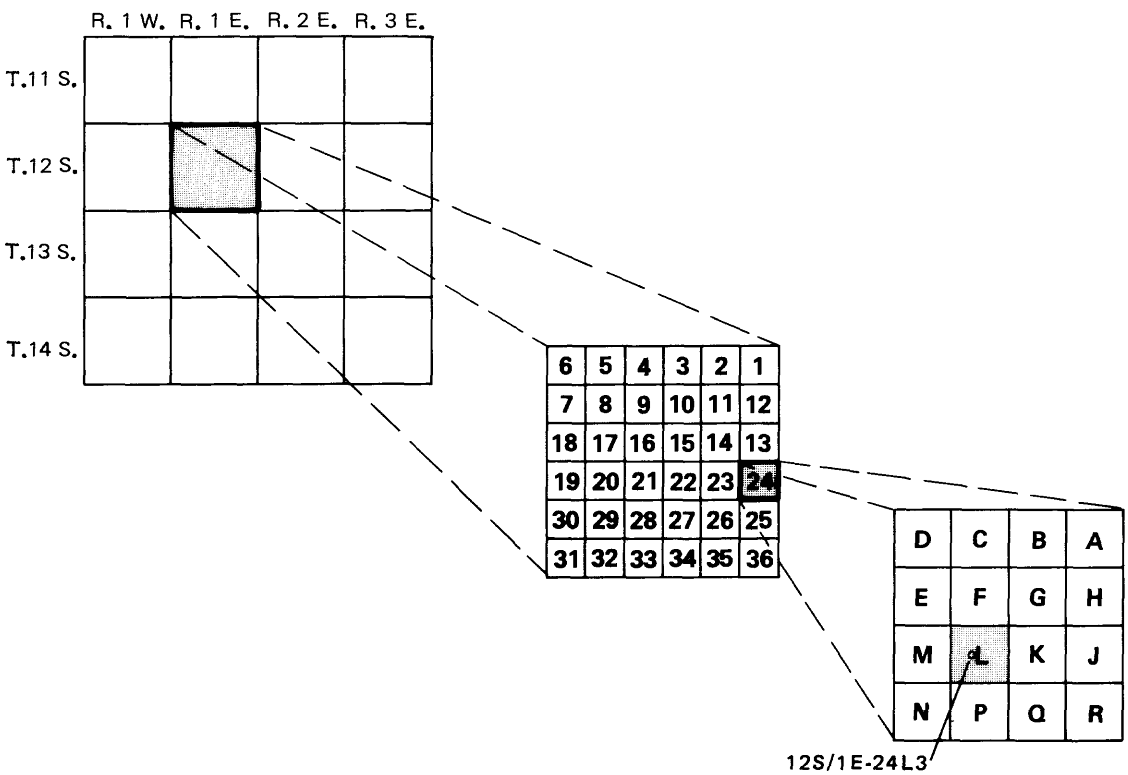


FIGURE 1.--Location of study area.

Well-Numbering System

Wells are numbered according to their location in the rectangular system for subdivision of public lands. For example, the number 12S/1E-24L3 is assigned to a well in Pajaro Valley (see diagram). The part of the number preceding the slash indicates the township (T. 12 S.); the part following the slash indicates the range (R. 1 E.); the number following the hyphen indicates the section (sec. 24); the letter following the section number indicates the 40-acre subdivision; and the final digit is a serial number for wells in each 40-acre subdivision. All wells mentioned in this report are referenced to the Mount Diablo baseline and meridian.



CONSIDERATIONS IN DESIGNING A GROUND-WATER MONITORING NETWORK

The basic purpose in designing a ground-water monitoring network is to provide hydrologic data needed for planning, managing, and administering ground-water development and conservation. A properly designed network will provide, in the most economical and timely manner, data that can be used to identify changes in the quantity and quality of the ground water in a basin caused by both natural and management-induced changes. These changes can be identified by measuring ground-water levels to monitor changes in storage and by analyzing water samples to monitor changes in the chemical quality of the water.

To determine changes in ground-water storage, a network of water-level observation wells is necessary. Basinwide changes in ground-water storage can be assessed by studying water-level fluctuations in a network of properly distributed observation wells.

Observation wells that meet specified criteria as to depth and perforated interval assure that representative water levels are obtained. If well depths and perforated intervals are known, water levels can be related to a specific aquifer. Wells having multiple screens that draw water from several aquifers are not as useful as those having only one screened interval. Wells that reflect local water-level anomalies in the aquifer (such as a local pumping depression) are not as useful as those representative of the level outside the anomalous areas.

The amount of ground water in storage in a particular aquifer is affected by seasonal variations such as natural winter and spring recharge, artificial recharge, spring and summer pumping for agriculture, and natural flow into the basin. Monthly measurements of water levels in a well for a period of at least 1 year will indicate the seasonal fluctuations in ground-water storage. Hydrographs (plots of water levels versus time) available for wells measured monthly in Santa Cruz County indicate that the highest ground-water level (and greatest amount of storage) for a given year usually occurs in the late winter or early spring (February to April) and the lowest occurs in late summer or early autumn (August to October). Therefore, definition of yearly changes in storage would require water-level measurements at least twice a year (for example, March and September) to determine the approximate high and low water levels for that year. Timing of these measurements is critical to meaningful estimates of yearly storage changes.

Monthly water-level measurements in a few key wells could provide additional detail regarding seasonal fluctuations in water levels and storage. Water-level measurements in wells along the coast could provide information on the relation of aquifer water levels to sea level, for assessment of the potential for seawater intrusion.

The first goal of water-quality network design is to identify the existing water types from past water-quality analyses or from analyses of a representative number of samples when the network is established. Once the water types and potential water-quality problems are known, the subsequent sampling scheme can be tailored to monitor for only the constituents that are relevant. For example, an area known to be affected or potentially affected by seawater intrusion might be sampled specifically for chlorides.

Observation wells selected to monitor water quality will be most useful if they conform to the same criteria as those established for water-level wells and have a sampling point in the distribution system as close to the well as possible. Best results are obtained by sampling while the well is being pumped and before anything is added to the water (chlorine, fertilizer, or other materials). Analyses of samples from holding tanks or pressure tanks are not reliable, since the chemistry of water is likely to change during its exposure to the atmosphere or tank prior to sampling. Samples taken when water levels are lowest usually are the most informative in defining the chemical quality because the maximum advance of any contaminants toward the well usually occurs when water levels are lowest.

The frequency of water-quality sampling required depends on the kinds of problems or potential problems that exist. If there are no special problems and the goal is to monitor gradual changes, then an analysis once a year will suffice. Special problems, such as seawater intrusion, require more frequent sampling so that the rate of change can be closely monitored.

EVALUATION OF EXISTING NETWORK AND PROPOSED CHANGES

Many of the wells in the existing network have incomplete construction records; that is, information regarding well depth, depth to perforations, seals, construction method, and lithologic or drillers' logs is not available. Water-level data collected in the past have shown that water levels at any given locality vary, depending on the aquifer supplying water to the well. Because the head varies among aquifers, water-level data are meaningful only if the corresponding aquifers can be identified.

The proposed well network would eliminate most of the current network wells for which construction information is inadequate to determine the aquifer. A well with incomplete construction information would be retained only if no suitable replacement well could be located.

In the proposed network, water levels would be measured semiannually or, in a few key wells, monthly. Semiannual water-level measurements made in March and September would provide data sufficient to determine changes in ground-water storage. Monthly measurements are proposed in a few key wells to provide information on the length of time that water levels remain low or high. In addition, monthly water-level measurements are proposed in areas known to have potential water-quality problems, such as seawater intrusion, landfill leaching, and infiltration of poor-quality surface water.

Water-quality data collected under the current ground-water monitoring program are adequate to monitor seawater intrusion but not to monitor water-quality problems that may exist in other parts of the county.

In the proposed observation-well network, water-quality data collection would include annual sampling and analysis for major ions and nutrients as well as the currently monitored characteristics--temperature, specific conductance, pH, and chlorides. The proposed network would also include sampling and analysis for trace elements at least once every 4 years. More frequent analyses are proposed in areas where water-quality problems are known to exist or might occur.

Analyses for major ions, nutrients, and trace elements are included in the proposed network to provide baseline data for monitoring long-term changes in water quality and to provide a means to reveal any unexpected change in quality.

In the proposed network, the inclusion of analysis for dissolved organic carbon at selected sites is intended to detect contamination of native ground water by pesticides used in agricultural areas and by lubricants, pesticides, and other manmade products disposed of in landfill sites. In addition, samples collected from wells located near and downgradient from sanitary landfill sites would be analyzed for bacteria.

Water level and water-quality data collected by various water districts, municipalities, the County Community Resources Agency, and others were taken into consideration in designing the proposed ground-water monitoring network, as outlined in the following sections of this report. If the data are collected by these agencies on a regular basis (at least annually), they could be used to complement the Santa Cruz County Flood Control and Water Conservation District's proposed network.

PAJARO VALLEY SUBAREA

Location and General Features

The Pajaro Valley subarea covers approximately 120 mi^2 in southern Santa Cruz County and northern Monterey County (pl. 1). Approximately 80 percent of the subarea is north of the Pajaro River, which forms the boundary between Santa Cruz and Monterey Counties. The Pajaro Valley subarea is bordered on the west by the Pacific Ocean, on the east by the Santa Cruz Mountains, and on the north by the Aptos-Soquel subbasin. The subarea is the major agricultural center in the county and is heavily dependent on ground water.

The Monterey County Flood Control and Water Conservation District monitors water levels and water quality in observation wells in the Monterey County part of the subarea. The location and specifications of these observation wells were considered in the Santa Cruz County network evaluation.

Hydrogeology

The aquifers in the subarea are the Tertiary Purisima Formation, the Quaternary Aromas Sand, terrace deposits, and alluvium. The subarea receives ground-water recharge from precipitation, seepage from the Pajaro River, underflow from the Aptos-Soquel subbasin, and return irrigation water (Muir, 1972). Seawater intrusion is a problem in coastal areas.

Water-Quality Problems

As a result of excessive ground-water pumping during the past 25 to 35 years (Muir, 1974), the area near the mouth of the Pajaro River is being intruded by seawater. The southeast part of the subarea receives recharge water of poor quality from the Pajaro River and from return irrigation water. A sanitary landfill west of Watsonville (pl. 1) is a potential source of pollution from leachates.

Ground-Water Monitoring Network

The wells currently measured and sampled in the Pajaro Valley subarea are shown in table 1. Water levels in these wells are measured on either a monthly or triannual basis, and the water is sampled and analyzed with the same frequency for specific conductance, pH, temperature, and chlorides.

The proposed monitoring network consists of 69 wells (table 2 and pl. 1). Careful consideration was given to selecting wells that would provide representative water-level data for both areal and individual aquifer coverage.

TABLE 1. - Wells currently measured and sampled by Santa Cruz County Flood Control and Water Conservation District in Pajaro Valley Subarea

[Frequency: M, monthly; T, triannually]

Well No.	Water-level measurement frequency	Water-quality sample frequency[1]	Well No.	Water-level measurement frequency	Water-quality sample frequency[1]
11S/1E-11H1	T	--	12S/1E-1R1	M	M
11J1	T	T	2N1	T	T
11L1	T	T	2Q1	--	M
13A2	M	--	3B1	--	T
14R1	T	T	3E1	T	T
24A1	T	T	3H1	M	--
24H3	T	T	3H2	--	M
24J1	M	M	3K1	M	M
24Q2	T	T	10B1	T	T
36G1	T	--	11A2	M	M
11S/2E-15M3	T	T	11C1	T	T
17B1	M	M	11M2	--	M
17J1	T	T	11M3	M	M
17P1	M	M	11Q1	M	M
19N3	M	M	12E1	T	T
20H1	T	T	13R1	M	M
21R1	T	T	14D1	M	M
22M1	T	T	23R1	--	M
23F1	M	--	24G1	M	M
23N2	T	T	24L1	M	M
25E4	M	M	24L3	M	M
26K1	T	T	24N1	M	M
26R2	T	T	24Q1	T	T
27A1	T	T	25B1	M	--
27C1	T	T	25B3	M	M
28C2	T	T	25F1	M	M
28F1	T	T	25G1	M	M
28K1	T	--	12S/2E-2H3	T	T
28Q1	T	--	2L1	T	T
29F2	M	M	3A2	M	M
29J1	T	T	5N1	T	T
31J1	T	--	6D2	M	M
31P3	T	T	6E2	T	T
32L1	T	--	6P1	T	--
33A4	M	M	8F1	T	--
33C1	T	--	8G3	T	T
33E1	T	T	8K2	M	M
34A1	T	T	8K3	T	T
34D2	T	T	18D1	M	M
34K1	M	M	18K3	T	T
35H2	T	T	18L1	T	--
36F1	T	T	12S/3E-6A1	T	T
36M1	M	M	6N2	M	M
36M3	T	T	7B1	T	T
12S/1E-1C2	M	M	9F2	M	M
1L1	T	T			

[1]Analyzed for chloride, temperature, pH and specific conductance.

TABLE 2. - Wells proposed and monitoring type and sampling schedules for Santa Cruz County Flood Control and Water Conservation District network in Pajaro Valley subarea

[Monitoring schedule: M, monthly; S, semiannual (March and September); A, annual (September); B, once every 4 years (September). Reason for monitoring: L, long-term evaluation; C, seawater intrusion; R, Pajaro River water and return irrigation water; F, sanitary landfill]

Site location and description				Monitoring type and schedules								
Well No. (pl. 1)	Well depth (feet)	Casing openings (feet below land surface)	Aquifer	Water level	Major ions[1]	Specific conductance, pH, and temperature[2]	Chloride	Nutrients[3]	Trace elements[4]	Dissolved organic carbon	Bacteria[5]	Reason for monitoring
11S/1E- 1G1	350	--	Purisima	S	A	A	A	A	B	--	--	L
11J1	400	350-400	Aromas	S	A	A	A	A	B	--	--	L
11L1	180	112-180	Alluvium	S	A	A	A	A	B	--	--	L
13A2	300	240-300	Aromas	S	A	A	A	A	B	--	--	L
14R1	90	6-90	Alluvium	S	A	A	A	A	B	--	--	L
24A1	200	176-200	--do--	M	A	M	A	A	B	--	--	L
24Q2	230	160-230	Aromas	S	A	A	A	A	B	--	--	L
28R1[6]	355	345-355	--do--	M	A	M	A	A	B	--	--	L
28R2[6]	290	250-290	--do--	M	A	M	A	A	B	--	--	L
34P2	205	50-205	--do--	S	A	S	S	A	B	--	--	L,C
36G1	95	55-95	Alluvium	S	A	A	A	A	B	--	--	L
11S/2E-15M3	308	278-308	Purisima	S	A	A	A	A	B	--	--	L
17J1	250	218-250	Aromas	S	A	A	A	A	B	--	--	L
17P1	200	--	--do--	S	A	A	A	A	B	--	--	L
20H1	75	--	Terrace	S	A	A	A	A	B	--	--	L
21R1	174	--	Alluvium	S	A	A	A	A	B	--	--	L
23F1	300	230-300	Purisima	S	A	A	A	A	B	--	--	L
25E4	377	317-377	--do--	S	A	A	A	A	B	--	--	L
26K1	297	--	Terrace	S	A	A	A	A	B	--	--	L
26R2	191	141-191	--do--	M	A	M	A	A	A	A	--	L,R
27A1	250	--	--do--	S	A	A	A	A	B	--	--	L
28F1	265	--	Aromas	S	A	A	A	A	B	--	--	L
29F2	656	236-656	--do--	S	A	A	A	A	B	--	--	L
31P3	195	136-195	Terrace	S	A	A	A	A	B	--	--	L
32L1	20	--	--do--	S	A	A	A	A	B	--	--	L
33C1	125	--	Alluvium	S	A	A	A	A	B	--	--	L
33E1	240	--	Aromas	S	A	A	A	A	B	--	--	L
34A1	160	--	Terrace	S	A	A	A	A	B	--	--	L
34D2	177	--	Alluvium	S	A	A	A	A	B	--	--	L
34K1	240	188-240	--do--	S	A	A	A	A	B	--	--	L
35H2	180	--	Terrace	S	A	A	A	A	B	--	--	L
36M1	160	--	Alluvium	S	A	A	A	A	A	A	--	L,R

12S/1E-	1C2	240	184-240	Aromas	S	A	A	A	A	B	--	--	L
	1L1	220	140-216	Terrace, Aromas.	S	A	S	S	S	A	S	S	L,F
	2D1	396	289-388	Aromas	S	A	S	S	A	B	--	--	L,C
	2Q1	461	110-461	--do--	S	A	S	S	A	B	A	--	L,C,F
	3B1	256	196-256	--do--	S	A	S	S	A	B	--	--	L,C
	3E1	340	--	--do--	S	A	S	S	A	B	--	--	L,C
	3K1	270	180-260	--do--	M	A	M	M	A	B	--	--	L,C
	10B1	--	--	--	M	A	M	M	A	B	--	--	L,C
	11K1	495	254-495	Aromas	S	A	S	S	A	B	--	--	L,C
	11Q1	201	140-201	--do--	S	A	S	S	A	B	--	--	L,C
	12E1	--	--	--do--	S	A	A	A	A	A	A	--	L,F
	13R1	370	--	--do--	S	A	S	S	A	B	--	--	L,C
	14D1	232	164-224	--do--	S	A	S	S	A	B	--	--	L,C
	23R1	300	--	--do--	M	A	M	M	A	B	--	--	L,C
	24G1	200	--	Alluvium	M	A	M	M	A	B	--	--	L,C
	24L1	163	147-163	--do--	S	A	S	S	A	B	--	--	L,C
	24L3	196	120-196	--do--	S	A	S	S	A	B	--	--	L,C
	24N1	675	535-675	Aromas	M	A	M	M	A	B	--	--	L,C
	24Q1	557	--	--do--	M	A	M	M	A	B	--	--	L,C
	25B1	168	135-168	Alluvium	S	--	--	--	--	--	--	--	L,C
	25B3	580	495-580	Aromas	S	A	S	S	A	B	--	--	L,C
	25F1	604	400-604	--do--	S	A	S	S	A	B	--	--	L,C
	25G1	604	--	--do--	M	A	M	M	A	B	--	--	L,C
12S/2E-	2H3	--	--	--	S	A	A	A	A	A	A	--	L,R
	2L1	--	--	--	S	A	A	A	A	A	A	--	L,R
	3A2	200	160-200	Alluvium	S	A	A	A	A	B	--	--	L
	3E1	206	--	--do--	M	A	M	A	A	A	A	--	L,R
	5N1	60	--	--do--	S	A	A	A	A	B	--	--	L
	6P1	--	--	Terrace	S	A	A	A	A	B	--	--	L
	8K2	168	--	Alluvium	S	A	A	A	A	B	--	--	L
	9C2	177	103-147	--do--	S	A	A	A	A	B	--	--	L
	18D1	135	90-135	--do--	S	A	A	A	A	B	--	--	L
	18K3	155	137-155	--do--	S	A	A	A	A	A	A	--	L,R
	19E2	138	--	--do--	M	A	M	M	A	B	--	--	L,C
12S/3E-	6N2	123	--	--do--	M	A	M	A	A	A	A	--	L,R
	7B1	145	--	--do--	S	A	A	A	A	A	A	--	L,R
	9F2	108	--	Terrace	S	A	A	A	A	A	A	--	L,R

[1]Dissolved calcium, iron, magnesium, manganese, potassium, silica, sodium, boron, fluoride, sulfate, bicarbonate, alkalinity, dissolved solids.

[2]Field determinations of specific conductance, pH, and temperature.

[3]Dissolved nitrate plus nitrite as nitrogen, and orthophosphate.

[4]Dissolved arsenic, cadmium, chromium, copper, cyanide, lead, mercury, zinc.

[5]Fecal coliform and fecal streptococcus.

[6]Water level measured monthly and samples (collected in autumn) analyzed for major ions including chloride, nitrate plus nitrite as nitrogen and specific conductance by Soquel Creek County Water District.

APTOS-SOQUEL SUBBASIN

Location and General Features

The Aptos-Soquel subbasin (pl. 2) covers approximately 77 mi^2 between the San Lorenzo subbasin and the Pajaro Valley subarea. Mountains in the north gradually give way to rolling hills toward the south. The subbasin is bordered by prominent marine terraces along the coast. Wells supply most of the water used in this subbasin. The major uses are domestic, agricultural, and light industrial.

Hydrogeology

The major aquifers in the subbasin are the Purisima Formation, the Aromas Sand, terrace deposits, and alluvium. Most ground-water development in this subbasin has occurred in the coastal area south of the Zayante fault (pl. 2), which trends northwesterly across the area. The area north of the fault has had little ground-water development because of the small quantity of water yielded by the geologic formations and because of the excessive depth to the more productive aquifers (Johnson, 1980).

Water-Quality Problems

Seawater has intruded one area of the Aptos-Soquel subbasin. A recent investigation of this problem (Muir, 1980) concluded that the area of seawater intrusion is limited to about 1 mi^2 of coastal land near Capitola and that only the first 100 ft below sea level has been affected. Locally, hardness, iron, and manganese concentrations are excessive in the ground water, and there is a potential problem of local contamination from malfunctioning septic tanks.

Ground-Water Monitoring Network

The current Santa Cruz County Flood Control and Water Conservation District network does not include any wells in the Aptos-Soquel subbasin. Because the subbasin, especially the southern part, is heavily dependent on ground water, changes in ground-water storage that may, in turn, cause changes in water quality are likely to occur.

The proposed network consists of 23 wells, all of which are located in the southern part of the subbasin (table 3 and pl. 2). No wells were selected in the northern part, where there is little ground-water development and the potential for change in water quality is slight. Some of the wells selected for the network in this subbasin are owned, measured, and sampled by the Soquel Creek County Water District and the city of Santa Cruz; the California Department of Water Resources monitors water levels in two wells.

Data collected by these agencies could be obtained on an annual basis and added to the Santa Cruz County Flood Control and Water Conservation District data base.

TABLE 3. - Wells proposed and monitoring type and sampling schedules for Santa Cruz County Flood Control and Water Conservation District network in Aptos-Soquel subbasin

[Monitoring schedule: M, monthly; S, semiannual (March and September); A, annual (September); B, once every 4 years (September). Reason for monitoring: L, long-term evaluation; C, seawater intrusion]

Site location and description				Monitoring type and schedules						
Well No. (pl. 2)	Well depth (feet)	Casing openings (feet below land surface)	Aquifer	Water level	Major ions[1]	Specific conductance, pH, and temperature[2]	Chloride	Nutrients[3]	Trace elements[4]	Reason for monitoring
10S/1W-35L1	340	--	Purisima	S	A	A	A	A	B	L
11S/1W- 9M2	110	65-105	--do--	S	A	A	A	A	B	L
10C1[5]	350	--	--do--	M	A	A	A	A	B	L
11L1[6]	628	368-628	--do--	M	A	S	S	A	B	L,C
11L2[6]	650	340-600	--do--	M	A	S	S	A	B	L,C
11L3	150	106-150	--do--	S	A	S	S	A	B	L,C
11N1[6]	398	--	--do--	M	A	S	S	A	B	L,C
11R1	220	--	--do--	M	A	M	M	A	B	L,C
12K1[6]	1020	460-1000	--do--	M	A	A	A	A	B	L
13G1[6]	330	200-330	--do--	M	A	S	S	A	B	L,C
14A2	194	--	--do--	S	--	S	S	--	--	L,C
15A1	168	100-165	--do--	M	A	M	M	A	B	L,C
15L1[6]	211	--	--do--	M	A	S	S	A	B	L,C
15L2[6]	256	184-256	--do--	M	A	S	S	A	B	L,C
16H1[5]	101	--	--do--	M	A	A	A	A	B	L
21G1[7]	125	87-125	--do--	S	A	S	S	A	B	L,C
11S/1E-17F1[6]	460	200-460	Aromas	M	A	A	A	A	B	L
18E1[6]	214	--	Purisima	M	A	S	S	A	B	L,C
18F1[6]	713	243-713	--do--	M	A	A	A	A	B	L
20E1[6]	400	194-394	--do--	M	A	S	S	A	B	L,C
20G1[6]	495	254-495	Aromas	M	A	A	A	A	B	L
28D1[6]	550	310-550	--do--	M	A	A	A	A	B	L
28M1	184	132-180	--do--	S	A	S	S	A	B	L,C

[1]Dissolved calcium, iron, magnesium, manganese, potassium, silica, sodium, boron, fluoride, sulfate, bicarbonate, alkalinity, dissolved solids.

[2]Field determinations of specific conductance, pH, and temperature.

[3]Dissolved nitrate plus nitrite as nitrogen and orthophosphate.

[4]Dissolved arsenic, cadmium, chromium, copper, cyanide, lead, mercury, zinc.

[5]Water level measured monthly by California Department of Water Resources.

[6]Water level measured monthly and samples (collected in autumn) analyzed for major ions including chloride, nitrate plus nitrite as nitrogen, and pH and specific conductance by Soquel Creek County Water District.

[7]Water level measured and samples analyzed periodically by City of Santa Cruz.

SAN LORENZO SUBBASIN

Location and General Features

The San Lorenzo subbasin (pl. 2) covers approximately 140 mi^2 north and northwest of Santa Cruz. Most of the area is densely forested, mountainous terrain. Ground water in this subbasin is used primarily for domestic supply and light industry.

Hydrogeology

The principal aquifers in this subbasin are granitic rock, the Santa Margarita Sandstone, the Lompico Sandstone, and alluvium. The granitic rock yields about 10 gal/min of water to wells only where it is extensively fractured or deeply weathered. A more detailed discussion of these aquifers is included in reports by Akers (1969) and Akers and Jackson (1977).

Water-Quality Problems

A large part of the ground water pumped in this subbasin is from the Santa Margarita Sandstone. A sanitary landfill east of the town of Ben Lomond is located on an outcrop of the Santa Margarita Sandstone in the aquifer's recharge area. The landfill could be a source of leachate contamination of the ground water. Other water-quality problems could result from septic-tank systems, seawater intrusion into terrace deposits and alluvium in the southern part of the subbasin, an abandoned quarry in Scotts Valley, and abandoned wildcat oil wells near Bear Creek. The abandoned quarry, in the Santa Margarita Sandstone, has had sewage dumped into it in the past. The oil wells are suspected of leaking water of poor quality into the aquifers in that area (Akers and Jackson, 1977).

Ground-Water Monitoring Network

The San Lorenzo subbasin is not included in the current Santa Cruz County Flood Control and Water Conservation District monitoring network. Because the subbasin has potential ground-water-quality problems, and pumping in the subbasin is increasing, especially in the Scotts Valley area, 12 wells in the San Lorenzo subbasin are included in the proposed countywide network (table 4 and pl. 2).

TABLE 4. - Wells proposed and monitoring type and sampling schedules for Santa Cruz County Flood Control and Water Conservation District network in San Lorenzo subbasin

[Monitoring schedule: M, monthly; S, semiannual (March and September); A, annual (September); B, once every 4 years (September). Reason for monitoring: L, long-term evaluation; C, seawater intrusion]

Site location and description				Monitoring type and schedules						
Well No. (pl. 2)	Well depth (feet)	Casing openings (feet below land surface)	Aquifer	Water level	Major ions[1]	Specific conductance, pH, and temperature[2]	Chloride	Nutrients[3]	Trace elements[4]	Reason for monitoring
9S/2W-30D1	85	25-85	Lompico Sandstone	S	A	A	A	A	B	L
10S/1W- 7L1	144	112-144	Santa Margarita	S	A	A	A	A	B	L
19B3	400	220-400	--do--	M	A	M	A	A	B	L
10S/2W- 3A3	400	150-400	Monterey Shale	S	A	A	A	A	B	L
9N1	400	340-400	Lompico Sandstone	S	A	A	A	A	B	L
10C3	280	180-250	Santa Margarita	S	A	A	A	A	B	L
11F1	156	126-156	--do--	S	A	A	A	A	B	L
13F1	285	159-285	--do--	S	A	A	A	A	B	L
24E1	220	48-220	--do--	M	A	M	A	A	B	L
28B1	220	--	Lompico Sandstone	S	A	A	A	A	B	L
28H2	365	165-365	Granite	S	A	A	A	A	B	L
11S/2W-12C2	117	30-100	Alluvium	M	A	M	M	A	B	L,C

[1]Dissolved calcium, iron, magnesium, manganese, potassium, silica, sodium, boron, fluoride, sulfate, bicarbonate, alkalinity, dissolved solids.
[2]Field determinations of specific conductance, pH, and temperature.
[3]Dissolved nitrate plus nitrite as nitrogen and orthophosphate.
[4]Dissolved arsenic, cadmium, chromium, copper, cyanide, lead, mercury, zinc.

A number of wells are currently being sampled for water quality and measured for water levels by several water companies and other agencies in this subbasin. Some of these wells are included in the proposed county network. The additional data collected by water companies and other agencies could be obtained on an annual basis to supplement data collected by the Flood Control and Water Conservation District.

Six observation wells have been constructed around the landfill site near Ben Lomond. A study was conducted by Emcon Associates, San Jose, Calif. (1980), to determine if leachates from the landfill are entering the ground water. Contamination from the landfill could be monitored by using data from the Emcon study and continued sampling of the same observation wells.

Insufficient information is available at this time to adequately assess the possible contamination problems associated with the abandoned quarry in Scotts Valley and the abandoned wildcat oil wells near Bear Creek. Because defining water quality and sources of pollutants in these two areas would require intensive study and perhaps the drilling of test wells, they are not dealt with in the design of this network.

SANTA CRUZ COASTAL SUBBASIN

Location and General Features

The Santa Cruz Coastal subbasin (pl. 2) covers about 150 mi^2 northwest of Santa Cruz, approximately one-third of which is in San Mateo County.

The coastal subbasin is characterized by heavily forested, mountainous terrain except along most of the coast, where a marine terrace occupies a strip of land generally less than 1 mi wide.

Almost all the water used in this subbasin is ground water. Irrigation accounts for the greatest quantity used; domestic, livestock, and other uses are minor. Ground-water development north of Davenport Landing is minimal.

Hydrogeology

The major aquifers in this subbasin are the alluvium along the major creeks, the Santa Cruz Mudstone, and the Santa Margarita Sandstone. Ground water occurs locally in the weathered and fractured part of metamorphic and granitic rock on Ben Lomond Mountain (Akers and Jackson, 1977).

Water-Quality Problems

The potential ground-water quality problems in this subbasin have been identified in an earlier report (Muir, 1977) as seawater intrusion, septic-tank system effluents, saline connate water, return irrigation water, and leachates from sanitary landfills. There have also been local problems with excessive dissolved concentrations of iron, manganese, and hydrogen sulfide.

Ground-Water Monitoring Network

The Santa Cruz County Flood Control and Water Conservation District currently monitors 17 wells in this subbasin (table 5). On a monthly basis, water levels are measured, field values are determined for temperature, pH, and specific conductance, and samples are collected and analyzed for chloride.

TABLE 5. - Wells currently measured and sampled by Santa Cruz County Flood Control and Water Conservation District in Santa Cruz Coastal subbasin

Well No.	Water-level measurement (monthly)	Water-quality sample[1] (monthly)
10S/3W-19A1	X	X
-19H1	X	X
-19J1	X	X
11S/2W-18E1	X	X
-18F2	X	X
-18L1	X	X
-19A1		X
-20C1	X	X
-21C1	X	X
-21E1	X	X
-21F1	X	
-21F3	X	X
-21F4	X	X
-21H1	X	X
-22K3	X	X
-22M1		X
-27B1		X

[1]Analyzed for chloride concentration, temperature, pH, and specific conductance.

Current network wells not included in the proposed network are those for which no information on well construction is available; those not needed because they are close to another monitor well; and those that no longer have access for sampling or measuring water levels.

The proposed network consists of 16 wells (table 6 and pl. 2). Eleven wells are located along the coastal terrace, one well is located about 1 mi inland along Scott Creek, and four wells are located in the Bonnie Doon area. No wells were selected northwest of the mouth of Scott Creek because ground-water development is limited mainly to a few domestic supply wells in this sparsely populated area.

The city of Santa Cruz operates a landfill site about 4 mi west of Santa Cruz (pl. 2). An observation well drilled to monitor landfill leachates is located 0.7 mi south of the landfill and is sampled for water quality (chlorides, nitrates, chromium, and specific conductance) by the city of Santa Cruz. Data collected from this well could be obtained by the County Flood Control District. Additional monitoring for leachate contamination can be accomplished by sampling two wells, 11S/2W-19A1 and 20C1, located south of Highway 1.

Ground water percolating beneath the landfill is collected behind a check dam, 0.7 mi south of the landfill, and is pumped to settling and evaporation ponds on a ridge 0.5 mi southeast of the landfill. Potential seepage from these ponds cannot be adequately monitored by sampling any wells in the area. If monitoring seepage from ponds is desired, a monitoring well could be drilled south of and downstream from the ponds.

TABLE 6. - Wells proposed and monitoring type and sampling schedules for Santa Cruz County Flood Control and Water Conservation District network in Santa Cruz Coastal subbasin

[Monitoring schedule: M, monthly; S, semiannual (March and September); A, annual (September); B, once every 4 years (September). Reason for monitoring: L, long-term evaluation; C, seawater intrusion; F, sanitary landfill]

Site location and description				Monitoring type and schedules							
Well No. (pl. 2)	Well depth (feet)	Casing openings (feet below land surface)	Aquifer	Water level	Major ions[1]	Specific conductance, pH, and temperature[2]	Chloride	Nutrients[3]	Trace elements[4]	Dissolved organic carbon	Reason for monitoring
10S/3W-13G1	100	60-100	Granite	S	A	A	A	A	B	--	L
13M1	100	50- 95	Santa Margarita Sandstone	S	A	A	A	A	B	--	L
18R1	180	60-180	Santa Cruz Mudstone	S	A	A	A	A	B	--	L
19H1	110	50-110	Alluvium	S	A	S	S	A	B	--	L,C
23J1	345	50- 70 250-335	Granite	S	A	A	A	A	B	--	L
24G1	146	125-145	Santa Margarita Sandstone	S	A	A	A	A	B	--	L
33E1	--	--	--	S	A	S	S	A	B	--	L,C
11S/2W-18L1	405	50-400	Santa Cruz Mudstone	S	A	S	S	A	B	--	L,C
19A1	700	--	--do--	S	A	S	S	S	A	A	L,C,F
20C1	502	--	--do--	S	A	S	S	S	A	A	L,C,F
21E1	215	--	--do--	M	A	M	M	A	B	--	L,C
21F3	395	170-330	Santa Margarita Sandstone	M	A	M	M	A	B	--	L,C
21H1	300	180-300	--do--	S	A	S	S	A	B	--	L,C
22K3	365	125-285	Santa Cruz Mudstone	M	A	M	M	A	B	--	L,C
27B1	320	--	--do--	S	A	S	S	A	B	--	L,C
11S/3W-11J1	145	30-40	Alluvium and Santa Cruz Mudstone	S	A	S	S	A	B	--	L,C

[1]Dissolved calcium, iron, magnesium, manganese, potassium, silica, sodium, boron, fluoride, sulfate, bicarbonate, alkalinity, dissolved solids.
[2]Field determinations of specific conductance, pH, and temperature.
[3]Dissolved nitrate plus nitrite as nitrogen and orthophosphate.
[4]Dissolved arsenic, cadmium, chromium, copper, cyanide, lead, mercury, zinc.

REFERENCES CITED

Akers, J. P., 1969, Ground water in the Scotts Valley area, Santa Cruz County, California: U.S. Geological Survey open-file report, 12 p.

Akers, J. P., and Jackson, L. E., Jr., 1977, Geology and ground water in western Santa Cruz County, California, with particular emphasis on the Santa Margarita Sandstone: Menlo Park, Calif., U.S. Geological Survey Water-Resources Investigations 77-15, 7 p.

Allen, J. E., 1946, Geology of the San Juan Bautista quadrangle, California: California Division of Mines Bulletin 133, 112 p.

Emcon Associates, 1980, Hydrogeologic investigation and site development evaluation, Ben Lomond sanitary landfill, Santa Cruz County, California: report for Santa Cruz County, 21 p.

Hickey, J. J., 1968, Hydrogeologic study of the Soquel-Aptos area, Santa Cruz County, California: U.S. Geological Survey open-file report, 48 p.

Johnson, M. J., 1980, Geology and ground water in north-central Santa Cruz County, California: Menlo Park, Calif., U.S. Geological Survey Water-Resources Investigations 80-26, 33 p.

Muir, K. S., 1972, Geology and ground water of the Pajaro Valley area, Santa Cruz and Monterey Counties, California: U.S. Geological Survey open-file report, 33 p.

______1974, Seawater intrusion, ground-water pumpage, ground-water yield, and artificial recharge of the Pajaro Valley area, Santa Cruz and Monterey Counties, California: Menlo Park, Calif., U.S. Geological Survey Water-Resources Investigations 9-74, 31 p.

______1977, Initial assessment of the ground-water resources in the Monterey Bay Region, California: Menlo Park, Calif., U.S. Geological Survey Water-Resources Investigations 77-46, 33 p.

______1980, Seawater intrusion and potential yield of aquifers in the Soquel-Aptos area, Santa Cruz County, California: Menlo Park, Calif., U.S. Geological Survey Water Resources Investigations 80-84, 29 p.

GPO 790-912/1002