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APPENDIX A
METHODS

A. MINE SELECTION

Inactive mines were selected by two criteria: 1) mines that were known water quality threats, and 2) mines that were considered major producers. The inactive mines in Buer et al., 1979, were included as known water quality threats. Mines extensively discussed in mining journals were considered major producers. Reports reviewed for major producers included DOM, 1957 and CDMG, 1966 and 1970b. Lode gold mines that produced over 1 million dollars were included (from CDMG, 1970a). Other mines were periodically added if there was a known discharge or were near other visited mines (eg., Turkey Run, Pick and Shovel, Black Oak). There was extensive overlap in the mines included between the two criteria, i.e., very few mines were added to the 1979 survey.

B. FIELD SAMPLING AND QUALITY CONTROL PROCEDURES

1. Water

Sub-surface grab samples were collected using, 1 liter, polyethylene bottles pre-preserved by the laboratory with 2.5 milliliters nanograde nitric acid. Samples were collected from mine drainage before contact with the receiving waters. Receiving water samples were collected just upstream the drainage and below after thorough mixing. Samples were transported to the laboratory on ice and analyzed within 2 weeks. The July, 1989 samples were analyzed by Cal-Enseco, West Sacramento, CA; the rest were analyzed by Anlab Laboratory, Sacramento, CA. Approved laboratory methods (U.S.EPA, 1983b) were followed for the analysis of total arsenic, cadmium, chromium, copper, nickel, lead, silver and zinc. One of three instruments used for the analyses - the Perkin-Elmer 460, 5000, or 5100 - was coupled with graphite furnace or flame atomic absorption spectroscopy. Concentrations of metals generally over 35-50 ppb were analyzed by ICPES. Calcium and magnesium were analyzed by atomic absorption spectroscopy for the hardness analysis. Electrical conductivity, pH, and Eh were field measured respectively using a Myron L Digital meter and a YSI 53560 Water Quality Monitoring System with silver/silver chloride - platinum electrodes. Flow measurements were made with a Swoffer 2100 current velocity meter.

Quality control samples were included blindly along with each sample batch submitted to the laboratory. Batch submissions included a representative number of laboratory or travel blanks (triple de-ionized water and preservative), a large number of laboratory replicates (splits) for precision, and sample spikes. For the spikes, triple de-ionized water was fortified using 1000 ppm atomic absorption standard metal solutions (EM Industries, Inc., Cherry Hill, NJ) at concentrations expected in the drainage water. An intermediate standard solution of all metals (except silver) served as the primary source - two serial dilutions were made per spike. Spike samples were prepared at the regional board laboratory using glassware that was washed, soaked in five percent nitric acid, and rinsed with triple de-ionized water prior to use.

Percent recovery was calculated as the quotient of the analysis levels to the quantity supplemented. Analytical precision was determined from replicate sample results using the "modified Shewart" method (U.S.EPA, 1983a). Replicate concentration sums (A+B) were separated into four ranges (<20, 20-<50, 50-<100, and above 100 ug/l) before calculation to allow equitable comparisons at differing concentration levels.

2. Sediment

Sediment samples were collected using wide-mouth glass jars with teflon lined lids. Sub-samples were composited at a number of different locations from the waste rock piles based on texture and color, roughly simulating a representative portion of each waste rock type according to it's surficial abundance. Samples were stored at room temperature for up to 1 year, 2 months prior to preparation and analysis. Sediment was dried at room temperature, crushed, and passed through a 65 micron stainless steel screen prior to analysis (protocol in Sobek et al., 1978). Approved laboratory methods (EPA, 1982) were used for the total analysis of arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc. Soil pH was measured with a 2:1 sediment:water ratio ("paste method"). Acid base accounts were performed according to Sobek et al., 1978. Acid producing compounds are detected using the Leco sulfide detection method which are stoichiometrically subtracted from the buffering capacity determined after extraction with hot acid. Net acid generating capacity values were estimated as the amount of carbonate needed to obtain a pH of 8. Samples were split for precision measurements.

C. LABORATORY QUALITY CONTROL RESULTS

1. Water

The pH values for June and July, 1989, are considered erroneous because of faulty equipment. Redox measurements were not adjusted for stream temperature and therefore, the natural stream Eh values ranged between approximately 100 and 200 millivolts (mV). Abnormal ionic influence in waste streams was indicated by redox extremes outside this range (e.g.,

negative or high [400-500] values). Therefore, Eh measurements should be used as a gross indicator of the water redox potential.

Accuracy: With the exception of the low level zinc analyses and a few isolated submissions, spiked recoveries were generally good (Table A-1). Zinc recovery of spiked de-ionized (D.I.) water was consistently variable at the low level concentration (10-20 ug/l) but was good to exceptional at the high spike levels (24-200 ug/l). With the exception of two batch submissions, the low level zinc recoveries were statistically different from a normalized population of 100 +- 30 (95% C.I.) percent. Both the high and low zinc recovery values were similar to the performance of other nationwide laboratories using the same methods (Table A-2). The general over-recoveries of zinc at the low spike levels would indicate contamination, although, on a selective basis as indicated by the high variability. The spiking method of spiking used would have resulted in consistent errors among the other metals, indicating interferents. Regardless, most of the low level zinc values in this report should be assigned a high variability (e.g., +- 2X or 3X).

Other anomalies include the 13 June 1989 submission. It is unknown why this submission had such poor results, however, it should be noted that 1) the blank results showed some slight chromium contamination, and 2) the laboratory performed analyses only on one batch (see footnote 1, Table A-1). The 28 December 1989 submission shows no recovery of nickel at 10 ug/l and poor recovery at 20 ug/l. Since past analysis of this compound by the same laboratory was consistently exceptional, it is assumed to be a sample mixup error. Although both the high and low concentration recoveries of all compounds for the 30 April 1990 submission were consistently above 100 percent, the fault likely lies in the spiking procedure which was a "new technique" being tested.

Precision: The precision of laboratory replicate samples, reported as coefficient of variation (COV) in percent, was fair to good (Table A-3). Most of the highly variable replicates were reported in the "A+B<=20" range and reflect the statistically induced variation of concentrations approaching zero. Other reputable laboratories double the acceptable precision threshold to account for this phenomenon at concentrations below 10 ug/l (Kingsley, 1984). Although the COVs outside of 30 percent were above expected EPA methodology COVs (or Relative Standard Deviation [RSD]) (Table A-2), EPA commissioned only one laboratory to participate in the analysis. Alternately, the ASTM methodology performance results reflect averages from several laboratories (as many as 80), although, the extraction techniques are slightly different. For Cd, Cr, Ni, Cu, and Pb the ASTM methods contain 2 fewer boildown/reflux steps than the corresponding EPA methods: The difference in recoveries would unlikely be substantial since most of the acid-labile metals in the preserved samples would already be in the dissolved state prior to the extraction step. Based on this assumption, the ASTM precision values would more realistically reflect actual method precision attainability and are also closer to the variabilities reported here.

2. **Sediment**

Precision: Laboratory replicate results for the sediment samples were excellent (Table A-4). Values (COVs) ranged from 0.0 to 20.2 percent, although, a majority were below 10 percent. The paste method pH analyses were perfectly precise.

D. MASS LOADING CALCULATIONS

Mass loads for Iron Mt. Mine were calculated using the monthly average of weekly metals data and daily flow measurements of Spring Creek Debris Dam release water (Table A-5). Data from water year 1989 and 1990 were used for the calculations. Concentration data was collected by U.S.BR and regional board staff (Redding office). Flow data was obtained from the regional board, Redding office, which is essentially U.S.BR data corrected for low flow inaccuracies.

Loads for mines in the Little Backbone and West Squaw creek watersheds were calculated using both downstream creek flows and the sum of all individual sources in the watersheds (Table A-6). Both sites were used to account for banking processes going on in the watersheds. Data was obtained largely from surveys conducted by Dennis Heiman of the Redding office during dry periods between 1989 and 1992.

For most other mines, loads were calculated as the product of average flow and concentration data collected between 1987 and 1991. For a few Shasta District mines (e.g., Afterthought, Sutro mines) any available data from the 1980s was used. For mines with limited data on lead, nickel, iron, arsenic, chromium, any existing concentration values were used regardless of the year in which they were collected.

Table A-1. ANALYTIC RECOVERY PERCENTAGES OF SPIKED SAMPLES SUBMITTED BLINDLY TO THE LABORATORY. 1/

SUBMISSION DATE	METALLIC ION 2/	SPIKE, UG/L (LO/HI)	NUMBER, N (LO/HI)	AVERAGE RECOVERY, % (+- 95% C.I.) LOW (LO)	AVERAGE RECOVERY, % (+- 95% C.I.) HIGH (HI)	LAB & TRAVEL BLANK RANGE, UG/L (N)
Jun 13, '89	Arsenic	10 /-	4 /-	104 +- 7	- +-	<1-1.0 (2)
	Cadmium	10 /-	4 /-	99 +- 1	- +-	<0.20 (2)
**	Chromium	10 /-	4 /-	148 +- 19	- +-	3.8-4.1 (2)
*	Copper	10 /-	4 /-	133 +- 23	- +-	<1.0 (2)
*	Lead	10 /-	4 /-	133 +- 22	- +-	<5.0 (2)
*	Mercury	10 /-	4 /-	61 +- 11	- +-	<0.20 (2)
	Nickel	10 /-	4 /-	97 +- 3	- +-	<4.0 (2)
**	Zinc	10 /-	4 /-	293 +-104	- +-	<10 (2)
Jul 7, '89	Arsenic	10 /100	3 / 2	93 +- 8	97 +- 7	<2 (2)
	Cadmium	10 /100	3 / 2	96 +- 6	89 +- 13	<0.1 (2)
	Chromium	10 /100	3 / 2	97 +- 8	94 +- 11	<1 (2)
	Copper	10 /100	3 / 2	107 +- 8	110 +- 0	<1 (2)
	Lead	10 /100	3 / 2	103 +- 8	98 +- 4	<5 (2)
	Mercury	10 /100	3 / 2	91 +- 1	99 +- 49	<0.2 (2)
	Nickel	10 /100	3 / 2	90 +- 0	98 +- 9	<4 (2)
**	Zinc	10 /100	3 / 2	180 +- 48	105 +- 22	<5 (2)
Jul 31, '90	Arsenic	10 /100	3 / 3	93 +- 16	95 +- 6	<2 (3)
	Cadmium	10 /100	3 / 3	100 +- 0	87 +- 2	<0.1 (3)
	Chromium	10 /100	3 / 3	103 +- 8	99 +- 2	<1 (3)
	Copper	10 /100	3 / 3	103 +- 8	107 +- 8	<1 (3)
	Lead	10 /100	3 / 3	103 +- 8	98 +- 0	<5 (3)
	Mercury	10 /100	3 / 3	88 +- 8	98 +- 3	<0.5 (3)
	Nickel	10 /100	3 / 3	97 +- 8	97 +- 8	<4 (3)
**	Zinc	10 /100	3 / 3	173 +- 42	100 +- 12	<5 (3)
Aug 16, '89	Arsenic	10 /100	1 / 1	90 +- -	97 +- -	-
	Cadmium	10 /100	1 / 1	110 +- -	91 +- -	-
	Chromium	10 /100	1 / 1	100 +- -	96 +- -	-
	Copper	10 /100	1 / 1	100 +- -	110 +- -	-
	Lead	10 /100	1 / 1	110 +- -	110 +- -	-
	Mercury	10 /100	1 / 1	100 +- -	99 +- -	-
	Nickel	10 /100	1 / 1	110 +- -	94 +- -	-
**	Zinc	10 /100	1 / 1	140 +- -	95 +- -	-
Sep 1, '89	Arsenic	10 / 50	2 / 4	100 +- 0	99 +- 3	<2 (2)
	Cadmium	10 / 50	2 / 4	100 +- 2	96 +- 3	<0.1 (2)
	Chromium	10 / 50	2 / 4	90 +- 0	96 +- 6	<1 (2)
	Copper	10 / 50	2 / 2	105 +- 22	102 +- 0	<1 (2)
	Lead	10 / 50	2 / 2	105 +- 22	108 +- 0	<5 (2)
	Mercury	10 / 50	2 / 2	88 +- 2	92 +- 4	<0.2 (2)
	Nickel	10 / 50	2 / 4	100 +- 0	100 +- 7	<4 (2)
	Zinc	10 / 50	2 / 4	125 +- 22	106 +- 3	<5 (2)
	Iron	- / 50	- / 2	- +-	104 +- 45	<30 (2)
	Silver	- / 50	- / 2	- +-	106 +- 0	<1 (2)
Dec 28, '89	Arsenic	10 /200	2 / 2	120 +- 0	80 +- 0	<2-3 (3)
	Cadmium	10 /200	2 / 2	94 +- 18	95 +- 0	<0.1 (3)
	Chromium	10 /200	2 / 2	110 +- 45	105 +- 0	<1-1 (3)
	Copper	10 /200	2 / 2	80 +- 0	105 +- 0	<1 (3)
	Lead	10 /200	2 / 2	110 +- 45	95 +- 0	<5 (3)
	Mercury	10 /200	2 / 2	96 +- 9	118 +- 11	<0.2-0.4 (3)

Table A-1. ANALYTIC RECOVERY PERCENTAGES OF SPIKED SAMPLES SUBMITTED BLINDLY TO THE LABORATORY. 1/

SUBMISSION DATE		METALLIC ION 2/	SPIKE, UG/L (LO/HI)	NUMBER, N (LO/HI)	AVERAGE RECOVERY, % (+- 95% C.I.) LOW (LO)	AVERAGE RECOVERY, % (+- 95% C.I.) HIGH (HI)	LAB & TRAVEL BLANK RANGE, UG/L (N)
	**	Nickel	10 /200	2 / 2	0 +- 0	95 +- 22	<4 (3)
	**	Zinc	10 /200	2 / 2	240 +- 0	110 +- 0	<5 (3)
		Arsenic	20 /-	2 /-	90 +- 0	- +- -	-
		Cadmium	20 /-	2 /-	90 +- 0	- +- -	-
		Chromium	20 /-	2 /-	115 +- 22	- +- -	-
		Copper	20 /-	2 /-	103 +- 11	- +- -	-
		Lead	20 /-	2 /-	100 +- 0	- +- -	-
		Mercury	20 /-	2 /-	108 +- 11	- +- -	-
	**	Nickel	20 /-	2 /-	50 +- 0	- +- -	-
		Zinc	20 /-	2 /-	115 +- 89	- +- -	-
Jan 18, '90		Arsenic Cadmium Chromium Copper Lead Mercury Nickel	10 /100	2 / 2	82 +- 2	85 +- 4	<0.1 (2)
		Zinc	10 /100	2 / 2	90 +- 0	110 +- 0	<1 (2)
			10 /100	2 / 2	88 +- 0	97 +- 7	<0.2 (2)
	*		10 /100	2 / 2	130 +- 45	100 +- 0	<5-8 (2)
Apr 30, '90		Arsenic	18 / 45	2 / 2	112 +- 25	108 +- 4	<2 (3)
		Cadmium	18 / 45	2 / 2	117 +- 0	118 +- 20	<0.1 (3)
		Chromium	18 / 45	2 / 2	125 +- 13	115 +- 7	<1 (3)
		Copper	18 / 45	2 / 2	128 +- 0	127 +- 20	<1-2 (3)
		Lead	18 / 45	2 / 2	106 +- 25	114 +- 11	<5 (3)
		Mercury	18 / 45	2 / 2	117 +- 25	- +- -	<0.2 (3)
	*	Nickel	18 / 45	2 / 2	139 +- 25	112 +- 4	<4 (3)
		Zinc	18 / 45	2 / 2	122 +- 0	120 +- 9	<5-9 (3)

1/ Analyses by Anlab Laboratory, Sacramento, CA except for June 13, '89 submission which was performed by Cal Enseco, Inc., West Sacramento, CA.

2/ Statistically different from 100 +- 30 (p-=0.95):
* Average recovery between 100 +- 30-<40%.
** Average recovery outside 100 +- 40%.

Table A-2. THE GENERAL PRECISION AND ACCURACY OF METHODS USED.

METALS	EPA 1/							ASTM 4/						
	METHODS	O.C.R. 2/	R.S.D. 3/			RECOVERIES		METHODS	O.C.R. 2/	R.S.D. 3/			RECOVERIES	
Arsenic	206.2	5 - 100 ug/l	20 ug/l	50 ug/l	100 ug/l	20 ug/l	50 ug/l 100 ug/l	D2972-84C	5-100 ug/l	6.0 ug/l	22 ug/l	72 ug/l	6.0 ug/l	22 ug/l 72 ug/l
			3.5 %	2.2 %	1.6 %	105 %	106 % 101 %			15 %	14 %	8.6 %	87 %	105 % 99 %
Cadmium	213.2	0.5-10 ug/l	2.5 ug/l	5.0 ug/l	10.0 ug/l	2.5 ug/l	5.0 ug/l 10.0 ug/l	D3557-84D	0.5-10 ug/l	1.3 ug/l	2.5 ug/l	6.0 ug/l	1.3 ug/l	2.5 ug/l 6.0 ug/l
			5.0 %	3.2 %	3.3 %	96 %	99 % 98%			84 %	61 %	46 %	118 %	87 % 112 %
	200.7	not reported	2.5 ug/l	14 ug/l	50 ug/l	2.5 ug/l	14 ug/l 50 ug/l	D4190-82	not reported	S = 0.044X + 6.08 (overall)			50 ug/l	500 ug/l 1000 ug/l
			16 %	16 %	12 %	116 %	93 % 96 %			S = 0.025X + 4.96 (single)			100 %	97 % 97 %
Chromium	218.2	5 - 100 ug/l	19 ug/l	48 ug/l	77 ug/l	19 ug/l	48 ug/l 77 ug/l	D1687-86C	5-100 ug/l	8.0 ug/l	10 ug/l	28 ug/l	8.0 ug/l	10 ug/l 28 ug/l
			0.5 %	0.4 %	1.0 %	97 %	101 % 102 %			28 %	32 %	18 %	83 %	108 % 101 %
Copper	220.2	5 - 100 ug/l	Not available at this time					D1688-84F	5-100 ug/l	5.0 ug/l	11 ug/l	32 ug/l	5.0 ug/l	11 ug/l 32 ug/l
										77 %	21 %	25 %	180 %	109 % 113 %
	200.7	not reported	11 ug/l	70 ug/l	250 ug/l	11 ug/l	70 ug/l 250 ug/l	D4190-82	not reported	S = 0.038X + 5.58 (overall)			50 ug/l	500 ug/l 1000 ug/l
			40 %	8 %	5 %	100 %	96 % 94 %			S = 0.031X + 0.956 (single)			101 %	99 % 99 %
Iron	200.7	not reported	20 ug/l	180 ug/l	600 ug/l	20 ug/l	180 ug/l 600 ug/l	D4190-82	not reported	S = 0.051X + 14.3 (overall)			50 ug/l	500 ug/l 1000 ug/l
			15 %	6 %	3 %	95 %	99 % 99 %			S = 0.013X + 10.7 (single)			110 %	94 % 94 %
Lead	239.2	5 - 100 ug/l	25 ug/l	50 ug/l	100 ug/l	25 ug/l	50 ug/l 100 ug/l	D3559-85D	5-100 ug/l	12 ug/l	24 ug/l	72 ug/l	12 ug/l	24 ug/l 72 ug/l
			1 %	2 %	4 %	88 %	92 % 95 %			30 %	14 %	14 %	87 %	87 % 90 %
Mercury	245.2	not reported	0.5 ug/l	1.0 ug/l	5.0 ug/l		10 ug/l	D3223-86	not reported	.21 ug/l	3.4 ug/l	9.6 ug/l	.21 ug/l	3.4 ug/l 9.6 ug/l
			8 %	4 %	4 %		87 to 100 %			79 %	44 %	39 %	166 %	100 % 95 %
Nickel	249.2	5 - 50 ug/l	Not available at this time					D1886-84E	5-100 ug/l	8.0 ug/l	30 ug/l	80 ug/l	8.0 ug/l	30 ug/l 80 ug/l
										20 %	17 %	12 %	95 %	97 % 101 %
	200.7	not reported	30 ug/l	60 ug/l	250 ug/l	30 ug/l	60 ug/l 250 ug/l	D4190-82	not reported	S = 0.078X + 5.47 (overall)			50 ug/l	300 ug/l 800 ug/l
			11 %	14 %	5.8 %	93 %	92 % 98 %			S = 0.029X + 7.17 (single)			106 %	96 % 94 %
Silver	272.2	1 - 25 ug/l	25 ug/l	50 ug/l	75 ug/l	25 ug/l	50 ug/l 75 ug/l	D3866-82C	1-25 ug/l	2 ug/l	9 ug/l	22 ug/l	2 ug/l	9 ug/l 22 ug/l
			2 %	1 %	1 %	94 %	100 % 104 %			41 %	19 %	26 %	98 %	90 % 91 %
Zinc	289.1	.05 - 1 mg/l	7 ug/l	56 ug/l	310 ug/l	7 ug/l	56 ug/l 310 ug/l	D1691-84C	.01-2 mg/l	1.16 mg/l	1.5 mg/l	1.8 mg/l	1.16 mg/l	1.5 mg/l 1.8 mg/l
			118 %	45 %	37 %	306 %	111 % 99 %			233 %	302 %	147 %	107 %	96 % 98 %
	200.7	not reported	16 ug/l	80 ug/l	200 ug/l	16 ug/l	80 ug/l 200 ug/l	D4190-82	not reported	S = 0.025X + 8.38 (overall)			50 ug/l	500 ug/l
			45 %	10 %	6 %	119 %	103 % 101 %			S = 0.011X + 6.67 (single)			102 %	100 %

1/ U.S.EPA, 1983b. 2/ Optimum concentration range. 3/ Relative Standard Deviation. 4/ ASTM, 1988.

Table A-3. AVERAGE ANALYTICAL PRECISION FROM REPLICATES SUBMITTED BLINDLY. 1/

SUBMISION DATE	REPLICATE SUM (A+B)	COEFFICIENT OF VARIATION OF REPLICATE PAIRS IN PERCENT (N) 2/ As	Cd	Cr	Cu	Fe	Pb	Hg	Ni	Zn
13JUN89	<=20	13(3)		*35(7)*	*51(3)*		*141(1)*	*141(1)*	6(1)	
	20 TO <50								*57(1)*	27(1)
	50 TO <100									
	>=100	4(2)	*52(1)*		*48(1)*				5(1)	0(1)
# BELOW DETECTION		(2)	(6)		(3)		(4)	(5)	(3)	(5)
07JUL89	<=20		*94(2)*	*141(1)*	0(2)			*141(3)*	18(1)	28(2)
	20 TO <50									
	50 TO <100									
	>=100	8(1)			*101(1)*					*92(1)*
# BELOW DETECTION		(3)	(2)	(3)	(1)		(4)	(1)	(3)	(1)
17JUL89	<=20		*39(4)*		*71(2)*			28(1)		0(1)
	20 TO <50				3(1)					3(2)
	50 TO <100				2(1)					
	>=100				0(2)					
# BELOW DETECTION		(6)	(2)	(6)			(6)	(5)	(6)	(3)
31JUL89	<=20	0(1)	*47(3)*	14(2)	20(1)				8(1)	*141(1)*
	20 TO <50		5(1)	0(1)	0(1)		3(1)		3(2)	8(1)
	50 TO <100	2(1)					22(1)			
	>=100	*87(1)*	0(2)		3(3)					3(3)
# BELOW DETECTION		(4)	(1)	(4)	(2)		(4)	(6)	(4)	(2)
16AUG89	<=20	0(1)		0(1)	*71(2)*				0(1)	
	20 TO <50									6(1)
	50 TO <100									
	>=100			4(1)					0(1)	3(1)
# BELOW DETECTION		(1)	(2)				(2)	(2)		
01SEB89	<=20	0(1)	*141(1)*	24(2)	*71(2)*					7(1)
	20 TO <50								9(1)	3(1)
	50 TO <100	2(1)		0(1)						0(1)
	>=100								3(3)	1(1)
# BELOW DETECTION		(3)	(4)	(2)	(3)		(5)	(5)	(1)	(1)
17OCT89	<=20	0(1)		*47(1)*					0(1)	0(1)
	20 TO <50									
	50 TO <100									
	>=100									
# BELOW DETECTION			(1)		(1)		(1)	(1)		
28DEC89	<=20	11(1)	6(2)	18(3)						
	20 TO <50			3(1)					0(1)	4(1)
	50 TO <100					3(1)				
	>=100	6(2)	5(1)		1(3)		6(7)		4(3)	1(4)
# BELOW DETECTION		(1)	(1)	(1)	(1)	(1)		(3)		(1)
18JAN90	<=20		3(3)		0(1)			*52(3)*		11(1)
	20 TO <50									
	50 TO <100									
	>=100		2(1)		4(4)			2.2(1)		3(4)
# BELOW DETECTION								(1)		
4APR90	<=20	28(1)	1(2)	0(2)						
	20 TO <50	7(1)	0(1)	3(1)	0(1)		4(2)	7(1)		0(1)
	50 TO <100	9(2)							6(1)	
	>=100		4(2)	1(1)	2(4)	10(2)	3(1)		2(4)	4(5)
# BELOW DETECTION		(1)						(1)		
29JUN90	<=20	16(1)		0(1)						
	20 TO <50						5(1)		0(1)	
	50 TO <100									
	>=100		4(1)		6(1)					7(1)
# BELOW DETECTION										

1/ Analyses by Anlab Laboratory, Sacramento, CA except for the June 13, 1989 submission which was performed by Cal Enseco, Inc., West Sacramento, CA.

2/ "Modified Shewart" variation (U.S.EPA, 1983a). N=number of replicate pairs. * x * indicates variation outside of accepted limits.

Table A-4. WASTE ROCK METAL VARIABILITY OF LABORATORY REPLICATES.

MINE		TOTAL CONCENTRATION (MG/KG, DRY WEIGHT)									
		pH	ARSENIC	CADMIUM	CHROMIUM	COPPER	LEAD	ZINC	NICKEL	MERCURY	SILVER
Iron Mt. loading area		1.4 1.4									
	AVERAGE	1.40									
	COV	0.00									
Rising Star		2.8	650	30	3.8	1400	100	3500	ND	16	5.2
		2.8	600	28	3.8	1300	110	3500	ND	15	4.2
	AVERAGE	3	625	29	4	1350	105	3500	0	16	5
	COV	0.0	5.7	4.9	0.0	5.2	6.7	0.0		4.6	15.0
Bully Hill		3.6	190	27	15	5000	630	4000	7	4.6	14
		3.6	170	25	17	5100	660	3900	7.5	4.3	14
	AVERAGE	4	180	26	16	5050	645	3950	7	4	14
	COV	0.0	7.9	5.4	8.8	1.4	3.3	1.8	4.9	4.8	0.0
Big Buzzard		3.1 3.1									
	AVERAGE	3.10									
	COV	0.00									
Corona		2.8 2.8									
	AVERAGE	2.80									
	COV	0.00									
Spenceville		2.6	90	0.8	2.4	120	240	40	ND	0.59	46
		2.6	85	0.6	3	100	220	46	ND	0.58	55
	AVERAGE	3	88	1	3	110	230	43	0	1	51
	COV	0.0	4.0	20.2	15.7	12.9	6.1	9.9		1.2	12.6

Table A-5. LOADS CALCULATED FOR IRON MT. MINE AT SPRING CREEK DEBRIS DAM. 1/

YEAR	MONTH	TOTAL FLOW/MONTH (CFS)	CADMIUM 4/ MG/L	S.E.	N	KG	COPPER 4/ MG/L	S.E.	N	KG	ZINC 4/ MG/L	S.E.	N	KG
1988	OCT	28	0.3800	0.0000	2	26	8.100	0.0000	2	555	46.0	0.000	2	3,151
	NOV	463	0.0877	0.0387	3	99	3.730	1.3100	10	4,225	15.2	13.140	10	17,263
	DEC	946	0.0820	0.0000	1	190	1.667	0.1639	8	3,858	11.4	1.561	8	26,422
1989	JAN	581	0.0534	0.0124	5	76	1.448	0.0927	9	2,058	8.4	2.306	9	11,950
	FEB	390	0.0763	0.0208	3	73	1.588	0.2133	8	1,515	11.5	4.037	8	10,964
	MAR	1,904	0.0242	0.0087	5	113	0.807	0.2070	27	3,759	4.0	1.152	27	18,479
	APR	1,705	0.0285	0.0065	4	119	0.811	0.1850	30	3,383	4.2	0.612	27	17,720
	MAY	1,487	0.0545	0.0233	2	198	1.766	0.5089	17	6,424	8.9	2.827	17	32,466
	JUN	1,164	0.0700	0.0000	1	199	2.033	0.2141	8	5,788	10.6	0.808	8	30,275
	JUL	596	0.1167	0.0226	3	170	4.730	0.6710	4	6,897	20.5	3.526	4	29,856
	AUG	372	0.1870	0.0000	1	170	5.617	0.3253	3	5,112	26.2	4.126	3	23,875
	SEP	49	0.3090	0.0000	1	37	8.175	1.0079	4	980	48.8	6.902	4	5,853
	OCT	246	0.6500	0.0000	1	391	3.927	1.3924	6	2,363	21.2	11.334	6	12,729
	NOV	551	0.1273	0.0641	3	172	3.830	1.5449	7	5,163	16.9	5.928	7	22,748
	DEC	149	0.1312	0.0424	5	48	4.830	0.7060	7	1,761	20.3	4.345	7	7,395
1990	JAN	560	0.0685	0.0417	4	94	2.161	1.0662	11	2,961	10.8	9.525	11	14,786
	FEB	656	0.0253	0.0051	4	41	1.124	0.1001	8	1,804	4.2	1.149	8	6,753
2/	MAR	475	0.0288	0.0038	5	33	1.062	0.1076	5	1,234	4.0	0.594	5	4,679
	APR	293	0.0840	0.0384	3	60	1.764	0.3465	8	1,264	14.4	5.777	8	10,349
	MAY	181	0.0903	0.0651	3	40	1.875	0.7192	11	831	17.3	8.883	11	7,645
	JUN	2,318	0.0290	0.0000	1	164	0.805	0.2738	15	4,563	4.6	0.834	15	25,948
	JUL	1,052	0.1380	0.0000	1	355	1.642	0.5295	6	4,225	18.1	7.692	6	46,543
	AUG	102	0.3690	0.0000	1	92	5.218	0.6400	5	1,302	60.3	9.375	5	15,048
	SEP	145	0.3670	0.0000	1	130	5.096	0.5533	5	1,808	57.7	4.836	5	20,484
MONTHLY AV		684	0.149				3.08				19.4			
LOAD/YEAR (KG)						1,546				36,917				211,691
LOAD SE (KG)						161				4,535				34,500

	ARSENIC	CHROM.	LEAD	NICKEL
AVE. CONC., UG/L (N=5)	44	11	20	12
COEFFICIENT OF VARIATION	0.55	0.45	0.20	0.58
ANNUAL LOAD (KG) 3/	858	214	390	234

1/ SOURCE: Heiman, D. Computer data sheets containing U.S.BR and regional board flow and concentration data. Redding, CA.
2/ Average of the surrounding month's flow. 3/ Using 7,969 CFS as annual outflow.
4/ MG/L=Concentration; S.E.=Standard Error; N=Number of samples; KG=Loads in kilograms.

Table A-6. LOADS CALCULATED FROM WESTERN SHASTA DISTRICT MINES.

MINE DRAINAGE	LOCATION	SAMPLE DATE	SOURCE 1/	ANNUAL LOADS, KILOGRAMS ARSENIC	CADMIUM	CHROMIUM	COPPER	NICKEL	LEAD	ZINC
West Squaw Creek watershed	Sum of all drainage	4-28-89	1		44.5		5,780			8,344
		4-17-91	2		23.5		5,895			5,326
		1-17-92	3	ND	58.6	ND	8,446	ND	ND	11,481
	Creek below drainage	4-28-89	1		37.0		4,987			8,383
		7-27-89	*		25.2		11,744			4,194
		4-17-91	2				8,826			11,480
		1-17-92	3				2,820			3,550
	AVERAGE				37.8		6,928			7,537
	STANDARD DEVIATION				13.0		2,729			3,034
	COEFFICIENT OF VARIATION				0.34		0.39			0.40
Little Backbone Creek watershed										
	Sum of all drainage	5-12-89	4		155		14,069			29,167
	Creek below drainage	5-12-89	4		114		12,310			20,805
	Creek below drainage	7-27-89	*	56	197	14	21,854	32	81	37,465
	AVERAGE			56	155	14	16,078	32	81	29,146
	STANDARD DEVIATION				34		4,147			6,801
	COEFFICIENT OF VARIATION				0.22		0.26			0.23
Shoemaker Gulch watershed										
	Friday-Lowden portal	5-12-89	4		39.8		3,766			12,028
	Gulch below mines	7-27-89	*	3	22.0	1	2,000	ND	ND	3,200
	AVERAGE			3	30.9	1	2,883			7,614
	STANDARD DEVIATION				8.9		883.0			4,414
	COEFFICIENT OF VARIATION				0.29		0.31			0.58
Total Little Backbone Crk and Shoemaker Gulch				59	186	15	18,961	32	81	36,760
Standard deviation					35		4,240			8,108
Coefficient of variation					0.19		0.22			0.22

1/ SOURCES * This study.
1 Heiman, D. 1989. Squaw Creek Survey, 28 April 1989. Memorandum from D. Heiman to J. Pedri. CVRWQCB Redding. 9-13.
2 Heiman, D. 1991. West Squaw Creek Survey - April 17, 1991. Memorandum from D. Heiman to J. Pedri. CVRWQCB, Redding. 6-4.
3 Heiman, D. 1992. West Squaw Creek Investigations. Memorandum from D. Heiman to J. Pedri. CVRWQCB, Redding. 2-14.
4 Heiman, D. 1989. Little Backbone Creek Survey -- 12 May 1989. Memorandum from D. Heiman to J. Pedri. CVRWQCB, Redding. 9-28.

APPENDIX B
SPENCEVILLE MINE RAINFALL RUNOFF MONITORING

A. Methods

Sequential, discrete, water samples were collected from a waste rock pile stream over the duration of a storm event occurring on 12-13 January 1989. Electrical conductivity and rainfall were also measured prior to each water sample. Samples were collected at 1/2 to 1 hour increments from the center channel of a sub-watershed of the mine site. Shoreline sub-surface grab samples were collected from Dry Creek above the mine and about 100 feet below at periodic intervals coinciding with site runoff sampling. Specific collection, preservation, and analytical methods are presented in Appendix A.

B. Results and Discussion

Approximately 3.15 inches of rain fell at the mine site over a 24 hour period during January 12-13, 1989 (Table B-1). Based on measurements up to 1810 MST (January 12), the runoff coefficient (Rv) was about 0.38. Later measurements were not included in the calculation of this number because of the longer time span between measurements (3 hours instead of 0.5-1 hour). Runoff coefficients from similar mine sites have been reported between 0.11-0.156 with higher values of 0.33 measured from very large storms (Harries and Ritchie, 1982). The January 12-13 event was considered large and the Rv of 0.38 is probably a higher than normal value due to quick oversaturation of the upper surface during intense rainfall. Infiltration is usually greater than runoff depending on the soil conductivity and present degree of saturation (Harries and Ritchie, 1987). Lighter rains were observed to be completely absorbed by the site even after long periods of precipitation.

The runoff contained high copper (2200-6000 ppb) and zinc (810-1800 ppb) levels and relatively low cadmium levels (2.5-4.7 ppb); mercury was also detected in runoff water (Table B-1). Electrical conductivity generally decreased in the runoff water from 800 to 190 uS/cm as the storm progressed. Salt buildup at the surface during the dry period could explain this decrease. Salts are carried to the surface of the pile via capillary action after infiltrated water solubilizes waste rock constituents below the surface. A majority of these salts would be flushed from the surface during the initial stages of the storm event. Metal concentrations and incipient rainfall were correlated, but not much else co-varied. Measurements of pH were not taken due to equipment malfunction. The samples showed very high visual turbidity.

Loads were calculated for copper, cadmium, and zinc from the single storm event. Total annual loads were extrapolated using the full area of the mine site (which was larger than the sub-watershed sampled) and an annual rainfall of 20.5 inches (average for Marysville). These rough estimates show that 5-18 percent of the total annual metal loads (dry + estimated rainfall runoff contributions) result from surface runoff discharges (Table B-2). The estimated loads from this site are distorted somewhat since they assumed all of the site's runoff makes it directly to the receiving water. At Spenceville Mine, a portion of the site runoff drains to an on-site pit. The pit further leaches metals from the waste rock. The pit then seeps water into nearby streams. In actuality, the runoff entering the pit is transformed to a less turbid solution and is slowly released well after the storm passes.

Copper in Dry Creek below the mine exceeded the EPA hardness factored criteria by 2-10 times (23-120 ug/l). Copper levels in Dry Creek above the mine were just above the detection limit during most of the storm (2-7 ppb). Zinc levels in Dry Creek below the mine were elevated above the upstream concentrations but did not exceed the criteria. The upstream watershed is gentle to rugged foothill scrub-oak rangeland.

Total suspended solids increased in Dry Creek from 4.5-59 mg/l above the mine to 5.5-114 mg/l below the mine. Runoff from a portion of the mine site and a nearby road likely contributed to the increase. Multi-colored water was observed coming from the mine site's variably composed waste rock piles.

Table B-1. WATER QUALITY OF RAINFALL RUNOFF FROM SPENCEVILLE MINE.

LOCATION	DATE, 1989 (MO/DAY)	TIME	RAINFALL (INCHES) INCIPIANT	RAINFALL (INCHES) CUMULATIVE	FLOW (CFS)	VELOCITY	EC (uS/cm)	TSS (MG/L)	HARDNESS (MG/L)	TOTAL CONCENTRATION (UG/L) CADMIUM	COPPER	ZINC	MERCURY
Mine site	JAN 12	1145	0.05	0.05	DRY								
		1245	0.05	0.10	DRY								
		1300	0.05	0.15	DRY								
		1330	0.05	0.20	0.21	1.4	800			4.4	6,000	1,500	0.5
		1400	0.10	0.30	0.06	0.4	720			3.6	4,100	1,300	1.0
		1428	0.05	0.35	0.16	1.7	600			4.4	5,300	1,400	<0.2
		1440	0.05	0.40	0.19	1.9	480			2.7	3,000	920	0.5
		1500	0.10	0.50	0.47	2.4	400			4.7	4,300	1,800	0.4
		1535	0.15	0.65	0.29	2.0	380			2.5	2,500	810	1.1
		1625	0.15	0.80	0.37	1.9	480			3.9	3,900	1,200	0.3
		1650	0.10	0.90	0.21	2.2	380			2.5	2,600	860	<0.2
		1750	0.10	1.00	0.18	1.2	510			4.0	4,200	1,400	<0.2
		1810	0.60	1.60	0.12	0.6	200			3.4	2,400	980	2.7
		2140	0.80	2.40	1.19	3.5	220			4.1	3,900	1,500	7.0
	JAN 13	740	0.60	3.00	1.19	3.5	190			2.5	2,200	850	2.2
		925	0.15	3.15	DRY								
Dry Creek above mine	JAN 12	1150					200	4.5	82		2	<5	<0.2
		1410					200	4.5	82		2	<5	<0.2
		1532					240	6.5	82		2	<5	<0.2
		1900					180	59	69		7	10	<0.2
Dry Creek below mine	JAN 12	1150					220	5.5	86		23	26	<0.2
		1300					220				31	30	<0.2
		1410					200	8	86		39	45	<0.2
		1500					220				56	64	<0.2
		1545					220	25	85		90	90	<0.2
		1800					220				31	35	<0.2
		1920					200	114	79		120	83	<0.2
		2140					100				63	68	<0.2

Table B-2. METALS LOADING COMPARISONS FROM SPENCEVILLE MINE RUNOFF.

LOADING PARAMETER	CADMIUM	COPPER	ZINC
kilograms per inch of rainfall from this event (kg/1.6 inches)	0.00049	0.4975	0.169
kilograms per year from the mine site (rainfall runoff) (kg/1.6)*20.5*2) 1/	0.02	20	7
kilograms per year from the mine site (dry period) (from Table ____)	0.09	175	144
percent of the total loads from rainfall runoff	18	10	5

1/ Annual rainfall = 20.5 inches at nearby Marysville.
Total annual loads from the mine site are approximately 2 time those measured.

Table C-1. WATER QUALITY CHARACTERISTICS OF MINE DRAINAGE & RECEIVING WATERS IN SEVERAL SACRAMENTO VALLEY WATERSHEDS.

MINE	SAMPLE LOCATION	COUNTY	SAMPLE DATE	FLOW (l/s)	Eh (mV)	EC (uS/cm)	pH	HARDNESS AS CACO3 (mg/L)	CONCENTRATION, UG/L (DETECTION LIMITS IN PARENTHESES) ARSENIC (<1.0)	CADMIUM (<0.10)	CHROMIUM (<2.0)	COPPER (<1.0)	NICKEL (<4.0)	ZINC (<10)	LEAD (<5.0)	MERCURY (<0.20)	SILVER (<0.50)	IRON (<30)	SOURCE
BEAR RIVER/DRY CREEK WATERSHEDS																			
Empire		Nevada																	
	air shaft discharge		13JUN89			525	6.60		53	ND	ND	ND	ND	5	ND	ND	ND		*
			13DEC89	5.98	229	489	6.66		92					ND				4,700	*
			13APR90	10.27		354	6.79		2					29					*
Lava Cap		Nevada																	
	seepage discharge		14JUN89			390	6.80		58	0.1	ND	2	ND	25	ND	0.6	ND		*
			04SEP89	5.05		510	7.60												1
			13DEC89	6.34	275	518	7.42		70	0.3		2		12		ND		160	*
			82-86						42										2
			M-J 84	6.2															3
Spenceville		Yolo																	
	Little Dry Crk. above mine		13MAR86			140	6.70					<25		85	590				4 1/
			22JUN87			140	8.00	55	<4	<100	<100								5
			03DEC87						<200	<5	<10	<25	<40	<20	<50	<0.2		<100	5
			01FEB88			131	7.60	76				60		<50					5
			07FEB89			204		83	7	<1		3.5	8	2.2				128	6
			28JUN89									30		20				400	7
			13JUN89	15.00		212	7.50		ND	ND	ND	3	ND	1	ND	0.5	ND		*
			11DEC89	16.02		297	6.83			ND		ND		ND		ND		130	*
			8JUN90	15.2		250	7.3			ND		2		3		0.2			*
	Little Dry Crk. below mine		25JUL85					134	5	<2.0		1,500		930	<20			3,400	8
			13MAR86			120	6.80					64		140				490	5
			03DEC87						<200	<5	<10	110	<40	240	<50	<0.2		<100	5
			01FEB88			158	7.08	67				120		200					5
			07FEB89			224		88	7.5	<1		235	<5	128				500	6
			13JUN89	15.00		580	7.30	90	ND	0.2	ND	180	ND	140	ND	0.6	ND		*
			11DEC89	16.02		318	6.95	130		0.7		415		315		ND		1,050	*
			8JUN90			278	7.09			0.5		320		250		0.5			*
	Dry Creek above Little Dry Crk		13JUN89						<1	<0.2	<2	2	<4	<10	<5	0.6	<0.5		*
			11DEC89		204	237	6.72			<0.1		2		<5		<0.2		210	*
			13JAN89			205		79				3.3		3		ND			* 2/
	Dry Creek below Little Dry Crk		13JUN89			245	7.80		<1	<0.2	<2	32	<4	24	<5	<0.2	<0.5		*
			11DEC89		220	249	7.42			0.2		100		50		<0.2		330	*
			13JAN89			200		84				57		56		ND			* 2/
Valley View		Placer																	
	adit discharge		01APR87				1.70		<200	4,500	130	97,000	760	230,000	<50		<10	510,000	9
			27APR90	0.11	427	6,280	2.44		150	6,500	210	150,000	540	260,000	78	ND		810,000	*
	spring/seep above mine		08JUN89						1.9	ND	3.4	7.4	ND	ND	ND	ND	ND		*
	irrig. water above mine		08JUN89						ND	ND	9.1	8.6	ND	ND	ND	ND	ND		*
			21DEC89		196	75	6.17			ND	1	2	ND	ND		ND		190	*
	irrig. water below mine		08JUN89						ND	67.0	3.4	1,120	19.0	4,300	ND	0.1	ND		*
			21DEC89	2.18	247	607	4.59	220		190	2	4,900	41	13,000		ND		360	*
			27APR90	2.81	160	560	4.83			160	2	4,200	59	11,000		ND		440	*

SOURCE:
1. CVRWQCB Data sheet.
2. Cranmer Engineering, Inc. Monitoring data sheets. 35 data points averaged from 11-11-82 to 11-4-86.
3. Hydro-search, Inc. 1984. Report of WDR. June. 6 data points averaged from 4-4 to 5-31-84.
4. Newman, B. 1986. Inspection report.
5. S.S. Papadopulos & Assoc., Inc. 1988. Spenceville Hydrological Assessment Report. April.

Table C-1. WATER QUALITY CHARACTERISTICS OF MINE DRAINAGE & RECEIVING WATERS IN SEVERAL SACRAMENTO VALLEY WATERSHEDS.

MINE	SAMPLE LOCATION	COUNTY	SAMPLE DATE	FLOW (l/s)	Eh (mV)	EC (uS/cm)	pH	HARDNESS AS CACO3 (mg/L)	CONCENTRATION, UG/L (DETECTION LIMITS IN PARENTHESES) ARSENIC (<1.0)	CADMIUM (<0.10)	CHROMIUM (<2.0)	COPPER (<1.0)	NICKEL (<4.0)	ZINC (<10)	LEAD (<5.0)	MERCURY (<0.20)	SILVER (<0.50)	IRON (<30)	SOURC
6. Bond, S. 1989. Data sheet from Sierra Foothill Laboratory. March 3.																			
7. Bond, S. 1989. Spenceville mine. TPCA MINE exemption request review. October 4.																			
8. U.S. BLM. 1986. Memo & data sheet to William Crooks, CVRWQCB, February.																			
9. McDonald, A. 1987. Inspection data sheet.																			
* This study.																			

1/ Not included in the load estimates.

2/ Average of four samples.

YUBA RIVER WATERSHED

Brush Creek																		
main adit	Nevada	30MAR88	1/					186		22	70	290		72				2
		29MAY88						237										1
		06JUN88						210										1
		09JUN88			337	7.50		250										1
		17JUN88			336	7.50		230										1
		28JUN88			362	7.50		210										1
		03JUL88			341	7.50		217										1
		08JUL88			342	7.50		196										1
		09JUL88			367	7.50		270										1
		11AUG88			354	7.50		256										1
		03OCT88			365	7.50		240										1
		05NOV88			348	7.50		260										1
		05DEC88			387	8.20		210										1
		10APR89			331	7.40		176										1
		09JUN89			245			170	ND	4.2	ND	155	ND	ND	ND	ND		*
		12APR90	26.9	83	309	6.90		180		ND	2	110		ND			ND	*
upper adit		30MAR88						61		<2	2	27	<10					1
		29MAY88						76										1
		06JUN88						68										1
		17JUN88			253			81										1
		28JUN88			284			75										1
		03JUL88			303			57										1
		08JUL88			316			69										1
		09JUL88			315			74										1
		11AUG88			365			62										1
		03OCT88			414			32										1
		05NOV88			423			41										1
		05DEC88			210			67										1
		10APR89			227			43										1
		12APR90	6.51	87	186	7.10		60			ND	29						*
Woodruff Crk		28MAR88						20	<1	<5	<10	10	<5	<8	<0.5			1
below mine		30MAR88						20		<2	4	10		<10				1
		29MAY88						21										1
		09JUN88			172	8.00		21										1
		28JUN88			214	8.30		25										1
		17JUN88			210	8.20		26										1
		03JUL88			193	8.20		22										1
		08JUL88			213	8.30		26										1
		09JUL88			235	8.40		29										1
		11AUG88			234	8.20		29										1

Table C-1. WATER QUALITY CHARACTERISTICS OF MINE DRAINAGE & RECEIVING WATERS IN SEVERAL SACRAMENTO VALLEY WATERSHEDS.

MINE	SAMPLE LOCATION	COUNTY	SAMPLE DATE	FLOW (l/s)	Eh (mV)	EC (uS/cm)	pH	HARDNESS AS CACO3 (mg/L)	CONCENTRATION, UG/L (DETECTION LIMITS IN PARENTHESES) ARSENIC (<1.0)	CADMIUM (<0.10)	CHROMIUM (<2.0)	COPPER (<1.0)	NICKEL (<4.0)	ZINC (<10)	LEAD (<5.0)	MERCURY (<0.20)	SILVER (<0.50)	IRON (<30)	SOURC
			03OCT88			209	8.20		26										1
			05NOV88			225	8.10		29										1
			05DEC88			174	7.90		17										1
			10APR89			108	7.90		7										1
			10APR89			111	7.90		7										1
			09JUN89	323		140	10.10		21	<0.2	4.5	<1	8.3	<10	<5	<0.2	<0.5		*
			15DEC89	87	211	192	7.77	100	30		2		5					<30	*
			12APR90	431	85	142	7.00		17				5						*
Champion																			
	adit discharge	Nevada	15JUN89	2.26		107	5.8		ND	0.7	ND	1	ND	11	ND	ND	ND		*
Columbo		Sierra																	
	adit discharge		09JUN89	42.79					2.4	ND	4.5	ND	ND	ND	2.9	ND	ND		*
			15DEC89	16.83	216	153	7.46		ND		2				ND			ND	*
			12APR90	31.82	115	153	7.01		ND		1				ND				*
Kanaka Creek mines 2/		Sierra																	
	confluence with M.F. Yuba R.		14DEC89	278	191	182	6.86	79	25		2		ND		ND			ND	*
			13APR90	1,226		114	6.46	45	15		ND								*
	M.F. Yuba R. above Kanaka Crk.		13APR90			60.1	6.54		ND										*
	M.F. Yuba R. below Kanaka Crk.		13APR90			65	6.77		ND										*
Malakoff Diggins		Nevada																	
	Hillar Tunnel discharge		23FEB89				6.80	40	9	<200	100	80	80	90	<20	0.5	<200	35,000	3
			14JUN89			117	6.50		ND	ND	ND	3	9	24	ND	0.3	ND		*
			14DEC89	26.32	176	163	6.52				2		68	24		ND		3,000	*
			13APR90	17.52		203	6.82					ND	19	26		ND			*
	Humbug Crk. above mine		14JUN89			82	6.70		ND	ND	ND	1	7	ND	ND	ND	ND		*
			14DEC89		224	142	6.61	61			ND		12	ND		ND		40	*
	Humbug Crk. below mine		14DEC89		210	133	6.67	51			ND		15	8		ND		110	*
Pick & Shovel		Sierra																	
	adit discharge		06OCT89	1.24		733	6.75		3	ND	1.5	ND	180	21	ND	ND	ND		*
			19APR90	3.18	126	342	6.28		ND		ND		93	7				30	*
	Pats Gulch above mine		06OCT89	0.71		58	7.25		ND	ND	1	ND	ND	ND	ND	ND	ND		*
			19APR90			27	6.58				ND		ND	ND					*
	Pats Gulch below mine		06OCT89			378	6.79	130	ND	ND	1	ND	100	13	ND	ND	ND		*
			19APR90		125	83	6.62	26			ND		18	5					*
	Pats Gulch 1 mile below mine		06OCT89			112	7.3		ND	ND	ND	ND	ND	ND	ND	ND	ND		*
Plumbago		Sierra																	
	adit discharge		13MAY88			250	8.10		370		ND	6	40		ND	ND			4
			10JUN89	4.25		300			280	ND	5.2	ND	6.2	ND	ND	ND	ND		*
			20JUN89			284	7.90		85			ND		ND		ND			5
			14DEC89	2.29	235	325	7.39		320		1.5		ND					65	*
	Buckeye Ravine above mine		10JUN89			130			1.7	ND	12	ND	8.8	ND	ND	ND	ND		*
			14DEC89		209	207	7.64		ND		8		ND					ND	*
	Buckeye Ravine below mine		14DEC89		208	234	7.46	130	170		9		ND					ND	*
Sierra Buttes mines		Sierra																	
	Howard Creek		09JUN89			24	4		1.2	ND	3	ND	ND	ND					*

Table C-1. WATER QUALITY CHARACTERISTICS OF MINE DRAINAGE & RECEIVING WATERS IN SEVERAL SACRAMENTO VALLEY WATERSHEDS.

MINE	SAMPLE LOCATION	COUNTY	SAMPLE DATE	FLOW (l/s)	Eh (mV)	EC (uS/cm)	pH	HARDNESS AS CACO3 (mg/L)	CONCENTRATION, UG/L (DETECTION LIMITS IN PARENTHESES) ARSENIC (<1.0)	CADMIUM (<0.10)	CHROMIUM (<2.0)	COPPER (<1.0)	NICKEL (<4.0)	ZINC (<10)	LEAD (<5.0)	MERCURY (<0.20)	SILVER (<0.50)	IRON (<30)	SOURC
			15DEC89	60.66	201	44	6.60		ND		1	ND		ND				ND	*
Spanish		Nevada																	
	Lower adit (16 to 1)		14JUN89			170	3.50		9	7.1	1	370	160	2,300	39	0.3	ND		*
			15DEC89	2.92	240	468	5.54		7	5.1	1	220	70	1,950	28	ND		3,400	*
			12APR90	1.38	89	5,060	4.05		2.5	3.7	ND	210	100	1,900	20	ND		3,850	*
			14AUG90	1.81	102	509	4.45	69										8,900	*
			26SEP88						<10	5	<5	170							
			03MAY89						<5	12	<5	590							
			20DEC89						<5	5	<5	200							
	Poorman Creek above lower adit		15DEC90		208	62	6.46		ND	0.2	ND	ND	ND	10	ND	ND		ND	*
			12APR90		107	32	6.43			ND		ND		ND				ND	*
	Poorman Creek below lower adit		14JUN89			57	6.20	25	ND	ND	ND	2	ND	14	ND	ND	ND		*
			15DEC89		211	72	6.26	28	ND	0.1	ND	ND	ND	15	ND	ND		ND	*
			12MAY90		96	33	6.35	12		ND		1		15					*
	Upper adit		14AUG90	2.3	68	478	5.67	66.7	18	7.5	ND	80	19	21	110			37000	*
			27SEP88						5	4	<5	<100							6
			03MAY89						41	<29	<5	500							6
			31DEC89						<5	<1	<5	<50							6
	Devels Canyon Cr above upper adit		03APR89						<5	<1	<5	<10							6
	Devels Canyon Crk ca 1 mi below upper adit		26SEP88						<10	<1	<5	<10							6
			03APR89						<5	2	<5	60							6
			31DEC89						<5	<1	<5	<10							6
	Devels Canyon Crk ca 2 mi below upper adit		14AUG90	8.9	51	175	7.53	98.84	ND	ND	2	ND	6	2	ND			ND	*
			27SEP88						<10	<1	<5	<1							6
			03MAY89						<5	<1	<5	20							6
			20DEC89						<5	<1	<5	<50							6

1/ Not included in the loading estimates.
2/ At the confluence with the M.F. Yuba R. Several mines exist in the watershed (e.g., Sixteen-to-One, Oriental, Kenton).

SOURCE:
1. Sierra County Case #1455, Brush creek Mine.
2. Clementsen, K. 1988. Data sheet from CH2M Hill. May 6.
3. Waggoner, M. 1989. Inspection report on Malakoff Diggins.
4. Daniels, D. 1988. Inspection report. Jun.10
5. Daniels, D. 1989. Inspection report. Jun.30
6. Vector Engineering, Inc. 1990. Operations and reclamation plan for the phase II exploration program, Spanish Mine, Washington, CA. VEI, Grass Valley, CA. May.
* This study.

FEATHER RIVER WATERSHED

Beardsley		Plumas																
	Hosselkus Creek below mine		26AUG89		131	7.05		ND	ND	ND	2	ND	ND	ND	ND	ND		*
Engel/Superior		Plumas																
	Lights Creek above mine		27JUN89		120	6.70		ND	ND	ND	4	ND	ND	ND	0.4	ND		*
	Lights Crk. below Superior Gulch		27JUN89		98	7.70		ND	ND	ND	3	ND	ND	ND	0.3	ND		*
	Lights Creek 3 mi. below mine		27JUN89		134	7.30		3	ND	ND	12	ND	ND	ND	ND	ND		*

Table C-1. WATER QUALITY CHARACTERISTICS OF MINE DRAINAGE & RECEIVING WATERS IN SEVERAL SACRAMENTO VALLEY WATERSHEDS.

MINE	SAMPLE LOCATION	COUNTY	SAMPLE DATE	FLOW (l/s)	Eh (mV)	EC (uS/cm)	pH	HARDNESS AS CACO3 (mg/L)	CONCENTRATION, UG/L (DETECTION LIMITS IN PARENTHESES) ARSENIC (<1.0)	CADMIUM (<0.10)	CHROMIUM (<2.0)	COPPER (<1.0)	NICKEL (<4.0)	ZINC (<10)	LEAD (<5.0)	MERCURY (<0.20)	SILVER (<0.50)	IRON (<30)	SOURC
Iron-Dyke		Plumas																	
	Taylors creek above mine		27JUN89			159	6.70		ND	ND	ND	ND	ND	ND	ND	ND	ND		*
	Taylors creek below mine		27JUN89	2.30		90	6.70		ND	0.5	ND	21	ND	18	ND	ND	ND		*
Lucky-S		Plumas																	
	lower shaft water		26AUG89	seep		57	6.73		ND	0.3	ND	1	ND	14	ND	ND	ND		*
	adit discharge		26AUG89	3.22		106	6.54		ND	2.9	ND	80	ND	260	ND	ND	ND		*
			20APR90	4.06	130	101	6.04			2.5		63		335				25,000	*
	Peters Creek below mine		26AUG89			101.7	7.01	42	ND	3.8	ND	110	ND	510	ND	ND	ND		*
			20APR90		140	36	6.45	13		0.4		24		88					*
Plumas-Eureka		Plumas																	
	caved drainage shaft water		26JUN89			130	8.20		4	0.1	ND	2	ND	6	ND	0.2	ND		*
	Jamison Creek below mine		26JUN89			150	6.50		ND	ND	ND	ND	ND	ND	ND	ND	ND		*
Reward #7		Plumas																	
	Ward creek below mine		20DEC89		185	146	7.23		130	ND	ND	ND	ND	ND	ND	0.2		ND	*
			10APR90			108	6.41	47	ND										*
	Ward creek above mine		10APR90			106	6.68		ND										*
Walker																			
	main adit discharge	Plumas	26MAR88	0.57								290		10					1
			02JUN88	0.37								248		5.4					1
			16JUL88									240		<10					1
			03AUG88	0.28								220		<50					1
			03NOV88	0.28								229		7					1
			03NOV88	0.28								229		6.5					1
			03NOV88									240		40					1
			29JAN89	1.16								250		14					1
			29MAR89	0.93								450		<5					1
			20JUN89									310		20					1
			06JUN89									260		20					1
			06JUN89									280		10					1
			06JUN89			107	7.34		ND	0.1	ND	290	ND	9	ND	ND	ND		*
	Dollie Creek above mine		03AUG88									8		23					1
			03NOV88	0.03								6.2		2.8					1
			03NOV88									7		45					1
			29JAN89	0.08								<2		<5					1
			20JUN89	1.25								<1		<10					1
			26JUN89			118	7.70		ND	ND	1	ND	ND	ND	ND	ND	ND		*
	Dollie Creek below mine		03AUG88									69		7					1
			03NOV88	7.87								28		3					1
			26JUN89	15.15								90		10					1
			26JUN89	8.5		114	7.60		ND	ND	ND	49	ND	ND	ND	ND	ND		*

SOURCE: 1. Croyle, B. 1990. Walker mine data report (data collected post-plugging)
* This study.

Table C-1. WATER QUALITY CHARACTERISTICS OF MINE DRAINAGE & RECEIVING WATERS IN SEVERAL SACRAMENTO VALLEY WATERSHEDS.

MINE	SAMPLE LOCATION	COUNTY	SAMPLE DATE	FLOW (l/s)	Eh (mV)	EC (uS/cm)	pH	HARDNESS AS CACO3 (mg/L)	CONCENTRATION, UG/L (DETECTION LIMITS IN PARENTHESES) ARSENIC (<1.0)	CADMIUM (<0.10)	CHROMIUM (<2.0)	COPPER (<1.0)	NICKEL (<4.0)	ZINC (<10)	LEAD (<5.0)	MERCURY (<0.20)	SILVER (<0.50)	IRON (<30)	SOURC
PIT RIVER WATERSHED																			
Golden Eagle	Dammed pond water	Lassen	03AUG89	0		325	6.60		9	ND	ND	3	ND	14	ND	ND	ND		*
UPPER SACRAMENTO RIVER WATERSHED																			
Afterthought	main adit	Shasta	MAR78							1,230		48,900		313,000				330,000	1
			JUN78				2.60			720		25,600		149,000				96,000	1
			MAY82				2.57			800		33,500		185,000				160,000	1
			APR84	1.20			2.80			410		17,600		100,000				92,400	1
			JUN84	0.30			2.85			320		12,100		91,400				70,600	1
			AUG84	0.20			2.74			300		10,600		83,600				51,400	1
			DEC84	1.80			2.60			740		34,100		177,000				202,000	1
			12JUL89			3,000	2.70		25	340	2	14,000	32	93,000	91	<0.2	<1		*
	Afterthought Crk. above mine		MAR78							60		1,720		1,120				430	1
			APR84	1.10			5.00			40		1,090		8,060				430	1
			DEC84	1.80			4.65			70		1,120		12,200				380	1
	Afterthought Crk. below mine		MAR78							440		16,500		96,500				90,300	1
			MAY78				2.85			580		19,400		127,000				106,000	1
			APR84	2.30			2.90			260		9,480		61,200				42,900	1
			DEC84	3.70			2.65			420		18,300		98,500				760	1
			FEB85						142		<50		<50		50	<0.2			1
	Little Cow Crk. above mine		MAR78							<10		<10		20				20	1
			MAY78				6.00			<10		<10		10					1
			JUN78				7.10					<10		<10					1
			MAY82				8.11			<10		<20		<20				200	1
			APR84	3,569			7.90			<0.2		<2		<20				110	1
			JUN84	748			8.45			<0.2		<2		7				50	1
			AUG84	296			7.97			<0.2		3		16				50	1
			DEC84				7.90			<0.2		90		5				60	1
			12JUL89			191	6.70		<	0	<1	<1	<4	<5	<5	<0.2	<1		*
	Little Cow Crk. 0.5 mile below mine		MAY78				5.70			<10		0		0					1
			MAY82				8.14			<10		130		860				1,750	1
			APR84	3,572			7.80			<0.2		7		40				130	1
			JUN84	748			8.40			<0.2		2		60				70	1
			AUG84	296			8.63			1		8		60				50	1
			DEC84				7.75			0.2		11		110				170	1
			12JUL89			180	8.00	71	<	1	<1	17	<4	110	<5	<0.2	<1		*
Gladstone	Cline Creek below mine	Shasta	12JUL89			192	6.50		23	ND	ND	ND	ND	ND	ND	ND	ND		*

SOURCE:
* This study.

Table C-1. WATER QUALITY CHARACTERISTICS OF MINE DRAINAGE & RECEIVING WATERS IN SEVERAL SACRAMENTO VALLEY WATERSHEDS.

MINE	SAMPLE LOCATION	COUNTY	SAMPLE DATE	FLOW (l/s)	Eh (mV)	EC (uS/cm)	pH	HARDNESS AS CACO3 (mg/L)	CONCENTRATION, UG/L (DETECTION LIMITS IN PARENTHESES) ARSENIC (<1.0)	CADMIUM (<0.10)	CHROMIUM (<2.0)	COPPER (<1.0)	NICKEL (<4.0)	ZINC (<10)	LEAD (<5.0)	MERCURY (<0.20)	SILVER (<0.50)	IRON (<30)	SOURC
Greenhorn		Shasta																	
	North adit discharge		APR81	0.32			2.40			990		125,000		180,000				1,350,000	1
			APR82	0.95			2.40			920		138,000		152,000				1,113,000	1
			MAY83				2.70			920		118,000		78,000				642,000	1
			FEB84	0.47			2.70			1,510		117,000		151,000				931,000	1
			APR84	0.63			2.70			1,350		69,000		124,000				712,000	1
			SEP84	0.38			2.60			1,240		65,600		142,000				1,000,000	1
			DEC84	0.68			2.70			1,400		63,400		140,000				874,000	1
			12JUL89			5,540	2.34		170	680	12	80,000	190	160,000	91	ND	ND		*
			20DEC89	0.01	425	6,150	2.63			645	9	67,000	61	170,000	ND			1,000,000	*
			13APR90	0.06	422	5,650	2.60		39	670	9	61,000	165	150,000	ND	ND		780,000	*
	South adit discharge		FEB79				3.30			190		56,000		25,500					1
			APR82				3.00			123		57,100		26,000				42,000	1
			20DEC89	0.04	136	1,431	5.74			15	ND	200	ND	4,500	ND			120,000	*
			13APR90	0.06	134	1,364	5.87		ND	10		200		4,700					*
	Middle adit discharge		JAN81				2.70												1
			APR81				2.60			160		95,000		29,000				230,000	1
			APR82							160		101,000		38,700				221,000	1
			DEC84	0.03			2.90			160		87,300		33,300				48,500	1
			20DEC89	0.39	168	682	5.72			2	ND	1,500	ND	1,100	ND			29,000	*
			13APR90	0.60	173	718	5.16		8	3.1		3,400		1,800					*
	lower pile seep		AUG76				3.50					13,800		4,500				3,500	1
			FEB79				4.00			20				2,300					1
			JAN81									5,800							1
			APR81				3.60			<10		30		1,800				47,600	1
			APR82				3.70			12		4,010		1,990				230	1
			APR84	0.09			3.30			13		480		5,650				140,000	1
			SEP84	0.06			3.50			20		390		6,160				131,000	1
			DEC84	0.07			3.60			10		690		4,790				134,000	1
	Willow Crk. upstream mine		AUG76				6.90					60		50				220	1
			FEB79				7.20			<10		<20		<20					1
			APR81				7.80			<10		<20		30				370	1
			APR82				7.10			<5		<20		<6				110	1
			FEB84	129.70			7.80			<1		13		70				330	1
			APR84	75.70			7.50			<0.2		<2		<10				<50	1
			SEP84	14.70			7.60			<0.2		<2		7				370	1
			DEC84	102.00			7.60			<0.2		<2		10				260	1
			12JUL89			154	7.80		ND	ND	ND	ND	ND	23	ND	ND	ND		*
			20DEC89	33.09	177	149	6.45			ND	ND	ND	ND	ND	ND			590	*
			13APR90	30.58	114	152	7.00		ND	ND	ND	2	ND	ND	ND			280	*
	Willow Crk. downstream mine		FEB79				5.90			<10		500		330					1
			APR82				6.70			<5		120		300				540	1
			MAY83				6.70			3		590		290				2,460	1
			FEB84	152.00			7.00			7		580		610				3,730	1
			APR84	89.00			6.80			16		400		820				2,200	1
			SEP84	14.80			6.30					1,180		1,740				9,360	1
			DEC84	104.90			7.20			1		210		220				1,810	1
			12JUL89	56.63		378	4.70	130	ND	14	ND	1,600	9	2,700	ND	ND	ND		*
			20DEC89	41.08	140	233	6.83	85		3	2	390	ND	720	ND			4,400	*
			13APR90	35.68	77	268	6.78	82		3		460		820				5,100	*

Table C-1. WATER QUALITY CHARACTERISTICS OF MINE DRAINAGE & RECEIVING WATERS IN SEVERAL SACRAMENTO VALLEY WATERSHEDS.

MINE	SAMPLE LOCATION	COUNTY	SAMPLE DATE	FLOW (l/s)	Eh (mV)	EC (uS/cm)	pH	HARDNESS AS CACO3 (mg/L)	CONCENTRATION, UG/L (DETECTION LIMITS IN PARENTHESES) ARSENIC (<1.0)	CADMIUM (<0.10)	CHROMIUM (<2.0)	COPPER (<1.0)	NICKEL (<4.0)	ZINC (<10)	LEAD (<5.0)	MERCURY (<0.20)	SILVER (<0.50)	IRON (<30)	SOURC
Iron Mountain		Shasta																	
	Spring Creek Debris Dam		1/ 1980	3,256										28,400					2
			1/ 1981	2,435										30,880					2
			1/ 1982	5,239										25,490					2
			1/ 1983	8,325										25,660					2
			1/ 1984	2,917			2.90			88		1,690		21,040					2
			1/ 1985	1,274			2.80			70		2,100		22,570					2
			1/ 1986	3,794										33,080					2
			1/ 1987	1,246			2.79			42		1,340		29,480					2
			1/ 1988	1,586			2.83			118		2,870		23,330					2
			1/ 1989	1,897			2.90			81		1,970		17,920					2
			13JUL89			1475	2.44		37	95	10	3,500	13	15,000	22	0.2			*
			26JUL89			2050	2.60		56	140	15	5,000	17	21,000	24	<0.2			*
			21DEC89		538	1626	2.86		47	92	12	4,900	<4	17,000	15				*
			1/ 1990				2.80			56		1,460							2
			14APR90		499	1157	2.89		4.5	72	3	1,150	11	9,950	14.5				*
Midas		Shasta																	
	Harrison Creek above mine		26JUL89	1.98		300	6.80		ND	ND	ND	ND	ND	ND	ND	ND	ND		*
	Harrison Creek below mine		26JUL89			510	4.90		4	ND	ND	ND	ND	ND	ND	ND	ND		*
Round Bottom		Shasta																	
	adit discharge		26JUL89	seep		610	7.10		ND	1.2	16	ND	54	ND	ND	ND	ND		*
Silver Falls		Shasta																	
	ponded adit water		26JUL89	0		480	6.70		ND	ND	ND	ND	ND	6	ND	ND	ND		*
Thompson		Shasta																	
	pit water		13JUL89	0		197	6.30		ND	0.2	ND	10	ND	6	ND	ND	ND		*

1/ Annual average.

SOURCE:

1. California Department of Water Resources(CDWR).1985.The Greenhorn and Afterthought mines-A plan for the control and abatement of acid and heavy metal pollution Shasta County CA.Memorandum report CDWR Northern District. July
2. Heiman, D. 1991. Database printout from weekly Spring Creek Debris Dam sampling.
* This study.

STONY CREEK/ELDER CREEK WATERSHEDS

Gray Eagle		Glenn																
	pit water		20JUL89	0		698	8.79		ND	ND	ND	1	ND	ND	ND	ND	ND		*
Noble Electric Co.		Tehama																
	West ravine seepage		04AUG89	seep		540	8.20		ND	ND	5	ND	ND	ND	ND	ND	ND		*
	North Fork Elder Creek above mine		04AUG89			700	8.20		ND	ND	2	ND	ND	5	ND	ND	ND		*
	North Fork Elder Creek below mine		04AUG89	48.71		1030	8.30		ND	ND	2	ND	ND	5	ND	ND	ND		*

Table C-1. WATER QUALITY CHARACTERISTICS OF MINE DRAINAGE & RECEIVING WATERS IN SEVERAL SACRAMENTO VALLEY WATERSHEDS.

MINE	SAMPLE LOCATION	COUNTY	SAMPLE DATE	FLOW (l/s)	Eh (mV)	EC (uS/cm)	pH	HARDNESS AS CACO3 (mg/L)	CONCENTRATION, UG/L (DETECTION LIMITS IN PARENTHESES) ARSENIC (<1.0)	CADMIUM (<0.10)	CHROMIUM (<2.0)	COPPER (<1.0)	NICKEL (<4.0)	ZINC (<10)	LEAD (<5.0)	MERCURY (<0.20)	SILVER (<0.50)	IRON (<30)	SOURCE
SOURCE: * This study.																			
CACHE CREEK WATERSHED																			
Turkey Run		Lake																	
	adit discharge		25AUG89	0.19		803	7.83		ND	ND	3	ND	ND	ND	ND	ND	ND		*
Reed		Yolo																	
	adit discharge		25AUG89	0.32		3,010	6.33		59	ND	46	ND	1,200	20	ND	ND	ND		*
			27APR90	seep															*
	Davis Creek above mine		25AUG89	0.24		1,024	8.22		ND	ND	ND	1	ND	14	ND	ND	ND		*
			27APR90		94	907	8.07		ND		2		4	6					*
	Davis Creek below mine		25AUG89			3,450	6.67	1100	29	ND	30	1	875	10	ND	ND	ND		*
			27APR90	0.3	93	1,010	7.5	540	ND		1		17	7				100	*
Sulpher Creek mines **			02AUG89	4.73		>10,000	7.90		7	ND	3	1	8	36	ND	<20	ND		*
SOURCE: * This study. ** Sulphur Creek below Central, Empire, Manzanita, Wide Awake, and Elgin mines.																			
LAKE BERRYESSA, PUTAH CREEK WATERSHED																			
Anderson Springs		Lake																	
	west adit		24AUG89	0.08		1,092	6.16		7	ND	9	15	240	260	ND	ND	ND		*
			18DEC89	0.15	-105	900	7.02		ND	ND	ND	ND	10	17				7,000	*
			09APR90	0.19	-65	1,081	6.77		3		4	11	70	190					*
	east adit		24AUG89	0.59		1,282	6.61		4	ND	ND	ND	74	61	ND	ND	ND		*
			18DEC89	0.53	122	1,347	7.21		6				32	84				2,700	*
			09APR90	0.37	59	1,208	6.58		18			30	170						*
	creek above West adit		09APR90		92	308	7.28		ND				6	8					*
	creek below West adit		18DEC89		71	346	6.96		2	ND		ND	ND	5				870	*
			09APR90		12	318	7.11	160	ND				6	5					*
	Anderson Springs creek below both adits		24AUG89			139	6.96		ND	ND	1	1	ND	ND	ND	ND	ND		*
			18DEC89		180	184	7.28		ND	ND	2	ND	ND	ND		ND		ND	*
			09APR90		103	244	7.58		ND				ND	ND					*
Great Western		Lake																	
	adit discharge		24AUG89	0.24		325	7.39		ND	ND	5	2	26	10	ND	ND	ND		*
			19DEC89	0.13	172	302	7.36				4	ND	17	10				790	*
			09APR90	0.63		321	7.50		ND	ND	3	1	59	26	ND	ND			*
	St Marys Creek below mine		19DEC89		160	720	7.44				3	ND	ND	ND				50	*
			09APR90			604	7.79				4	ND	8	120					*
Knoxville		Napa																	

Table C-1. WATER QUALITY CHARACTERISTICS OF MINE DRAINAGE & RECEIVING WATERS IN SEVERAL SACRAMENTO VALLEY WATERSHEDS.

MINE	SAMPLE LOCATION	COUNTY	SAMPLE DATE	FLOW (l/s)	Eh (mV)	EC (uS/cm)	pH	HARDNESS AS CACO3 (mg/L)	CONCENTRATION, UG/L (DETECTION LIMITS IN PARENTHESES) ARSENIC (<1.0)	CADMIUM (<0.10)	CHROMIUM (<2.0)	COPPER (<1.0)	NICKEL (<4.0)	ZINC (<10)	LEAD (<5.0)	MERCURY (<0.20)	SILVER (<0.50)	IRON (<30)	SOURC
	Knoxville Creek above mine		03AUG79				7.60									0.1		200	1
	Knoxville Creek below mine		03AUG79				7.50									0.4		200	1
Red Elephant		Napa																	
	ponded shaft Water		24AUG89			1474	7.41		ND	ND	ND	ND	ND	ND	ND	ND	ND		*
	Aetna Etension, south slope creek below mine	Napa	24AUG89	0.32		778	7.52		ND	ND	8	ND	9	10	ND	ND	ND		*
Corona		Napa																	
	main adit discharge		15MAR79	3.50			5.60									0		8,000	1
			06MAY81	0.30		725	6.50		5	<10						1			2
			10AUG89	seep		754	7.40		<2	<0.1	44	<1	1,900	41	<5	<0.2	<1		*
			09APR90	0.29		1,051	5.73				21	1	4,000	44				53,000	
	water release tunnel		15MAR79	21.30			5.00									0		620,000	1
			10AUG89	3.10		1,593	5.00	630	<2	<0.1	71	<1	10,000	230	<5	<0.2	<1		*
			19DEC89	2.87	120	1,177	6.03				21		6,050	100				150,000	*
			09APR90	2.65		1,906	5.67				30		12,000	260				350,000	*
	James Crk upstream mine		15MAR79	4.90			6.40									0		400	1
			19DEC89		124	258	6.89				1		130	<5				460	*
			09APR90			277	6.66				ND		120	ND				ND	*
	James Crk downstream mine		15MAR79	31.20			5.40					0		100		0		110,000	1
			19DEC89		85	966	6.38				10		4,800	80				110,000	*
			09APR90			1,110	6.29	360			8	2	6,000	110					*
	James Crk downstream mine (1.5 mile down)		23AUG89	4.12		894	6.69	540	<2	<0.1	1	1	3,000	23	<5	<0.2	<1		*
Twin Peaks		Napa																	
	adit discharge at pipe		23AUG89	0.28		393	4.89		ND	0.4	10	ND	2,000	30	ND	ND	ND		*
			19DEC89	0.20	143	471	6.30			ND	3		1,800	30				16,000	*
			09APR90	0.25		416	6.43			ND	4		1,600	26				14,000	*
	discharge at base of waste pile		23AUG89	0.06		445	5.11		ND	ND	2	3	2,200	17	ND	ND	ND		*
	Bateman Creek above mine		23AUG89			176	5.92		ND	ND	ND	ND	ND	ND	ND	ND	ND		*
			19DEC89		170	97	6.61			ND	ND		ND	ND				ND	*
			09APR90			103	7.06			ND	ND		ND	5					*
	Bateman Creek below mine		23AUG89			294	6.66	140		ND	1	1	250	7	ND	ND	ND		*
			19DEC89		169	120	6.75	48		ND	ND		32	ND				60	*
			09APR90			127	6.99	47		ND	ND		62	ND					*

SOURCE:
1. Pinkos, T. 1979. Downstream water quality. CVRWQCB Internal memo. March 15.
* This study.

LAKE BERRYESSA, POPE CREEK WATERSHED

SOURCE:
1. Pearson, L. 1979. Inspection of Corona Mine/James Ck. area. CVRWQCB Internal Memo. April 12.
2. Crawford, E. 1981. Requirements checking Corona Mine, Napa County. CVRWQCB Internal Memo. June 9.
* This study.

Table C-2. WATER QUALITY CHARACTERISTICS OF MINE DRAINAGE AND RECEIVING WATERS IN THE SHASTA DAM WATERSHED.

SAMPLE LOCATION	SAMPLE DATE YEAR	MONTH/DAY	E.C. (uS/cm)	pH	FLOW (l/s)	HARDNESS AS CACO3 (mg/l)	TOTAL CONCENTRATION (UG/L) ARSENIC	CADMIUM	CHROMIUM	COPPER	IRON	LEAD	MERCURY	NICKEL	SILVER	ZINC	SOURCE
BALAKLALA MINE																	
main adit	1975	4 / 1	675	3.20	65.10			40		6,250	29,000					7,000	1
	1975	9 / 17	513	3.60	4.00			100		9,500	48,000	96				16,000	1
	1978	12 /	700	3.00	0.80			80		10,500						15,200	7
	1979	8 /		2.90	5.10			60		7,300	5,500					11,800	8
	1979	9 /		2.80	4.70			60		7,500	7,200					12,000	8
	1979	10 /		2.50	9.50			200		43,800	276,000					33,000	8
	1979	11 /		2.60	9.50			150		31,100	201,000					25,700	8
	1980	1 /		3.10	18.90			100		6,700	85,000					14,000	8
	1980	2 /		3.20	33.40			40		8,500	16,300					9,100	8
	1980	3 /		3.60	33.40			400		6,700	8,600					9,300	8
	1980	4 /		4.20	19.00			40		6,600	6,300					9,300	8
	1980	5 /		2.80	19.00					6,300	2,000					10,100	8
	1980	6 /		2.60	11.80					6,200	3,400					11,400	8
	1980	6 / 27						120		12,100						22,000	6
	1980	6 /			2.80					12,000	24,000					21,400	8
	1980	7 /		5.60	2.90					11,900	53,700					23,000	8
	1980	7 / 6						110		13,300						21,700	5
	1980	8 /		3.80	2.10					12,500	33,000					25,000	8
	1980	9 /		3.30	1.90					12,700	55,000					26,000	8
	1980	10 /		3.20	1.60					13,900						27,000	8
	1980	10 /			2.00					13,000	89,000					25,900	8
	1980	11 /		3.30	3.70					9,900	50,000					16,000	8
	1980	12 /		3.30	1.60					45,000	280,000					43,000	8
	1981	3 /			4.70			120		20,200	96,400					19,000	8
	1981	4 /			12.60			80		12,700	65,300					14,500	8
	1981	4 / 10						80		12,700	65,300					14,500	4
	1981	6 /		2.70	2.80			130		14,900	103,000					24,800	8
	1981	7 / 1		2.70	2.80			130		14,900	103,000					24,800	3
	1981	8 / 27		2.70				170		16,440	61,000					29,000	2
	1981	9 /		2.70	6.10			170		16,400	61,000					29,000	8
	1982	10 / 26	1550	2.80	19.03			110		17,000	132,000					19,000	23
	1982	11 / 23	1325	2.60	15.89			110		15,000	98,000					17,000	23
	1982	12 / 28	1250	2.60	35.14		40	80	0	13,000	68,000	60				13,000	23
	1983	1 / 27	820	2.80	279.49			50		9,000	50,000					6,100	23
	1983	3 / 1	3450	2.90	589.00			610		11,000	790,000					130,000	23
	1983	4 / 21	1310	2.90	37.58												23
	1984	4 / 9		2.90	12.60			70		9,430	144,000					45,700	10
	1984	6 / 22		3.10	9.50			90		11,700	176,000					19,400	15
	1985	1 / 10			17.90			90		12,600						17,600	11
	1985	4 / 4		2.48	14.80			90		15,500						20,600	11
	1985	10 / 4						90		11,500	191,000					19,500	16
	1986	4 / 7		2.57	25.20			50		6,400						8,000	12
	1986	6 / 24						110		11,400						18,400	13
	1986	6 / 10		2.70	3.20			120		15,000						22,500	13
	1986	12 / 23			2.50			108		12,500						20,000	14
	1987	10 / 6								25,800						46,000	18
	1987	11 / 10								18,900						25,000	19
	1988	1 / 29		2.70	28.40			60		10,400						14,500	20
	1989	3 / 13	2300	2.40	1.60			2,240		37,200						39,100	22
	1989	4 / 28			1.80			138		18,400						24,500	17
	1989	4 / 9	1830	2.60	2.40			171		26,800						28,700	21

Table C-2. WATER QUALITY CHARACTERISTICS OF MINE DRAINAGE AND RECEIVING WATERS IN THE SHASTA DAM WATERSHED.

SAMPLE LOCATION	SAMPLE DATE YEAR	MONTH/DAY	E.C. (uS/cm)	pH	FLOW (l/s)	HARDNESS AS CACO3 (mg/l)	TOTAL CONCENTRATION (UG/L) ARSENIC	CADMIUM	CHROMIUM	COPPER	IRON	LEAD	MERCURY	NICKEL	SILVER	ZINC	SOURCE
	1989	5 / 4	1650	2.70	1.60				137	18,600						23,500	21
	1989	5 / 31	1700	2.60	1.45				149	16,000						27,600	24
	1989	7 / 9	1810	5.40	1.45				148	14,900						27,500	25
	1989	7 / 31	1720	3.12	0.76				132	13,000						24,500	26
	1989	9 / 1	1690	3.13	0.42				160	15,400						29,600	27
	1989	10 / 2	1970	2.71	0.56				177	16,500						33,400	28
Weil adit	1982	10 / 26	8000		0.03				6,500	912,000	8,900,000					1,380,000	23
	1982	11 / 23	8000	2.30	0.02				6,600	886,000	8,740,000					1,380,000	23
	1982	12 / 28	8000	2.40	0.07				6,800	910,000	8,850,000					1,500,000	23
	1983	1 / 27	8000	2.30	0.03				6,800	569,000	8,500,000					1,400,000	23
	1983	2 / 28	8000	2.30	0.03				6,400	453,000	7,750,000					1,300,000	23
	1983	4 / 21	8000	2.20	0.03												23
	1984	4 / 9		2.52	0.06				4,020	199,000	9,580,000					1,690,000	10
	1985	1 / 10		2.55	0.03				5,960	310,000						1,430,000	11
	1985	4 / 4		2.55	0.02				4,300	216,000						1,180,000	11
	1986	4 / 7			0.00				700	120,000						160,000	12
	1986	6 / 10		2.15	0.01				3,000	490,000						580,000	13
	1986	12 / 23			0.10				1,030	158,000						190,000	14
	1987	10 / 6								109,000						143,000	18
	1987	11 / 10		2.71						316,000						532,000	19
	1989	4 / 28			0.38				34	5,250						5,430	17

SOURCE:1:Fuller,R.,Shay,J.,Ferreira,R.,and Hoffman,R.1978.An evaluation of problems arising from acid mine drainage in the vicinity of Shasta reservior ,Shasta County,California.Water-Resouces Investigation 78-32 May.
2:Heiman,D.1981.Inspection report.CVRWQCB Inspection report.September.
3:Heiman,D.1981.Compl.Ispect.-Silver King.CVRWQCB office memo July 1.
4:Heiman,D.1981.Compliance inspection-West Squaw Creek mines CVRWQCB Internal Memo.May 11.
5:Heiman,D.1980.Inspection,West Squaw Creeek/Balaklala,Silver King mines,Inc.,Shasta County CVRWQCB Internal Memo.September 2.
6:Silver King Mine,1980. Report.From Silver King Mines.Inc.Salt Lake City, Utar to CWQCB Redding .August 6.
7:Smarkel,k.1979.West Squaw drainage inspection Shasta County.CVRWQCB Internal Memo.February 5.
8:CVRWQCB.Balaklala,Keystone,and Shasta King mines.Table 1.Water quality information for Shasta King ,Keystone,and Balaklala mines.
10:Heiman,D.1984 inspection report .CVRWQCB Inspection report.May 14.
11:Heiman,D.1985.Water quality surveys-West Squaw Creek mines.CRWQCB.CVR Internal Memo.August 26.
12:Heiman,D.1986.Inspection report.CVRWQCB Inspection report.March 25.
13:Heiman,D.1986.Inspection report.CVRWQCB Inspection report.July 8.
14:Heiman,D.1987.Result of samples-Balaklala,Keystone and early Bird mines,23 December 1986.CVRWQCB Office Memo.January 29.
15:Heiman,D.1984.Data sheet. Reported by Environmental Laboratory to WQCB Redding July 13.
16:Heiman,D.1984.Data sheet. Reported by Environmental Laboratory to WQCB Redding October 28.
17:Heiman,D.1989.Squaw Creek survey.28 April 1989.CRWQCB.CVR Internal Memo.September 13.
18:Heiman,D.1984.Data sheet. Reported by Environmental Laboratory to WQCB Redding.november 17.
19:Heiman,D.1984.Data sheet. Reported by Environmental Laboratory to WQCB Redding december 16.
20:Heiman,D.1988.inspection-Balaklalaand Early Bird mines.CRWQCB.CVR Internal Memo.April 20.
21:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.June 5.
22:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.May 1.
23:Department of Water Resouces Northern District.1983.Quantification of acid and heavy metal discharges from mine portals and dumps at Balaklala, Keystone and Shasta King mines.Report to WRCB.CVR.Interagency Agreement #2-092-158-0(DWR #163109).
24:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.August 2.
25:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.August 22.
26:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.September 12.
27:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.October 4.
28:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.november 22.

Table C-2. WATER QUALITY CHARACTERISTICS OF MINE DRAINAGE AND RECEIVING WATERS IN THE SHASTA DAM WATERSHED.

SAMPLE LOCATION	SAMPLE DATE YEAR	MONTH/DAY	E.C. (uS/cm)	pH	FLOW (l/s)	HARDNESS AS CACO3 (mg/l)	TOTAL CONCENTRATION (UG/L) ARSENIC	CADMIUM	CHROMIUM	COPPER	IRON	LEAD	MERCURY	NICKEL	SILVER	ZINC	SOURCE
BALAKLALA MINE WATERSHED, WEST SQUAW CREEK																	
upstream mine	1979	10 /							<20	<20						<20	2
	1980	6 / 27							<10	<20						<20	1
	1983	9 / 14		7.65	20.70				35	130						150	3
	1984	1 / 4		7.10	693.80				<5	20						40	3
	1989	3 / 13	360	6.39					<2	4						35	5
	1989	4 / 9	46	6.86					<2	4						31	4
	1989	4 / 28			82.71				0	<4						21	6
	1989	5 / 4	71	7.04					<2	31						54	4
downstream Shasta King	1975	9 / 18	277	4.60	141.60				30	2,100	2,100	13				3,400	7
	1976	7 / 2	1100	2.50						22,000	36,000					66,000	9
	1980	7 / 16							40	7,410						7,860	8
	1982	10 / 27		3.22	51.82				30	2,700	11,000					3,200	34
	1982	11 / 23	260	3.00	305.82				10	1,600	8,800					1,900	34
	1982	12 / 28	178	3.20	566.34	10		0	10	1,100	8,000	0			0	910	34
	1983	1 / 27	86	3.40					0	580	4,200					340	34
	1983	2 / 28	200	3.40					10	510	22,000					2,600	34
	1983	4 / 21	180	3.40					10	660	13,000					2,800	34
	1983	9 / 14		2.98	48.10				30	2,150						7,390	3
	1984	1 / 4		3.55	880.70				6	720						1,550	3
	1984	4 / 9	144	3.98					6	831						1,160	4
	1989	3 / 13	200	3.51					9	1,010						1,240	5
	1989	4 / 28			195.10				6	809						1,360	6
	1989	5 / 4	151	4.09					8	924						1,280	4
lake confluence	1975	4 / 10	103	4.02	3483.00				5	650	650					630	7
	1975	9 / 18	607	3.00	169.90				30	5,100	15,000	11				5,600	7
	1976	7 / 2	620	2.60						6,600	6,200					8,600	9
	1980	5 / 26		3.50					8	1,650						1,800	18
	1980	5 / 16							20	4,260						4,950	19
	1980	5 / 7		3.51					<10	1,370						1,430	20
	1980	6 / 27							10	2,360						2,650	17
	1980	7 / 16							20	3,170						3,450	8
	1980	8 /							20	4,200						4,800	2
	1980	10 /							20	4,100						4,400	2
	1980	11 / 17							30	4,440						4,610	16
	1981	1 / 5							10	2,490	8,080					2,480	15
	1981	2 / 2							10	1,810						1,640	14
	1981	4 / 29		3.51					<10	1,260						1,320	12
	1981	4 / 10							100	1,680	10,400					1,630	13
	1981	7 / 1		2.97					20	3,430	13,200					3,790	11
	1981	8 / 27		3.00					40	4,820	3,610					5,630	10
	1981	8 / 5		3.10					30	4,210	3,480					5,020	10
	1981	9 /		3.00					40	4,800	3,600					5,600	2
	1981	11 /								1,300	6,800					1,000	2
	1982	10 / 29	150	4	214.08				10	820	1,500					1,100	34
	1982	11 / 23	95	3	662.62				10	560	2,000					630	34
	1982	12 / 29	60	4	1398.86	0		0	0	480	2,700	0			0	540	34
	1983	1 / 27	50	4					0	160	2,000					120	34

Table C-2. WATER QUALITY CHARACTERISTICS OF MINE DRAINAGE AND RECEIVING WATERS IN THE SHASTA DAM WATERSHED.

SAMPLE LOCATION	SAMPLE DATE YEAR	MONTH/DAY	E.C. (uS/cm)	pH	FLOW (l/s)	HARDNESS AS CACO3 (mg/l)	TOTAL CONCENTRATION (UG/L) ARSENIC	CADMIUM	CHROMIUM	COPPER	IRON	LEAD	MERCURY	NICKEL	SILVER	ZINC	SOURCE
	1983	2 / 28	90	3				0		160	10,000					860	34
	1983	4 / 21	70	4	2260			0		220	3,600					1,400	34
	1983	10 / 4						10		640	3,110					2,080	30
	1984	2 / 7						3		330						700	29
	1984	3 / 8						4		360	3,410					760	27
	1984	5 / 22		4.44				6		520	3,740					980	28
	1985	3 / 22		4.45				2		550						800	26
	1985	4 / 4		3.24	170.00			8		1,470						1,960	21
	1985	6 / 6						10		670						110	25
	1986	3 / 25		6.90				<0.2		180						190	22
	1986	4 / 3		6.90				2		210						250	22
	1986	5 / 29		6.92				1		260						350	22
	1986	5 / 13		5.30				3		440						750	22
	1986	5 / 20		7.10				1		190						280	22
	1986	6 / 4		5.30				3		650						740	22
	1986	6 / 19		5.00				2		490						810	22
	1987	5 / 4						3		380						560	24
	1987	6 / 11						6		520						870	23
	1987	11 / 10		4.13						940						1,500	31
	1988	1 / 29		5.87				<10		270						360	32
	1988	7 / 30								1,290							33
	1988	9 / 7								1,570							33
	1988	11 / 1								2,310						3,180	33
	1989	3 / 13	60	5				4		591						648	5
	1989	4 / 9	68	6.26				2		287						391	4
	1989	5 / 4	81	6.37				4		305						452	4
	1989	7 / 31	340	5.20	133.00		<	6	<1	2,800			<0.2	<4	<1	1,000	*

SOURCE 1:Silver King Mine,1980. Report.From Silver King Mines.Inc.Salt Lake City, Utar to CWQCB Redding .August 6.
2:CVRWQCB.Balaklala,Keystone,and Shasta King mines.Table 1.Water quality information for Shasta King ,Keystone,and Balaklala mines.
3:Heiman,D.1984.West Squaw Creek surveys-September 1983 and January 1984 CRWQCB.CVR Internal Memo. February 15.
4:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.June 5.
5:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.May 1.
6:Heiman,D.1989.Squaw Creek survey.28 April 1989.CRWQCB.CVR Internal Memo.September 13.
7:Fuller,R.,Shay,J.,Ferreira,R.,and Hoffman,R.1978.An evaluation of problems arising from acid mine drainage in the vicinity of Shasta reservior ,Shasta County,California.Water-Resouces Investigation 78-32 May.
8:Heiman,D.1980.Inspection,West Squaw Creeek/Balaklala,Silver King mines,Inc.,Shasta County CVRWQCB Internal Memo.September 2.
9:Departmentof fish and game-Region 1.1976 .Little(West) Squaw Creek,tributary to Shasta Lake.Shasta County.The Resources Agency of CA Internal Memo. September 2.
10:Heiman,D.1981 Inspection.27 August 81
11:CVRWQCB.Balaklala,Keystone,and Shasta King mines.Data sheet made by Heiman,D.
12:CVRWQCB.Balaklala,Keystone,and Shasta King mines.Data sheet made by Heiman,D.
13:Heiman,D.1981.Compliance inspection-West Squaw Creek mines CVRWQCB Internal Memo.May 11.
14:CVRWQCB.Balaklala,Keystone,and Shasta King mines.Data sheet made by Heiman,D.
15:CVRWQCB.Balaklala,Keystone,and Shasta King mines.Data sheet made by Heiman,D.
16:CVRWQCB.Balaklala,Keystone,and Shasta King mines.Data sheet made by Heiman,D.
17:CVRWQCB.Balaklala,Keystone,and Shasta King mines.Data sheet made by Heiman,D.
18:CVRWQCB.Balaklala,Keystone,and Shasta King mines.Data sheet made by Heiman,D.
19:Heiman,D.1980.On 16 May 1980,Ken Smarkel and I made a routine inspection of the Keystone,Balaklala and Mammoth mines,Shasta county.CRWQCB.CVR Intern Memo.June 25.
20:Heiman,D. 1980.Fish kills at West Squaw and Little Backbone creeks,5/7/80,Shasta county.CRWQCB.CVRInternal Memo.May 21.
21:Heiman,D.1985.Water quality surveys-West Squaw Creek mines.CRWQCB.CVR Internal Memo.August 26.
22:CVRWQCB.West Squaw Creek 1986 fish kill summary.###

Table C-2. WATER QUALITY CHARACTERISTICS OF MINE DRAINAGE AND RECEIVING WATERS IN THE SHASTA DAM WATERSHED.

SAMPLE LOCATION	SAMPLE DATE YEAR	MONTH/DAY	E.C. (uS/cm)	pH	FLOW (l/s)	HARDNESS AS CACO3 (mg/l)	TOTAL CONCENTRATION (UG/L) ARSENIC	CADMIUM	CHROMIUM	COPPER	IRON	LEAD	MERCURY	NICKEL	SILVER	ZINC	SOURCE
23--31:Heiman,D.Data sheet.Made by Heiman,D.																	
32:Heiman,D.1988.inspection-Balaklalaand Early Bird mines.CRWQCB.CVR Internal Memo.April 20.																	
33.Data sheet from Redding office.																	
34:Department of Water Resouces Northern District.1983.Quantification of acid and heavy metal discharges from mine portals and dumps at Balaklala, Keystone and Shasta King mines.Report to WRCB.CVR.Interagency Agreement #2-092-158-0(DWR #163109).																	
*.This study.																	
BULLY HILL MINE																	
main adit	1978	11 / 29		5.10		180		1,350	<0.003	10					9,400		1
(BH3)	1979	3 / 8		3.00		270		6,200	2,800	90					13,300		1
	1979	5 / 2		4.60	1.48	320		7,100	4,160	80					16,900		1
	1979	6 / 2		4.10	1.48	300		6,400	3,200	60					16,700		1
	1979	7 / 21		4.90	0.82	270		4,960	3,690	80					14,000		1
	1979	9 / 15		4.80	0.23	240		4,660	27,500	270					15,200		1
	1979	12 / 8		6.50	0.23	210		2,480	3,870	50					12,100		1
	1980	2 / 9		4.30	2.26	450		10,900	20,100	250					24,400		1
	1980	5 / 14		4.20	7.76	320		8,180	330	50					15,500		1
	1980	6 / 21		4.20	0.56	300		7,750	22,700	600					16,800		1
	1980	8 / 22		4.00	0.44	270		5,900	1,460	90					14,600		1
	1980	12 / 29		5.30		210		3,210	3,770	60					12,400		1
	1981	2 / 4		4.80	2.21	220		3,910	4,320	90					11,700		1
	1981	4 / 21		4.00	7.76	350		8,970	210	60					19,400		1
	1981	6 / 11		3.80	0.78	290		7,740	1,720	70					16,400		1
	1982	2 / 24		4.20		270		7,810	20						15,200		1
	1982	6 / 21		3.90	1.06	290		6,200	130	50					12,700		1
	1982	8 / 9		3.60	0.24	270		5,410	300	50					13,000		1
	1983	1 / 14		5.10		120		3,100	<0.02	50					9,400		1
	1983	10 / 28		4.80		180		1,780	430	50					8,500		1
	1987	4 / 14		4.60		260		6,450							13,800		1
	1987	11 / 5		5.20				3,360							11,800		1
	1989	7 / 20	680	4.30	1.70	< 230	<1	5,000		31	<0.2	24	<1		13,000	*	
	1989	7 / 20	680	4.30	2.02	255		5,400							14,900	#	
town crk	1978	11 / 29		7.30													1
upstream	1979	3 / 8		7.70		<10		<20	250	<50					<20		1
mine	1979	5 / 2		6.20		<10		<20	130	<50					70		1
	1979	6 / 2		7.70	3.28	<10		<20	60	<50					<20		1
	1979	7 / 21		7.80	1.32	<10		<20	<50	<50					<20		1
	1979	9 / 15		6.40	1.14	<10		<20	<50	<50					<20		1
	1979	12 / 8		7.90	3.26	<10		<20	60	<50					<20		1
	1980	2 / 9		7.40	39.37	<10		<20	70	<50					<20		1
	1980	5 / 14		7.60	14.89	<10		<20	50	<50					<10		1
	1980	6 / 21		7.50	16.40	<10		<20	<50	<50					40		1
	1980	8 / 22		7.90	13.50	<10		<20	<50	<50					30		1
	1980	12 / 29		7.50		<10		50	70	<50					60		1
	1981	2 / 4		7.80	4.92	<10		30	60	<50					40		1
	1981	4 / 24		7.80	33.63	<10		40	170	<50					70		1
	1981	6 / 11		7.90	2.64	<10		<20	<50	<50					40		1
	1982	2 / 24		7.20				190	120						70		1
	1982	6 / 21		7.30	2.64	<10		30	30	40					50		1

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	1982	8 / 9		6.40	0.56			<10		10	<10	40				30	1
	1983	1 / 14		6.30				<10		<10	<20	<50				<10	1
	1983	10 / 28		7.20				<10		<50	<20	<50				<50	1
	1987	4 / 14		8.00				<10		<10						10	1
	1987	11 / 5								<10						<10	1
	1989	7 / 20	140	6.80	2.33		<	<0.1	<1	<1		<5	<0.2	<4	<1	20	*
town crk	1978	11 / 29		5.20													1
downstream	1979	3 / 8		5.20				110		3,600		50				10,000	1
mine	1979	12 / 8		6.90	4.84			120		3,030	110	70				12,700	1
	1979	9 / 15		3.90	0.45			160		4,100	50	140				15,200	1
	1979	5 / 2		5.70				230		5,900	250	90				22,800	1
	1979	7 / 21		4.20	1.32			190		5,110	180	150				15,800	1
	1979	6 / 2		4.70	1.32			150		4,200	180	80				14,900	1
	1980	5 / 21		6.60				100		2,270	190	<50				7,280	1
	1980	6 / 21		5.50	5.94			120		3,220	250	70				9,770	1
	1980	8 / 22		3.90	0.25			160		4,340	<50	150				13,500	1
	1980	2 / 9		5.70	11.99			120		3,910	190	50				11,300	1
	1980	12 / 29		5.70				100		2,300	140	50				9,630	1
	1981	6 / 11		5.00	4.43			130		4,020	100	70				11,100	1
	1981	4 / 24		6.30	14.89			120		3,620	250	60				9,790	1
	1981	2 / 4		6.80	8.77			80		2,270	120	<50				9,180	1
	1982	6 / 21		4.90	3.77			150		4,080	60	100				10,440	1
	1982	8 / 9		3.90	0.38			180		4,320	50	200				14,900	1
	1982	2 / 24		4.90				110		3,630	100	100				9,120	1
	1983	10 / 28		4.80				120		2,300	90	80				8,110	1
	1983	1 / 14		4.10				330		7,500	130	70				15,800	1
	1987	11 / 5		7.70						460						1,810	1
	1987	4 / 14		7.60				50		1,200						2,600	1
	1989	7 / 20	510	5.70	7.38			116		1,200						18,000	#

SOURCE: 1.CH2M HILL.1988.PRELIMINARY ACID MINE DRAINAGE ASSESSMENT BULLY HILL MINE REDING,CALIFORNIA.CH2M HILL SEARCH REPORT FOR SCM CHEMICALS.MARCH
*:This study.
#:It is exactly same sample with *, but tested by Redding office by Heiman,D.

KEYSTONE MINE

main adit	1975	9 / 17	340	3.50	2.30			50		3,800	5,100	21				8,200	1
	1978	12 / 19	320	3.50	0.50			40		5,500						11,000	6
	1979	8 /		3.30	1.60			<10		4,700	300					9,800	7
	1979	9 /		3.20	1.40			50		5,800	600					11,000	7
	1979	10 /		3.30	1.30			30		6,600	500					12,200	7
	1979	11 /		3.20	1.30			30		6,100	1,900					12,000	7
	1980	1 /		3.00	2.70			220		54,000	131,000					31,000	7
	1980	2 /		2.60	6.30			180		38,000	86,000					42,000	7
	1980	3 /		3.20	6.30			700		9,100	12,000					14,600	7
	1980	4 /		4.30	5.40			40		6,300	11,300					5,900	7
	1980	5 /		2.60	3.80					4,100	600					9,300	7
	1980	5 / 16						50		5,270						11,200	5
	1980	6 / 27						70		8,000						16,000	4
	1980	6 /		3.60	3.20					2,900	600					8,600	7
	1980	7 /		3.60	3.20					2,700	1,100					8,600	3

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SAMPLE LOCATION	SAMPLE DATE YEAR	MONTH/DAY	E.C. (uS/cm)	pH	FLOW (l/s)	HARDNESS AS CACO3 (mg/l)	TOTAL CONCENTRATION (UG/L) ARSENIC	CADMIUM	CHROMIUM	COPPER	IRON	LEAD	MERCURY	NICKEL	SILVER	ZINC	SOURCE
	1980	8 /		3.60	1.90					3,500	90					9,100	3
	1980	9 /		3.40	1.70					3,800	200					10,000	3
	1980	10 /		3.80	1.60					4,700	400					11,000	3
	1980	11 /		2.70	1.10					4,800	1,400					12,000	7
	1980	12 /		3.60	1.20					4,600	2,500					12,000	7
	1981	4 /			3.80			110		18,000	18,000					23,500	7
	1981	4 /	10		3.80			110		18,000	180,000					23,500	2
	1982	10 /	26	400	3.80	1.36		50		5,200	12,000					8,500	16
	1982	11 /	23	495	3.20	4.08		60		5,400	20,000					10,000	16
	1982	12 /	28	750	3.00	6.03		80		12,000	41,000					14,000	16
	1983	1 /	27	800	2.90	8.13		80		13,000	58,000					12,000	16
	1983	2 /	28	335	3.10	30.70		20		3,300	8,600					3,600	16
	1983	4 /	21	310	3.20	12.37		40		2,400	8,000					4,400	16
	1984	4 /	9		2.95	1.90		80		4,100	15,300					7,410	8
	1985	1 /	10		2.82	0.40		60		7,060						11,900	9
	1985	4 /	4		2.85	0.80		45		5,560						10,400	9
	1986	3 /	7			12.60		120		18,800						23,000	10
	1986	6 /	10		3.15	4.70		40		2,800						8,400	11
	1986	12 /	23			0.50		50		4,000						11,000	12
	1988	1 /	29			1.90		90		18,600						19,200	14
*	1988	7 /	1		3.00			78		6,250	17,900					16,500	20
	1989	4 /	28			4.20		87		11,200						16,400	13
	1989	4 /	9	983	2.47			64		9,040						13,700	15
	1989	5 /	4	1,420	2.67			64		7,890						13,400	15
*	1989	5 /	31	1,300	3			69		7,370						14,800	17
	1989	7 /	9	1,250	3			74		7,710						15,300	18
	1989	7 /	31	1,130	3			80		8,080						16,600	19
	1989	9 /	1	240	5			25		2,450						4,660	21
	1989	10 /	2	1,190	3			84		8,110						17,400	22

SOURCE 1:Fuller,R.,Shay,J.,Ferreira,R.,and Hoffman,R.1978.An evaluation of problems arising from acid mine drainage in the vicinity of Shasta reservior, Shasta County,California.water-Resources Investigations78-32 May.
2:Heiman,D.1981.Compliance inspection-West Squaw Creek mines CVWQCB Internal Memo.May 11.
3:Silver King Mine,1980. Report.From Silver King Mines.Inc.Salt Lake City, Utar to CWQCB Redding .August 6.
4:Silver King Mine,1980. Report.From Silver King Mines.Inc.Salt Lake City, Utar to CWQCB Redding.November 24.
5:Heiman,D.1980.On 16 May 1980,Ken and I made a routine inspection of the Keystone,Balaklala and Mammoth mines,Shasta County. CVRWQCB Internal Memo.June 25.
6:Smarkel,k.1979.West Squaw drainage inspection Shasta County.CVRWQCB Internal Memo.February 5.
7:CVRWQCB.Balaklala,Keystone,and Shasta King mines.Table 1.Water quality information for Shasta King ,Keystone,and Balaklala mines.
8:Heiman,D.1984 inspection report .CVRWQCB Inspection report.April 9.
9:Heiman,D.1985.Water quality surveys-West Squaw Creek mines.CRWQCB.CVR Internal Memo.August 26.
10:Heiman,D.1986.Inspection report.CVRWQCB Inspection report.March 25.
11:Heiman,D.1986.Inspection report.CVRWQCB Inspection report.July 8.
12:Heiman,D.1987.Result of samples-Balaklala,Keystone and early Bird mines,23 December 1986.CVRWQCB Office Memo.January 29.
13:Heiman,D.1989.Squaw Creek survey.28 April 1989.CRWQCB.CVR Internal Memo.September 13.
14:Heiman,D.1988.inspection-Balaklalaand Early Bird mines.CRWQCB.CVR Internal Memo.April 20.
15:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.June 5.
16:Department of Water Resouces Northern District.1983.Quantification of acid and heavy metal discharges from mine portals and dumps at Balaklala, Keystone and Shasta King mines.Report to WRCB.CVR.Interagency Agreement #2-092-158-0(DWR #163109).
17:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.August 2.
18:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.August 22.
19:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.September 12.
20:Heiman, D. 1988. Data sheet. From CH2M HILL.July 28.

Table C-2. WATER QUALITY CHARACTERISTICS OF MINE DRAINAGE AND RECEIVING WATERS IN THE SHASTA DAM WATERSHED.

SAMPLE LOCATION	SAMPLE DATE YEAR	MONTH/DAY	E.C. (uS/cm)	pH	FLOW (l/s)	HARDNESS AS CACO3 (mg/l)	TOTAL CONCENTRATION (UG/L) ARSENIC	CADMIUM	CHROMIUM	COPPER	IRON	LEAD	MERCURY	NICKEL	SILVER	ZINC	SOURCE
21:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.October 4.																	
22:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.November 22.																	
GOLINSKY MINE																	
main adit	1978	9 / 14	1,500	2.90						17,000						47,000	1
	1978	11 / 9		3.50				1,510		17,600	71,000					78,000	1
	1983	4 / 18		2.90		3		223		7,950	29,300					20,640	2
	1983	6 /		3		0		504		8,600	22,600					34,100	3
	1983	12 /		3		1		227		10,600	23,200					22,200	3
	1984	5 /		3		0		280		22,500	43,300					31,200	3
SOURCE 1.Smarkel,K. 1979. Little Backbone Creek acid mine drainage, Shasta County. CVRWQCB Internal Memo. March 23.																	
2.Heiman,D. 1983. Golisky Mine. CRWQCB.CVR Internal Memo. May 16.																	
3.Heiman,D. 1991. Data sheet from D. Heiman, CVRWQCB.																	
SUTRO MINE																	
Upper adit	1983	6															1
	1983	12		3.80	3				8	960	1,060					410	1
	1984	5															1
Upper Waste rock pile	1983	6		6.80	5				2	<10	110					900	1
	1983	12		6.90	15				<5	290	230					170	1
	1984	5		6.93	4				1	30	340					90	1
Lower adit	1983	6		6.40	20				18	1,200	560					2,000	1
	1983	12		6.80	17				14	1,010	80					1,550	1
	1984	5		6.50	21				20	1,420	710					2,100	1
SOURCE: 1. Heiman, D. 1991. Summary of water quality data. Data sheet from D. Heiman.																	
MAMMOTH MINE																	
main adit	1978	9 /		3				190		13,000						23,800	13
	1982	12 /		3				44		2,900	2,610					6,000	13
	1983	6 /		4	6			32		980	250					3,520	13
	1983	12 /		4	32			16		1,170	1,700					2,500	13
	1984	5 /		3	15			30		1,850	1,920					4,830	13
	1988	6 / 27		3				240		25,400	204,600					45,000	1
	1989	5 / 12			18.80			237		20,800						44,900	4
gossen #2 adit	1980	5 / 16					20	10		3,830	155,000	<50				1,220	2
	1983	6 /		4	11			15		3,500	23,000					1,400	13
	1983	12 /		4	13			8		4,000	11,300					1,000	13
	1984	5 /		5	10			10		2,470	8,260					1,800	13
	1984	3 / 8						110		14,800	69,900					20,500	3

Table C-2. WATER QUALITY CHARACTERISTICS OF MINE DRAINAGE AND RECEIVING WATERS IN THE SHASTA DAM WATERSHED.

SAMPLE LOCATION	SAMPLE DATE YEAR	MONTH/DAY	E.C. (uS/cm)	pH	FLOW (l/s)	HARDNESS AS CACO3 (mg/l)	TOTAL CONCENTRATION (UG/L) ARSENIC	CADMIUM	CHROMIUM	COPPER	IRON	LEAD	MERCURY	NICKEL	SILVER	ZINC	SOURCE
	1988	6 / 27		4					11	5,250	19,150					1,430	1
	1989	5 / 12			6.06				70	8,270						12,800	4
	1989	5 / 24		2.10					191	130,000						31,900	5
	1989	7 / 18		2					186	112,000						27,700	6
300 level	1983	6 /		2	0				460	35,000	511,000					66,200	13
adit	1983	12 /		2	0				400	47,400	500,000					66,000	13
	1984	5 /		2	0				500	53,800	870,000					83,800	13
	1988	6 / 27		2					1030	150,400	1,280,000					172,400	1
	1989	5 / 12			0.06				110	63,300						19,500	4
Friday-	1983	6 /		3	38				87	5,950	39,600					13,200	13
Lowden adit	1983	12 /		3	43				113	15,800	170,000					22,000	13
	1984	5 /		3	31				110	9,700	59,200					19,000	13
	1984	11 /		3	18				120	11,100	66,700					22,200	13
	1988	6 / 27		4					41	5,080	24,200					6,820	1
	1989	5 / 12			13.12				97	9,100						16,300	4
	1989	6 / 6							34	3,640						5,610	7
	1989	6 / 22							32	3,190						5,230	7
Little	1978	9 /		3						3,200						5,500	13
Backbone	1982	12 /		5					6	500						840	13
Creek	1983	4 /		5					<2	180						250	13
below mine	1983	6 /		5					9	310						410	13
	1983	12 /		5					<5	260						290	13
	1984	2 / 7							3	330						700	12
	1984	5 / 30		5					6	540						680	12
	1984	5 /		5					6	450						740	13
	1984	11 /		4					2	420						640	13
	1985	6 / 11		5					5	300						540	13
	1985	6 / 6							7	400						810	10
	1987	5 / 4							2	410						640	9
	1987	6 / 11							5	520						670	8
	1989	5 / 12			124.03				29	3,140						5,310	4

SOURCE:
3. Heiman, D. 1984. Data sheet from CH2MHILL Laboratory. 3-19-84.
4. Heiman, D. 1989. Little Backbone Creek Survey, 12 May 1989. Memo to J. Pedri, CVRWQCB, Redding, CA. 10-28-1989.
8. Heiman, D. 1987. Data sheet from CH2MHILL Laboratory. 7-13-87.
9. Heiman, D. 1985. Data sheet from CH2MHILL Laboratory. 7-5-85.
10. Heiman, D. 1985. Data sheet from CH2MHILL Laboratory. 4-5-85.
11. Heiman, D. 1984. Data sheet from CH2MHILL Laboratory. 6-21-84.
12. Heiman, D. 1984. Data sheet from CH2MHILL Laboratory. 2-21-84.
13. Heiman, D. 1991. Summary of water quality data. Data table from D. Heiman (CVRWQCB).

EARLY BIRD MINE

main adit	1984	4 / 9		2.61	0.63		210	33,700	162,000							19,000	1
	1985	1 / 10			0.18		160	51,400								30,000	1
	1985	4 / 4			0.30			39,100								22,700	2
	1986	6 / 10		2.48	0.32		150	44,000								29,000	1
	1986	12 / 23					250	80,000								46,000	1
	1987	8 / 6			0.17		460	130,000								79,000	1
	1988	1 / 27		2.85	0.13		130	44,900								29,700	1
	1988	6 / 28		2.25			2,320	370,000	4,520,000							520,000	9

Table C-2. WATER QUALITY CHARACTERISTICS OF MINE DRAINAGE AND RECEIVING WATERS IN THE SHASTA DAM WATERSHED.

SAMPLE LOCATION	SAMPLE DATE YEAR	MONTH/DAY	E.C. (uS/cm)	pH	FLOW (l/s)	HARDNESS AS CACO3 (mg/l)	TOTAL CONCENTRATION (UG/L) ARSENIC	CADMIUM	CHROMIUM	COPPER	IRON	LEAD	MERCURY	NICKEL	SILVER	ZINC	SOURCE
	1988	7 / 30			0.13					299,300							1
	1988	9 / 7			0.13					212,000							1
	1988	11 / 1			0.13					164,300						396,000	1
	1989	3 / 13	2,390	2.81	0.16			200		14,400						47,100	4
	1989	4 / 9	1,830	2.61	0.16			171		26,800						28,700	3
	1989	4 / 28			0.13			480		55,000						118,000	5
	1989	5 / 4	4,100	2.46	0.13			499		60,200						114,000	3
	1989	5 / 31	4,090	2.24	0.13			640		67,400						147,000	6
	1989	7 / 9	4,620	2.24	0.06			532		75,800						115,000	7
	1989	7 / 31			0.07			549		73,200						124,000	8
	1989	9 / 1	4,580	2.51	0.05			539		76,600						120,000	10
	1989	10 / 2	5,000	2.16	0.05			502		69,200						110,000	11

SOURCE 1:CVRWQCB. Data sheet from the Redding office.
2:Heiman,D.1985.Water quality surveys-West Squaw Creek mines.CRWQCB.CVR Internal Memo.August 26.
3:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.June 5.
4:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.May 1.
5:Heiman,D.1989.Squaw Creek survey.28 April 1989.CRWQCB.CVR Internal Memo.September 13.
6:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.August 2.
7:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.August 22.
8:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.September 12.
9:Heiman, D. 1988. Data sheet. From CH2M HILL. July 28.
10:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.October 4.
11:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.November 22.

SHASTA KING MINE

upper adit	1983	9 / 14		2.10	<0.30		520		100,000						90,800	1
	1984	1 / 4		2.40	0.60		147		28,000	223,000					27,000	1
lower adit	1978	12 / 19	2,600	2.20	<0.06		120		115,000						100,000	2
	1980	7 / 16			0.06		410		66,000						76,000	3
	1982	10 / 27	4,900	2.29	0.02		520		80,000	1,720,000					97,000	6
	1982	11 / 23	5,400	2.40	0.09		550		81,000	1,730,000					99,000	6
	1982	12 / 28	3,500	2.40	0.71	320	280	20	57,000	396,000	100			0	42,000	6
	1983	4 / 21	2,450	2.40	3.00		150		24,000	185,000					27,000	6
	1984	1 / 4		2.40	2.50		165		32,500						28,500	1
	1989	4 / 28			0.22		310		51,700						63,500	5
	1989	4 / 9	3,530	1.34	0.13		277		50,000						47,000	4
	1989	5 / 4	3,480	2.21	0.13		295		56,000						58,000	4
	1989	5 / 31	3,650	2.07	0.13		340		56,300						70,900	7
	1989	7 / 9	3,940	4.96	0.13		421		71,200						78,600	8
	1989	7 / 31	4,110	1.96	0.13		450		75,900						87,500	9
lower seep	1984	1 / 4		3.30	0.30		7		1,210						1,250	1

SOURCE 1:Heiman,D.1984.West Squaw Creek surveys-September 1983 and January 1984 CVRWQCB Internal Memo. February 15.
2:Smarkel,k.1979.West Squaw drainage inspection Shasta County.CVRWQCB Internal Memo.February 5.
3:Heiman,D.1980.Inspection,West Squaw Creeek/Balaklala,Silver King mines,Inc.,Shasta County CVRWQCB Internal Memo.September 2.
4:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.June 5.

Table C-2. WATER QUALITY CHARACTERISTICS OF MINE DRAINAGE AND RECEIVING WATERS IN THE SHASTA DAM WATERSHED.

SAMPLE LOCATION	SAMPLE DATE YEAR	MONTH/DAY	E.C. (uS/cm)	pH	FLOW (l/s)	HARDNESS AS CACO3 (mg/l)	TOTAL CONCENTRATION (UG/L) ARSENIC	CADMIUM	CHROMIUM	COPPER	IRON	LEAD	MERCURY	NICKEL	SILVER	ZINC	SOURCE
5:Heiman,D.1989.Squaw Creek survey.28 April 1989.CRWQCB.CVR Internal Memo.September 13.																	
6:Department of Water Resouces Northern District.1983.Quantification of acid and heavy metal discharges from mine portals and dumps at Balaklala, Keystone and Shasta King mines.Report to WRCB.CVR.Interagency Agreement #2-092-158-0(DWR #163109).																	
7:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.August 2.																	
8:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.August 22.																	
9:Silver King Mine. 1989.Letter.From Silver King Mines.Salt Lake City.Utah to US EPA San Francisco,CA.and RWQCB.Redding,CA.September 12.																	
RISING STAR MINE																	
main adit	1979	1 /			2.80				180	3,200	93,700					32,500	3
	1979	3 / 9			3.10				510	19,000	173,000					69,000	2
	1979	5 / 2			3.00				300	6,100	116,000					44,500	1
	1979	9 /			2.80	0.50			360	8,200	34,800					53,900	3
	1979	12 /			2.80	0.90			190	4,500	144,300					38,100	3
	1980	2 /			2.70	1.80			390	18,800	131,000					55,000	3
	1980	4 /			2.70	1.60			260	5,200	43,000					43,700	3
	1980	6 /			2.80	1.10			210	3,800	58,000					39,600	3
	1980	8 /			2.90	1.10			170	2,700	89,100					35,000	3
	1980	12 /			3.20	0.80			140	2,900	142,000					34,800	3
	1981	2 /			3.40	2.60			240	7,700	153,000					45,200	3
	1989	7 / 20		1900	3.30	2.55		865	130	3	3,100		45	<0.2	12	<1	30,000	*
	1989	7 / 20		1900	3.30	2.78			157		3,100					32,000	#
	AVERAGE			1900	2.96	1.44		865	257	3	7,100	107,082	45	0	12	0	43,442	
seep near adit	1979	3 / 9			2.90				260		29,500					11,500	2
	1979	5 / 2			2.90												1
	AVERAGE																
Horse Crk upstream mine	1979	5 / 2			5.70				10		110					60	1
	AVERAGE				5.70				10		110					60	
Horse Crk downstream mine	1979	3 / 9			2.50				380		15,400					46,000	2
	1979	5 / 2			2.80				290		8,100					38,000	1
	1989	7 / 20		2000	2.70	3		4	210	3	6,300		38	<0.2	18	<1	36,000	*
	1989	7 / 20		2000	2.70	3.28			247		6,700					39,600	#
	AVERAGE			2000	2.67	3.39		4	293	3	9,933		38	0	18	0	40,000	

Source 1.Smarkel,K.1979.Bully Hill and Rissing Star mine sampling inspection,Shasta County.CVRWQCB Internal Memo.June 19.
2.Smarkel,K.1979.Bully Hill and Rissing Star mine sampling inspection,Shasta County.CVRWQCB Internal Memo.April 9.
3:CVRWQCB.Bully Hill and Rising Star mines.
*.This study. The concentration of arsenic is average of replicates(1400 and 330 ppb).
#.It is the exactly same sample with *, but tested by Heiman, D.

APPENDIX D
INDIVIDUAL MINE DESCRIPTIONS BY WATERSHED

The characteristics of each mine visited are described as to their potential for water quality degradation. Historical information concerning mineralogy and past ore processing operations were taken from Table IV-1. Water concentration data was reported from Appendix C tables. Sediment characteristics were described from Table IV-3 and are reported as dry weight. Many of the Shasta District mines were not visited but have been extensively characterized by Redding Office staff. Information on these mines were taken from historic files.

FOLSOM LAKE WATERSHED

Folsom Lake watershed mines are located in the foothills and were worked for their chromium, copper, and gold content. Although the mineralogy suggests otherwise, no deleterious discharges were observed from the mines visited. This is due, in part, to the dry nature of the area (ca 20 inches/year, Folsom Dam) and the relatively low elevation topography.

Alhambra: Not visited. The mine is in a prospect stage with proposed plans for reopening and discharges a small volume of arsenic laden water (Butz, pers. comm.).

Big Buzzard: The mine is located near the top of a gradually sloping hill several hundred feet above Folsom Lake. Two shafts were observed with dry side adits extending from just below the shaft openings. The waste rock was reactive (pH = 3.5) and contained moderate lead (270 mg/kg) and copper (210 mg/kg) levels. The waste rock was confined to a small area and was only slightly eroded. Rainfall runoff from the site would flow diffusely over a grassy field into an undefined channel before reaching the lake.

Black Oak: The gold mine site was overgrown with brush and any waste rock present was indistinguishable from the natural landscape. The surrounding soil did not appear reactive. One adit and one shaft was observed though neither showed evidence of discharges.

El Dorado, Funnybug, and Georgia Slide: Not visited.

Lilyama: Located at the base of several large hills, the mine complex is made up of two completely caved adits and several more above the main workings. The caretaker said one mine provided drinking water up until three years prior to the drought (in 1986). The adits were observed to be dry at the time of inspection. The caretaker also stated the site milled chromite ore from the Pillikan Mine. The waste rock piles were located in an ephemeral gulch, about 0.25 mile from Hastings Creek and appeared to be only slightly reactive. The majority of the waste material was large chunks of non-friable country rock. A sedimentation pond had been constructed below the mine site in the ephemeral drainage-way, but was full of silt. Another tunnel, apparently drilled to convey water from the underground workings, was draining a small volume of neutral, clear, water directly into Hastings Creek.

Pillikan (areas 1-11): The chromite workings are located over several square miles of small knolls above Folsom Lake and consist of several shafts and open pits. No discharges were observed, although, several open pits contained, neutral, ponded water. The waste rock did not appear reactive.

BEAR RIVER/DRY CREEK

The Bear River/Dry Creek watersheds contain mines from both the foothill copper and foothill gold belts. The copper belt mines (Spenceville, Dairy Farm, and Valley View) are characterized by the extensive sulfides in their geological makeup that are highly similar in reactivity to the Shasta District mines. Precipitation in the area is somewhat limited (ca 21 inches/year, Marysville). This, in conjunction with the low surrounding topography in the copper belt areas results in low or zero volume discharges from these mines. The gold belt mines exhibit arsenic containing drainage corresponding, in part, to a high precipitation average (34 inches/year, Colfax).

Empire: Located on a local knoll, the gold mine is now a state park with some apparent, periodic seepage near Little Dry Creek (Waggoner, pers. comm.). On the north side, outside the park, an air shaft (memorial adit) discharges (6-10 l/s) slightly acidic waters containing low to moderate arsenic (2-92 ug/l) and zinc (<10-29 ug/l) concentrations. The waste rock at the site appeared non-reactive although several tailings ponds had, in the past, been removed from the site (ibid).

Idaho-Maryland: New urban developments in the area made the mine complex nearly indistinguishable, but an apparent waste rock disposal site tested neutral. Much of the site had been paved over with streets and commercial construction.

Lava Cap: Located on a hillside, the mine is composed of a shaft and extensive gold processing works. Clear, neutral, arseniferous water is discharged (5-6.3 l/s) from a caved adit which is directly connected to the shaft. Arsenic concentrations in shaft water (ca 200-400 ug/l) were reduced by about half after passing through extensive, neutral (pH = 7.2) waste rock piles. The waste rock samples were analyzed differently than the other mines: HCl dissolution was employed to completely dissolve the material representing the absolute (mineral, labile) metallic concentration. As expected, the arsenic content of the waste rock was high (3.6 g/kg). Other metals were also present but cannot be compared to the other mines because of the differing method of analysis. Erosion and subsequent downstream siltation

results from ephemeral area drainage that passes over a failing tailings dam. The site is under consideration for re-activation.

Spenceville: The complex is composed of an extensive waste rock pile and a deep (ca 70 feet) pit filled with acidic water (pH ca 2.5). The mine is situated immediately adjacent the confluence of Little Dry Creek and Dry Creek. Much of the runoff water from the waste rock is diverted to the pit. Seepage to Little Dry Creek occurs resulting in high copper (64-1500 ug/l), zinc (140-930 ug/l) and possibly cadmium (<1-0.7 ug/l) concentrations. Runoff from a portion of the site and pit overflow can make it directly to the stream during storm events. The acidic waste rock (pH=3.0) contained moderate copper (277 mg/kg), lead (152 mg/kg), and zinc (148 mg/kg) levels and high silver levels (23.5 mg/kg).

Dairy Farm: The polymetallic mine was worked for it's gold, copper, and silver using underground and open pit mining techniques. The mine is located on (and below) the shore of Camp Far West Reservoir. The site once contained cyanide leachate basins and tailings pits, and is presently composed of imported soils covering most of the site with a small amount of highly acidic (pH=2.7) exposed soils containing high copper (1350 mg/kg), lead (370 mg/kg), zinc (455 mg/kg), and silver (14.5 mg/kg) levels. California Fish and Game staff (Jack Linn) have observed an adit, uncovered when lake levels receded in the 1990 dry season, although no discharge was observed from it.

Valley View: The mine was worked for it's copper, gold, and silver from at least two shafts. A glory hole with a connected adit discharged a small volume (0.11 l/s) of highly acidic water from the the base of several small hills. The mine outflow (0.11 l/s) was highly acidic and contained very high levels of cadmium (4.5-6.5 mg/l), copper (97-150 mg/l), and zinc (230-260 mg/l) and high levels of arsenic (<200-150 ug/l), chromium (130-210 ug/l), nickel (540-760 ug/l), and lead (<50-78 ug/l). The drainage courses over a graded waste rock pile and into an irrigation watercouse that flows past the site and to the surrounding ranchlands. Most of the irrigation/mine water is pumped out of the channel before going very far. A clean spring also passes over the waste rock dumps and disappears underground. Exposed waste rock was observed at several locations on the site. The waste rock was acidic (pH=2.7) and contained moderate to high levels of cadmium (246 mg/kg), copper (390 mg/kg), lead (189 mg/kg), zinc (480 mg/kg), and silver (9 mg/kg).

YUBA RIVER

With a few exceptions, the mines in the Yuba River watershed (Allegheny/Downieville District) were worked for their gold content and are characterized by, alkaline, arsenic containing drainage. Gold deposits are closely associated with arsenopyrite (FeAsS2) which is the perceived source of arsenic in drainage that is very clear visibly. The general area receives high precipitation (67 inches/year, Downieville) and, subsequently, several of the mines have large volume discharges.

Banner: Not visited.

Champion: Located adjacent Deer Creek, the mine complex was difficult to distinguish because of recent urban developments, but perceived drainage was sampled and contained a few metals at just above detection.

San Juan: The area was very overgrown with brush and the mine site (waste rock, shaft, structures) could not be distinguished.

Spanish: Over four adits were observed near the site but the size of the complex extended throughout the watershed. Two adits are known to be discharging low to moderately acidic water containing moderate to high levels of copper (210-900 ug/l), lead (20-110 ug/l), zinc (1900-2300 ug/l), nickel (70-160 ug/l), and cadmium (3.7-7.1 ug/l). The upper adit discharges to Devels Canyon creek approximately 2-3 miles from Poorman Creek and contains high copper levels (80-900 ppb) among other metals. The lower adit (called 16 to 1) discharges over a vegetated waste rock pile for about 60 feet prior to entering Poorman Creek. Waste rock at the lower complex was deposited on the steep slope directly below the adit and into Poorman Creek. The waste rock was slightly acidic (pH=5.1) and contained moderate copper (330 mg/kg), zinc (130 mg/kg), and arsenic (340 mg/kg) levels. The mine is under county reclamation for a barite pit and there is some exploration in progress for potential re-activation of the mine.

Brush Creek: Located at the base of a mountainside the gold mine discharges above neutral water that is visibly clear with moderate (32-81 ug/l) to high (180-270 ug/l) arsenic levels from the upper an main adits, respectively, and moderate nickel levels (110-290 ug/l). The high volume of alkaline drainage from the main adit (ca 27 l/s) had been diverted from Woodruff Creek to holding ponds (Higgins, pers. comm.) resulting in a lower Woodruff Creek arsenic concentration during the later sampling runs. Waste rock was visibly non-friable and non-acid generating and had been deposited into the Woodruff Creek streambed composing a portion of the stream bank. The site is regulated under NPDES and TPCA permits and is being considered for re-activation (ibid).

Columbo: The gold mine is located near the base of a large mountain and 900-1000 feet from the Valley floor. The drainage water was clear and near neutral with a few metals at just above detection limits. Extensive waste rock piles appeared non-reactive. Several rusting gold leaching basins were scattered around the area.

Kanaka Creek mines: According to U.S.FS staff there are over 140 known mine sites in the Kanaka Creek watershed (Daniels, pers. comm.) including, Sixteen-to-one and Kenton. Although not all of the mines have a discharge, Kanaka Creek at it's confluence with the Yuba River, Middle Fork, provides the most accurate loading estimate from the sum of

all the mines. Kanaka Creek arsenic levels ranged from 18 to 25 ug/l, diluting to below detection in the M.F. Yuba.
Kenton: The mine is located at the base of a mountainside and in the Kanaka Creek watershed. No discharge was observed but the mine has been known to discharge at other times (Daniels, pers. comm.). An extensive number of waste rock piles were spread over the steep terrain down to the Kanaka Creek streambank and were non-reactive (pH=7.3).
Malakoff Diggin's: The mine complex consists of several large hydro-stripped hillsides that have been preserved in the Malakoff Diggin's state park. Water from one exposed depression drains a large volume of water (17-26 l/s) that flows through the Hiller Tunnel that was once used to collect gold in sluice-box fashion and contains nominal levels of nickel (9-80 ug/l) and zinc (24-90 ug/l). The major threat to water quality would appear to be erosional discharges to Humbug Creek during rainfall events. The soils collected from the site contained low levels of all metals and were moderately acidic (pH=4.5). The state park is under permit not to prevent vegetation of the hillside scars and are required to conduct water quality monitoring (Waggoner, pers. comm.).
Pick and Shovel: Located directly adjacent Pats Gulch, the moderate discharge (1-3 l/s) is slightly acidic (pH=6.28-6.75), contains moderate levels of nickel (93-180 ug/l), and causes heavy iron mineralization in the streambed of Pats Gulch directly downstream the mine. The discharge makes up most of the flow (in Pats Creek) below the mine but metal levels are undetectable and iron staining is not present at it's confluence with Slate Creek (ca 1 mile below the mine). No buildup of waste rock was observed at the mine site.
Plumbago: The gold mine is located at the base of a large mountainside and discharges a high volume (2-4 l/s) of above neutral water containing high arsenic levels (85-370 ug/l). Waste rock was alkaline and extensive over the steep terrain and made up the shoreline of Buckeye Ravine for several hundred feet. Mercury was the only metal analyzed and was present at 1.8 mg/kg. Ore processing equipment was present at the mine including rock crushing and milling machines and several mercury amalgamation shaker tables.
Sierra Buttes, Sierra Homestake: Not Visited.
Sixteen-to-one: Not visited although extensive information exists on the mine. The gold mine is periodically active and regulated under an NPDES permit. An arsenic laden discharge drains to Kanaka Creek (Daniels, pers. comm.).
Zuver: The mine adit was dry with no evidence of discharge and waste rock was indistinguishable from the surrounding landscape.

FEATHER RIVER WATERSHED

With the exception of Walker and Lucky S, the mines observed in this watershed do not discharge adit drainage although the waste rock piles were potential sources of metals. Although these mines are generally located in a copper produding belt, many of them were also worked for their gold and silver. The precipitation in the area varies from 26 inches/year (chico) to 40 inches/year (Quincy).
Big Bend: Not visited.
Beardsley: One main shaft and several shallow exploratory adits were observed around the complex. Located at the base of a mountain, there was no evidence of any adit or shaft discharges. Cement foundations were all that remained of what likely was an ore processing facility. Waste rock was moderately acidic (pH=4.4) and contained high levels of copper (16 g/kg) and lead (2.7 g/kg) and low to moderate levels of other compounds. The waste rock was composed of hard chunks of non-friable country rock. The ephemeral drainage route coursed through a meadow and a moderate sloped gulch before reaching Hosselkus Creek (perennial).
China Gulch: Not visited.
Iron-Dyke: This polymetallic mine was located at the base of a large mountain directly atop Taylors Creek. No water discharges were observed from an adit situated at the lowest elevated position in the complex. Waste rock had covered the Taylors Creek streambed which disappeared underneath the pile, re-appearing 70 feet later. Although the waste rock was somewhat acidic (pH=3.4), the pH of the downstream water tested unchanged after passing through the pile. However, the stream did pick up copper (21 ug/l), zinc (18 ug/l), and possibly cadmium (0.5 ug/l) with a corresponding reduction in the conductivity, indicating that unsaturated leaching occurs without any noticeable acid production. The waste rock contained high copper (1600 mg/kg) and silver (29 mg/kg) levels and moderate zinc (270 mg/kg) and lead (63 mg/kg) levels.
Lucky S: Located near 7,000 feet MSL, the main adit discharges a high volume (3.22-4.06 l/s) of slightly acidic water (pH 6.04-6.54) but contains moderate levels of cadmium (2.5-2.9 ug/l), copper (63-80 ug/l), and zinc (260-335 ug/l). Furthermore, although there was an apparent high iron level, no iron precipitates existed in the adit drainage or in Peters Creek below the adit. The waste rock was acidic (pH=2.7) and reflected the metals in mineralogical surveys (high arsenic, zinc, and lead), however, stream and ponded water below the waste rock was only slightly acidic. The waste rock appeared non-friable and remained as extracted grade in the unprocessed form. A series of ponds composed of earth and waste rock were crudely constructed below the site of most waste rock deposition.
Mountain Meadows: Located at the foot of a small mountain, the two observed adits were dry with no evidence of past adit discharges. Waste rock appeared non-reactive, non-friable, composed mostly of large country rock fragments. The

site was located on the side of steep, rocky, mountainous slopes. Not much waste rock was observed at either of the individual sites, although, the lower adit was directly adjacent Mt. Meadows Creek which likely served to transport sediment off-site during high flows. Metals were not analyzed.

Plumas-Eureka: The high elevation (6,500-10,000 feet MSL) gold mine is maintained as an historical state park. According to a ranger, there are an uncounted number of adits both inside and outside the Jamison Creek watershed - there are likely as many waste rock piles. According to a local fisherman, the Jamison Mine portion was the largest and most recently operated mine (1890-1940) in the complex. A flooded, caved, water shaft from the Jamison Mine portion was sampled and although it contained several metals at just the detection limits, the levels in the immediate receiving waters (Jamison Creek) below the suspected discharge point were below detection. Although the waste rock was not chemically characterized, the observed piles appeared to be composed of stable country rock, not prone to leaching and oxidation processes. Characterization of the volume of waste rock would be difficult because of the numerous prospects around the high Sierra Valley.

Reward #7: This copper/gold mine consists of several dry adits (some only partially completed in recent times [after 1960]) with no evidence of past adit discharges. Although the waste rock piles are extensive, they were composed largely of non-reactive (pH=7.4) rock fragments. Although a very high level of arsenic was measured in Ward Creek (130 ug/l) below the mine, a followup survey indicated that it was likely an artifact of the laboratory.

Superior-Engle: The once large mine is located at the base of a mountainside with extensive waste rock piles extending about 100-200 feet down a steep slope, composing a portion of the shoreline of Lights Creek. There were several adits located at the top of the waste rock pile but none showed evidence of discharges. The Superior Mine portion was not visited but watercourses above and below the area were sampled. The waste rock tested neutral (pH=7.0) with high copper (6550 mg/kg) and silver (15.8 mg/kg) levels and moderate zinc levels (165 mg/kg). Other offsite locations contained extensive, unvegitated, tailings piles (similar to Walker Mine tailings piles) but were not sampled.

Walker: The copper mine workings are located at the base of a mountain with a single discharging adit. The adit has been successfully plugged, reducing the copper loads by 98.2% (Croyle, pers. comm.). The present copper concentration (220-450 ug/l) in the discharge is a result of residual copper precipitates in the groundwater conveyance structure and is not a result of plug leakage (ibid). Waste rock piles remain moderately acidic (pH=4.1-4.8) and were composed of moderate to high levels of copper (790-2000 mg/kg), lead (43-70 mg/kg), and silver (5.9-16 mg/kg). Waste rock at the site varies from coarse rock fragments to tailings which were deposited into Little Grizzly Creek downstream from Dollie Creek.

BUTTE CREEK

Mineral Slide: Not visited.

PIT RIVER

Golden Eagle: The gold mine workings are composed of numerous open pit excavations and shafts spread around a large hill (Hayden Hill). The landscape is dry sagebrush with no discernable watercourse from the mine. Although there was ponded water in a man-made dam below the only observed adit, the water was near-neutral and contained nominal metals levels. The waste rock tested alkaline (pH=7.8) and appeared to be composed of earthen material (dirt). Even though the land had been extensively surface excavated, the low rainfall (ca 12.5 inches/year, Alturas) and lack of a nearby receiving water indicates a low threat from erosional processes.

SHASTA LAKE

The polymetallic mines in the Shasta Lake watershed are well known for their acidic drainage containing high concentrations of copper, cadmium, and zinc. Mine drainage in the area is a result of the extensive past underground mining activity that tapped into the massive pyrite formations. The streams carrying the drainage to the Lake are virtually devoid of aquatic life and trout kills at their confluence have been common occurrences. Several mines clustered in the West Shasta Mining District drain to West Squaw Creek and Little Backbone Creek. Two other discharging mines (Rising Star and Bully Hill) are located in the Eastern Shasta Mining District. Extensive monitoring data exists for these mines as conducted over the last 10 years by the Redding Office and, therefore, they were not visited for this study. Several abatement projects have been completed or are in progress at most sites. The rainfall in this area is high, averaging around 40-75 inches/year at Redding.

Balaklala, Keystone, Shasta King, Early Bird: Not visited but extensive information exists on these mines which are located within close proximity to each other. Acidic water with very high levels of cadmium, zinc, copper, and sometimes lead discharge from each mine. Discharges from 2 of Balaklala's adits flow over waste rock piles to West Squaw Creek. The Keystone Mine has one main discharging adit. Several of the mines have had their adits plugged in the past 10 years resulting in significant load reductions.

Bully Hill: This mine was operated on and off from 1860 to 1956 (U.S.GS, 1974) to extract silver, gold, copper, and zinc and contains one caved, discharging adit. The acidic drainage (pH 3.0-5.2) contains high cadmium (120-450 ug/l), copper (1.35 -10.9 mg/l), lead (10-600 ug/l), and zinc (9.4-24.4 mg/l) levels. The drainage courses over waste rock into adjacent Town Creek which continues to flow through a waste rock streambed and disappears under a large, filled, tailings reservoir. The water emanates again from below the tailings dam below the high waterline of the lake. The waste rock was reactive and contained high levels of copper (3005 mg/kg), lead (1620 mg/kg), and zinc (2975 mg/kg), and arsenic (690 mg/kg). The reactive waste rock is extensive and is assumed to be highly variable due to the smelters and flotation process plants that operated at various locations on the site.

Castella: Only a chromite processing complex existed here which serviced several mines in the area. The complex owner donated the land to the state (Castle Crags State Park) and, according to a ranger, the tailings piles were removed and the complex was revegatated and built over. A few dry adits were observed but none with any noticeable waste rock. The stream draining the area (Indian Creek) showed less than detectable metals.

Coggins: The chromite mine was located on the side of a steep mountain about 200-400 feet above the Castle Creek drainage. The one caved adit found showed no evidence of discharge and the waste rock piles consisting of crushed rock were non-reactive (pH=7). A portion of the waste rock appeared to have been planted with pines that were estimated at 15-20 years old.

Early Bird: Not visited but extensive information exists on this mine which is one of several mines located in the West Squaw Creek drainage. Low flows (0.05-0.63 l/s) discharge an acidic matrix with high copper (14-370 mg/l), zinc (19-520 mg/l), and cadmium (0.1-2.3 mg/l) concentrations.

Forest Queen: Three dry adits were observed at this chromite mine located on the top of a large mountain ridge. Waste rock was composed mainly of large crushed rock fragments that tested near neutral (pH=6.5) and contained high chromium (2.5 g/kg) and nickel (1.6 g/kg) levels. The mine was on a very steep slope several thousand feet above the nearest watercourse.

Golinsky: The mine is located near the top of a steep hill several hundred feet from the Lake shore. Past data shows acidic discharges containing high copper (7.95-17.6 mg/l), cadmium (223-1,510 ug/l), and zinc (20.6-78.0 mg/l) levels. The waste rock was extensive and slightly acidic (pH=6.1). Although the mineralogy information suggests otherwise, the waste rock appeared stable and was, therefore, not analyzed for metals.

Mammoth: Not visited but extensive information exists on the mine. The complex contains several adits discharging hi copper (0.9-130 mg/l), zinc (1-172 mg/l), and cadmium (8-1000 ug/l) levels directly to Little Backbone Creek a Shoemaker Gulch. Adit plugging operations have been ongoing since 1981.

Rising Star: The mine is located on the other side of the hill from Bully Hill Mine and contains one main discharging adit that drains over waste rock to an ephemeral stream called Horse Creek. The acidic drainage contains high copper (3-19 mg/l), cadmium (140-510 ug/l), zinc (32-69 mg/l), and lead (45 ug/l) levels. The water flows several hundred feet before entering Shasta Lake. Extensive, reactive waste rock surrounds the mine complex positioned on steeply graded slopes. Waste rock was acidic (pH=2.8) and contained high arsenic (625 mg/kg), copper (1350 mg/kg), zinc (3500), and lead (105 mg/kg) levels.

Shasta King: Not visited but extensive data exists on the mine. The mine has 2 adits discharging low pH water with high cadmium (147-550 ug/l), copper (28-115 mg/l), zinc (27-100 mg/l), lead (100 ug/l) and arsenic (350 ug/l) levels. The water drains over waste rock piles to West Squaw Creek.

Sutro: Not visited but discharges coming from the site contain relatively moderate concentrations of cadmium (<5-20 ug/l), copper (<10-1,420 ug/l), and zinc (90-2,100 ug/l). The discharge drains to Little Backbone Creek.

SACRAMENTO RIVER, UPPER

The upper Sacramento River Watershed includes several mines with a wide range of extraction products (copper, zinc, silver, chromite, and gold), the largest of which is Iron Mt. mine. Several of the polymetallic mines that produce typical acid mine drainage (Afterthought, Iron Mt., Greenhorn, Stowell) have extensive monitoring databases. Abatement action at many of these mines has been ongoing for over 10 years. Rainfall in the area is moderate (ca 22 inches/year, Red Bluff) to high (40-80 inches/year, Redding).

Afterthought: The mine is located at the base of a mountain with several adits, shafts, and site locations. The main adit is the primary source of acid drainage and contains high levels of cadmium (0.3-1.23 mg/l), copper (10.6-48.9 mg/l), zinc (83.6-313 mg/l), lead (91 ug/l), and moderate levels of arsenic (125 ug/l) and nickel (32 ug/l). Adit discharges flow over waste rock directly into Little Cow Creek. The waste rock tested moderately acidic (pH=4.7) with high levels of copper (1090 mg/kg), lead (4000 mg/kg), zinc (4300 mg/kg), silver (28 mg/kg), and arsenic (500 mg/kg). The waste rock was extensive and composed several hundred feet of the Little Cow Creek streambank. **Gladstone:** The gold mine was located at the base of a large hill with a seep discharging neutral, clear water (Heiman, pers. comm.). The waste rock was extensive, slightly acidic (pH=5.1), and composed mostly of country rock fragments containing and moderate copper (179 mg/kg) and zinc (140 mg/kg) levels and high lead (76 mg/kg) and arsenic (800 mg/kg) levels. Cline Creek below the mine

showed arsenic was present at 25 ug/l although any potential inputs were not bracketed.

Greenhorn: The mine complex contains an open pit area at the top of a large hill with several discharges at the hill's base which drain directly to Willow Creek and vary in pH (2.3-5.87) and metals content. The north adit discharge contains the highest levels of copper (61-138 mg/l), zinc (78-180 mg/l), cadmium (645-1510 ug/l), and moderate nickel (61-190 ug/l) and arsenic (39-170 ug/l) levels. Waste rock piles exist at both the upper and lower areas with a high erosion potential because of the steeply sloped terrain (60-80 degrees). The waste rock was extensively eroded and composed a portion of the Willow Creek stream bank. The moderately acidic waste rock (pH=3.8) was collected from the upper workings and contained only moderate levels of copper and zinc.

Iron Mt.: Not visited but extensive information exists on the mine. The complex is a major source of copper, zinc, cadmium to the Sacramento River and is presently under-going a variety of abatement measures including superfund (CERCLA) remediation (Heiman, pers. comm.). Several adits discharge highly acidic water with elevated levels of metals to Spring Creek. Spring Creek flows into Spring Creek Debris Dam (SCDD) and then to Keswick reservoir. Because of the many on-site discharges, concentrations were tabulated (and loads were calculated) at the point where Spring Creek enters the Sacramento River. One waste rock sample was collected at the ore loading site adjacent the Sacramento River above the confluence of Spring Creek. The waste rock material was highly acidic (pH=1.9) and contained moderate copper (480 mg/kg) and zinc (580 mg/kg) levels. The material appears to be a product of the beneficiation process and does not represent the characteristics of the other diverse waste rock piles.

JCL: Not visited.

Midas: The gold mine was located in a valley adjacent Harrison Creek. One shaft was seen but no discharges were observed. Water in Harrison Creek below the mine contained arsenic at slightly higher levels (4 ug/l) than water collected upstream the mine (<1 ug/l). The alkaline (pH=8) waste rock had been deposited on the hillside down to Harrison Creek and up in the surrounding hillsides on either side of the Creek.

Round Bottom: The chromite mine was located in a steeply sloped valley and contained an apparent caved adit which was seeping neutral neutral water with low nickel (54 ug/l) and cadmium (1.2 ug/l) levels. The seep disappeared into the ground several feet from the source. Waste rock was alkaline (pH=7.6) and vegetated to some extent.

Silver Falls: The silver mine was located at the base of a hill range in an ephemeral canyon and contained an adit with near-neutral, ponded water with near detection levels of metals. The waste rock was also near neutral (pH=6.7) and located approximately one-fourth mile from Andrews Creek.

Stowell: This site was not visited but extensive information exists on the mine. Located above Iron Mt. Mine in the Spring Creek watershed, it contributes around 1 percent of the total loads estimated to come from Spring Creek Debris Dam (Heiman, pers. comm.). Abatement projects are ongoing.

Thompson: The copper mine site was located in a flat watershed adjacent an ephemeral stream. There was some ponded water in the location of the shaft with nominal concentrations of analyzed metals. The soil material that appeared to be waste rock was moderately acidic (pH=3.9) and high copper (940 mg/kg) and moderate zinc (260 mg/kg) levels. The waste rock was graded flat around the caved shaft and made up a short length of the dry stream bank.

White Star: This silver mine was not visited.

Yankee John: This gold mine contained a single adit and shaft with no evidence of discharges to the nearby ephemeral stream. Waste rock tested neutral (pH=7.3) and appeared to be composed of non-friable, stable rock particles that were distributed over a large area.

STONY/ELDER CREEK

These chromite mines are located in a dry, steeply sloped watershed in the rainshadow effect of the western valley foothills. Many of the mines showed evidence of open pit excavations and all contained extensive, non-reactive, waste rock. The extensive surface extraction operations have resulted in massively scarred hillsides with a high potential for erosion. The landscape supports dry xeric vegitation with rainfall at Willows averaging around 16 inches/year.

Black Diamond: This chromite mine was located near the top of a mountain just above Grey Eagle Mine and was composed of an exposed open pit with waste rock that appeared non-reactive.

Grey Eagle: This large chromite mine consisted of an extensive open surface excavation operation with several observed adits. One large pond below the main adit was alkaline with just above detection levels of zinc and chromite. The very extensive waste rock piles that exist at the mine site were alkaline (pH=8.7) and spread into several steeply sloped, dry, canyons. Extracted ore was transported off-site via an aerial tramway.

Noble Electric: The mine extended over a large area on the side of a steeply sloped canyon wall. Neutral seepage from the area showed mostly non-detectable metal levels. Similar results were found in Elder Creek below the mine. The high EC in Elder Creek is apparently due to salt springs observed in the area (CSMB, 1916). Extensive erosion events are apparently occuring during rainy period. Much of the waste rock and erosional material had been carried down to the streamside. Waste rock tested alkaline (pH=8.7) with high nickel (2400 mg/kg) and chromium (400 mg/kg) levels. Some rock crushing equipment was observed at the site.

Grau: This chromite mine is located upstream the Noble Electric mine and exhibits similar erosional potential. No discharged was observed. Waste rock tested alkaline (pH=8.8).

CACHE CREEK WATERSHED

Mercury mines in the Cache Creek watershed all processed cinnabar ore at the site of extration using furnace/condensation equipment. The area is moderately wet (ca 27 inches/year, Lakeport) to dry (ca 15 inches/year, Williams). Most of the mines employed both underground and surface mining techniques. Several of the mines are eventually drained by Sulphur Creek which is largely ephemeral. Downstream of the Sulphur Creek mines, multi-colored seeps initiate stream flow which contains an extremely high salt content (EC > 10 mS/cm), occluding the detection of specific metals.

Central: One of five mines located in the Sulphur Creek valley. The mine site is characterized by a few buildings - any shaft or waste rock could not be distinguished from the surrounding vegetated landscape.

Elgin: Not visited.

Empire: Located in the Sulphur Creek valley, one dry adit and a large glory hole are present at the complex which was situated on the side of a large hill. The adit showed no evidence of any past discharges and the vegetated waste rock tested neutral (pH=7.2).

Manzanita: The mine is located in the Sulphur Creek valley with a combination of surface and underground mining scars. No evidence of a discharge was observed and the waste rock was, at places, indistinguishable from disturbed surface soils. The waste rock collected was alkaline (pH=7.9) with a high mercury content (785 mg/kg) and low levels of other metals.

Wide Awake: The mine consisted of several dry adits situated on a hillside located 100 feet above an ephemeral, erosion prone, gully. The waste rock was alkaline (pH=7.5) and containd a moderate concentration of mercury (13 mg/kg). The mine site included a very large furnace which apparently serviced other Sulphur Creek valley mines.

Abbott: Located on the side of a large and steep hillside, the mine workings consist of a shaft, surface mining scars, and furnace/condensation equipment. There was no history or evidence of discharges but the waste rock piles were extensive, extending 100-200 feet from the complex to the bottom of the Grizzly Gulch. The waste rock tested alkaline (pH=7.9) and contained a high mercury level (910 mg/kg).

Sulphur Bank: Not visited but extensive information exists on this mine. The mine is an open pit excavation covering approximately 2 acres directly adjacent Clear Lake. It was mined for mercury, sulfur, and borax. There is a large pit (Herman Pit) filled with low pH water (<3.0). Runoff from the site and erosion from a portion of the shoreline made up of tailings contributes to the lake's mercury loads (Walker, pers. comm.). There is a CDHS Health Advisory in effect for the lake against eating mercury tainted fish. The site is under consideration for various cleanup schemes.

Harrison: Not visited.

Reed: The mine site contains an adit located at the base of a large hill and at one time discharged a small volume (ca. 0.32 l/s) of slightly acidic water containing high nickel levels (1200 ug/l), moderate arsenic levels (59 ug/l), and low chromium (46 ug/l) and zinc (20 ug/l) levels. The adit discharges directly into Davis Creek above Davis Creek Reservoir and has caused, in the past, extensive iron floc buildup. The mine adit was plugged during this study reducing the discharge to a seep. Waste rock piles were deposited on the steeply sloped hillside and extend down to Davis Creek where it forms the streambank for several hundred feet. The waste rock was moderately acidic (pH=3.8) and contained high nickel (870 mg/kg) and chromium (440 mg/kg) levels, although halfway through this study, the waste rock was covered with imported soil and vegetated with barley. The mine site contained a rotary furnace and vapor condensation equipment. The study and reclamation of the mine site is conducted by a nearby active mining firm responsible for maintaining the quality of Davis Creek and Davis Creek Reservoir (Walker, pers. comm.).

Turkey Run: The small mine is located at the base of a large hill next to Abbott mine and a single adit discharges alkaline water with a nominal chromium concentration. Waste rock was extensive, composing the streambed of the gully draining the adit. The waste rock characteristics are probably similar to those at the Abbott mine due to their close proximity.

LAKE BERRYESSA/POPE CREEK

The James Creek watershed (a tributary of Pope Creek) remains impacted from several mercury mines located in the same watershed. Impacts occur from adit discharges, erosion, and mercury inputs into the food chain. James Creek is coated with an orange gelatinous floc extending up to 2 miles from Corona mine. The potential from erosion in the watershed is great due to past surface extraction operations, waste rock dumps, and the steep nature of the slopes. Because of the high content of cinnabar deposited in James Creek from the surrounding mines, the creek itself once supported a gravel washing operation during the early 1960's. Much of the historical information on these mines was recounted from Anthony A. Cerar, a past employee of several of the mining operations in the valley.

Corona: The mine complex contains an upper and lower workings which include several adits and a water release tunnel. The road from Oat Hill Mine was completed in 1894 with startup occuring soon after. In 1905-07 water from an uphill spring began infiltrating and flooding the mine tunnels. Mining was started in 1913 at the upper site and is located about

250 feet from the lower site. The lower site is about 500-600 feet above James Creek on a steeply sloped hillside. During 1925-27 a water release tunnel was blasted 1500 horizontal feet to the ledge of the main tunnel complex. The tunnel release is located directly adjacent to James Creek. The only other discharge comes from an adit at the lower site which was discharging only a seep although past monitoring and downstream iron staining indicated discharges could be substantial. The water release tunnel discharged the highest flows (3-21 l/s) which contained very high nickel (6-12 mg/l) and iron (150-620 mg/l) concentrations and high zinc (100-260 ug/l) levels. The high nickel content can be explained by mineralogical assays identifying nickel sulfide in approximately 5 percent of the surrounding orebody (CSMB, 1915). Secondary mineral formation at the adit release (prior to discharge to James Creek) was identified as iron oxide (HFeO2, FeO3) by the Sacramento Office of Mines and Geology (Walker, Pers. comm.). Waste rock piles were extensive around the site and were deeply gullied from upstream runoff. The waste rock was acidic (pH=2.6) and contained high mercury levels (1.37 g/kg) with low to moderate levels of other metals. Several mercury extraction operations were conducted on-site. A recent fish survey reported both trout and suckers as present inhabitants of the stream in the impacted area.

Twin Peaks: The mine became active in 1911 and at one time operated a rock crushing mill and a pipe furnace. The site is situated approximately 600 feet above Bateman Creek on a steep (ca 60 degrees) slope. Only one of the two adits that were drilled maintains a small discharge (0.2-0.3 l/s) containing high nickel (1.6-2 mg/l) and iron (14-16 mg/l) concentrations. The water was moderately acidic (pH=5-6) and flowed directly over a highly eroded waste rock pile. The waste rock was slightly acidic (pH=5.9) and contained low to moderate levels of all metals.

Oat Hill: This was the fifth largest mercury mine in the world at one time and produced over 800,000 flasks in its lifetime. Several adits were tunnelled starting in 1876 and during the mercury price rise (late 1950's), open pit mining techniques were used at several locations in the Valley's hillsides. No discharges were observed, although, seepage or releases had been observed at the base of the hill. Exposed soils and waste rock was slightly acidic (pH=5.8) and contained a high mercury content (590 mg/kg). No other compounds were analyzed.

Oat Hill Extension: The mine site once processed ore from other mines around the valley and consisted of a large vegetated waste rock pile and a large processing facility. The site was not sampled.

Aetna: The site is composed of several dry adits tunnelled into the side of a glory hole. The glory hole was highly eroded but the waste rock piles were apparently deposited in areas of housing construction. The waste rock was moderately acidic (pH=4.5) with a high mercury content (620 mg/kg) and low levels of several other compounds.

Aetna Extension: The mine is located above James Creek on the opposite side of the hill as the Aetna Mine. Several, dry, caved adits were observed among disturbed soils and waste rock which was largely vegetated. Several exposed waste rock piles tested alkaline (pH=7.6) and contained a relatively low mercury content (6.8 mg/kg). No other compounds were analyzed.

Grenada: The small site was located approximately 400 feet above James creek in moderately sloped terrain (40-60 degree incline). No mercury was ever produced from the tunnel which discharged a clear seep. The surrounding waste rock was alkaline (pH=7.9) and deeply gullied from upstream runoff in the ephemeral watercourse.

Toyon: The mine was located about 250 feet above the Grenada mine in a small, steeply sloped canyon. The small mine site apparently produced only 200 flasks in it's lifetime. The site contained a caved adit with a slight, clear seep and a smal brick retort. The alkaline waste rock (pH=8.2) contained moderately high mercury levels (86 mg/kg).

LAKE BERRYESSA/PUTAH CREEK WATERSHED

With the exception of Copper Prince Mine (a copper mine), the mines in this watershed were mined for their mercury containing ores. Precipitation in the area can be variable (ca 41 inches/year, Middletown). Most of the mines had no perennial discharge. Cinnabar extraction equipment was present or reported at all mercury mines in this watershed.

Anderson: Located near the town of Anderson Springs, the mine contains 2 known adits discharging near-neutral water with moderate to high levels of nickel (10-240 ug/l) and zinc (17-260 ug/l) and low levels of copper, chromium, and arsenic. Anderson Springs Creek water below the mine showed mostly below detection levels of these compounds. The west adit discharged water exhibiting reducing conditions (Eh=-65 to -105 mV). However, those reducing conditins only slightly affected the immediate downstream receiving water redox conditions. The extent of the waste rock piles appeared minimal and appeared non-reactive.

Big Chief: Located just above the Anderson Mine approximately 300-400 feet from Anderson Springs Creek, the site contained 2 dry adits. Waste rock was acidic (pH=2.5) and contained low levels of all metals analyzed with the exception of mercury (840 mg/kg).

Big Injun: No evidence of the mine workings exist since a geothermal power generation plant was built over the site (Daniels, pers. comm.).

Copper Prince: Not visited.

Great Western: Extensive surface and underground operations occurred in two watersheds - the "new" mine was inspected for this study. A single adit discharging alkaline water contained nominal nickel, zinc, and chromium levels. Waste rock tested alkaline and was deposited at several locations around the watershed. St. Marys Creek below the mine site was

alkaline with variable nickel levels (<5-120 ug/l). Extraction operations were extensive at the mine site according to observations and historical records.

Knoxville: The mercury mine was located in a flat valley with a single observed shaft and a tailings dam. No discharge was observed. The tailings dam contained dry, red, "soils", similar to dry ferric hydroxide and was fully contained within the dam structure.

Red Elephant: Located at the top of a local knoll, the surface/underground mercury mine contained one water filled shaft with no detectable metals. A gully extending from the shaft indicated past discharges. A large portion of the hillside had been excavated and the resultant unvegitated soil had formed deep erosional gullys. The landscape did not appear to receive much precipitation. The exposed soil tested near neutral (pH=7.3) and contained a high mercury content (240 mg/kg).

Manhattan: The original mine site has been converted to an active gold mining operation.

Table E-1. TRACE ELEMENT SURVEY OF SEVERAL SACRAMENTO VALLEY WATERBODIES.

SAMPLE LOCATION	COUNTY	DATE	EC	pH	TRACE METALS, UG/L (DETECTION LIMITS IN PARENTHESES)								
					ARSENIC (1-2)	CADMIUM (0.1)	CHROMIUM (1)	COPPER (1)	NICKEL (4)	ZINC (5-10)	LEAD (5)	MERCURY (0.2)	SILVER (1)
NF Yuba River	Sierra	09JUN89											
at Hwy 49			78		1.6	ND	3.4	1.1	ND	ND	ND	ND	ND
at Downieville			38		1.3	ND	2.4	ND	ND	15			
at Bassett			36		1.1	ND	4.1	ND	ND	ND			
Kanaka Creek	Sierra	10JUN89											
above Kenton mine			88		18	ND	4.6	ND	5.9	20	ND	ND	ND
at M.F. Yuba River		14DEC89	182	6.86	25		2	ND	ND	ND	ND		
		13APR90	114	6.46	15		ND						
Howard Creek	Sierra	09JUN89											
at Bassett			24		10	ND	2.5	1.1	ND	25	ND	ND	ND
Camp Far West Res.	Yuba	08JUN89											
at base of dam			97		1.6	ND	3.8	2.9	ND	ND			
Rock Creek	Yuba	08JUN89											
trib. to Camp Far West			300		1.3	ND	2.8	1.4	ND	ND			
Dry Creek	Yuba	08JUN89											
trib. to Camp Far West			240		1.1	ND	5.3	2.8	ND	ND			
Yuba River	Nevada	08JUN89											
Englebright Res. release			70		1.5	ND	5.4	2.9	ND	ND			
Deer Creek	Nevada	08JUN89											
Lake Wildwood dam release			100		2.2	ND	2.6	1.6	ND	ND			
Squirrel Crk. next to dam	Nevada	08JUN89	160		1.9	ND	2.6	1.6	ND	ND			
Fiddle Creek	Sierra	09JUN89											
at Hwy 49			46		1.7	ND	2.8	ND	ND	ND			
Goodyears Creek	Sierra	09JUN89											
at Goodyear Crk Rd			142		1.8	ND	9.3	ND	ND	ND			
Downie River	Sierra	09JUN89											
at Hwy 49			87		2.1	ND	5.5	2.1	ND	ND			
Salmon Creek	Sierra	09JUN89											
at Hwy 49					1.2	ND	ND	ND	ND	ND			
MF Yuba River	Nevada	09JUN89											
at Hwy 49					2.9	ND	2.3	ND	ND	ND			
below Plumbago Mine			40		1.0	ND	2.5	ND	ND	ND			
above Kanaka Crk		13APR90	60.1	6.54	ND								
below Kanaka Crk		13APR90	65	6.77	ND								
SF Yuba River	Nevada	09JUN89											
at Hwy 49					ND	ND	2.5	ND	ND	ND			
Oregon Creek	Sierra	10JUN89											
at confl. MF Yuba			70		1.7	ND	2.6	1.2	ND	ND			
Unnamed stream	Sierra	09JUN89											
from Sierra Buttes					1.2	ND	3.0	ND	ND	ND			
Indian Creek	Plumas	27JUN89											
at Taylorsville			118		ND	ND	ND	2	ND	ND	ND	ND	ND
Lights Creek	Plumas	27JUN89											
at B.G. Rd. & Dia Mt. Rd.			134		3	ND	ND	12	ND	ND	ND	ND	ND
above China/Superior Gulch			120		ND	ND	ND	4	ND	ND	ND	0.4	ND
between Superior & Engel			98		ND	ND	ND	3	ND	ND	ND	0.3	ND
below Superior & Engel					ND	ND	ND	2	ND	ND	ND	0.3	ND
Wolf Creek	Nevada	13JUN89											
in Grass Valley			135		ND	ND	1	2	ND	5	ND	ND	ND
above Grass Valley					ND	ND	ND	2	ND	2	ND	0.4	ND
Malakoff Diggins	Nevada	14JUN89											
from Hillar Tunnel			117		ND	ND	ND	3	9	24	ND	0.3	ND
Humbug Creek u/s mine			82		ND	ND	ND	1	7	ND	ND	ND	ND
Shady Crk @ Hwy 49	Nevada	09JUN89			1.2	ND	4.8	1.0	ND	19.0	ND	ND	ND
Dry Fork	Shasta	27AUG89			ND	0.1	ND	ND	ND	ND	ND		
West Squaw Crk	Shasta	27AUG89			ND	6	ND	2800	ND	1000	ND		
Shoemaker Gulch	Shasta	27AUG89			3	22	1	2000	ND	3200	ND		
Little Backbone Crk	Shasta	27AUG89			16	63	4	7000	9	12000	23		
Big Backbone Crk	Shasta	27AUG89			ND	ND	ND	ND	ND	39	ND		
Shasta dam	Shasta	11JUL89	123		ND	ND	1	3	ND	7			
		12JUL89	123		ND	0.1	2	4	ND	10			
		12JUL89	120		ND	ND	2	11	ND	17			
		13JUL89	103		ND	ND	1	4	ND	9			
		14JUL89	118		ND	ND	2	3	ND	7			
		25JUL89			ND	ND	1	3	ND	7			
		27JUL89			ND	0.4	2	4	ND	18			
		03AUG89	100			ND	1	3	ND	8			
		04AUG89	100			ND	1	3	ND	13			

Table F-1. COMMON MINERALS IN CALIFORNIA CONTAINING METALS AND METALLOIDS OF CONCERN. 1/

CMD	MINERAL NAME	ASSOCIATED MINERALS	ELEMENTAL FORMULA	COMMENTS
As	Arsenopyrite			The primary arsenic mineral in CA; As content of most base-metal ores is below 1%
	Lollingite			
	Enargite			
	Tennantite			
	Realgar			
	Orpiment			
Cd	Greenockite			Chief Cd-bearing minerals, invariably occuring with sphalerite
	xanthochroite			Chief Cd-bearing minerals, invariably occuring with sphalerite; occurs as yellow coating on sphalerite
	cadmiumoxide			Present in the oxidized portion of zinc sulfide bodies
	otavite			Present in the oxidized portion of zinc sulfide bodies
Cr	Chromite		Cr2 O3	Primary source of chromium; serpentine and peridotite are the host rock
	Kammererite			Secondary source of chromite occuring as vienlets, stains, or incrustations in or on the ore
	Uvarovite			Secondary source of chromite occuring as vienlets, stains, or incrustations in or on the ore
Cu	Chalcopyrite	pyrite, pyrrhotite, sphalerite	Cu Fe S2	Chief Cu mineral in CA; 34.5% Cu when pure. Sometimes called fool's gold.
	Chalcocite	are associated; galena,	Cu2 S	Second most common Cu mineral in CA; 79.8% Cu when pure
	Bornite	magnetite, and ilmenite are	Cu5 Fe S4	Subordinate mineral; 63.3% Cu when pure
	Covellite	commonly also present; zinc	Cu S	
	Enargite	minerals not abundant in Plumas	Cu3 As5 S4	
	Tetrahedrite	Co. deposits; all CA deposits	Cu8 Sb2 S7	Subordinate mineral; commonly shows various amounts of Fe, An, and Ag
	Malachite	had to be concentrated prior to	Cu CO3 Cu(OH)2	
	Azurite	smelting	2[Cu O3 Cu(OH)2]	
	Cuprite		Cu2 O	
Pb	Galena	Zn & Ag minerals commonly as-	Pb S	Chief source of lead
	Anglesite	sociated with Pb minerals in CA	Pb SO4	Important secondary ore minerals
	Cerussite		Pb CO3	Important secondary ore minerals
Ni	Pentlandite	nickeliferous material can consist	[Ni, Fe] S	By far the most important
	Polydymite	of primarily pyrrhotite with	Ni3 S4	
	Millerite	subordinate amts of pentlandite	Ni S	
	Niccolite		Ni As	
	Chloanthite		Ni As2	
	Garnierite			
Fe	Pyrite	most common gangue mineral in metallic ore deposits; most massive	Fe S2	By far the most important. Commonly called pyrite or fool's gold. 46.55% Fe and 53.45% S when when pure (pyrite and marcasite)
	Marcasite	sulfides contain minor amts of As,	Fe S2	Not as common in metaliferous veins or crystalline rocks, orthorhombic form of pyrite.
	Pyrrhotite	Cu, Ag, Zn, & lime	Fe[1-(0to0.2)]S	Contains small amounts of Cu, Co, and Ni; commonly associated w/chalcopyrite, pyrite, magnetite, pendlantite and molybdenite
Zn	Sphalerite	Zn & Pb and Zn & Cu minerals ordinarily occur in close association	Zn S	67.0% Zn when pure; only important primary ore of zinc; present in nearly all types of sulfide deposits
	Marmatite		Ferriferous ZnS	Contains 10% or more Fe
	Smithsonite			Common oxidized product of ZnS
	Hememorphite			Less common oxidized product of ZnS

1/ Taken from CDMG, 1966 and DOM, 1957.

Table G-1. INPUT-OUTPUT CALCULATIONS OF METALS MOVING THROUGH SHASTA RESERVOIR.

MAIN SHASTA RESERVOIR INPUT	ANNUAL OUTFLOW (AC-FT)	SAMPLING PERIOD 1/	N 2/	COV	SOURCE *	CONC. (UG/L)	SAMPLING PERIOD 1/	N	COV	SOURCE *	LOADS (KG/YR)	STAND. ERROR (KG)
West Squaw Creek	4,712	1989-1992	4	0.383	A	1327	1989-1992	4	0.746	A	7,714	6,466
Little Backbone Creek	2,863	1989	2	0.11	A	5070	1989	2	0.38	A	17,907	7,084
Shoemaker Gulch	639	1989	1		A	2000	1989	1		A	1,577	
Big Backbone Creek	11,808	1989	1		A	0.6	1989	1		C	8.7	
Pit River	2,945,111	WY 1989	N.A.		B	0.240	1991	2	0.0589	D	872	51.4
upper Sacramento River	638,400	WY 1989	N.A.		B	0.270	1991	2	0.0524	D	213	11.1
McCloud River	411,400	WY 1989	N.A.		B	0.245	1991	2	0.664	D	124	82.3
TOTAL	4,014,933										28,416	9,592

CALCULATED AND ACTUAL COPPER CONCENTRATION IN SHASTA DAM RELEASE WATER, ANNUAL AVERAGE.

CONCENTRATION ORIGIN	SAMPLING PERIOD	N 2/	SOURCE	MEAN UG/L)	STANDARD ERROR (UG/L)
Expected using above data				5.74	1.94
Expected excluding mine drainage 3/				0.27	0.03
Actual data	7-89 to 8-89	9	Table E-1	4.2	2.6
Actual data	7-88 to 6-89	21	Heiman, 1989	4.2	1.9
Actual data	7-90 to 6-91	22	Heiman, 1991	2.4	1.1
Actual data	2-91 to 12-91	7	Connor, unpub.	2.601	0.866

1/ Single year indicates when data was collected and extrapolated for the year. WY=outflow measured during the water year.
2/ Number of samples taken to obtain the average.
3/ Calculated by substituting a copper concentration of 10.75 +- 13.50 ug/l into the above concentration columns for West Squaw Creek, Little Backbone Creek and Shoemaker Gulch. This was the average measured from 4 samples taken in West Squaw Creek above mine influence.

* SOURCE:
A: See source list corresponding to date and location in Table A-5.
B: U.S.GS Water Resources Data, California, Water Year 1983. Volume 4. U.S.GS Water-Data Report CA-89-4.
C: Nordstrom, et. al., 1977.
D: Connor, unpub.

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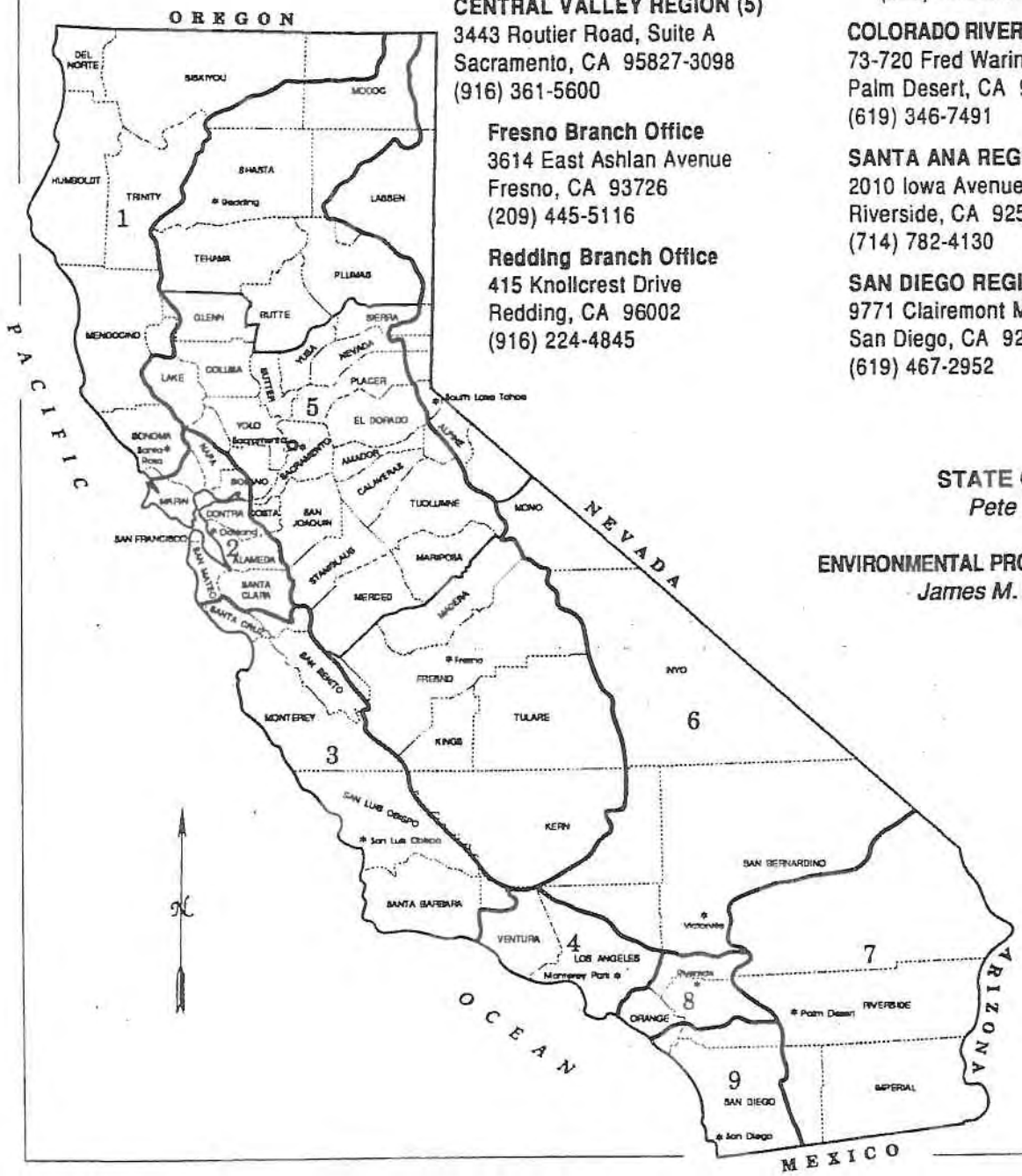

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ENVIRONMENTAL PROTECTION AGENCY
James M. Strock, Secretary

1 June 1992