Chapter 4

Mineral Water Quality

4.1 Introduction

Zone 7 operates several water quality monitoring programs which collect and evaluate an extensive amount of water quality data. The focus of this effort historically has been on collecting the relevant data necessary to accurately track trends in spatial variations in groundwater quality. Water quality monitoring has primarily been concerned with general dissolved mineral (ion) composition. In general, laboratory analyses for most samples include Calcium (Ca), magnesium (Mg), Sodium (Na), Potassium (K), Bicarbonate (HCO_3), Sulfate (SO_4), Chloride (Cl), Nitrite (NO_3), Silica (SiO_2), alkalinity, boron (B), electrical conductivity (EC), pH, total dissolved solids (TDS), and hardness. In the late 1990's arsenic (As) and manganese (Mn) were added to the list of analytes. Sampling frequencies typically are monthly or quarterly for new sites, and are usually reduced to quarterly, biennially or annually for well characterized sites. Dissolved mineral data are used to track sources of water and water quality trends, as well as to calculate annual and long-term salt loading to the Main Basin.

The purpose of this chapter is to summarize historic water quality data as they relate to groundwater salt impacts, to provide a synopsis of the most significant water quality trends, and to explain how the water that Zone 7 delivers to its customers is affected by changes in local and imported water quality. Zone 7 delivered water is a combination of groundwater, imported surface water, and local surface water. The water quality of each of those components varies geographically, seasonally, and annually. Section 4.6 describes delivered water quality and the historic variability of that delivered water quality.

Section 4.7 briefly describes tertiary recycled water quality and RO recycled water quality produced by the Livermore and DSRSD treatment plants and membrane filtration/reverse osmosis (RO) facilities. Comparisons are shown between raw (untreated) and treated water and the RO recycled water.

Reference F contains extensive monitoring data prepared by Zone 7 in the form of a groundwater annual report. Data from these monitoring programs are used not only to describe historic and current water quality and quantity, as described in this chapter, but are also used to calculate current and predict future salt loading to the Main Basin. Salt loading to the Main Basin directly impacts groundwater quality, which in turn impacts Zone 7 delivered water quality. Salt loading calculations are discussed in detail in Chapter 5. Chapter 6 presents recommended extensions to current monitoring programs aimed at

tracking changes in future water quality and quantity associated with increased urban and agricultural irrigation.

4.2 Imported Water

Zone 7 currently has a maximum entitlement from the State Water Project of 80.619 TAF per year. State Water Project (SWP) water is imported from the Sacramento-San Joaquin Delta at the Banks Pumping Plant and delivered through the South Bay Aqueduct (SBA) along which Zone 7 has several turnouts. This imported surface water is then: 1) treated and delivered to M&I retailers; 2) used to artificially recharge the Main Basin aquifers; or 3) delivered as untreated water for agricultural irrigation.

The actual volume of SWP water, which Zone 7 has access to, varies annually with climatic conditions. Historically during wet years it was likely that Zone 7's full entitlement would be delivered. However, during periods of drought, deliveries may be restricted by the State to as low as 10% of entitlement. Other restrictions can, and have been imposed for environmental protection purposes. Based upon the State Department of Water Resources Simulation Model for State Water Project deliveries studies, the long-term average SWP deliveries are expected to be about 75% of maximum entitlements. When Zone 7 supply exceeds the 75% average, Zone 7 stores the excess in the groundwater basin. When Zone 7 demand exceeds the available State Project supply, Zone 7 makes up the difference by using Lake del Valle water, pumping stored groundwater, and/or requesting pumpback from Zone 7 storage in the Semitropic Groundwater Basin.

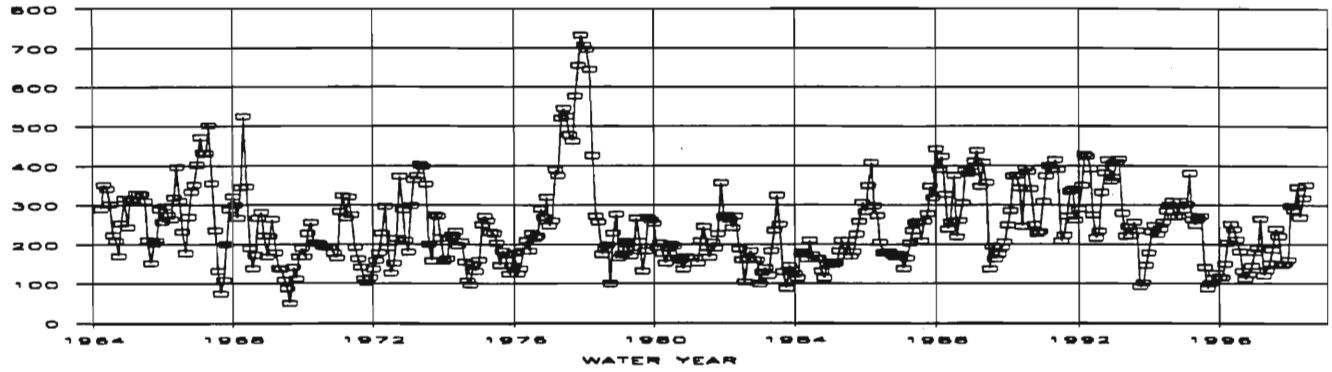
In addition to quantity, imported water quality from the State Water Project also varies. Figure 4.1 presents historic monthly average TDS and percent sodium values for South Bay Aqueduct water above and below Lake del Valle. Figure 4.1 shows that between 1962 and 1999 the historic monthly average TDS ranged from less than 100 mg/L to over 700 mg/L, that the TDS varied significantly between years, and that the TDS also commonly varied significantly between months in the same year. The percent sodium shows similar variations as did TDS between months and years. Hardness increases with the increase in TDS and decreases with the increase in the percentage of sodium.

Figure 4.2 illustrates in greater detail the variability that can be expected from SBA water. Monthly average TDS values for SBA water delivered to the Patterson Pass Water Treatment Plant and the Del Valle Water Treatment Plant for the 1993-1998 water years ranged from less than 100 mg/L to over 410 mg/L. The time period shown in Figures 4.1 and 4.2 covers typical climatic conditions ranging from very wet years to drought conditions.

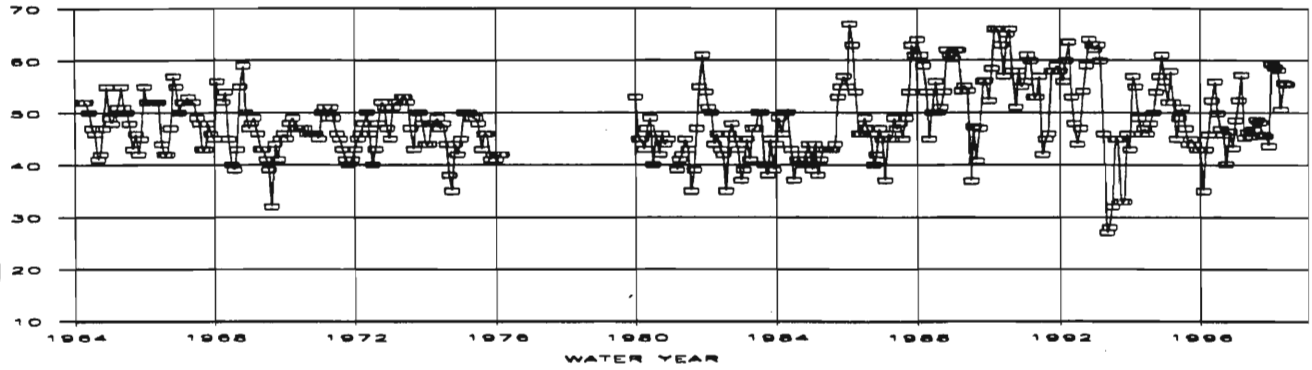
Figure 4.1

ZONE 7
WATER RESOURCES ENGINEERING
ARTIFICIAL GROUNDWATER RECHARGE WATER QUALITY
HISTORIC RECORD

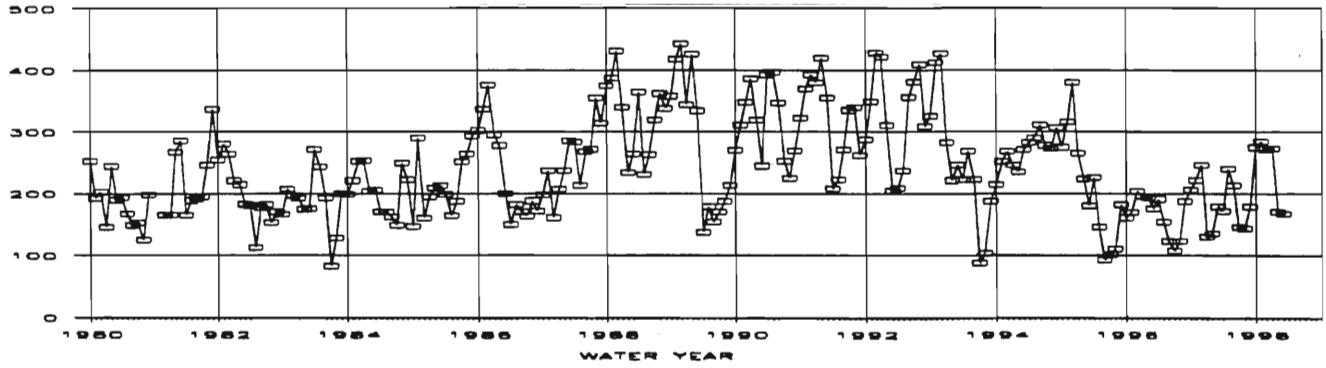
SOUTH BAY AQUEDUCT TURNOUT ABOVE LAKE DEL VALLE (PPWTP)
TOTAL DISSOLVED SOLIDS



PERCENT SODIUM



SOUTH BAY AQUEDUCT TURNOUT BELOW LAKE DEL VALLE (DVWTP) 1980 - 1995
TOTAL DISSOLVED SOLIDS



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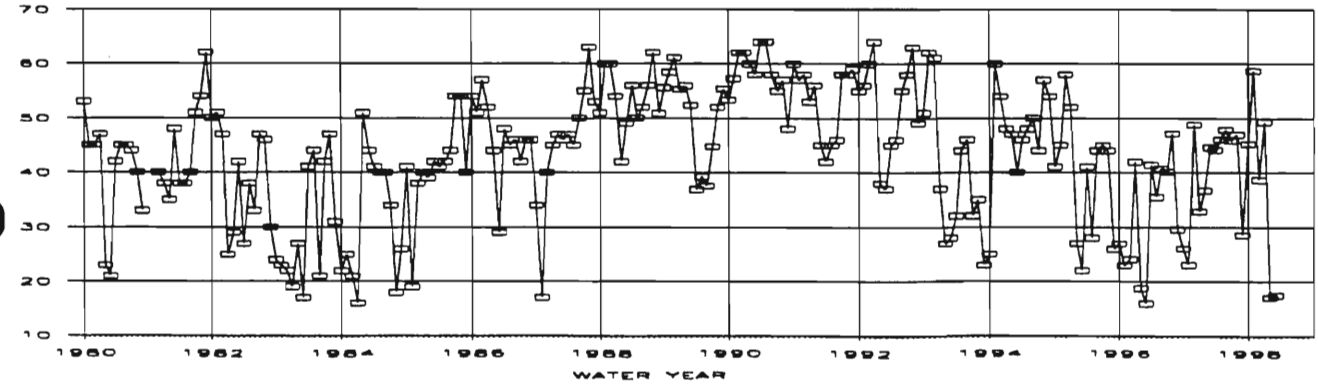
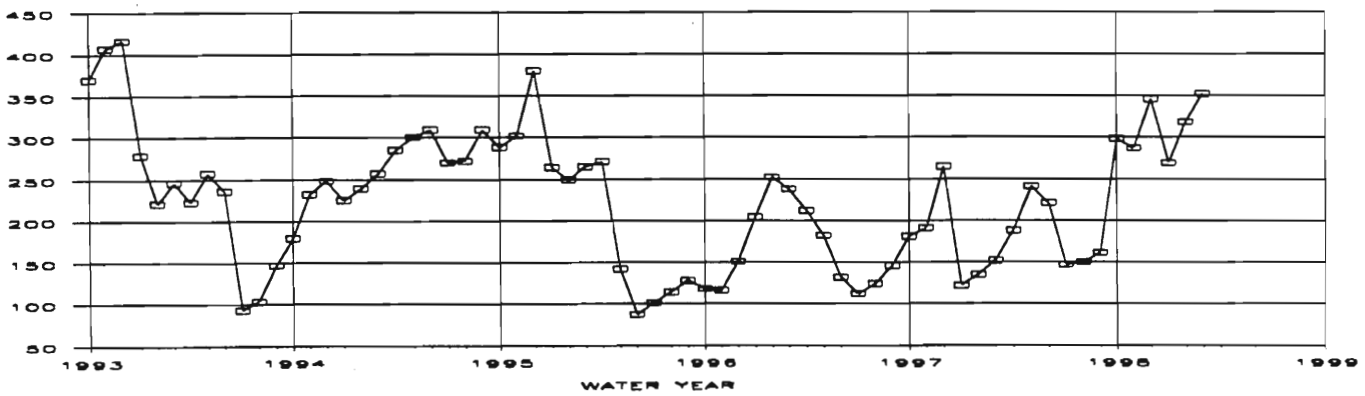


Figure 4.2

ZONE 7
WATER RESOURCES ENGINEERING
ARTIFICIAL GROUNDWATER RECHARGE WATER QUALITY
1993-1998 WATER YEARS

SOUTH BAY AQUEDUCT TURNOUT ABOVE LAKE DEL VALLE (PPWTP)
TOTAL DISSOLVED SOLIDS



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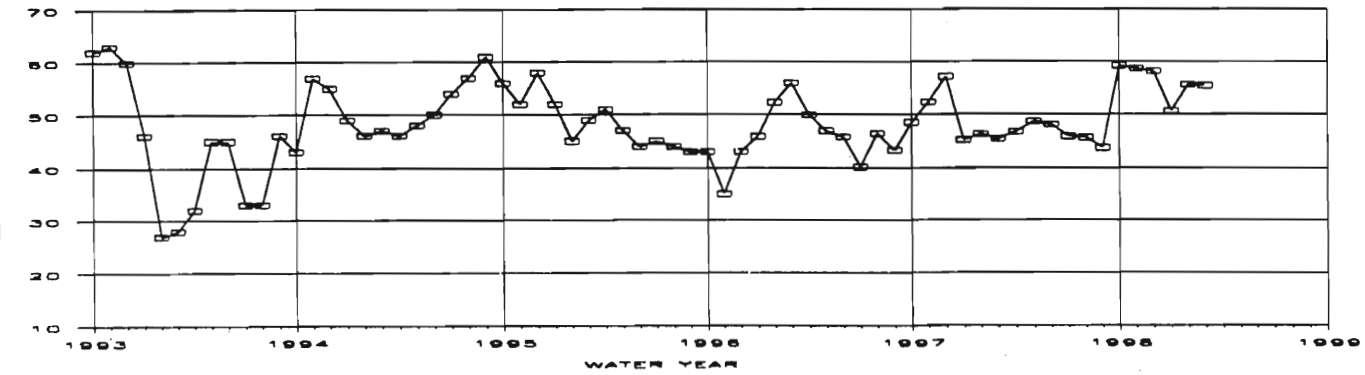
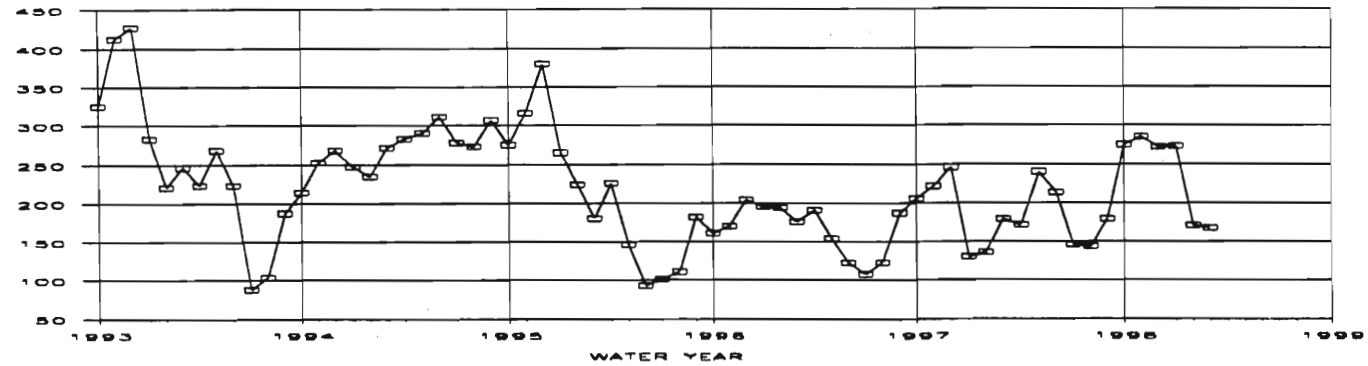


SOUTH BAY AQUEDUCT TURNOUT BELOW LAKE DEL. VALLE (DVWTP)
TOTAL DISSOLVED SOLIDS



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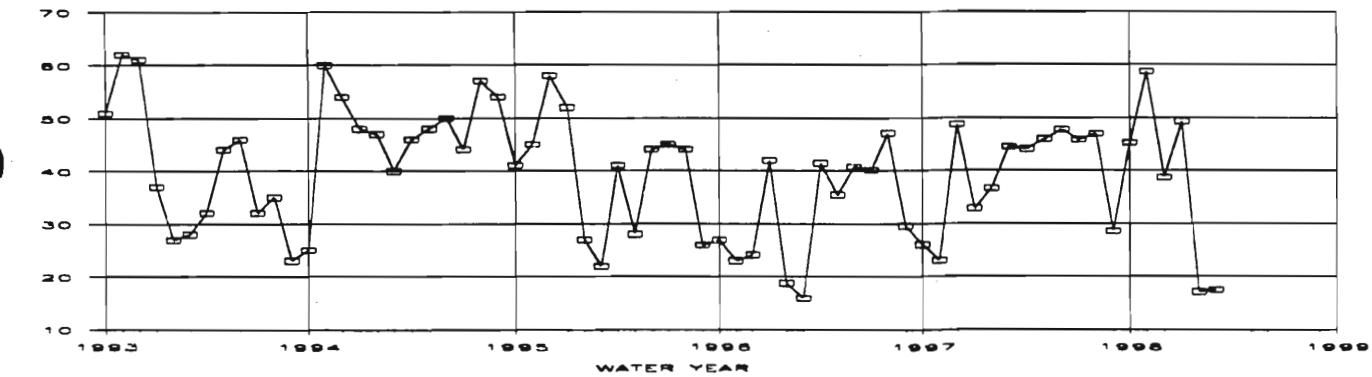

4.3 Local Surface Water

Zone 7 local surface water consists of upper Del Valle watershed runoff into Lake Del Valle, local natural runoff into four major streams (Arroyo del Valle, Arroyo Mocho, Arroyo las Positas, and Arroyo de la Laguna), water from several quarry ponds, rainfall and urban runoff, and applied irrigation water seepage and runoff. Zone 7 monitors (and in a few cases estimates) the quantity and quality of each component and uses the information to calculate the annual hydrologic inventory (groundwater recharge and pumpage), and salt accumulation in the groundwater basin. Water quality data results are the focus of this section. Additional information on specific monitoring programs is discussed in Chapter 6.

Lake del Valle

Lake del Valle is used to capture stream outflow and rainfall runoff from the upper Del Valle watershed. In addition, State Water Project (SWP) water is diverted into the reservoir by the California Department of Water Resources (DWR) for recreational use and for storage to meet seasonal peak demands on the South Bay Aqueduct (SBA). On occasion, particularly as the reservoir approaches full levels, the DWR makes flood control releases from the reservoir to the SBA and to the Arroyo Valle. Zone 7 and ACWD share the "water rights" for the natural inflow to the reservoir and can take it either through the various SBA turnouts or by direct release to the Arroyo Valle for "artificial" recharge of the groundwater basin.

The water quality in Lake del Valle is a combination of rainfall runoff and SWP water quality. The quality of flood releases is measured at the Zone 7 Del Valle Water Treatment Plant inlet or at the Arroyo Valle near Livermore (AVNL) gaging station. Average TDS concentrations of the flood releases have ranged from 130 mg/L to 240 mg/L between 1993 and 1998. The quality of the Arroyo Valle recharge releases (release from upper turnouts over 10 cfs) and the natural seepage from the lake is measured at the Arroyo Valle near Livermore gaging station. The TDS concentrations measured at this station during base flow conditions (flow less than 2 cfs) between 1992 and 1998 represent the seepage component, and have ranged from 340 mg/L to 710 mg/L.

Local Streams

Water quality in the local streams varies by reach and by season. The streams can contain one or more of the following components: 1) natural inflow, including groundwater seepage (i.e., rising groundwater); 2) imported water from SBA releases; 3) urban runoff; 4) groundwater discharges from aggregate mining operations; and occasionally 5) flood control releases from Lake del Valle. The quantity and quality of each component is monitored by Zone 7. Electrical conductivity, pH and temperature are measured monthly at stream gaging stations throughout the basin and daily at various SBA turnouts to the

Table 4.1
Zone 7 SURFACE WATER MONITORING
1997 WATER YEAR
MONTHLY CONDUCTIVITY SAMPLING
(EC in Micromhos/cm.Flow in CFS)

	ARROYO VALLE Below LANG CANYON		ARROYO VALLE Near LIVERMORE		ARROYO VALLE At PLEASANTON		ARROYO MOCHO Near LIVERMORE		ARROYO MOCHO At LIVERMORE		ARROYO MOCHO Near PLEASANTON		ARROYO LAS POSITAS At LIVERMORE		ARROYO LAS POSITAS At EL CHARRO		ARROYO DE LA LAGUNA Near PLEASANTON		DATE OF SAMPLING
	EC	FLOW	EC	FLOW	EC	FLOW	EC	FLOW	EC	FLOW	EC	FLOW	EC	FLOW	EC	FLOW	EC	FLOW	
OCT	DRY	0	680	3.5	910	12	1240	1.1	DRY	0	1020	7.1	1570	2.6	1460	1.3	1110	25.7	15-Oct-96
NOV	520	19	760	1.3	800	11.3	880	1.0	640	9.0	1100	28.7	1570	12.0	1160	18.5	630	146.0	19-Nov-96
DEC	470	41	890	2.4	780	7.5	790	2.4	DRY	0	940	27.0	2040	3.7	1890	4.2	1230	52.0	17-Dec-96
JAN	500	116	520	55	490	96.6	610	17.0	535	13.7	690	291	1140	33.7	755	68.3	650	307.0	15-Jan-97
FEB	525	64	610	3.5	650	14.8	740	9.5	785	0.4	1230	30.4	2110	8.0	1860	11.5	1140	80.0	14-Feb-97
MAR	590	29.0	740	3.9	800	9.3	860	6.4	DRY	0	1380	11.6	1870	4.2	1850	6.0	1150	54.0	19-Mar-97
APR	690	15.0	780	1.2	890	2.9	740	4.2	DRY	0	1100	12.1	1800	3.3	1750	3.3	1210	42.0	14-Apr-97
MAY	710	4.5	850	1.0	900	5.6	1010	1.2	DRY	0	1910	16.2	1620	2.3	1590	0.6	1120	37.0	19-May-97
JUN	740	1.9	870	1.0	DRY	0	1100	0.5	DRY	0	1010	16.0	1470	2.3	1570	0.3	1140	38.0	17-Jun-97
JUL	DRY	0	820	1.0	DRY	0	1180	0.2	DRY	0	990	14.0	1260	2.1	1250	0.5	1100	30.0	17-Jul-97
AUG	DRY	0	770	0.6	860	5.9	1250	0.1	DRY	0	870	18.0	1240	2.1	1420	0.4	1140	46.0	18-Aug-97
SEP	DRY	0	410	20	540	11.3	1190	0.1	DRY	0	1050	14.5	1430	2.1	1320	0.5	1230	44.0	12-Sep-97

Table 4.2
Surface Water Quality Monitoring
1997 Water Year

Station Name	DATE	Flow (cfs)	TEMP	EC	pH	Ca	Mg	Na	K	HCO3	S04	Cl	NO3	SIO2	Hardness	B	Fl	TDS
ALAMO CANAL NEAR PLEASANTON	5/19/97	5.6	28.8	1250	7.9	93	34	145	2	390	137	136	1	22	373	0.6	0.40	769
ALAMO CANAL ABOVE SOUTH SAN RAMON	5/20/97		22.5	1160	7.9													
ARROYO DE LA LAGUNA NEAR PLEASANTO	3/19/97	54.0	18.7	1150	8.0	71	44	113	3	343	112	134	5	15	358	1.1	0.30	673
ARROYO VALLE AT PLEASANTON	3/19/97	9.2	19.4	800	8.2	50	38	65	2	253	65	95	2	13	284	0.6	0.20	463
ARROYO LAS POSITAS AT LIVERMORE	3/19/97	4.2	17.1	1870	8.0	81	51	260	3	466	110	306	23	16	414	4.6	0.70	1089
ARROYO LAS POSITAS AT EL CHARRO	3/19/97	6.0	17.5	1850	8.1	72	47	262	4	434	110	284	20	19	374	4.3	0.70	1042
ARROYO MOCHO NEAR LIVERMORE	3/19/97	6.4	17.1	860	8.4	44	77	34	2	430	73	31	0	16	426	0.3	0.20	515
ARROYO MOCHO NEAR PLEASANTON	3/19/97	11.6	22.5	1380	8.4	61	48	164	3	349	95	204	11	18	351	2.4	0.40	777
DRY CREEK AT ARROYO MOCHO	5/21/97	1.0	23.2	1050	7.8													
ARROYO VALLE BELOW LANG CANYON	3/19/97	29.0	17.8	590	8.1	63	31	23	2	283	69	18	0	11	285	0.2	0.20	366
ARROYO VALLE NEAR LIVERMORE	3/19/97	3.9	16.1	740	7.4	60	32	50	2	239	121	42	0	15	280	0.6	0.20	441
CAYETANO CREEK ABOVE POSITAS	5/20/97	0.1	26.6	1850	7.9	88	34	296	8	464	335	172	0	31	359	1.3	0.80	1203
DSRSD (LINE G-1-1)	5/19/97	0.3	29.4	7700	7.5	156	143	683	4	397	1202	596	0	14	977	3.7	0.80	2999
DUBLIN CREEK AT DUBLIN RD	5/19/97	0.5	18.2	1525	7.4	196	41	112	3	372	440	79	1	34	658	0.3	0.30	1097
SOUTHBAY TRIBUTARY	5/21/97		18.1	621	8.8	34	19	64	2	152	63	78	0	5	162	0.3	0.30	349
SOUTH SAN RAMON CREEK ABOVE SOUTH	5/20/97		23.9	1060	7.9													
TASSAJARA CREEK ABOVE ARROYO MOCHO	5/28/97		25.0	1098	8.2	41	30	165	3	300	124	121	0	4	227	0.7	0.60	641
TASSAJAR CREEK AT EB Park	5/28/97	0.6	22.2	1360	8.2	52	42	197	4	450	134	141	0	8	302	0.9	0.50	808

Zone 7 treatment plants. The electrical conductivity (EC) measurements are used to estimate TDS content using the formula TDS ≈0.56 x EC. Table 4.1 shows the monthly EC data for the 1997 water year for the major streams monitored by Zone 7. Additionally, surface water samples are collected periodically and analyzed for major and total ion content (Table 4.2). See Section 6.2, Existing Monitoring Programs, for additional information regarding the specific surface water monitoring stations.

Natural inflow and groundwater seepage are measured (gaged) by Zone 7 at various gaging stations along the streams. Water quality of the natural inflow/seepage into the upper reach of Arroyo Valle is monitored at the Arroyo Valle near Livermore (AVNL) gaging station, as discussed above. Inflow into the lower reach is essentially a mixture of urban runoff and mining discharges (see below). Water quality of the natural inflow into the Arroyo Mocho is monitored at the Arroyo Mocho near Livermore (AMNL) gaging station. The annual average TDS concentrations measured at AMNL have ranged from 350 mg/L to 580 mg/L between 1992 and 1998.

At various times during average and wet years, surplus SWP water is released into the Arroyo Mocho and Arroyo Valle to supplement the natural recharge of the groundwater basins. This "artificial stream recharge" began in 1962 with the importation of State Water Project water into the valley. Since water quality of the imported water at the stream channel turnouts is essentially the same as the water entering the Zone 7 water treatment plants, the water quality data collected at the treatment plant intakes are used for the artificial recharge component (See Section 4.2 - Imported Water for additional detail). The volume of SBA releases is metered at the respective SBA turnouts.

Natural inflow into the Arroyo las Positas is from the Seco, Upland Positas and the Positas drainage basins (see Reference G) plus seepage or outflow from the Spring and May subbasins. Water quality of the natural inflow into the Arroyo las Positas is monitored at the Arroyo las Positas near Livermore (ALPL) gaging station. The annual average TDS concentrations measured at ALPL have ranged from 1,080 mg/L to 1,590 mg/L between 1992 and 1998. The elevated TDS concentrations in the Arroyo las Positas are mainly due to the contributing subbasin groundwater components, but also due to runoff from the undifferentiated marine formations of the Altamont Hills. The poor quality groundwater flowing into the Arroyo las Positas is believed to get its salts from the particles and clasts of undifferentiated marine formations which help to makeup the alluvial aquifers in the Spring and May sub-basins. Evaporative concentration of these marine salts through the evaporation of shallow groundwater is also a cause of the high TDS in this area.

The Arroyo de la Laguna conveys the outflow from the Livermore-Amador basin. It contains a mixture of outflow from Alamo Canal, Arroyo Mocho, Arroyo las Positas and Arroyo Valle, and groundwater from the Bernal subbasin. Water quality of the various stream outflow components are monitored at the respective gaging stations by Zone 7. The subsurface groundwater outflow water quality is determined by averaging the TDS concentrations of several shallow monitoring wells located in the vicinity of the rising groundwater (near the Arroyo Valle and Arroyo de la Laguna confluence). Between 1995

and 1998 the subsurface groundwater outflow TDS values ranged from 830 mg/L and 980 mg/L. Groundwater seepage into the Arroyo de la Laguna did not occur in significant quantities from 1992 through 1995 (see Section 3.3 discussion). Alameda County Water District monitors the quantity and quality of the Arroyo de la Laguna near Pleasanton.

Natural Stream Recharge—Figure 3.3 has shown the relative recharge capacity associated with each of the major streams in the watershed and the associated water quality in terms of TDS. Note that the dashed lines represent areas of rising groundwater rather than areas of stream recharge. Table 4.1 and Figure 3.3 show that the TDS in the local surface water varies significantly throughout the watershed from approximately 350 mg/L to over 1,000 mg/L TDS. The highest quality surface water recharging the basin occurs through Arroyo Mocho and Arroyo Valle where the TDS is generally less than 500 mg/L. The poorest quality surface water recharging the basin has a TDS of approximately 1,000 mg/L and occurs in Arroyo Las Positas. On average, given 1997 land use conditions, approximately 2,700 AF of natural recharge occurs through Arroyo Mocho, 1,200 AF through Arroyo Las Positas, and 2,700 AF through Arroyo Valle annually.

The volume of flow through each of the major streams varies significantly on a seasonal basis. Further, the EC/TDS values at times of peak flow are often well below those during other times of the year (Table 4.1). For example, base-flow conditions for Arroyo de la Laguna (ADLLP) occurred during the months of April through October when flow was approximately 40 cfs and EC about 1,100 µmhos/cm. During high flow conditions at ADLLP in January (300 cfs), the EC was 650 µmhos/cm.

Rainfall and Urban Runoff

The quantity of local rainfall is monitored by Zone 7 at several rain gage stations located strategically around the basin. For the purpose of salt loading estimates, all of the rainfall is assumed to have a TDS concentration of 0 mg/L.

The quantity and quality of the urban runoff component is empirically determined. Previous studies found a correlation between rainfall and urban runoff. Now simple factors are used to determine the runoff components of several stream reaches. These estimated values are then checked against stream gaging data and adjusted if necessary. The water quality of this runoff component was also monitored in the past, and was found to average about 250 mg/L TDS. This average value is used in the Zone 7 salt loading calculation for the lower reach of Arroyo Valle.

Mining Ponds and Discharges

Zone 7 monitors the water level, electrical conductivity and TDS content of over 25 mining ponds located along the Arroyo Mocho and Arroyo Valle. In addition, Zone 7 monitors the water discharges made to the two Arroyos by the mining companies. Based

on the monitoring results, the flow-weighted average TDS content of the mining export has ranged from 490 mg/L to 550 mg/L between 1992 and 1998.

Applied Irrigation

Urban and agricultural irrigation are monitored separately. The quality of the urban irrigation water is determined by flow-weighting the average of SWP water quality, groundwater quality, and recycled water quality on an annual basis. Agricultural irrigation water quality is determined by flow-weighting the average qualities of the SWP and groundwater components.

4.4 Groundwater

Zone 7 operates a groundwater monitoring program that collects groundwater level and quality data from approximately 200 "program" wells annually. The data is stored in a computerized database for ready retrieval and reporting. A map showing the location of the program wells in the groundwater monitoring program is presented in Figure 4.3. The current Zone 7 groundwater monitoring program and future monitoring plans with respect to the Salt Management Plan are discussed in Chapter 6, Watershed Salt Management Monitoring Program.

In addition to data from the program wells, Zone 7 has compiled a computerized database of historic water level and mineral quality data from other wells within the local watershed. In general, laboratory analyses for most well samples include Ca, Mg, Na, K, HCO_3, SO_4, Cl, NO_3, SiO_2, alkalinity, boron (B), electrical conductivity (EC), pH, TDS, and hardness. In the late 1990's arsenic (As) and manganese (Mn) were added to the list of analytes.

Table 4.3 contains representative summaries of the groundwater quality data collected in each of the main subbasins during 1997. Figure 4.3 shows the locations of the wells with their numbers as listed in Table 4.3. A copy of the 1996 water year groundwater monitoring program annual report is included as Reference F.

Figures 4.4 and 4.5 show the contours of average TDS concentrations in the upper and lower aquifers of the main and fringe basins from the 1990 through 1995 water years. The upper aquifer contour map was created primarily using data from wells having a total depth of 150 feet or less, whereas the lower aquifer contour map uses water quality data from deeper aquifer monitoring wells and the municipal supply wells.

Graphical map-based summaries of the TDS, chloride, hardness, and nitrate concentrations measured in 1997 in the program wells are provided in Figures 4.6, 4.6A, 4.7 and 4.8, respectively. On this series of figures, the size (area) of each symbol (circle or square) is proportional to the concentration of the respective constituent. Larger symbols